The Keadby 3 (Carbon Capture Equipped Gas Fired Generating Station) Project

Document Ref: -

Planning Inspectorate Ref: EN010114

The Keadby 3 (Carbon Capture Equipped Gas Fired Generating Station) Order

Land at and in the vicinity of the Keadby Power Station site, Trentside, Keadby, North Lincolnshire

Environmental Statement
Volume II - Appendix 12A: Flood Risk Assessment

The Planning Act 2008

The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017

Applicant: Keadby Generation Limited

Date: November 2021

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GLOSSARY

Abbreviation	Description
AEP	Annual Exceedance Probability
AGI	Above Ground Installation
AIL	Abnormal Indivisible Load
ANNWLMB	North Nottinghamshire Water Level Management Board
AOD	Above Ordnance Datum
AStGWF	Areas Susceptible to Groundwater Flooding
BGL	Below Ground Level
BGS	British Geological Survey
CC	Climate Change
CCP	Carbon Capture Plant
CCGT	Combined Cycle Gas Turbine
CEMP	Construction Environmental Management Plan
CFL	Critical Flood Level
CFMP	Catchment Flood Management Plan
CIRIA	Construction Industry Research and Information Association
CRT	Canal and River Trust
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
DEMP	Decommissioning Environmental Management Plan
DPD	Development Plan Documents
EA	Environment Agency
ES	Environmental Statement
FRA	Flood Risk Assessment
GPP	Guidance for Pollution Prevention
HCA	Homes and Communities Agency
kV	Kilovolt
LLFA	Lead Local Flood Authority

Abbreviation	Description
LWS	Local Wildlife Site
MAGIC	Multi-agency geographical information for the countryside
MW	Megawatt
NLC	North Lincolnshire Council
NPPF	National Planning Policy Framework
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
NTS	Non-Technical Summary
PINS	Planning Inspectorate
PFRA	Preliminary Flood Risk Assessment
PPG	Planning Practice Guidance
PWS	Private Water Supply
RoFSW	Risk of Flooding from Surface Water
SAC	Special Area of Conservation
SFRA	Strategic Flood Risk Assessment
SPA	Special Protection Area
SPZ	Source Protection Zone
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Urban Drainage System
RBMP	River Basin Management Plan
WFD	Water Framework Directive

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TABLES

1.0 INTRODUCTION

1.1 Overview

1.1.1 AECOM Infrastructure and Environment Limited ('AECOM') was commissioned by the Applicant to prepare a Flood Risk Assessment (FRA) in support of a Development Consent Order (DCO) application for a proposed low carbon gas fired generating station on the Keady Power Station site at Keadby, Scunthorpe, DN17 3EF (hereafter referred to as the 'Proposed Development'). The Application was accepted by the Planning Inspectorate for examination on 28 June 2021 and was accompanied by an FRA (**APP-084**). The FRA has been updated following new data on the Humber Extreme Water Levels and comments provided by the Environment Agency in July 2021.

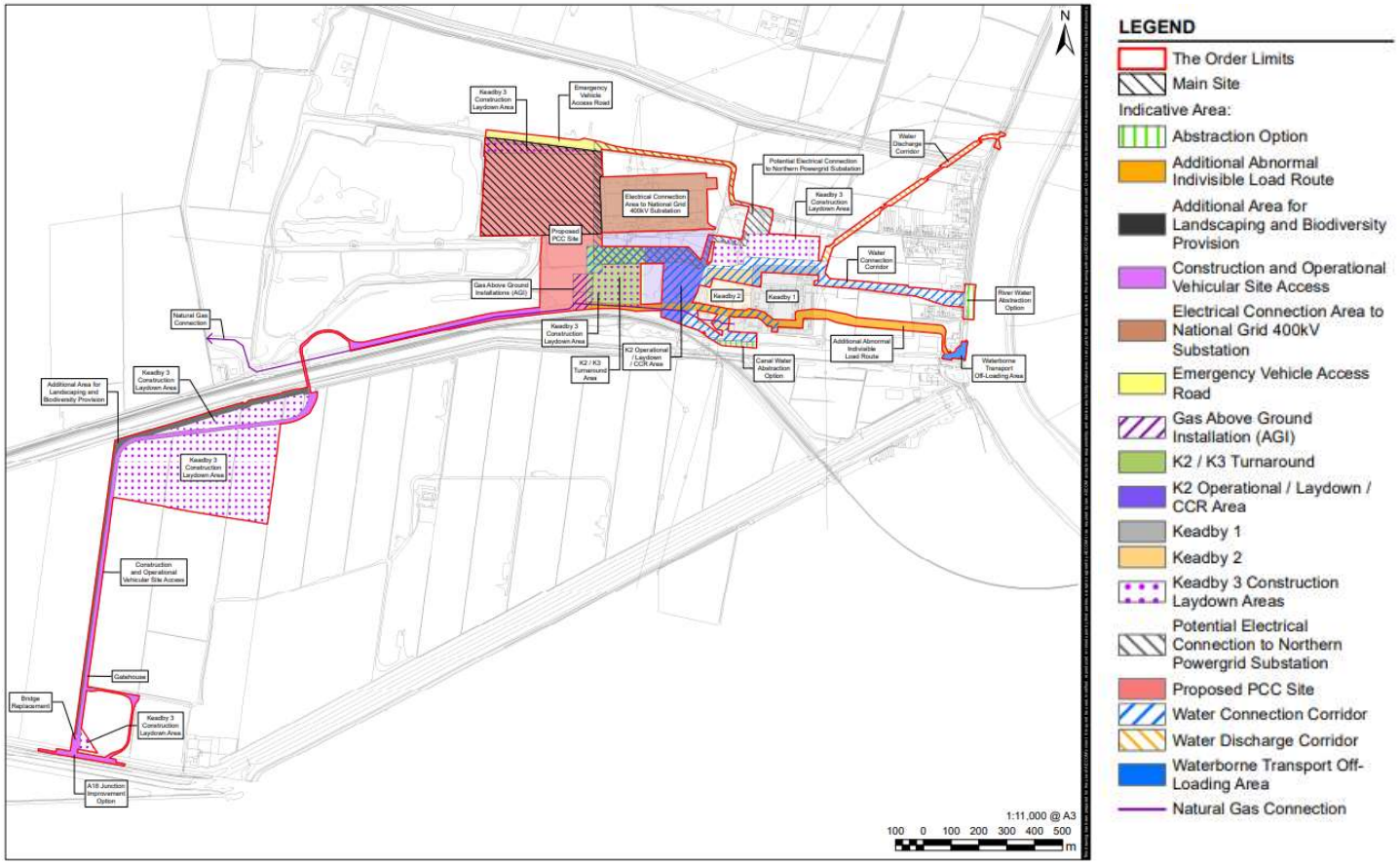
1.1.2 Sections 1 - 4 of this appendix provide the FRA for the Proposed Development whilst Sections 5 - 6 relate to the Conceptual Drainage Strategy for the Proposed Development Site.

1.1.3 The terms of reference used to describe the Proposed Development in this report are broadly consistent with those defined within the main chapters of the Environmental Statement (ES) (ES Volume I – **Application Document Ref. 6.2**) and illustrated on **Figure 3.3**: Areas of the Site Referred to in the Environmental Statement (ES Volume III – **Application Document Ref. 6.4**) reproduced in **Plate 1** for ease of reference.

1.1.4 The Proposed Development Site encompasses an area of approximately 69.4 hectares (ha) which includes circa 20.7ha of land for construction laydown.

1.1.5 The Proposed PCC Site comprises an area of approximately 18.7ha of the Proposed Development Site within the wider Keadby Power Station site that is located within Keadby Common. Overhead electricity transmission lines associated with the existing National Grid 400kV Substation bisect the Proposed PCC Site. Land to the south of these overhead lines within the Proposed PCC Site is proposed for administration/ control room/ warehouse buildings and car parking areas and an above ground installation (AGI) for the gas connection. The area of the Proposed PCC Site on which the power generation (CCGT), Carbon Capture and Compression (CCP) and associated stacks will be developed is referred to as the 'Main Site' herein.

Plate 1: Areas of the Site Referred to in the Environmental Statement (reproduced Figure 3.3 (ES Volume III - Application Document Ref. 6.4))



1.2 The Purpose and Scope of this Document

1.2.1 The Environment Agency's (2021a) 'Flood Map for Planning' identifies that the Proposed Development Site and surrounding environs is within Flood Zone 3, with the exception of a small section of the Proposed Development Site within the New Permanent Access from A18, which is in Flood Zone 2. Flood Zone 3 is defined by the National Planning Policy Framework (NPPF) Planning Policy Guidance: Flood risk and coastal change (PPG) (Ministry of Housing, Communities and Local Government, 2019b), as land with a high probability of flooding (>1% Annual Exceedance Probability (AEP)) (1 in 100 or greater annual chance of river flooding), or a >0.5% AEP (1 in 200 or greater annual chance) of flooding from the sea. Flood Zone 2 is defined as land that has a medium probability of flooding (between 1 in 100 and 1 in 1,000 annual probability of river flooding (0.1-1% AEP), or between 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.1-0.5% AEP).

1.2.2 The North Lincolnshire Strategic Flood Risk Assessment (SFRA) (North Lincolnshire Council, 2011) defines the Proposed Development Site as in the Tidal Flood Zone 3a. It is not defined as in Zone 3b; land where water has to flow or be stored in times of flood, as the Proposed Development Site does not act as a functional floodplain due to existing Environment Agency defences which prevent natural flooding from occurring.

1.2.3 As the Proposed Development Site comprises an area in excess of one ha and is located within Flood Zone 3, a FRA is required to accompany the DCO Application, in line with the requirements of NPS EN-1 Paragraph 5.7.4 .

1.2.4 This document comprises a FRA that is appropriate to the nature and scale of the Proposed Development, meets the necessary requirements of current planning policy (NPS EN-1 and the PPG), to support the DCO Application for the Proposed Development. In producing this FRA, the following has been undertaken:

- consultation with and obtaining data from North Lincolnshire Council (NLC), and from the Environment Agency including the Humber 2100 Strategy Team as well as consultation with Isle of Axholme and North Nottinghamshire Water Level Management Board (the local internal drainage board (IDB)) in regard to the Proposed Development, the flood risks posed to Proposed Development Site and the necessary measures that would be required to protect the Proposed Development from flooding (refer to paragraph 1.3.2 and **Annex A**);
- review of publicly available data to determine the flood risks associated with all sources of flooding including the Humber Estuary, main rivers, ordinary watercourses (including those under the jurisdiction of the IDB), groundwater, artificial sources, surface water runoff/ overland flow and drainage and surrounding areas; and

- review of the Proposed Development design in light of the identified flood risks and identification of measures, where necessary, that would manage any residual flood risk to the Proposed Development Site to acceptable levels.

1.3 Data Sources

1.3.1 The baseline conditions for the Proposed Development Site were established through a desk-based study and via consultation with the Environment Agency and other key statutory consultees. This information has been used to inform the assessment made within the FRA. Data collected during the course of this assessment is detailed in Table 1, below.

Table 1: Data Sources to inform this FRA

Purpose	Source	Comments
Identification of hydrological features	1: 10,000 Ordnance Survey (OS) mapping	Identifies the position of the Proposed Development Site, local hydrological features, and riparian owners.
Historical Land Use and Hydrological Features	Historic OS maps dating back from 1842- Present (Ordnance Survey, 2021)	Identifies historical land use change and hydrological features over the last 176 years.
Identification of Existing Flood Risk	Environment Agency (2021a) Flood Map for Planning	Identifies fluvial/ tidal inundation extents.
	Environment Agency (2019a) Flood Risk from Surface Water Map	Identification of flood risk from surface water.
	Environment Agency (2019b) Flood Inundation Mapping	Provides information on the risk of flooding from reservoirs (artificial sources).
	Environment Agency (2020a) Groundwater Conditions Map	Identification of groundwater designations through geology.
	North and North East Lincolnshire Strategic Flood Risk Assessment (SFRA) (North East	Assesses flood risk across the NLC boundary area. Includes flood risk

Purpose	Source	Comments
	Lincolnshire Council, 2011)	from fluvial/tidal, sewers, overland flow and groundwater.
	North Lincolnshire Preliminary Flood Risk Assessment (PFRA) (North Lincolnshire Council, 2011a)	
	NLC Local Flood Risk Management Strategy (LFRMS) (North Lincolnshire Council, 2016)	
	Environment Agency (2021c) Humber Extreme Water Levels (provided July 2021 following submission of the Application)	Identifies modelled extreme water levels in the Humber estuary for various climate change scenarios
	British Geological Survey (BGS) (2018) records	Provides details of geology and hydrogeology in the vicinity of the Proposed Development Site.
Identification of Historical Flooding	SFRA	Provides details of historical flooding.
	PFRA	
	NLC Consultation	
	Environment Agency (2021) Historic Flood Map	
Details of the Proposed Development	Indicative Work Areas Referred to in the Environmental Statement – **Figure 3.3** and Indicative Layout Proposed PCC Site – **Figure 4.1** (ES Volume III – **Application Document Ref. 6.4**)	Provides layout of the Proposed Development.

Consultation with Key Stakeholders

1.3.2 Consultation was undertaken with the Environment Agency and NLC as part of this FRA prior to and following submission of the Application. The data request letters, and their responses are provided in **Annex A** and **Annex B** respectively. These advisory recommendations are summarised and addressed in Table 2, below.

Table 2: Consultation for the FRA

Consultee and date of consultation	Comment	Response
North Lincolnshire Council Response to PINS Scoping Opinion, June 2020	NLC state that the scoping report provided indicates an acceptable level of surface water drainage & flood risk information that is required to be provided as part of DCO.	Further detail relating to surface water drainage and flood risk is provided in this FRA.
Environment Agency Response to PINS Scoping Opinion, June 2020	The ES should include a comprehensive drainage strategy, which considers both potential impact on flood risk and also potential hydrological impacts on receiving watercourses, including alterations in flow around discharge outlets and the impacts they may have on local water quality.	A concept drainage strategy has been provided within Section 5 of this FRA. **Chapter 12**: Water Resources and Flood Risk (ES Volume I – **Application Document Ref. 6.2**) assesses the hydrological impacts on watercourses and describes the consultation with the Environment Agency, the LLFA and IDB on the FRA and concept drainage strategy.

Consultee and date of consultation	Comment	Response
Environment Agency Response to PINS Scoping Opinion, June 2020	The Environment Agency advises that the application needs to be supported by a FRA containing plans to identify rivers, water bodies (including existing culverts/drains on site), other geographical features and the floor plans of the Proposed Development highlighting uses. A topographical survey should be provided, including proposed site levels and the heights of existing flood defences should be included. Flood risk should be assessed from all sources and consider breach, overtopping and climate change. Current and future flood management measures should be considered. It must be demonstrated that flood risk will not increase. If found to increase it may be required to implement floodplain compensation. The development is located on the Isle of Axholme for which a critical flood level of 4.1m above ordnance datum (m AOD) has been established, it is advised that all new developments are set with 300 mm freeboard above this level.	This FRA identifies rivers, waterbodies and other geographical features, and these are shown on **Figures 12.1 – 12.5** (ES Volume III – **Application Document Ref. 6.4**). This FRA also describes the heights of existing flood defences; no additional flood defences are proposed. This FRA assesses flood risk from all sources and outlines mitigation measures, where required. The FRA considers breach, overtopping and climate change. A flood risk management strategy for the Proposed Development Site has been developed which considers

Consultee and date of consultation	Comment	Response
		risk for the lifetime of the Proposed Development.
Environment Agency January 2021 (Stage II Consultation / PEI Report)	The Environment Agency provided detailed comments relating to the draft FRA provided to inform Stage II formal consultation noting that further clarification and updates are required in order to: • take into account the Critical Flood Level for North Lincolnshire, as described in the North Lincolnshire SFRA; • provide details of the site-specific breach assessment which is being used for the Proposed Development Site to assess the risk of the Trent defences breaching adjacent to the site during a severe flood event; • provide details of how the provided climate change flood levels for the Trent have been calculated and applied; and • propose finished floor levels for the development in m AOD. **Critical Flood Level – North Lincolnshire SFRA** The Isle of Axholme is an area of land (the historic flood plain of the River Trent), which has been artificially drained, with water levels managed by a network of pumping stations. The Isle of Axholme critical flood level of 4.1m AOD is an estimated flood level following a prolonged breakdown of the pumping station network and high water levels on the River Trent. The North Lincolnshire SFRA states that finished floor levels	Comments on flood risk relating to critical flood levels (CFL), site-specific breach assessment, climate- change and flood risk, proposed finished floor levels and mitigation measures have been noted and accounted for in the updated FRA (this document). The North Lincs SFRA allows the option for a developer to undertake detailed hydraulic modelling to demonstrate a flood level that differs from the CFL, as long as that modelling includes breach. The

Consultee and date of consultation	Comment	Response
	in this area should be set no lower than 4.4m AOD; 300mm above the critical flood level. **Site specific breach assessment:** The Environment Agency notes that aside from the Critical Flood Level in the SFRA, the greatest risk to the site for rapid-onset flooding is a breach of the River Trent defences in line with the site during a severe flood event. On page 24 of the FRA there is reference to a site specific breach model undertaken for the Keadby 2 development in 2015. We would like to review the location of the modelled breach and details of the calculation methods: we request that the full report for the site specific breach model and any accompanying calculations are submitted to us so we can check that it is relevant to the Keadby 3 site and uses the correct data. **Climate change and flood risk** The Environment Agency notes that the plus 30% climate change allowance as stated in the FRA is acceptable but that the application should also assess the H++ climate change scenario. The Environment Agency asked for an explanation where the data in Table 9 of the PEI Report is from and how it has been calculated as it does not appear that the flood levels in Table 9 have been assessed within the FRA.	approach to raising development on the Proposed Development Site, is sequential, risk based and raised critical operational infrastructure will be well above the modelled breach levels. A new breach model has now been undertaken for the Proposed Development and site specific results are presented in Section 4 of this FRA.

Consultee and date of consultation	Comment	Response
	The Environment Agency notes that relevant climate change allowances should be included when assessing the site specific breach flood levels and also any overtopping of defences flood scenarios which affect the site. **Proposed finished floor levels and mitigation measures** The Environment Agency notes that the FRA does not appear to propose any specific flood mitigation measures for the Proposed Development. Proposed finished floor levels should be given in m AOD. Where areas of the Proposed Development Site are below the critical flood level or breach flood level, the FRA should propose alternative mitigation measures such as flood resilience measures and safe refuges for occupants of the site above the maximum flood levels. If large areas of the site are to be raised the FRA must take into account the impact on flow paths. For example during an overtopping or breach of defences flood, would flood water be diverted onto neighbouring properties? **Further information/advice:** The Environment Agency reiterated advising that the Humber Strategy Team are contacted to discuss the Proposed Development further. **Flood Risk Permits**	Where reasonably practicable critical infrastructure will be raised to 4.4m AOD and to a minimum of 3.6m AOD. A safe refuge will be installed at a height of 4.4m AOD or higher. Areas of the Proposed PCC Site below the 4.4m AOD level will be designed to safely flood should flooding occur and remain operational, and refuge areas are provided. The breach model shows the impact on flow paths of the proposed land raising. The Humber Strategy team has been consulted and

Consultee and date of consultation	Comment	Response
	Several parts of the proposed development are close to Environment Agency main rivers and flood defences, including the Stainforth and Keadby Canal, the Three Rivers and the River Trent. Development in these areas will require Flood Risk Activity Permits.	were supportive of the approach taken. The comments on Flood Risk Activity Permits (FRAP) are noted, and the need for these is acknowledged within this FRA and within the Schedule of Other Consents and Licences (**Application Document Ref. 5.4**) that accompanies the Application.
Environment Agency March 2021 Stage – additional technical engagement	The FRA should take into account the Critical Flood Level for North Lincolnshire, as described in the North Lincolnshire SFRA: The Environment Agency are of the view, that essential infrastructure should be designed to remain operational and safe during times of flood, and this should include consideration of the residual risk to the development. Provide details of the site-specific breach assessment which is being used for the site to assess the risk of the Trent defences breaching adjacent to the site during a severe flood event:	The breach model completed for the Proposed Development Site demonstrates that the worst-case residual risk (highest level) from a breach of the Trent defences is associated with a 0.5% tidal event with climate change. The predicted water level on site

Consultee and date of consultation	Comment	Response
	The Environment Agency acknowledge the site is within a tidally dominant location along the River Trent. However, an assessment of the breach during the fluvial 1% AEP plus 30% climate change allowance and the tidal 0.5% AEP plus climate change allowance should be undertaken. The breach assessment should use the data from the Tidal Trent detailed hydraulic model (Mott Macdonald 2014), as this is still considered the latest available information. Assessment should also include a scenario using the extreme Humber water levels as a sensitivity test. To meet current planning requirements the proposed development will need to be safe for its designed lifetime, this means it will need to implement appropriate flood mitigation measures up to 4.1m AOD plus 300mm freeboard. **Flood Risk Permits:** The Environment Agency welcome the acknowledgement of the permitting requirements for works close to Main Rivers and flood defences. The Environment Agency has reviewed Appendix A and would expect the bridge to be set no lower than the existing soffit level.	as a result of a breach for this event is 2.47 mAOD. Full details of the breach model are provided in **Annex C.** Extreme climate change scenarios have also been modelled. This area of the Trent is tidally dominated. Breach model runs have been completed for fluvial events, however the water levels from a breach are highest in a tidal event.

Consultee and date of consultation	Comment	Response
		A Flood Management Strategy for the Proposed Development Site, which includes raising critical operational infrastructure to a minimum of 3.6m AOD and up to 4.4m AOD where reasonably practicable, is set out in this FRA.
Environment Agency March 2021 and July 2021 – additional technical engagement	A consultation meeting took place with the Environment Agency's Humber Strategy Team. Following this in July 2021, modelled extreme water levels on the River Trent were provided by the EA.	Extreme water levels provided were used to model climate change breach for the H and H++ scenarios as part of the breach modelling. The results are included in this FRA.
Environment Agency July 2021	Detailed technical comments provided on initial April 2021 hydraulic breach model including breach function, uncertainty and sensitivity analysis.	An addendum to the breach technical note (Annex A) has been provided which describes the additional hydraulic

Consultee and date of consultation	Comment	Response
		modelling completed to address comments raised.
Internal Drainage Board (IDB) and Isle of Axholme and North Nottinghamshire Water Level Management Boards	Note that Glew Drain, an open watercourse, exists on the Northern boundary of the site and which Byelaws and Land Drainage Act 1991 apply. The Board's consent is required for any works that increase the flow or volume of water to any watercourse or culvert within the Board's district (other than directly to a main river). The proposed surface water discharge from the site is in excess of that usually permitted by the Board. There is a potential impact upon the receiving watercourse. However, perhaps more importantly the capacity at both Bewcarrs and Paupers Pumping Stations is a matter that will require consideration. Further discussions will be required to determine the acceptability of the proposal and agree any mitigation measures or financial contributions that may be deemed necessary to accommodate the additional flows both within the receiving watercourse and at the above mentioned pumping stations. The Board's consent is required to erect any building or structure (including walls and fences), whether temporary or permanent, or plant any tree, shrub, willow or other similar growth within 9 metres of the top edge of any Board maintained watercourse or the edge of any Board maintained culvert. With this in mind the position of any boundary/ security fence will need to be considered and potentially consented.	The consent of the IDB would be sought for the proposed surface water discharge and engagement on this matter is described in Section 5 including in respect of agreeing runoff rates. Noted

Consultee and date of consultation	Comment	Response
	The Board's consent is required for any works, whether temporary or permanent, in, over or under, any Board maintained watercourse or culvert. The construction of an emergency access point over the Board maintained watercourse will require consent. The site is bounded to the east and west by riparian watercourses. Any future proposal to install culverts or headwalls within these features would require consent. Furthermore, the applicant is advised that they are likely to have a riparian responsibility to maintain the proper flow of water in any riparian watercourse which borders or flows through land owned or occupied by them. The Board's consent will only be granted where proposals are not detrimental to the flow or stability of the watercourse/culvert or the Board's machinery access to the watercourse/culvert which is required for annual maintenance, periodic improvement and emergency works.	Noted. The emergency access bridge (refer to Emergency Access Bridge General Arrangement and Sections (**Application Document Ref. 4.17**)) proposals have been designed taking into account IDB bylaws and copies provided to the IDB for comment prior to submission of the DCO application.
North Lincolnshire Council – LLFA January 2021 (Stage II	Any application will require a full Flood Risk Assessment, Drainage Strategy and Sustainable Urban Drainage System (SuDS) Guidance Document. References should be made to the Consultation Document. When developing the detailed surface water drainage scheme reference should be made to North Lincolnshire Council's SuDS and Flood Risk Guidance Document, which is available on the Council's website.	This FRA accompanies the DCO Application and includes a Concept Drainage Strategy (Section 5) including the SuDS strategy for the Proposed Development, taking into

Consultee and date of consultation	Comment	Response
Consultation / PEI Report)		account North Lincolnshire Council's SuDS and Flood Risk Guidance Document.
North Lincolnshire Council – LLFA (Additional Technical Engagement	A draft copy of the FRA, including concept drainage strategy was provided for comment prior to submission of the Application in May 2021. Comments were received following submission of the Application (June 2021) relating to agreeing runoff rates with the IDB and the need for future SUDS design.	Noted. The Applicant will continue to engage with the IDB in respect of agreement of runoff rates following submission of the Application.

2.0 THE PROPOSED DEVELOPMENT AND SITE DESCRIPTION

2.1 The Proposed Development

2.1.1 The Proposed Development includes the following elements (references to 'Work No.' is to the corresponding work numbers in Schedule 1 of the draft DCO (**Application Document Ref 2.1** – and the location of each Work No. within the Proposed Development Site is shown on the Works Plans (**Application Document Ref. 4.3**):

- a new build carbon capture enabled electricity generating station fuelled by natural gas and with a gross output capacity of approximately 910 megawatts (Mwe) unabated ('the Low Carbon Gas Power Station' – **Work No. 1**) comprising:
  - a CCGT plant (**Work No. 1A**);
  - cooling infrastructure for the CCGT (**Work No. 1B**);
  - CCP absorption unit(s) and stack(s) (**Work No. 1C**);
  - natural gas reception facility (**Work No. 1D**);
  - generating station supporting uses including buildings, raw water storage tanks and permanent plant laydown for operation and maintenance (**Work No. 1E**);
- a high pressure natural gas pipeline to supply the CCGT including a gas compound for National Grid Gas's apparatus (**Work No. 2A**) and a gas compound for the Applicant's apparatus (**Work No. 2B**) (Natural Gas Connection);
- electrical power export lines from the Low Carbon Gas Power Station to the existing 400 kilovolt National Grid Electricity Transmission substation located adjacent to Keadby Power Station, including works within the substation (which would be undertaken by National Grid) (**Work No. 3A –** Electrical Connection Area to National Grid 400 kilovolt (kV) Substation); and up to 132 kilovolt underground electrical cables to the Low Carbon Gas Power Station from the existing Northern Powergrid substation located at Chapel Lane, including works within the substation (**Work No. 3B** – Potential Electrical Connection to Northern Powergrid Substation);
- water supply connections works (**Water Connection Corridor**) to provide cooling and make-up water to the Low Carbon Gas Power Station, comprising either:
  - underground and/ or overground water supply pipeline(s) and intake structures within the Stainforth and Keadby Canal (**Work No. 4A** – Canal Water Abstraction Option); or
  - in the event that the canal abstraction option is not available, works to the existing cooling water supply pipelines and intake structures within the River Trent (**Work No. 4B** – River Water Abstraction Option);

- use of an existing outfall and associated pipework for the discharge of used cooling water and treated wastewater to the River Trent (**Work No. 5** – Water Discharge Corridor);
- towns water connection (**Work No. 6**);
- above ground carbon dioxide compression and export infrastructure comprising deoxygenation, dehydration, and staged compression facilities, and outlet metering, and electrical connection;
- new permanent access to the Low Carbon Gas Power Station (**Work No. 8**), comprising:
  - maintenance and improvement of an existing private access road from the junction with the A18, including A18 Junction Improvement and replacement of private bridge (Mabey Bridge) (**Work No. 8A** – Construction and Operational Vehicular Site Access Route, Mabey Bridge Replacement);
  - installation of layby and gatehouse north of the junction with the A18 (**Work No. 8B**);
  - emergency access route comprising the installation of a bridge crossing or an existing drainage channel, maintenance and improvement of an existing private track running between the Low Carbon Gas Power Station and Chapel Lane, Keadby and including new private bridge, (**Work No. 8C** – Emergency Vehicle Access Road);
- temporary construction and laydown areas (**Work No. 9A** – Construction Laydown Areas); the maintenance and improvement of the existing paved haulage routes running between the construction laydown areas including the skew bridge (**Work No. 9B**) and further temporary laydown area in association with the replacement of Mabey Bridge (**Work No. 9C**);
- retention, maintenance and improvement and removal of existing temporary haulage route (**Work No. 10A** – Additional Abnormal Indivisible Load (AIL) Route) and the maintenance of the existing jetty, and temporary placement of mobile crane(s) including temporary oversailing of crane arms (**Work No. 10B** – Waterborne Transport Offloading Area); and
- landscaping, planting and biodiversity enhancement measures (**Work No. 11A**); and security fencing and boundary treatment (**Work No. 11B**).

2.1.2 To the extent that it does not form part of any such works, further associated development within the meaning of the 2008 Act is proposed and has been assessed within the ES comprising:

- surface water drainage systems, including works to existing drainage systems;
- electrical, gas, potable water supply, foul water drainage and telecommunications infrastructure connections and works, and works to alter the position of such services and utilities connections;

- hard standings and hard landscaping;
- soft landscaping, including bunds and embankments;
- external lighting, including lighting columns;
- gatehouses and weighbridges;
- closed circuit television cameras and columns and other security measures;
- site establishment and preparation works, including site clearance, earthworks and excavations; site levelling and the formation of embankments, temporary construction access; alteration of services and utilities; and works for the protection of buildings and land;
- temporary construction laydown areas and contractor facilities, including materials and plant storage and laydown areas; generators; concrete batching facilities; vehicle and cycle parking facilities; pedestrian and cycle routes and facilities; offices and staff welfare facilities; fencing and gates; external lighting; roadways and haul routes; wheel wash facilities; and signage;
- vehicle parking and cycle storage facilities; and
- accesses, roads and pedestrian and cycle routes.

2.1.3 Further details of the Proposed Development are set out in Section 2.6 of this chapter and within **Chapter 4:** The Proposed Development (ES Volume I – **Application Document Ref. 6.2**). The areas of the Proposed Development Site described above are shown in **Figure 3.3** and an indicative Site Layout Plan is included as **Figure 4.1** (ES Volume III – **Application Document Ref. 6.4**).

2.1.4 The design life of the Proposed Development is approximately 25 years from the completion of construction. At the end of operation, it is expected that the Proposed Development will have some residual life remaining and an investment decision would then be made based on the market conditions prevailing at that time. If the operating life were to be extended, the Proposed Development would be upgraded in line with the legislative requirements at that time. Such a scenario may give rise to a greater operational lifetime of around 35 years which has been used for the purposes of this FRA.

2.1.5 As the Proposed Development will include certain critical operational infrastructure, surface water drainage assets will be designed to accommodate a 100-year return period storm event with an allowance for climate change, although this storm event is unlikely to occur during the Proposed Development's operational life. The Flood Management Strategy for the Proposed Development Site is designed such that the energy infrastructure can remain operational during a 0.5% AEP tidal flood event (including climate change).

2.1.6 For the purposes of the FRA, it has been assumed that the Proposed Development will become operational between 2026 and 2033, (depending on financial investment decision and construction programming). On this basis, and assuming a 35 year operational life, decommissioning could commence between 2061 and 2068.

2.2 Location

2.2.1 The Proposed Development Site is located within the wider Keadby Power Station site, to the west of Keadby 2 Power Station, under construction. The Proposed Development Site encompasses an area of approximately 69.4ha of which approximately 20.7ha comprises the temporary construction laydown areas. The Proposed Development Site is approximately centred on national grid reference (NGR) 482351, 411796.

2.2.2 The Proposed Development Site comprises land within the administrative area of NLC. The Keadby Power Station site currently encompasses the operational Keadby 1 Power Station and Keadby 2 Power Station (under construction), both owned and under control of the Applicant.

2.2.3 The Proposed Development Site is bordered by the tidal River Trent to the east, by Stainforth and Keadby Canal to the south, by agricultural land and Keadby Wind Farm to the north, and by the former Keadby Ash Tip and scrubland to the west. The Proposed Development Site is surrounded on all sides by numerous drains.

2.2.4 Full details of the Proposed Development Site and its surroundings can be found in **Chapter 3:** The Site and Surrounding Area (ES Volume I – **Application Document Ref. 6.2**). The location of the Proposed Development Site is shown in **Figure 1.1**: Site Location (ES Volume III – **Application Document Ref. 6.4**); an indicative Site Layout Plan is included as **Figure 4.1** (ES Volume III – **Application Document Ref. 6.4**).

2.3 Existing Land Use

2.3.1 The Proposed Development Site compromises industrial land including the existing Keadby 1 and Keadby 2 Power Stations, an existing 400kV Substation (owned and operated by National Grid) and 132kV Substation (owned and operated by Northern Powergrid), car parking, agricultural land and other industrial land. Existing roads within the Proposed Development Site include Trent Road, Chapel Lane and Bonnyhale Road.

Access

2.3.2 Access to the Proposed Development Site during construction and operation would be via the existing access road from the A18. Perpendicular and skewed construction access points off the A18, built for construction vehicles during construction of Keadby Wind Farm and currently used by all construction vehicles associated with the Keadby 2 Power Station, would be used to access

the Proposed Development Site. The skewed access would be used, where required, to transport oversized AILs into the Proposed Development Site during construction.

2.3.3 Additional routes for AIL are also available from the Waterborne Transport Offloading Area and via Ealand, along Bonnyhale Road (refer to **Chapter 10**: Traffic and Transportation (ES Volume I – **Application Document Ref. 6.2**).

2.3.4 The access to the existing Keadby Power Station site via Trent Road off the B1392 in Keadby village is not proposed to be used during construction or operation of the Proposed Development.

2.4 Hydrology and Flood Risk Management Infrastructure

Surface Waterbodies

2.4.1 The Proposed Development Site lies immediately west of the tidal River Trent, which flows in a northerly direction towards the Humber Estuary.

2.4.2 Approximately 300m to the north of the Proposed Development Site, beyond Keadby Common, is Warping Drain (also known as Eastoft Moors Drain). Warping Drain, an ordinary watercourse, flows east and into the tidal River Trent via sluice gates. This waterbody consists of two separate watercourses, Warping Drain and Paupers Drain approximately 13km long and drains an area of around 32km^2. It is an artificial waterbody. The drain is artificial in its character, being overwide, straight, and with flood embankments either side. Flows will also be influenced by tidal locking.

2.4.3 To the west of the Proposed Development Site is the Keadby Boundary Drain, an ordinary watercourse, which runs south to north and is a tributary of Warping Drain. At the point where the Keadby Boundary Drain joins Warping Drain via a sluice, there are flood gates on Warping Drain.

2.4.4 South of the Proposed PCC Site there are a number of watercourses running west to east in parallel with each other. These include the North Soak Drain and the South Soak Drain, which flow either side of the Sheffield and South Yorkshire Navigation – Stainforth and Keadby Canal. This waterbody is approximately 26km long and drains an area of around 56km^2. The North and South Soak Drains flow into the Three Rivers a short distance to the south, and this then connects with the River Trent via sluice gates at Keadby Pumping Station, which is a series of major pumps draining the Isle of Axholme. These three watercourses, plus the River Trent, are all main rivers.

2.4.5 The Sheffield and South Yorkshire Navigation – Stainforth and Keadby Canal is linked to the River Trent via Keadby Locks. It is managed by the Canal & River Trust (CRT).

Surrounding Land Use

2.4.6 Beyond the current Keadby Power Station Site, land uses are predominantly arable farming. Various types of power infrastructure have been developed near to the Proposed Development Site in recent years, including overhead electricity transmission and distribution infrastructure and the Keadby Windfarm to the north which became operational in 2014. Additional wind turbines and electricity transmission and distribution infrastructure is present over the wider surrounding area. Residential uses and canal and river related uses are found in the nearby villages of Keadby and Gunness. The former Keadby Ash Tip is located immediately west of the Proposed PCC Site.

2.4.7 Between the Three Rivers and Stainforth and Keadby Canal land drains are spaced every 150m across agricultural fields orientated in a north-south direction. The Isle of Axholme lies just south of here.

2.5 Topography

2.5.1 Land within and surrounding the Proposed Development Site is generally low lying at elevations below 10m AOD and with very shallow gradients. Surrounding area topography is illustrated on **Figure 14.2** (ES Volume IIII – **Application Document Ref. 6.4**).

2.5.2 According to the Environment Agency Digital Terrain Model, the ground level varies from a low point of approximately -0.6m AOD, to a high point of 6.7m AOD within the Proposed PCC Site, with average levels of circa 1.0m AOD across.

2.5.3 A notable steep ridge is present immediately to the west of the Proposed PCC Site (outside the Proposed Development Site boundary) where land associated with the former Keadby Ash Tip is in excess of 19m AOD.

2.5.4 Levels on the Keadby 1 and Keadby 2 Power Station sites are slightly elevated compared to the surrounding land within the Proposed Development Site, with levels typically between 1.0 – 3.0m AOD. Levels within the construction laydown areas (farmland) south of the Stainforth and Keadby Canal are typically circa 1.0m AOD.

2.5.5 The A18 carriageway is also at slightly higher levels (circa 2.5m AOD) than surrounding lower lying land.

2.6 Geology

2.6.1 According to the Phase 1 Geo-Environmental Site Assessment (**Appendix 13A** (ES Volume II – **Application Document Ref. 6.3**)), the local geology is characterised by approximately 12m to 17m of alluvium and drift deposits of clay, silt and sand, with occasional peat layers recorded at various depths between 0.45m and 1.6m thickness. These superficial deposits overlie the Mercia Mudstone Formation which shows evidence of near surface weathering,

the extent to which decreases with increasing depth. Although not mapped, made ground is assumed across the Proposed Development Site, given the historical phases of development that have taken place.

2.6.2 The Environment Agency classifies the underlying superficial geology as Secondary A aquifer and the Mercia Mudstone as a Secondary B aquifer. The Proposed Development Site does not contain or lie within or in close proximity (<1km) to any Source Protection Zones (SPZ).

2.6.3 Groundwater levels within the historical borehole records indicate generally shallow groundwater levels within the superficial geology of between 0.9m – 3.0m below ground level (bgl). Occasionally, deeper groundwater strikes were recorded between 5.4m – 6.9m bgl.

2.6.4 The Soilscape for England published by the National Soil Resources Institute describes the soils at the site as "*Loamy and clayey soils of coastal flats with naturally high groundwater*" (Cranfield Soil and Agrifood Institute, 2018). These soils are naturally wet and drain predominantly to local groundwater and marginal ditches.

2.7 The Keadby Power Station Site

2.7.1 The Proposed Development is situated adjacent to the under-construction 840MW CCGT Keadby 2 Power Station which, following the grant of a variation to an existing Section 36 consent in 2016, commenced construction in April 2019 on land adjacent to Keadby 1 Power Station.

2.7.2 Keadby 1 Power Station was built on the site of a former coal fired power station which was operational between 1952 and 1984. The Keadby 1 Power Station was commissioned in 1996. It has a contract to provide capacity to the grid until September 2022 and will have opportunities to secure further agreements in future auctions. It is recognised that Keadby 1 Power Station will not run at the same time as the Proposed Development. This is because the capacity of the existing natural gas pipeline precludes a scenario in which the Proposed Development and Keadby 1 Power Station could operate concurrently. Any future plans for Keadby 1 Power Station will be confirmed by the Applicant in due course and at that time, the public will be consulted as appropriate. Effects of decommissioning of Keadby 1 Power Station would be considered as part of any decommissioning consenting proposals at that time.

Proposed Access

2.7.3 As described in Section 2.3, access to the Proposed Development Site would be via the existing road access road from the A18 (centred at OSNGR 480331, 410012) which passes via the existing North Pilfrey Bridge over the Stainforth and Keadby Canal and the Scunthorpe to Doncaster passenger rail line (refer to **Figure 3.3** (ES Volume III – **Application Document Ref. 6.4**)). Vehicles would access the Proposed Development Site from the A18, via this existing access road/ Bonnyhale Road/ existing private access roads and a new main

access road to be constructed into the Proposed PCC Site. Early construction works will be undertaken to widen the northern carriageway of the A18 and replace Mabey Bridge.

2.7.4 Works proposed for Mabey Bridge replacement including indicative construction sequencing are shown on **Application Document Ref. 4.16**. Piling works would take place for foundations before the existing Mabey Bridge deck structure is removed and the new main steel structure is constructed.

2.7.5 The Proposed Development Site incorporates land currently used as a temporary construction haul road for Keadby 2 Power Station from the Waterborne Transport Offloading Area into the Keadby Power Station site for the purposes of transporting AIL that have been delivered and unloaded at the Waterborne Transport Offloading Area. This Additional AIL route commences at the Waterborne Transport Offloading Area, crosses a short section of the B1392 and then incorporates an existing temporary haul road that runs to the east of PD Port Services freight yard, through an agricultural field (owned by the Applicant). The temporary haul road has been constructed using geotextile separation membrane with granular compacted stone laid on top, using temporary steel bridges to span over drainage ditches. The additional AIL route then crosses the existing hardstanding 'Outage' car park and into the existing Keadby 1 Power Station Site.

2.7.6 This temporary haul road is the subject of a planning permission (PA/2019/1595) granted by NLC; conditions 7 and 8 of which have recently been varied by permission PA/2021/188 to enable temporary retention of the haul road following completion of Keadby 2 Power Station construction in order that it can be beneficially used for the Proposed Development, prior to its restoration. It is therefore included within the indicative Order Limits and effects associated with its retention as a temporary haul road, use for the Proposed Development AIL deliveries and subsequent restoration have been considered within this FRA.

2.7.7 An emergency vehicle access route is also proposed from Chapel Lane, bordering the northern edge of The Proposed Development Site in order to provide access for emergency vehicles to the Proposed PCC Site.

Proposed Development Drawings

2.7.8 Drawings illustrating the Proposed Development provided as part of the ES (ES Volume III – **Application Document Ref. 6.4**) which may aid in review of this Appendix are summarised below:

- **Figure 1.1** : Site Location Plan ;
- **Figure 3.1**: The Order Limits;
- **Figure 3.2**: Aerial Photo of the Order Limits;

- **Figure 3.3:** Indicative Work Areas Referred to in the Environmental Statement;
- **Figure 4.1**: Indicative Layout Proposed PCC Site;
- **Figure 5.1**: Construction Laydown Areas;
- **Figure 12.1**: Surface Water Features and their Attributes;
- **Figure 12.2**: Groundwater Bodies and their Attributes;
- **Figure 12.3**: Flood Risk;
- **Figure 12.4**: Surface Water Flood Risk; and
- **Figure 12.5**: Ecologically Designated Sites Relevant to the Water Environment.

3.0 PLANNING POLICY

3.1 Introduction

3.1.1 An overview of the legislative and policy context that is relevant to the Proposed Development is provided within **Chapter 7:** Legislative Context and Planning Policy and **Chapter 12**: Water Environment and Flood Risk (ES Volume I – **Application Document Ref. 6.2**).

3.1.2 The sections below consider the planning policies and guidance of relevance to the Proposed Development Site with regards to the flood risks from all sources and appropriate mitigation measures which should be considered.

3.2 National Policy

National Policy Statements

3.2.1 The Overarching National Policy Statement (NPS) for Energy (EN-1), Section 5.7 (Flood Risk) (Department for Energy and Climate Change (DECC), 2011a) details that projects of 1 ha or greater in Flood Zone 1 in England and all proposals for energy projects located in Flood Zones 2 and 3 in England should be accompanied by an FRA.

3.2.2 The requirements for FRA set out in Paragraph 5.7.5 are that they should:

- be proportionate to the risk and appropriate to the scale, nature and location of the project;
- consider the risk of flooding arising from the project in addition to the risk of flooding to the project;
- take the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made;
- be undertaken by competent people, as early as possible in the process of preparing the proposal;
- consider both the potential adverse and beneficial effects of flood risk management infrastructure, including raised defences, flow channels, flood storage areas and other artificial features, together with the consequences of their failure;
- consider the vulnerability of those using the Site, including arrangements for safe access;
- consider and quantify the different types of flooding (whether from natural and human sources and including joint and cumulative effects) and identify flood risk reduction measures, so that assessments are fit for the purpose of the decisions being made;

- consider the effects of a range of flooding events including extreme events on people, property, the natural and historic environment and river and coastal processes;
- include the assessment of the remaining (known as 'residual') risk after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular project;
- consider how the ability of water to soak into the ground may change with development, along with how the proposed layout of the project may affect drainage systems;
- consider if there is a need to be safe and remain operational during a worst-case flood event over the development's lifetime; and
- be supported by appropriate data and information, including historical information on previous events.

3.2.3 In determining an application for development consent, the Secretary of State should be satisfied that, where relevant:

- the application is supported by an appropriate FRA;
- the Sequential Test has been applied as part of site selection;
- a sequential approach has been applied at the site level to minimise risk by directing the most vulnerable uses to areas of lowest flood risk;
- the proposal is in line with any relevant national and local flood risk management strategy;
- priority has been given to the use of SuDS; and
- in flood risk areas the project is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed over the lifetime of the development.

3.2.4 Paragraph 5.7.12 of NPS EN-1 also states that in England, development should not be consented in Flood Zone 3 unless it is satisfied that the Sequential and Exception Test requirements have been met. However, when seeking development consent on a site allocated in a development plan through the application of the Sequential Test, informed by a strategic flood risk assessment, applicants need not apply the Sequential Test, but should apply the sequential approach to locating development within the site. Details of the Sequential Test and Exception Test requirements are provided in Sections 5.7.13-5.7.17 of the NPS EN-1; however, the PPG (Ministry of Housing, Communities and Local Government, 2019b) while not directly applicable to Nationally Significant Infrastructure Projects (NSIP) and not constituting policy, may provide more robust and conservative definitions of these, as discussed below. These have subsequently been considered as part of this FRA.

3.2.5 Paragraph 5.7.10 of NPS EN-1 provides further policy on good design and on SuDS:

"For construction work which has drainage implications, approval for the project's drainage system will form part of the development consent issued by the IPC. The IPC will therefore need to be satisfied that the proposed drainage system complies with any National Standards published by Ministers under Paragraph 5(1) of Schedule 3 to the Flood and Water Management Act 2010. In addition, the development consent order, or any associated planning obligations, will need to make provision for the adoption and maintenance of any SuDS, including any necessary access rights to property. The IPC should be satisfied that the most appropriate body is being given the responsibility for maintaining any SuDS, taking into account the nature and security of the infrastructure on the proposed site. The responsible body could include, for example, the applicant, the landowner, the relevant local authority, or another body, such as an Internal Drainage Board."

3.2.6 In terms of climate change allowances, EN-1 states at para 4.8.9 "Where energy infrastructure has safety critical elements (for example parts of new fossil fuel power stations or some electricity sub-stations), the applicant should apply the high emissions scenario (high impact, low likelihood) to those elements. Although the likelihood of this scenario is thought to be low, it is appropriate to take a more risk-averse approach with elements of infrastructure which are critical to the safety of its operation".

National Planning Policy Framework (NPPF) (Ministry of Housing, Communities and Local Government, 2021)

3.2.7 The NPPF (July 2021) is supported by the PPG (October 2019), neither are applicable to NSIP where the requirements of the NPS apply however having been updated in July 2021, the NPPF with the PPG does constitute the most up to date guidance for development in general.

3.2.8 The Flood Zone definitions used in both the NPS and the NPPF are defined in Table 1 of the PPG and as reproduced in Table 3, below. As discussed in Section 1.2, the Environment Agency's 'Flood Map for Planning' (Environment Agency, 2021a) identifies that the majority of the Proposed Development Site and surrounding environs are located within Flood Zone 3, with the exception of a small section of the Proposed Development Site within the New Permanent Access from A18, which is in Flood Zone 2. The Flood Zones are assessed without taking into account any flood defences which may be present.

Table 3: Environment Agency Flood Zone Definitions

Flood Zone	Definition
Flood Zone 1	Land that has a low probability of flooding (less than 1 in 1,000 annual probability of river or sea flooding (<0.1% AEP)
Flood Zone 2	Land that has a medium probability of flooding (between 1 in 100 and 1 in 1,000 annual probability of river flooding (0.1-1% AEP), or between 1 in 200

Flood Zone	Definition
	and 1 in 1,000 annual probability of sea flooding (0.1-0.5% AEP)
Flood Zone 3a	Land that has a high probability of flooding (1 in 100 year or greater annual probability of river flooding (>1% AEP), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5% AEP)
Flood Zone 3b (Functional floodplain)	Land where water has to flow or be stored in times of flood (Not separately distinguished from Zone 3a on the Flood Map).

Sequential Test

3.2.9 The development is a NSIP and requirements and restrictions in relation to its necessary location within Flood Zone 3 are set out in para 5.7.13 of NPS EN-1.

3.2.10 NPS EN-1 para 5.7.13 states: "*Preference should be given to locating projects in Flood Zone 1 in England or Zone A in Wales. If there is no reasonably available site in Flood Zone 1 or Zone A then projects can be located in Flood Zone 2 or Zone B. If there is no reasonably available site in Flood Zones 1 or 2 or Zones A & B, then nationally significant energy infrastructure projects can be located in Flood Zone 3 or Zone C subject to the Exception Test. Consideration of alternative sites should take account of the policy on alternatives set out in section 4.4 above".*

3.2.11 The PPG would also require an Exception Test for a development in this location if it were not defined as an NSIP. According to Table 2: Flood Risk Vulnerability Classification of the PPG, an electricity generating station (such as the Proposed Development) comprises the vulnerability classification of 'Essential Infrastructure'. The definition of Essential Infrastructure includes 'Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations'. The PPG provides a matrix (replicated in Table 4, below) identifying which vulnerability classifications are appropriate within each Flood Zone.

Table 4: NPPF PPG flood risk vulnerability and flood zone 'compatibility table.'

	Flood Risk Vulnerability Classification				
	Essential Infrastructure	**Water Compatible**	**Highly Vulnerable**	**More Vulnerable**	**Less Vulnerable**
Flood Zone 1	✓	✓	✓	✓	✓
Flood Zone 2	✓	✓	Exception Test required	✓	✓
Flood Zone 3a	Exception Test required	✓	×	Exception Test required	✓
Flood Zone 3b 'Functional Floodplain'	Exception Test required	✓	×	×	×
Key: ✓ Development is appropriate × Development should not be permitted.					

Exception Test

3.2.12 As Table 4 indicates, application of the Exception Test is required for the Proposed Development. The detail of the Exception Test required for an NSIP is set at Paragraph 5.7.16 of the NPS EN-1 which states:

"All three elements of the test will have to be passed for development to be consented. For the Exception Test to be passed:

- *it must be demonstrated that the project provides wider sustainability benefits to the community that outweigh flood risk;*
- *the project should be on developable, previously developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously developed land subject to any exceptions set out in the technology-specific NPSs; and*
- *a FRA must demonstrate that the project will be safe, without increasing flood risk elsewhere subject to the exception below and, where possible, will reduce flood risk overall."*

3.2.13 The sustainability benefits of the Proposed Development are presented in the Planning Statement (**Application Document Ref. 5.5**) that accompanies the Application. The majority of the Proposed Development Site occupies previously developed land including land associated with the former coal-fired Keadby Power Station (now demolished), on-site historic landfill and land recently developed for Keadby 2 Power Station. For those elements of the Proposed Development Site that are not previously developed and part of the

Keadby Power Station site, a site selection process was undertaken comprising both brownfield land and other areas of land under intensive agricultural management for temporary use as construction laydown areas, as explained in **Chapter 6**: Consideration of Alternatives (ES Volume I – **Application Document Ref. 6.2**). Element two has therefore been demonstrated for the Proposed Development. The final element is demonstrated in Sections 4.0 and 6.0 of this site-specific FRA.

3.2.14 The NPPF (July 2021) has clarified what flood resistant and flood resilient development comprises i.e. this is development that "in the event of a flood… could be quickly brought back into use without significant refurbishment."

Environment Agency Climate Change Guidance (2021)

3.2.15 The Environment Agency published updated climate change allowances in July 2021 (Environment Agency, 2021d) to support the NPPF, which supersede all previous allowances written in the 'PPG: Flood Risk & Coastal Change' and are predictions of anticipated change for:

- peak river flow (by WFD Management Catchments);
- peak rainfall intensity;
- sea level rise; and,
- offshore wind speed and extreme wave height.

3.2.16 Sea level rise predictions have not changed from previous guidance however the way they are applied to development has been clarified.

3.2.17 The climate change guidance should be considered within a FRA in regard to future impacts from climate change on application for development consent. The Environment Agency guidance outlines how and when allowances should be applied for FRA.

Tidal Climate Change Allowances

3.2.18 The revised (July 2021) guidance sets out how developers and their agents preparing flood risk assessments for planning applications, and development consent orders for nationally significant infrastructure projects should use climate change allowances in Flood Risk Assessments. It states that both the higher central and upper end allowances should be assessed. Although an assessment of the H++ allowance is not strictly required under EN-1, it has been included in this FRA to test the resilience of the Proposed Development Site to extreme climate scenarios.

3.2.19 Table 5 is an extract replicated from Humber Estuary site-specific (latitude 53.61, longitude -0.42) sea-level anomaly data downloaded from the UKCP18 User Interface using the RCP 8.5 climate scenario. The baseline is 1981-2000. Following Environment Agency guidance to determine anticipated sea level rise over the maximum anticipated operational lifetime of the Proposed

Development (up to 2068), the 70th percentile (higher central allowance) has been assessed as the design allowance and the 95th percentile (upper end allowance) has been assessed in planning for more severe climate impacts.

3.2.20 As the Proposed Development is classed as a nationally significant infrastructure project (NSIP) under EN-1 the High Emissions Scenario should be applied to test any safety critical areas of the site. This is the Higher Central allowance in the current guidance.

3.2.21 In previous consultations with the Environment Agency, they requested that the H++ sea level rise allowance also be considered to test the potential impact of more extreme climate change. The H++ is a single allowance of 1.9m total sea level rise to 2100 (Environment Agency, 2020b). There is no H++ value beyond 2100.

Table 5: Site-specific sea-level allowance based on a 1981 to 2000 baseline

Area of England	Allowance	Cumulative rise 2068 (metres)
Humber Estuary (latitude 53.61, longitude -0.42)	Higher central	0.48
	Upper end	0.60

3.2.22 The Environment Agency has provided climate change levels for the River Trent from the Environment Agency Humber Extreme Water Level Study (HEWL). These levels use the sea level rise predictions for the Humber and predict the resulting levels in the Trent. The HEWL levels are currently the best available information on potential future tidal levels in the Trent adjacent to the Proposed Development Site and have been used in this FRA (see Table 11).

Fluvial Climate Change Allowances

3.2.23 The revised (July 2021) guidance sets out how developers and their agents preparing flood risk assessments for planning applications, and development consent orders for nationally significant infrastructure projects should use climate change allowances in Flood Risk Assessments. It states that the Peak River Flow allowances to be used should be based on the peak river flow map for the relevant WFD Management Catchment (in this case the Lower Trent and Erewash). For essential infrastructure located in flood zones 2 and 3a, the Higher Central Allowance should be applied. Given the nature of the Proposed Development, the Upper End Allowances have also been considered in this FRA.

3.2.24 As such, peak river flow allowances for the Proposed Development have been assessed for its maximum anticipated operational lifetime (2050's) epoch as well as the 2080's epoch (Table 6). The Proposed Development is located in the Lower Trent and Erewash Management Catchment which is a part of the Humber River Basin

Table 6: Environment Agency Peak River Flow Climate Change Allowances for the Lower Trent and Erewash River Basin

	Total potential change anticipated for the '2020s' (2010 to 2039	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper End Allowance	29%	38%	62%
Higher Central Allowance	18%	23%	39%
Central Allowance	13%	17%	29%

Pluvial Climate Change Allowances

3.2.25 To account for the anticipated changes in rainfall intensity, the Environment Agency guidance states that an FRA should account for potential increases in Peak Rainfall Intensity using the figures shown in Table 7 below for small catchments (less than 5km^2-or urban drainage catchments). These are the most appropriate figures for the Proposed Development Site. Larger rural catchments are expected to use the peak river flow allowances (as shown in Table 6). The guidance requires that the site drainage system is designed to make sure there is no increase in the rate of runoff discharged from the site for the upper end allowance.

3.2.26

Table 7: Environment Agency Peak Rainfall Intensity Allowance in small catchments

	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)
Upper End Allowance	10%	20%
Central Allowance	5%	10%

3.2.27 The Proposed Development lifetime assessed in this FRA is 35 years and therefore, a +20% increase in rainfall to account for climate change is applicable to the Proposed Development. This has been taken into account in the

calculations of surface water runoff rates and volumes in the Concept Drainage Strategy for the Proposed Development Site provided in Section 5.

3.2.28 When assessing a range of allowances for peak river flow or rainfall intensity, the following must be considered:

- likely depth, speed and extent of flooding for each of the assessed climate change allowances;
- vulnerability of the proposed development types or land use allocations to flooding;
- 'built in' resilience measures used, for example, raised floor levels; and
- capacity or space in the development to include additional resilience measures in the future, using a 'managed adaptive' approach.

Non-Statutory SuDS Guidance

3.2.29 The Department for Environment, Food and Rural Affairs (Defra) published their Sustainable Drainage Systems: Non-Statutory Technical Standards (NSTS) in March 2015 (Defra, 2015) setting the requirements for the design, construction, maintenance and operation of SuDS. The NSTS are intended to be used alongside the NPPF and PPG.

3.2.30 The NSTS that are of relevance to the consideration of flood risk to and from the Proposed Development relate to runoff destinations, peak flow control and volume control.

3.2.31 These standards are summarised in Table 1 of the Conceptual Drainage Strategy which is provided within Section 5 of this FRA. Additional guidance is provided for structural integrity, designing for maintenance considerations and construction.

3.3 Regional Policy

Trent Catchment Flood Management Plan

3.3.1 The Trent Catchment Flood Management Plan (CFMP) (Environment Agency, 2010) considers the scale and extent of flooding and sets policies for managing flood risk in the catchment. The CFMP identifies the Proposed Development Site as being within the 'Axholme and NW Lincolnshire' region, recognising that there is an extensive risk from flooding to agricultural land on both sides of the Trent.

3.3.2 The CFMP also states that essential infrastructure, including Keadby Power Station, would only be affected in an extreme event (0.1% AEP). However, it is recognised that climate change and sea level rise will lead to more frequent overtopping of tidal River Trent defences, potentially causing them to fail. If this was the case then it is estimated that in the next 50 to 100 years (from 2010),

25,000 properties would be at risk in the Axholme and NW Lincolnshire sub area during a 1% flood event.

3.3.3 Within the Axholme and NW Lincolnshire regions, the CFMP identifies that flood risk management activities are to be focused on mitigating the impacts of climate change.

North Lincolnshire Preliminary Flood Risk Assessment

3.3.4 In accordance with the Flood Risk Regulations 2009 (HM Government, 2009), NLC is designated as a Lead Local Flood Authority (LLFA) and has produced a Preliminary Flood Risk Assessment (PFRA) (Entec, 2011). This was submitted to the Environment Agency in 2011. The PFRA reports on sources of flooding which the LLFA is responsible for under the requirements of the Flood Risk Regulations which are: ordinary watercourses, surface water, groundwater, artificial sources and flooding which results from the interaction of local sources and sources (tidal and main river) which the Environment Agency is responsible for. It does not include fluvial flood risk from main rivers, tidal flood risk and risk of flooding from large reservoirs.

3.3.5 The PFRA uses locally agreed significance thresholds to assess the consequences of past and future flooding in North Lincolnshire. The PFRA has reviewed the local sources of flooding and through an assessment of the potential consequences of this flooding, concluded that there were no areas in North Lincolnshire which reached the national thresholds for the identification of Flood Risk Areas (i.e. 30,000 people at risk in one area).

3.3.6 The PFRA was reviewed in December 2017 by NLC and an addendum produced (NLC, 2017). It was noted that:

- significant local flood risk had reduced in some areas compared to that presented in the 2011 PFRA;
- the current risk of flooding from local sources in North Lincolnshire is slightly reduced compared to that presented in the 2011 PFRA; and
- there is no change to Flood Risk Areas.

North and North East Lincolnshire Strategic Flood Risk Assessment

3.3.7 The Level 1 SFRA was published in 2011 to support the LPA assessment for development sites in relation to flood risk. The SFRA was completed in consultation with NLC, the Environment Agency and IDB to provide information on the probability of flooding. The report also takes into account the impacts of climate change.

3.3.8 It is intended that the SFRA will be used by NLC's planning and building control department to inform the application of the Sequential Test when allocating land or determining applications, in line with the NPPF.

3.3.9 The SFRA recognises that the western floodplain of the Trent, originally marshland, was reclaimed in the 16th and 17th Centuries and is very fertile but relies on an extremely complex drainage system, almost entirely pumped, to maintain water levels low enough for arable agriculture to take place.

3.3.10 CFL across North Lincolnshire were derived as part of the SFRA. These levels should be used to determine finished floor levels of developments. In Appendix D – Critical Flood Levels, the SFRA states that *"if a developer wishes to propose a different level they will need to provide detailed hydraulic modelling to show the probability of this level being reached is less than given above, even if the flood defences protecting the site are breached"* (Appendix D, Para D.3).

North Lincolnshire Council Local Flood Risk Management Strategy

3.3.11 As LLFA, NLC has a responsibility to develop a Local Flood Risk Management Strategy (LFRMS) which sets out a clear plan for future flood risk management in the region, ensuring people, businesses communities and other risk management authorities have an active role in how flood risk is managed.

3.3.12 The strategy (NLC, 2016) is for the residents and businesses of North Lincolnshire and sets out how the Council intends to manage local flood risks, as well as contribute to management from non-local sources, and to engage and inform residents on their own responsibilities and enable them to contribute to the management of flood risk.

3.4 Local Policy

3.4.1 The Proposed Development Site lies entirely within the administrative area of NLC. The statutory development plan for the area currently comprises the following documents:

- North Lincolnshire Core Strategy – adopted June 2011 (North Lincolnshire Council, 2011a);
- Employment and Land Allocations (North Lincolnshire Council, 2017) – adopted March 2016; and
- Saved Policies of North Lincolnshire Local Plan (North Lincolnshire Council, 2003) – adopted May 2003, saved September 2007.

3.4.2 It is considered that these documents may be 'important and relevant' as defined by EN-1 (DECC, 2011a). The following policies are considered relevant to the Proposed Development in relation to this FRA:

Core Strategy (2011) (North Lincolnshire Council, 2011a)

- CS5 – Delivering Quality Design in North Lincolnshire;
- CS16 – North Lincolnshire's Landscape, Greenspace and Waterscape; and

- CS19 - Flood Risk.

Local Plan (2003) (North Lincolnshire Council, 2003)

3.4.3 The following saved policies are considered relevant from the Local Plan:

- DS14 - Foul Sewage and Surface Water Drainage;
- DS15 - Water Resources; and
- DS16 - Flood Risk.

3.4.4 To the south of the Proposed Development Site is the Stainforth and Keadby Canal. The locks at the junction of the canal and the River Trent are grade II listed and also a scheduled monument. The lock is located adjacent to the Waterborne Transport Offloading Area.

3.4.5 The River Trent, immediately to the east of the Site is part of the designated Ramsar, Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC) for the Humber Estuary.

3.4.6 The Stainforth and Keadby Canal is designated as a Local Wildlife Site (LWS).

Emerging Policy

3.4.7 NLC is preparing a new Local Plan to 2036. Once agreed (formally adopted), it will replace the current North Lincolnshire Local Plan, the Core Strategy and the Housing and Employment Land Allocations Development Plan Documents (DPD).

3.4.8 The Council undertook their Regulation 18 'Preferred Options' between February and March 2020. NLC is currently working on 'The Draft Plan', the final version of the Local Plan, prior to its submission to the Planning Inspectorate.

North Lincolnshire Council's SuDS and Flood Risk Guidance Document

3.4.9 NLC, as LLFA, has produced a SuDS and Flood Risk Guidance Document Supplementary Guidance Document (SGD) (North Lincolnshire Council, 2017a) providing developers and designers with guidance on SuDS and guidance on what type of SuDS are appropriate to a particular development, depending on the size and location. It also provides advice regarding adoption and maintenance of SuDS, riparian responsibilities and specific NLC requirements, which include that:

- the LLFA drainage team should be consulted at pre-application stage;
- SuDS are required for all developments;
- no water should be stored above ground up to and including the 1 in 100 year event unless stored in a SuDS component;

- surface water runoff should be limited for all new developments to the greenfield runoff rate;
- storage components should not be constructed in private land;
- infiltration should only be viable for areas where the infiltration rate of soils are above 1 x 10-6m/s. Infiltration testing should be undertaken over a period of time, preferably over various seasons; and
- the level of betterment will be considered on a site by site basis for all brownfield sites.

3.4.10 A more comprehensive review of prevailing policy and guidance is presented in **Chapter 12**: Water Resources and Flood Risk (ES Report Volume I – **Application Document Ref. 6.2**) which this appendix accompanies.

4.0 FLOOD RISK SOURCES

4.1 Introduction

4.1.1 The NPS requires the effects of all forms and sources of flood risk to and from the Proposed Development to be considered within a FRA. There should be demonstration of how these risks should be managed so that the development remains safe throughout its lifetime, taking into account current climate change predictions.

4.1.2 This section discusses these potential risks in relation to tidal, fluvial, surface water runoff, groundwater and man-made/artificial sources (e.g. canals, reservoirs, pumping station failure).

4.2 Historical Flooding Incidents

4.2.1 The Environment Agency's Historic Flood Map indicates that the majority of fluvial flooding on the Trent around the Proposed Development Site is confined to the eastern floodplain. Any historic flooding within the vicinity of the Proposed Development Site has been confined to the Waterborne Transport Offloading Area where there is a small functional gap in the fluvial defences. In addition, a small amount of flooding is noted on Chapel Lane at the east of the Proposed Development Site.

4.3 Breakdown of Pumping Station Network

4.3.1 The Proposed Development is located in Flood Cell 3F5 (Garthorpe & Keadby and Isle of Axholme). According to the North Lincolnshire SFRA, the CFL for this cell is 4.1m AOD. This is an estimated water level following a prolonged breakdown of the Isle of Axholme pumping station network and breach on the River Trent.

4.3.2 The Environment Agency, during pre-Application discussions (March 2021 – see **Annex A**) has stated that *"essential infrastructure should be designed to remain operational and safe during times of flood, and this should include consideration of the residual risk to the development."* However, it was also acknowledged that *"if a lower finished floor level has to be proposed, the FRA should look to include other forms of flood mitigation measures up to the CFL"* as the residual risk that flood heights could reach 4.1m AOD during the lifetime of the Proposed Development will always exist.

4.4 Tidal Sources

4.4.1 The River Trent is considered tidal from the Humber Estuary to Cromwell Lock, with the normal tidal limit approximately 70km upstream of the Proposed Development Site at SK 80932 61242.

Flood Map for Planning

4.4.2 The Environment Agency's 'Flood Map for Planning' (Environment Agency, 2021a) identifies areas subject to fluvial/ tidal flood risk for the present day but does not include the benefits or impacts of any existing flood defences or climate change.

4.4.3 The Flood Map for Planning illustrates that the entire Proposed Development Site and surrounding environs (other than a small, slightly elevated area between Keadby Common in the east, Keadby Boundary Drain in the west, and the canal to the south, and around Crowle) is within the Environment Agency's indicative Flood Zone 3. Flood Zone 3 is land assessed as having a 1 in 200 or greater annual probability of flooding from the sea (>0.5% AEP) in any year. The River Trent is tidal adjacent to the site and tidal food risk (flooding from the sea) is the dominant source of flooding. The Proposed Development Site does however benefit from Environment Agency maintained flood defences (embankments) along the River Trent.

Tidal Flood Defences

4.4.4 In accordance with the NPPF, the requirements are to ensure any proposed developments are built to withstand tidal flooding up to a 0.5% AEP (1 in 200 chance) event taking into account the potential impacts of climate change.

4.4.5 The Environment Agency's 'Flood Map for Planning' (Environment Agency, 2021a) identifies there to be existing tidal flood defences located to the east of the Proposed Development Site. The Environment Agency Asset Management Dataset demonstrates that the tidal defences are 6.2m to 6.3m AOD and have been built to provide a 1 in 200-year level of protection (Environment Agency, 2021b). According to the additional information provided by the Environment Agency (**Annex A**), the tidal defences protecting this area consist of predominantly embankments along with concrete floodwalls. The concrete walls are in 'poor' to 'fair' condition and the embankments are in 'fair' condition. The Environment Agency inspect these defences routinely to ensure potential defects are identified. The residual risk of flooding in the event of a defence breach scenario needs to be considered, especially as the concrete floodwall which is in poor condition could result in high likelihood of a breach.

Modelled Tidal Water Levels

4.4.6 The Environment Agency has provided modelled tidal peak water levels for the South Humber Bank area to inform the FRA. The Environment Agency model indicates that during a 0.1% AEP (1 in 1000 year) event, tidal levels in the Humber Estuary could rise up to 5.27m AOD at the Grimsby gauge to the south-east of the Proposed Development Site, and 5.47m AOD at the Harborough gauge north-west of the Proposed Development Site.

4.4.7 In closer proximity to the Proposed Development Site, the Environment Agency has provided modelled tidal peak water levels from the Tidal Trent SFRM (Mott

MacDonald, 2014) (**Annex A**). The modelled flood levels provided by the Environment Agency are based on a complex hydraulic model which accounts for both fluvial flows from the Trent catchment and the tidal (sea) levels in the Humber. Model results are available for large tidal events and for large fluvial events and clearly show the tidal scenarios to be the worst-case in this location. The levels on the Trent during a 0.1% AEP (1 in 1000 year) tidal event, are modelled as 6.09m AOD (Table 9). This is below the height of the flood embankments which are a minimum of 6.2m AOD. During the same event, levels in the North and South Soak Drains could rise up to 0.73m AOD (Table 8). This is below the level of the defences on the Stainforth and Keadby Canal (1.3m AOD).

4.4.8 As a result, there is currently a low risk from tidal flooding when the flood defences are functioning as designed. There is however a risk of overtopping of defences during scenarios with climate change up to 2068, the assessed likely end date of the operational Proposed Development and assuming no increase in the height of the flood defences over that timescale. The modelled level from the Tidal Trent model for a 1 in 200 year plus climate change event is 6.23m AOD which, if it occurred in future as a result of climate change impacts, could very slightly overtop the lowest points on the existing defences.

4.4.9 Only the modelled climate change levels for the 1 in 200 +CC event are available for the Trent in this location. Other more up to date levels are available from the HEWL study, but production of the HEWL levels did not involve full updating and re-running of the full complex Trent model. It is understood that the Trent model is currently in the process of being updated by the Environment Agency to include a greater number of climate change scenarios based on more recent predictions of sea level rise as part of the ongoing updates to their tidal Trent model, but these are not currently available (July 2021).

4.4.10 In the original (May 2021) FRA options were explored to include the recently revised sea level rise prediction allowances in the modelled flood levels for the Proposed Development Site, this is not possible without re-running the Trent model with revised boundary conditions. This is the exercise that the Environment Agency is currently undertaking – but which would not deliver results in the timescale of the Proposed Development DCO application. On this reach of the Trent, although tidally dominated, Fluvial-Tidal interaction is significant and in addition, once the defences start to overtop (at levels above 6.2m AOD) the flood waters would utilise the extensive storage behind the defences and more accurate climate change levels cannot therefore be calculated or estimated without use of the model. The single modelled Climate Change level from the Trent model suitable for use in this assessment is the 0.5% AEP+ CC level from the 2013 Mott McDonald study which is 6.23m AOD. The HEWL levels, discussed below, now offer an alternative indication of the up to date climate change driven levels on the Trent and have subsequently been used in the current FRA (July 2021).

4.4.11 Since submission of the Application in June 2021 including **Appendix 12A**: Flood Risk Assessment (VP1.0) (APP-084) the Environment Agency has released climate change levels for the Trent as part of the Humber Extreme Water Level study (HEWL). The HEWL levels are not likely to be as accurate as the levels available in future from re-running the Trent model, however they are appropriate for use to test the potential impact of climate change on flooding, given the flood risk to the site is tidally dominated, and provide relevant information on the residual risk to the Proposed Development Site.

Table 8: Modelled water levels on North and South Soak Drains during tidal event (Mott MacDonald, 2013).

AEP	Level (mAOD)
0.5% AEP	0.73
0.5% AEP + CC	0.73
0.1% AEP	0.73

Table 9: Modelled water levels on the River Trent during tidal event (Mott MacDonald, 2013)

AEP	Level (m AOD)
0.5% AEP	6.01
0.5% AEP +CC	6.23
0.1% AEP	6.09

Modelled Humber Estuary Extreme Water Levels

4.4.12 Extreme still water levels produced as part of the Humber 2100+ project have been provided by the Environment Agency (2021c). The Humber Extreme Water Levels (HEWL) have been produced using a joint probability modelling approach, which considers the interaction between fluvial and tidal conditions. Joint probability scenarios for the full range of annual exceedance probability (AEP) events were run through the Humber 1D Flood Modeller Pro (FMP) model, which includes the Tidal Trent SFRM (Mott MacDonald, 2014), using 2021 as a baseline.

4.4.13 In addition to present-day extreme water levels, information has also been produced for several epochs: 2040, 2046, 2071 and 2121.

4.4.14 The extreme water levels adjacent to the Proposed Development Site on the River Trent for the 2071 epoch (Upper End and H++ scenarios) have been extracted from the model results provided by the Environment Agency's Humber Strategy Team as this coincides with the assumed end of the operational life of the Proposed Development. The extreme water levels, shown in Table 10 show that overtopping of the Trent defences, which are a minimum of 6.2mAOD would occur in these scenarios. However, any overtopping would be expected to be

minimal as the defences are between 6.2 to 6.3m AOD along the banks of the River Trent in this location.

4.4.15 To assess residual risk, the 1% AEP Upper End (H) and Extreme (H++) levels for 2071 have been modelled in a breach scenario. This can be anticipated to represent a pessimistic worst-case compared to when only overtopping is considered (as overtopping depths are not significant). The 1% (100 year) H++ level is higher than both the 0.5% (200 year) M and H levels and so allows these scenarios to also be considered. For the most extreme HEWL levels available (0.1% H++) overtopping along the length of the Trent defences is likely and consequently a reduced water level at the breach (and reduced water levels on site) can be expected. For this reason, the 1% H++ is considered the most appropriate scenario to use to assess the greatest potential residual risk from climate change at this specific location.

Table 10 Humber Extreme Water Levels on the River Trent near the site (Tidal Trent model node Trent14600DS) for the 2071 epoch (Environment Agency 2021c).

AEP	HIGHER CENTRAL (M) EXTREME WATER LEVEL (M AOD)	UPPER END (H) EXTREME WATER LEVEL (M AOD)	H++ EXTREME WATER LEVEL (M AOD)
50% AEP	5.77	5.89	6.16
20% AEP	5.9	6.0	6.2
10% AEP	5.99	6.08	6.22
5% AEP	6.07	6.13	6.24
2% AEP	6.15	6.19	6.29
1.33% AEP	6.18	6.25	6.33
1% AEP	6.2	6.26	6.34
0.5% AEP	6.27	6.3	6.35
0.2% AEP	6.29	6.33	6.36
0.1% AEP	6.33	6.35	6.38

Modelled Breach Water Levels Behind the Defences

4.4.16 The modelled levels which are available from existing models clearly show the Trent at this location is tidally dominated; the water levels in the River Trent are highest during tidal events and therefore in assessing flood risk to the Proposed Development Site, it is the Tidal Levels that are of greatest importance. The current defence levels are above the current 0.1% (1 in 1,000-year return period) tidal flood level.

4.4.17 Consequently, in the event of any future climate change driven overtopping within the lifetime of the Proposed Development, it is unlikely that the flood depths on the Proposed Development Site would be greater than the flood depths from a breach, which represents a catastrophic failure of the defences during an extreme water level event. Site specific breach modelling has been carried out as part of this FRA. The Breach Modelling Technical Note and Addendum is provided in **Annex C**.

4.4.18 Breach modelling was undertaken using level time hydrographs from the tidal Trent model provided by the Environment Agency (**Annex A**). As it is not possible to apply a climate change uplift to this data without re-running the Trent model (and as the Environment Agency is already doing so internally), the model was run with the worst-case event provided. As no information was provided on the climate change applied in these events, it has been assumed that, as would be usual, it was an increase in the downstream water level representing the projected sea level rise.

4.4.19 The 200-year tidal event plus climate change combined with a 2-year fluvial event (F02 T200CC) was modelled in order to determine the flood level at the Proposed Development Site in the event of a breach. Results are shown in Table 11.

4.4.20 The 1% AEP Humber Extreme Water Levels outlined in Table 10 were used to run a climate sensitivity on the breach model. A simple approach was taken to shift the stage-time boundary curve previously used (F02 T200CC) up by 3cm and 11cm respectively for the H and H++ scenarios (HEWL RP100 2071H and HEWL RP100 2071HPP). Results are shown in Table 11.

4.4.21 Results determine that the 200-year tidal event plus climate change event (F02 T200CC) results in water levels of 2.47m AOD across the Proposed Development site during the Development Scenario with the land raising on the Proposed PCC Site. This results in depths between 0.9m and 1.9m across the Proposed Development Site in its post-construction state. This poses a significant risk to the Proposed Development Site and any site workers and a flood management and land raising strategy has therefore been developed to manage the risk.

Table 11: Modelled maximum water levels at the Proposed Development Site following a breach in the Trent tidal defences immediately east of the site.

AEP	Level (m AOD)
F02 T200CC (Baseline Scenario)	2.41
F02 T200CC (Development scenario)	2.47
HEWL RP100 2071H	2.47
HEWL RP100 2071HPP	2.51

4.4.22 Breach modelling also determined that land raising has an impact on flow paths around the Proposed Development from a breach. As would be expected, flows are directed around the raised platform within the Main Site following land raising, instead of directly across the Proposed Development Site, as at present. However, there is no significant change in the velocity of flood waters around the Proposed Development Site and flood risk is not increased elsewhere. Further information on these results can be found in **Annex C**.

Summary

4.4.23 Based on the information provided by the Environment Agency, it has been determined that the Proposed Development Site is currently at a 'low' risk of flooding from tidal sources with the defences in place or resulting from overtopping of the defences during events that exceed a 0.5% AEP (1 in 200 chance) of flooding.

4.4.24 During the modelled HEWL 2071 climate scenarios, the risk is potentially more significant. Breach modelling indicates that during the modelled HEWL scenarios, overtopping of the defences is expected to occur and the model represents this alongside the breach. The Proposed Development Site is potentially at a 'high' residual risk of flooding as a result of overtopping and/ or breach during events that exceed a 0.5% AEP (1 in 200 chance) of flooding on the River Trent including the effects of climate change and assuming there is no future raising of the defences. This is an extreme scenario, with the extreme (H++) climate change scenario and a breach occurring simultaneously. It is not likely to occur, but as a residual risk has been taken into account in the design of the Proposed Development Site.

4.4.25 In the event that the defences were to breach during a high water level event on the Trent, the hazard to the Proposed Development Site in its unmitigated state would be 'high' as flood waters would rapidly reach the Proposed Development Site and areas would flood to depths over 1m. However, the probability of this occurring is 'low', as to occur it requires both a high-water level in the Trent and a structural defence failure, and this is therefore a residual risk.

4.5 Fluvial Sources

4.5.1 A review of OS mapping identified that the nearest main watercourse is the River Trent to the immediate east of the Proposed Development Site. Other main watercourses in proximity of the Proposed Development Site include the Three Rivers and the North and South Soak Drains. The SFRA states that high water levels on the River Trent is one of the main sources of flooding in the area however the Trent is tidally dominated in this area (tidal risk has already been discussed above). The high embankments along the Trent allow water levels on the Trent to rise much higher than the surrounding watercourses and much of the Isle of Axholme drainage (including the Three Rivers and North and South Soak Drains) is lifted by pumping into the River Trent.

4.5.2 Ordinary watercourses in proximity to the Proposed Development Site include the Stainforth and Keadby Canal, Warping Drain (to the north) and Keadby Boundary Drain (to the west). The SFRA states that the failure of the network of watercourses to drain the marshland surrounding the river is a further source of flooding.

Flood Map for Planning

4.5.3 The Environment Agency's 'Flood Map for Planning' (Environment Agency, 2021a) identifies that the Proposed Development Site is located in Flood Zone 3. Flood Zone 3 is defined by the NPPF PPG as land with a high probability of flooding (>1% AEP) (1 in 100 or greater annual chance of river flooding). However, this map does not differentiate between the tidal/ fluvial sources of risk and the flood defences are not taken into account.

Modelled Fluvial Water Levels and Extents

4.5.4 The Environment Agency has provided modelled fluvial peak water levels from the Tidal Trent SFRM (Mott MacDonald, 2013) (**Annex A**). No information was provided on the climate change scenario modelled; however, it is believed to be the former Higher Central allowance (20%) for the Humber River Basin. The current climate change allowances are outlined in Table 6 and would result in a higher allowance being applied. The model demonstrated that during a 0.1% AEP (1 in 1000 year) event, fluvial water levels in the North and South Soak Drains could rise up to 1.69 mAOD (Table 12, below).

Table 12: Modelled water levels on North and South Soak Drains during fluvial event (Mott MacDonald, 2013).

Scenario	Level (mAOD)
1% AEP	1.09
1% AEP + CC	1.15
0.1% AEP	1.69

Fluvial Flood Defences

4.5.5 The Environment Agency's 'Flood Map for Planning' (Environment Agency, 2021a) identifies existing fluvial flood defences on the North and South Soak Drains. These defences consist largely of earth embankments and higher ground at 1.3m AOD and are reported to be in fair to good condition. These defences are high enough to prevent overtopping during events with a 0.5% AEP and 0.5% AEP + CC but not the 0.1% AEP event (Table 13). However, there is a raised strip of land no lower than 2.0m AOD along the New Permanent Access from A18. This also acts as a barrier to fluvial flooding onto the Proposed Development Site.

Unmodelled Land Drains

4.5.6 The land drains surrounding the Proposed Development Site drain predominantly into Warping Drain, North and South Soak Drains and the Three Rivers.

4.5.7 Due to the very flat and low-lying nature of the surrounding area, the Proposed Development Site is surrounded to the north, south and west by a complex drainage system from agricultural fields as represented within **Figure 12.1** (ES Volume III - **Application Document Ref. 6.4**). These land drains are not included in the Environment Agency's hydraulic modelling. The land drainage system relies on pumping and as a result, pumping capacity and condition have the potential to influence flood risk, alongside meteorological factors.

Summary

4.5.8 Based on the information provided by the Environment Agency, it has been determined that the Proposed Development Site is at a 'low' risk of flooding from fluvial sources with the defences in place or resulting from overtopping of the defences during events that exceed a 0.5% AEP (1 in 200 chance) and 0.1% AEP (1 in 1000 chance). There is a residual risk associated with breach of the defences on the River Trent however as fluvial water levels are lower than tidal water levels the assessed tidal risk is the worst-case with regards to overtopping and breach on the Trent and has already been discussed and assessed above.

4.6 Groundwater Sources

4.6.1 Groundwater flooding can occur when groundwater levels rise above ground surface levels. The underlying geology has a major influence on where this type of flooding takes place; it is most likely to occur in low-lying areas underlain by permeable rocks (aquifers).

4.6.2 Historical data indicates that the Proposed Development Site is not at risk from reservoir flooding and groundwater flooding based on the geological setting of the wider area encompassed by Keadby 1 and Keadby 2 Power Stations (Mott MacDonald, 1991). Based on the previous assessment undertaken as part of the Keadby 2 Power Station ES (ERM, 2016), groundwater flooding is understood to be effectively managed via the extensive drainage system serving Keadby 1 and Keadby 2 Power Stations.

4.6.3 The 'Areas Susceptible to Groundwater Flooding' (AStGWF) dataset provided by the Environment Agency to inform the NLC SFRA can be used to identify areas where geological conditions could enable groundwater flooding to occur and where groundwater may come close to the ground surface. This information is shown as a proportion of 1km grid squares where there is potential for groundwater emergence. The data does not show where flooding is likely to occur, but instead is appropriate for reference at a strategic level to indicate areas for further investigation.

4.6.4 The areas around the Proposed Development Site are artificially drained by various land drains and pumping stations, which help to maintain the groundwater level. These are expected to remain operational through the lifetime of the Proposed Development, contributing to a low risk of groundwater emergence at the Proposed Development Site.

4.6.5 In addition, a significant proportion of the Proposed Development Site is covered in impermeable hardstanding surface, reducing natural infiltration potential as part of the Proposed Development. As a result, due to hardstanding ground intercepting groundwater and preventing it from reaching the surface, the likelihood of localised groundwater reaching the surface and causing flooding is reduced.

4.6.6 Based on the information provided, the Proposed Development Site is considered to be at low risk of flooding from groundwater sources.

4.7 Surface Water Runoff to the Site

4.7.1 Surface water flooding is caused by overland flow that results from rainfall that cannot drain into the ground through infiltration, instead travelling over the ground surface. This can be exacerbated where the permeability of the ground is low due to the type of soil (such as clayey soils) and geology or land use including urban developments with impermeable surfaces.

Overland Flow of Rainfall Runoff

4.7.2 The Environment Agency 'Risk of Flooding from Surface Water' (RoFSW) maps (Environment Agency, 2019a) indicate areas at risk from surface water flooding when rainwater does not drain away through the normal drainage systems or soak into the ground, but instead lies on or flows over the ground.

4.7.3 The RoFSW flood map identifies that the Proposed Development Site is generally not at risk from surface water flooding, classifying the majority of the land to be at 'very low' risk of flooding from surface water. The Environment Agency define 'very low risk' as an area that has a less than a 1 in 1000 (0.1%) probability of flooding in any given year. Mapping shows that there are isolated areas at low and medium risk along existing roads and paths on the Proposed Development Site, and one small area of high risk along East Road within the existing (operational) Keadby 1 Power Station site.

4.7.4 As the Proposed Development will increase the impermeable area and therefore increase the rate of surface water runoff from the Proposed Development Site, drainage infrastructure to mitigate this has been considered in Section 5 of this FRA.

Existing Drainage Infrastructure

4.7.5 Extensive site drainage already exists as a result of the Keadby 1 and Keadby 2 Power Stations (under construction). Aside from existing infrastructure for

Keadby 1 Power Station, information supplied by the Applicant (SSE, 2019) confirms that the Keadby 2 Power Station drainage system will comprise of three sub-systems:

- surface water system;
- oily-waste system; and
- condensate polishing plant wastewater system.

4.7.6 The surface water system is designed to collect all water generated by precipitation up to a 1 in 200-year storm event. The system separately collects surface water running off from building roofs and surface water running off from paved areas such as roads, due to the potential for oil contamination of the wastewater resulting from car parking and roads.

4.7.7 Rainwater from the roofs of buildings is collected by rainwater down comers and connected to nearby manholes. These manholes are connected to the surface water drainage system by underground gravity pipework and routed directly to the detention basin. Surface water from paved areas in the power island is collected by combined kerb drainage channels at the sides of the roads, with regular silt traps. The surface water collected from the roads is routed via gravity fed pipes to the detention basin through a bypass oil separator.

4.7.8 There is a detention pond which has a capacity of approximately 1,300 cubic meters (m^3) and is located in the north-west corner of the Keadby 2 Power Station plant area. Water from the detention basin is discharged in a controlled manner using a hydro brake (to control flow) to the Keadby Common Drain at the new proposed discharge point W11. Keadby Common Drain is connected to a wider drainage network managed by the IDB.

4.7.9 The Keadby 2 Power Station surface water drainage system is designed to comply with the following SuDS standards:

- no damage shall occur to any buildings, plant, equipment or assets within the Site, or downstream of the Site as a result of a 1 in a 200-year storm event;
- no flooding of property or public roads during a 1 in 200 rainfall event. The event shall be contained on-site without damage to property;
- on-site storage provided for up to 1 in 30-year event;
- nominal flow modelled, (1 in 30 years): 47 l/s, Peak flow (1 in 100 years + 20% climate change): 68.4 l/s; and
- an allowable discharge from the Site set at brownfield runoff rate with 30% betterment. As a result, the increased hardstanding introduced during construction will not increase the rate of runoff from the site and the system will increase retention as compared to existing conditions.

Summary

4.7.10 Based on the above information, the risk to the Proposed Development Site from overland flow of surface water generated adjacent to, or from waterbodies located within the Proposed Development Site is considered to be 'low' to 'very low'.

4.8 Artificial Sources

Reservoirs

4.8.1 The Proposed Development Site is not considered at risk from reservoir flooding.

4.8.2 The Reservoir Act 1975 as amended by the Flood and Water Management Act 2010 in England applies to reservoirs which hold over 25,000m³ of water and sets out safety and maintenance requirements. The Environment Agency has assessed the flood hazards associated with the breach or failure of large reservoirs or high risk reservoirs and the Environment Agency map of Flood Risk from Reservoirs (Environment Agency, 2019b) shows that the Proposed Development Site is not located in an area at residual risk of flooding from reservoirs in the event of a structural failure or breach.

Canals

4.8.3 The Sheffield and South Yorkshire Navigation – Stainforth and Keadby Canal is directly adjacent to the south of the Proposed Development Site but given its' shallow gradient and that it drains into the River Trent by a sluice, the risk of flooding is likely to be low. If any overtopping of the canal were to occur, this would drain into the North and South Soak drains located at a lower elevation on either side of the canal and drain away. However, the canal levels are monitored and maintained by the Canal & River Trust. As a result, overtopping is unlikely and so the site is at low risk of flooding from the canal.

Summary

4.8.4 The risk of flooding from artificial waterbodies is considered to be low.

5.0 MANAGEMENT OF SURFACE WATER FROM THE PROPOSED DEVELOPMENT SITE

5.1 Introduction

5.1.1 This Section summarises the approach taken in the Conceptual Drainage Strategy to define the scale of surface water runoff at the Proposed Development Site, and the choice of surface water management measures investigated.

5.2 Planning Policy and Guidance

5.2.1 There are a number of national, regional, and local policy requirements which are relevant to this outline drainage strategy. These policy requirements ensure that the Proposed Development will be sustainable and can, if possible, contribute to a decreased flood risk beyond the Proposed Development Site in the local area. The policy requirements are outlined below and discussed in the context of the Proposed Development.

National Planning Policy and Guidance

5.2.2 The NPS EN-1, the Environment Agency, the NSTS SuDS Guidance (Defra, 2015), the NLC Local Plan (2018) and the NLC SuDS Guide (NLC, 2016) require that new developments should not increase flood risk to the site or the surrounding area. Therefore, surface water runoff rates discharging from the Proposed Development at the Proposed Development Site should not exceed the existing runoff rates.

The Building Regulations 2010

5.2.3 The Building Regulations 2010 Approved Document H, Drainage and Waste Disposal (2015 Edition) (HM Government, 2015), has been issued by the Secretary of State for the purpose of providing practical guidance with respect to the requirements of Schedule 1 and Schedule 7 of the Building regulations 2010 for England and Wales.

5.2.4 This requires that surface water runoff be discharged according to the following discharge hierarchy:

- discharge to soakaway or some other adequate infiltration system;
- discharge to surface watercourses; or
- discharge to sewers.

Guidance

5.2.5 The Environment Agency's general advisory recommendations require the existing greenfield runoff rates to be maintained after development, using SuDS

where practicable to provide adequate storage up to the 1% AEP event (1 in 100 chance in any year) including an allowance for climate change.

5.3 Existing Surface Water Runoff Rates

5.3.1 The Proposed Development Site boundary is shown on **Figure 3.1**: The Order Limits, and surface waterbodies are shown on **Figure 12.1**: Surface Waterbodies and their Attributes (ES Volume III - **Application Document Ref. 6.4**).

5.3.2 The consideration of existing surface water runoff is focused on two principal areas within the Proposed Development Site: The Proposed PCC Site and the Construction Laydown Areas illustrated on **Figure 5.1** (ES Volume III – **Application Document Ref. 6.4**).

5.3.3 The Proposed PCC Site covers an area of approximately 18.7ha of the Keadby Power Station site. Until circa 2017/ 2018, this area was used for arable production but has since been re-seeded. The northern areas of Keadby Common where the CCGT and CCP are proposed (referred to as the 'Main Site') are occupied by improved grassland. Keadby Common has a drain on each boundary (four drains in total). The drain across the north of the Main Site is referred to in the ES as 'Drain 1'; it forms part of Glew Drain and is designated as a LWS immediately north-east of the Main Site. A further field drain crosses Keadby Common between a northern field and the southern area of the Main Site which is currently being temporarily used for soil storage during construction of the Keadby 2 Power Station. The Proposed PCC Site is bisected by overhead electricity transmission lines associated with the existing National Grid 400kV Substation to the east of the Proposed PCC Site. The Proposed PCC Site is illustrated on **Figure 3.2:** Aerial Photo of The Order Limits (ES Volume III - **Application Document Ref. 6.4**) and the context of the 'Main Site' on which the CCGT and CCP will be developed is shown in **Figure 3.3**: Indicative Work Areas Referred to in the Environmental Statement (ES Volume III - **Application Document Ref. 6.4**), reproduced in Plate 1 of this report.

5.3.4 The Proposed Development will require adequate hardstanding to provide the development platform for CCGT, CCP and associated buildings and equipment. Assumptions regarding hardstanding areas are set out in Section 5.5.

5.3.5 Approximately 20.4ha of land is proposed for construction laydown (refer to **Figure 5.1** (ES Volume III – **Application Document Ref. 6.4**). As depicted by **Figure 5.1** (ES Volume III – **Application Document Ref. 6.4**), this includes a small area near to the A18 (Area 1), a larger area of agricultural land to the south of the Stainforth and Keadby Canal (Area 2), other areas within and adjacent to the Proposed PCC Site (Area 2* and Area 3) and an area of land near the former Keadby 1 substation (Area 4) to the east of the Proposed PCC Site.

5.3.6 In some these temporary construction laydown areas, there is existing development or hardstanding including the former Keadby 1 substation site area

(Area 4), temporary laydown areas for Keadby 2 Power Station construction site (Area 2* and part of Area 2), whilst the remainder of areas under consideration are currently greenfield.

5.3.7 For concept drainage design and for the purposes of this FRA, it is assumed that existing runoff rates will be equivalent to the greenfield runoff rate. Discussions have been undertaken with the IDB and the Environment Agency regarding the proposed discharge volumes and ultimate discharge location. The IDB has confirmed that the proposed surface water discharge is in excess of that usually permitted by the Board which normally accepts discharges at the lower agricultural runoff rate of 1.4l/s/ha and that further discussions will be required to determine the acceptability of the proposal and agree any mitigation measures necessary to accommodate the additional flows within the receiving watercourse and at nearby pumping stations. The preferred option is to discharge into the IDB network at the greenfield runoff rate.

5.3.8 The greenfield runoff rate for the Proposed PCC Site and temporary construction and laydown areas have been estimated using the ReFH2 software with FEH 2013 data. A comparison with the agricultural runoff rate, for a site of 18.7ha, of 26.18l/s is also given The peak greenfield runoff rates for both areas are given in Table 13 and Table 14 respectively.

Table 13: Proposed PCC Site Greenfield Runoff Rates

Return Period (years)	Greenfield Runoff Rate (l/s)	Agricultural Runoff Rate shortfall
1	15.4	No Shortfall
2	17.8	No Shortfall
5	26.5	0.3
10	33.1	6.9
30	44.3	18.1
50	50.3	24.1
75	55.3	29.1
100	59.3	33.1
200	70.0	43.8
1,000	106.5	80.3

Table 14: Temporary Construction and Laydown Area Greenfield Runoff Rates

Return Period (years)	Greenfield Runoff Rate (l/s)
1	16.5
2	19.2
5	28.6
10	35.6
30	47.8
50	54.2
75	59.6
100	63.9
200	75.5
1,000	114.5

5.4 Un-attenuated Proposed Surface Water Runoff Rates

5.4.1 Storage volume calculations have been undertaken for the critical storm duration of the 100-year return period storm event plus climate change allowance. A discharge of 59.3l/s for the Proposed PCC Site and 63.9l/s for the temporary construction laydown areas has been calculated as equal to the existing 100-year return period greenfield runoff rate.

5.5 Surface Water Volume Attenuation Requirements

5.5.1 The storage volume estimate has been made using the quick storage estimate tool within the Microdrainage 2019.1 Source Control Program; results are shown in Table 15. FEH 2013 point descriptors were used to undertake this analysis.

5.5.2 It has been assumed at this stage that the Construction Laydown Areas will be 50% impermeable and that the total impermeable area for the Proposed PCC Site will be equal to the hardstanding area, 13.9ha. Detailed attenuation calculations would be undertaken as part of the detailed drainage design, secured by a requirement of the Draft DCO (**Application Document Ref. 2.1**) and attenuation solutions would be specified at this stage.

Table 15: Required Attenuation Volumes

Area	Rainfall Event	Impermeable Area (ha)	Minimum Storage Requirement (m^3)	Maximum Storage Requirement (m^3)
Proposed PCC Site	1 in 100 years +40% Climate Change	13.9	9,362	11,641
Construction Laydown Areas	1 in 100 years +40% Climate Change	12.7	7,984	9,855

5.6 Proposed Surface Water Attenuation Solution

Consideration of Appropriate SuDS Techniques

5.6.1 In line with Environment Agency advisory recommendations, the Construction Industry Research and Information Association (CIRIA) SuDS manual best practice guidelines and local planning policy, sustainable drainage systems should be used as a preferential option. A summary of sustainable drainage systems is given in Table 16, below. The SuDS management train should be taken into account during detailed drainage design with an aim of capturing surface water as close to the source as possible.

5.6.2 As the runoff rates generated will be greater than the greenfield runoff rate, attenuation systems will be required to store runoff prior to discharge. As the majority of the Construction Laydown Area (Area 2) is to be located to the south of the Stainforth and Keadby Canal, attenuation for the Proposed PCC Site and this portion of the Construction Laydown Area will be considered independently from each other. However, the Construction Laydown Area adjacent to Keadby 1 Power Station (Area 4) may be considered in combination with the Proposed PCC Site and if a pumped discharge system is used, there may be operational benefits to combining the discharge systems in one location. This may be upstream, or downstream of attenuation.

5.6.3 As the topography may limit the maximum depth of attenuation features, source control methods such as rainwater harvesting, and permeable paving should be considered to reduce the burden on attenuation systems.

Table 16: Sustainable Drainage Systems

Technique	Description	Restrictions of use
Storage Pond	Storage ponds can be used to attenuate overland runoff and slowly release it into a watercourse or sewer. These	Storage ponds may require substantial earthworks and thus incur high costs during the construction phase.

Technique	Description	Restrictions of use
	systems do not offer water quality benefits unless additional water quality measures are added such as filters or sedimentation volume.	Additionally, large ponds which store water above ground level may be classified as reservoirs which are subject to a range of legislative requirements. Land take requirements for storage ponds are likely to be substantial. Below ground attenuation depths may be limited by topography and the groundwater table.
Permeable Paving	Permeable paving allows rainwater to infiltrate through a hard-standing surface to underlying soils or drainage infrastructure. From which it may infiltrate or be directed to a local watercourse or sewer.	Permeable pavements may be restricted by the presence of basements or groundwater levels as well as high imposed loads.
Rainwater Harvesting	Rainwater from roofs and hard surfaces can be stored and used for non-potable purposes. This can provide a reduction of surface water runoff through control at source as well as reducing the demand on the water supply system. In the case of the Proposed Development, harvested rainwater could be used to supplement cooling water supplies.	Rainwater harvesting is dependent on a consistent supply of rainwater which cannot be ensured. As such it should be used as a supplement to conventional water supply only. Filtration is required for rainwater that is harvested from areas where sediment pick-up is likely.
Below Ground Attenuation	Below ground storage tanks will attenuate surface water flows in much the same way as surface water ponds, although with reduced land take. Storage tanks will typically require a hydro brake to ensure steady and controlled discharge.	Upfront costs are likely to be high for buried storage tanks. The maintenance regime may be onerous or involve heightened health and safety risks due to enclosed spaces. Depth of below ground attenuation may be limited by the groundwater table, although

Technique	Description	Restrictions of use
		this may be accounted for in design of buried tanks.

5.6.4 Due to anticipated high groundwater levels and the presence of an underlying aquifer, discharge through infiltration will not be possible. Furthermore, recorded groundwater levels indicate that resistance to floatation is likely to be a design requirement of all buried drainage assets.

5.6.5 Based on available site information and discussions with the IDB, Environment Agency and NLC, it is anticipated that surface water will be captured and attenuated on site prior to discharge to a watercourse. The preferred option is that the IDB network is the receiving watercourse and the discharge rate is equal to the existing greenfield runoff rate.

5.6.6 In line with NLC standards, a range of SuDS systems will be incorporated. It is proposed that as far as reasonably practicable, surface water runoff is conveyed through drainage ditches and filter drains. At the Proposed PCC Site, these would discharge into swales around the edge of the Proposed Development which would in turn discharge into the proposed attenuation pond indicated on **Figure 4.1** (ES Volume III – **Application Document Ref. 6.4**). Any areas of the Proposed PCC Site which cannot be drained through ditches or filter drains, such as those to be trafficked by heavy vehicles, would be drained through a gully and pipe network which would include catchpits and isolation valves.

5.6.7 The Construction Laydown Area is proposed to be drained through the same approach as the Proposed PCC Site, however discharge would be to drains which are owned and managed by the landowner. Due to the size of the Construction Laydown Area (Area 2), multiple discharge locations may be required; however, the total discharge rate would not exceed the present day greenfield runoff rate.

5.6.8 In-line oil separators would be installed within the Proposed PCC Site, the locations of which would be determined during detailed design. All surface water discharge leaving the relevant areas of the Proposed Development Site would pass through an oil separator.

5.6.9 Discussions have taken place with the IDB to determine the feasibility of the preferred method and rate of discharge (greenfield runoff rate) for surface water runoff to the IDB network. The IDB has noted that they do not normally accept discharges higher than agricultural runoff rate (1.4l/s/ha) but is considering the Applicant's proposals including any mitigation measures that may be required in order for such a discharge to be accepted. An alternative discharge route is also proposed, should this be required to meet the agricultural run-off rate. This is to attenuate runoff within the Proposed Development Site in the same way as

proposed for the preferred discharge solution, but in addition (or as a hybrid solution in combination with the preferred solution), to discharge excess surface water via the Water Discharge Corridor at the greenfield runoff rate. The ultimate discharge location will be to the River Trent via the Water Discharge Corridor, which is via the existing Keadby 1 Power Station cooling water culvert and outfall, which is also proposed to be utilised for treated water from Keadby 2 Power Station, once operational.

Foul Drainage Strategy

5.6.10 As described in **Chapter 4**: The Proposed Development (ES Volume I – **Application Document Ref. 6.2**) foul drainage from permanent welfare facilities would be directed to the local sewerage system, subject to agreement with the local sewerage undertaker. The existing foul sewer connection within the Keadby Site would be utilised if it is found to be fit for purpose for life of Proposed Development. If this is not the case, a package treatment plant will be used which will discharge into the cooling water outfall.

5.6.11 The Proposed Development will be an active industrial site controlled by an Environmental Permit and regulated by the Environment Agency. As such, pollution control measures will be required to demonstrate Best Available Techniques (BAT) in order to prevent accidental discharge of pollutants such as hydrocarbons to surface water systems. Pollution prevention measures considered would include (but not be limited to):

- the design of oil interceptors shall be undertaken based on manufacturer supplied information;
- foul flows and effluent arising from the Proposed Development operation will be kept separate from the surface drainage network;
- areas which may have a higher risk of pollutant spills to be isolated through the use of bunds; and
- during construction, the Contractor will adhere to all relevant pollution prevention guidelines[1] and measures in the Framework Construction. Environmental Management Plan (CEMP) which accompanies the DCO Application (**Application Document Ref. 7.1**).

[1] The construction of the Proposed Development would be in accordance with good practice guidance. A series of Guidance for Pollution Prevention (GPP) is in development, which provides updated good practice guidance to the UK. Where new GPP documents are yet to be published, previous Pollution Prevention Guidance (PPG) documents still continue to provide useful advice on the management of construction to avoid, minimise and reduce environmental impacts, although they should not be relied upon to provide accurate details of the current legal and regulatory requirements and processes. For further information, please refer to **Chapter 12:** Water Environment and Flood Risk (ES Volume I - **Application Document Ref. 6.2**).

6.0 MITIGATION OF FUTURE AND RESIDUAL FLOOD RISKS AND OFF-SITE IMPACTS

6.1 Overview

6.1.1 Consideration should be given to measures that protect the Proposed Development from the residual risk of flooding in the event that the existing tidal defences fail in the vicinity of the Proposed Development Site, or in the event of heavy rainfall that could result in surface water flooding at the Proposed Development Site, should the design capacity of the drainage network be exceeded.

6.1.2 This Section therefore provides recommendations for the construction and operation phases of the proposed development in accordance with the NPS, SFRA and by Environment Agency guidance on how the Proposed Development can be designed to withstand predicted flood risks and mitigate the impact.

6.2 Construction

6.2.1 Construction works undertaken adjacent to, beneath and within watercourses would comply with relevant guidance during construction, including the requirements of any Environmental Permit, Ordinary Watercourse Consent and/ or Environment Agency GPP and IDB Bylaws, particularly AN01, AN02, AN03, AN05 and AN06.

6.2.2 Activities carried out within the floodplain of a main river are considered regulated activities and as such require permission from the Environment Agency. A FRAP is likely to be required for certain works close to Environment Agency main rivers and flood defences, including works over Hatfield Waste Drain (**Work No. 8B** - Mabey Bridge replacement) and if required, works required to refurbish and upgrade the existing Keadby 1 Power Station River Trent water intake to comply with the Eels Regulations within the River Trent (**Work No. 4B**).

6.2.3 A CEMP would incorporate measures aimed at preventing an increase in flood risk during construction works, as far as reasonably practicable. The Framework CEMP (**Application Document Ref. 7.1**) incorporates measures to prevent an increase in flood risk during the construction works. Examples of such measures include:

- adequate containment of storage areas, to ensure that material does not wash away and cause pollution and damage to infrastructure;
- the construction laydown area site office and supervisor will be notified of any potential flood occurring by use of the 'Floodline Warnings Direct' service;

- the Contractor will be required to produce a Flood Risk Management Action Plan/ Method Statement which will provide details of the response to an impending flood and include:
  - a 24 hour availability and ability to mobilise staff in the event of a flood warning;
  - the removal of all plant, machinery and material capable of being mobilised in a flood for the duration of any holiday close down period;
  - details of the evacuation and site closedown procedures; and
  - arrangements for removing any potentially hazardous material and anything capable of becoming entrained in floodwaters, from the temporary works area.

6.2.4 Due to the residual risk to construction personnel and equipment resulting from a breach of defences on the River Trent, construction works should not take place during times of high flow when there is a Flood Alert.

6.3 Operation

6.3.1 The Applicant does not intend to build new flood defences for the Proposed Development Site. Rather, the Proposed Development will be designed taking into account the requirements to prevent flood damage to its own assets and to prevent displacement of flood water that could negatively impact land use elsewhere off-Site.

6.3.2 This Section therefore provides recommendations in accordance with the NPS, the local SFRA and by the Environment Agency on measures that will be considered by the Applicant in the detailed design to withstand predicted tidal flood levels and mitigate potential impacts. The following mitigation measures have been considered to protect the Proposed Development in accordance with the legislative and regulatory authority requirements:

- flood resistance and resilience measures (including raising critical operational infrastructure);
- flood emergency response plans;
- flood warnings and alerts;
- emergency access and egress; and
- design capacity exceedance.

6.3.3 It is proposed that required mitigation, including protection of critical operational infrastructure, would be secured by requirements of the Draft DCO (**Application Document Ref. 2.1**).

Flood Resistance and Resilience Measures

6.3.4 The following flood resilience and resistance mitigation measures have been considered to ensure the operation of the Proposed Development is maintained during any inundation, and to ensure the safety of people:

- flood resistant/ resilient design;
- raising external ground levels; and
- elevating critical operational infrastructure above the peak flood inundation level.

6.3.5 The NLC SFRA (North East Lincolnshire Council, 2011) states that a FRA should demonstrate that a proposal will be safe for its lifetime, including taking into account the potential impacts of climate change. This includes a requirement to demonstrate that the design internal finished floor levels are elevated above the modelled breach event peak flood level.

6.3.6 CIRIA Report C688 (2010) 'Flood Resilience and Resistance for Critical Infrastructure', states that:

"*Flood resilience involves designing an infrastructure asset or adapting an existing infrastructure asset so that although it comes into contact with floodwater during floods, no permanent damage is caused, structural integrity is maintained and, if operational disruption does occur, normal operation can resume rapidly after a flood has receded. Flood resistance involves designing an infrastructure asset or adapting and existing infrastructure asset so that floodwater is excluded during flood events and normal operation can continue with no disruption occurring to the essential services the asset provides*".

6.3.7 In order to protect against the residual risk of breach and the much lower future risk from defence overtopping, infrastructure within the Main Site will be raised above the modelled breach level during the 0.5% AEP plus climate change tidal event. Wholesale land raising of the Proposed Development Site is not considered to be a pragmatic or sustainable approach to managing the risk associated with circumstances that would result in the CFL being reached. For example, such an approach would require large scale import of material.

6.3.8 The Environment Agency has advised that *"essential infrastructure should be designed to remain operational and safe during times of flood".* As such, the development platform of the Main Site would be raised to the breach level (2.47m AOD) +300mm freeboard i.e. 2.8m AOD. Within this area critical operational infrastructure associated with the CCGT (defined in paragraph 6.3.11) will have a further minimum clearance of 800mm, therefore providing a level of resilience of no less than 3.6m AOD, which is also the approach that has been adopted for the Keadby 2 Power Station. This is a minimum level that will be achieved for critical operational infrastructure, but further clearance will be provided up to 4.4m AOD (i.e. the CFL + 300mm freeboard) where reasonably practicable to do so. These levels (respectively the 'Minimum

Critical Operational Infrastructure Design Level' and the 'Critical Operational Infrastructure Design Level') are proposed to be secured via a requirement of the Draft DCO (**Application Document Ref. 2.1**) and are reported as parameters in **Chapter 4**: The Proposed Development (ES Volume I – **Application Document Ref. 6.2**).

6.3.9 The risk of overtopping in the future and as a result of climate change driven sea level rise assumes that in the intervening period, no raising of the Trent tidal defences occurs. This is a highly conservative assumption and given the areas of land and property at risk across the wider area, it would be reasonable to assume that future defence raising, and upgrades may continue to protect the Proposed Development Site, mitigating the overtopping risk. This cannot however be relied upon. The modelled Humber Extreme Water Levels which have recently (July 2021) become available result in water levels on the Proposed Development Site a minimum of 0.25m below the development platform and provide confidence that the proposed site levels are also appropriate for residual risk climate change scenarios.

6.3.10 Based on the flood depth band information provided by the breach model, the predicted flood level for the Proposed Development Site following a breach in the tidal flood defences during a 0.5% AEP (1 in 200 chance) flood event is 2.47m AOD. This estimation is based on the worst-case scenario of a breach occurring in the immediate vicinity of the Proposed Development Site. In order to protect the Proposed Development, finished floor levels within the Main Site and within the Workshops/ Control/ Admin buildings within the south of the Proposed PCC Site will be raised to the breach level +300mm freeboard (2.8m AOD), with critical operational infrastructure raised beyond this (as discussed in paragraph 6.3.8 above). All proposed building and critical infrastructure levels are above the modelled Development Scenario and above the HEWL 1% 2071 breach water levels on the Proposed Development Site.

6.3.11 Relevant critical operational infrastructure is considered to include:

- electrical equipment, switchboards and control panels;
- transformers;
- main boiler feed pumps;
- condensate extraction pumps; and
- primary air fan and induced draught fans.

6.3.12 Where necessary, identification will also be undertaken of critical operational infrastructure items for which spares can be kept on site, and storage of those items on site would be implemented to reduce the potential recovery time in the event of a major flood event.

6.3.13 The following measures will be considered in the detailed design of the Proposed Development:

- boundary walls and fencing designed with high water resistance materials and/ or effective seals to minimise water penetration for low depth, short duration floods;
- tanks bunded to a level higher than the 0.5% AEP plus climate change breach flood level;
- pollution control considered to prevent/ reduce the chance of any fuel/ material stored on site leaking;
- site drainage and landscape design following guidance (e.g. CIRIA C635) to minimise the risk from exceedance flows and any overland flow entering the Proposed Development buildings;
- landscaping of the Proposed Development Site to direct or divert floodwater away from buildings; and
- SuDS designed to manage surface water flood risk and water quality.

6.3.14 The following measures are potentially also appropriate for consideration in the detailed design of the Proposed Development depending on risk:

- pipelines and storage tanks designed to withstand the water pressures associated with high return period event flooding;
- tanks securely tethered in such a way to ensure the infrastructure remains secure should flooding occur;
- electrical supply entering the Proposed Development from height and down to required connections;
- use of flood barriers on access points;
- protecting wiring for operational control of the Proposed Development, telephone, internet and other services by suitable insulation in the distribution ducts to prevent damage;
- materials with low permeability up to 0.3m and accept water passage through building at higher water depths;
- flood proofing including the use of flood resistant building materials, use of water-resistant coatings, use of galvanised and stainless-steel fixings and raising electrical sockets and switches;
- utilising floor materials that are able to withstand exposure to floodwater without significant deterioration and that can be easily cleaned, e.g. concrete-based or stone;
- incorporating water resistant services within the buildings, i.e. avoid services using ferrous materials;
- design development to drain water away after flooding;
- provide access to all spaces to permit drying and cleaning;

- carefully considering the type of usage and layout of ground floor areas to minimise the potential impact on business operations following a flood; and
- suitable waterproofing measures to development located below ground i.e. tanking below ground storage areas etc.

Flood Emergency Response Plan

6.3.15 Although the Proposed Development Site is at a low residual risk of flooding, in the event of defence failure, the hazard would potentially be very high, and the onset of flooding could be very fast (refer to **Annex C**). Therefore, a system would be put in place to safeguard the site occupants.

6.3.16 A Flood Emergency Response Plan will be developed for the Proposed Development. This will link closely with the wider Keadby Power Station Site emergency response plans and management system procedures to ensure the residual risk to the is mitigated and managed over the lifetime of the Proposed Development. This will include the recommendation of at least one designated Flood Warden to be appointed for the Proposed Development Site who is familiar with the risks and remains vigilant to news reports, Environment Agency flood warnings and water levels in the River Trent.

6.3.17 The Flood Emergency Response Plan will be prepared in consultation with the Environment Agency and shall cover emergency situations both during core (24/7) operating hours and over holiday periods. The plan will define access and egress routes from the Proposed Development Site which will include recommendations on the most appropriate route depending on location, signage strategy in and around the area and congregation points. The Plan will include the Proposed Development being registered to receive flood warnings from the Environment Agency's 'Floodline Warnings Direct' service to inform if there is a risk of flooding from a tidal storm surge type event which could result in overtopping or breach of defences.

6.3.18 As the Flood Emergency Response Plan will be set up to manage the residual risk of flooding, careful consideration will be undertaken as to what action will be taken at each level of warning. The plan will define how occupants of the Proposed Development Site will be evacuated to an appropriate safe place of refuge should the water level in the Trent become high and the probability of breach subsequently increase, to provide for the safety of all occupants, recognising that due to the nature of operations as 'essential infrastructure', it is important to only evacuate when essential to do so.

Flood Warnings and Alerts

6.3.19 The Environment Agency operates a Flood Warning Service (Environment Agency, 2019c) for many areas at risk of fluvial and tidal flooding. The service currently consists of three stages:

- **Flood Alert** - flooding is possible and that you need to be prepared;
- **Flood Warning** - flooding is expected and that you should take immediate action. Action should be taken when a flood warning is issued and not wait for a severe flood warning; and
- **Severe Flood Warning** - there is severe flooding and danger to life. These are issued when flooding is posing significant risk to life or disruption to communities.

6.3.20 Each code gives an indication of the expected level of danger. Although some members of the public find Flood Watches useful, they are predominantly targeted towards professional partners, alerting them to expected flooding of low-lying land and roads.

6.3.21 All stages of warning are disseminated via the 'Floodline Warnings Direct', which is a free service that provides warnings to registered customers by telephone, mobile, email, SMS text message and fax. Local radio, TV, loudhailers, sirens and Floodline are also used to deliver flood warning messages. The Floodline number is 0845 988 1188, and it is always kept up to date with the Environment Agency's latest flooding information.

6.3.22 More detailed information on the likely extent and time scale of these warnings can be obtained by request from the Environment Agency, by their 'Quickdial' recorded information service, or via their website.

6.3.23 For any proposed commercial or industrial developments within a designated floodplain (as in the case of the Proposed Development Site), a system for monitoring flood warnings should be developed with designated responsible persons (site managers) able to monitor and disseminate the warnings. This will provide more time to enable emergency access and egress of staff occupants away from the local area which may become flooded during a flood event (including routes for egress) prior to inundation. They should also enable sufficient time to implement protection measures for any equipment on site through sealing all external doors to prevent flood inflow into such buildings as a precaution.

6.3.24 The Proposed Development Site is located within a designated Environment Agency Flood Alert Area (short code 034WAB420, covering tidal flooding of the Trent for riverside areas from Gainsborough to the Humber confluence, including West Stockwith, Wildsworth, East Ferry, East and West Butterwick, Derrythorpe, Gunness and Keadby).

6.3.25 The Proposed Development Site is located within two designated Environment Agency Flood Warning Areas (FWA) (short code names 034FWBTRKEADBY, covering the River Trent at Scunthorpe including isolated properties from the M180 to the Humber Confluence, and 034FWBTRCROWLE, covering the River Trent at Crowle including isolated properties from the M180 to the Humber Confluence). Due to the 24/7 nature of the operations at the Proposed Development, the Proposed Development Site will be registered with the

Environment Agency's Flood Warnings Direct service and monitoring of the warnings is proposed at the site to mitigate the residual risk of tidal/ fluvial flooding in the event of defence failure in the vicinity.

Emergency Access and Egress

6.3.26 An emergency access and egress route is a route that is 'safe' for use by occupiers without the intervention of the emergency services or others. A route can only be completely 'safe' in flood risk terms if it is dry at all times.

6.3.27 For developments located in areas at flood risk, the Environment Agency consider 'safe' access and egress to be in accordance with paragraph 039 of the NPPF PPG, and 'FRA Guidance for new Developments FD2320' (Defra and Environment Agency, 2005), where the requirements for safe access and egress from new developments are as follows in order of preference:

- safe, dry route for people and vehicles;
- safe, dry route for people;
- if a dry route for people is not possible, a route for people where the flood hazard (in terms of depth and velocity of flooding) is low and should not cause risk to people; and
- if a dry route for vehicles is not possible, a route for vehicles where the flood hazard (in terms of depth and velocity of flooding) is low to permit access for emergency vehicles.

6.3.28 For 'essential infrastructure' development, it is considered that dry access and egress from the Proposed Development Site will be desirable during times of extreme floods. However, areas behind defences are at particular risk from rapid onset of fast-flowing and deep water flooding, with little or no warning if defences are overtopped or breached. The breach modelling (see Section 4.0) has illustrated that the Proposed Development Site and immediate surrounding area is located in an area of 'high' hazard during the event of a breach. As a result, the Proposed Development Site will be evacuated immediately upon receipt of a flood warning unless it is unsafe to do so, in which case a place of safe refuge will be provided and sought on-site.

6.3.29 The design of Mabey Bridge Replacement, shown in **Application Document Ref. 4.16** has taken into account feedback from the Environment Agency regarding the need to maintain clearance equivalent to the existing soffit level, where it is not practical to design to the CFL. The proposed clearance of the replacement Mabey Bridge provides a 15mm higher soffit level than the existing Mabey Bridge soffit level at the span ends (the lowest points). The concept design also incorporates a precamber curve so that the soffit level is increased towards midspan. The final soffit levels will be determined at detailed design, but will be above no worse than, and a slight improvement on the existing soffit levels, allowing any floating debris to pass freely through the replacement structure, as would have been the case prior to the Proposed Development.

Place of Safe Refuge

6.3.30 Safe places of refuge are generally considered an acceptable approach to flood risk management in areas adjacent to tidal river defences as in the event of a defence breach, inundation is likely to be rapid and therefore evacuation from the site and local area can sometimes be an unsafe option.

6.3.31 It is proposed that a room above ground floor level of the Proposed Development would be allocated and adapted to provide adequate facilities to provide a place of safe refuge including welfare facilities for employees occupying the Proposed PCC Site in the extremely rare and unlikely event that the Trent tidal defences were to breach. The internal finished floor level of this refuge area will be a minimum level of 4.4 m AOD (the CFL + 300mm freeboard) and will be set within a building with a minimum ground floor level of 2.8m AOD (the 0.5% AEP + CC breach level plus 300mm freeboard).

Drainage System Failure, Capacity Exceedance and Maintenance

6.3.32 Following the completion of the Proposed Development, an additional residual risk relates to maintenance of the on-site drainage infrastructure. Failure, blockage and capacity exceedance above that of the design events for the drainage system are a potential risk to the Proposed Development Site and the surrounding area.

6.3.33 In order to reduce the risks, an inspection and maintenance programme would be put in place for the drainage infrastructure to prevent/ minimise the residual risk of flooding from this source, should it occur.

6.3.34 CIRIA C6352 9 (CIRIA, 2006) provides guidance on measures that can be incorporated into the detailed design of developments to steer surface water that has exceeded the capacity of the drainage system away from buildings and route it towards the intended point of attenuation and discharge (for example along swales and roads using raised kerbing and through parking areas). The proposed drainage infrastructure design will be agreed with the LLFA before construction to ensure that the risks of flooding from drainage infrastructure are not increased due to the Proposed Development.

6.4 Decommissioning

6.4.1 At the end of its operating life, which for the purposes of the FRA, is assumed to be around 35 years (after 2061 but up to 2068, considering a 7 year DCO) it is anticipated most of the above-ground equipment associated with the Proposed Development will be decommissioned and removed from the Proposed Development Site. Prior to removing the plant and equipment, all residues and operating chemicals will be cleaned out from the plant and disposed of in an appropriate manner to manage any potential for pollution risk.

6.4.2 Prevention of contamination is a specific requirement of the Environmental Permit for the operation of the Proposed Development and therefore it is being

designed such that it will not create any new areas of ground contamination or pathways to receptors as a result of construction or operation. Once the plant and equipment have been removed to ground level, it is expected that the hardstanding and sealed concrete areas will be left in place. Any areas of the Proposed Development that are below ground level will be backfilled to ground level to leave a levelled area.

6.4.3 A Decommissioning Plan (including Decommissioning Environmental Management Plan (DEMP)) will be produced and agreed with the Environment Agency as part of the Environmental Permitting and site surrender process. The DEMP will consider in detail all potential environmental risks and contain guidance on how risks can be removed, mitigated or managed. This will include details of how surface water drainage should be managed on the Proposed PCC Site during decommissioning and demolition.

7.0 SUMMARY AND CONCLUSIONS

7.1 Flood Risk Summary

7.1.1 This FRA serves to demonstrate that the Proposed Development would remain safe during its lifetime and would not increase flood risk elsewhere. The following conclusions can be made regarding flood risk to the Proposed Development.

Tidal Sources

7.1.2 The Proposed Development Site is at a 'low' risk of flooding from tidal sources with the defences in place and the available flood and defence levels suggest there would not be overtopping of the defences during events up to and including a 0.5% AEP (1 in 200 chance) of flooding.

7.1.3 The Proposed Development Site is at 'low' residual risk of tidal flooding originating from the North and South Soak Drains (Table 9) where defences are 1.3m AOD.

7.1.4 The risk of overtopping in the future and as a result of climate change driven sea level rise assumes that in the intervening period, no raising of the Trent tidal defences occurs. This is a highly conservative assumption and given the areas of land and property at risk across the wider area, it is reasonable to assume that future defence raising, and upgrades may continue to protect the Proposed Development Site, mitigating the overtopping risk.

7.1.5 In the event that the defences were to breach during the 0.5% AEP event, the hazard to the Proposed Development Site would be 'high' as flood waters would enter the area. The flood levels resulting from a breach event are higher than those that would be expected from overtopping of the defences and therefore represent a conservative flood level on the Proposed Development Site. However, the probability of a breach occurring is 'low', meaning that the residual risk remains 'low'.

7.1.6 During the modelled HEWL 2071 climate scenarios, the risk is potentially more significant. Breach modelling indicates that during the modelled HEWL scenarios, overtopping of the defences is expected to occur and the model represents this alongside the breach. The Proposed Development Site is potentially at a 'high' residual risk of flooding as a result of overtopping and/ or breach during events that exceed a 0.5% AEP (1 in 200 chance) of flooding on the River Trent including the effects of climate change and assuming there is no future raising of the defences. This is an extreme scenario, with the extreme (H++) climate change scenario and a breach occurring simultaneously. It is not likely to occur but as a residual risk, has been taken into account in the design of the Proposed Development Site.

7.1.7 Appropriate mitigation measures are proposed to mitigate this residual risk and ensure the occupiers of the Proposed Development Site are safe and critical operational infrastructure can continue to function at the Proposed Development Site in the event of such inundation. It is proposed that finished floor levels across parts of the Main Site (northern part of the Proposed PCC Site where the CCGT and CCP are proposed to be located shown in Plate 1) would be raised to 2.8m AOD, with critical operational infrastructure associated with the CCGT (defined in paragraph 6.3.11) raised to at least 3.6m AOD. Consideration would be given at the detailed design stage to raising CCGT critical operational infrastructure further, taking into account the critical flood level + 300mm freeboard (up to 4.4m AOD) where it is reasonably practicable to do so. A safe place of refuge will be provided for employees in the extremely rare and unlikely event that the Trent tidal defences were to breach with a minimum internal finished floor level of 4.4 m AOD (the CFL + 300mm freeboard) within a building with a minimum ground floor level of 2.8m AOD (the 0.5% AEP + CC breach level plus 300mm freeboard). Additional flood resilience measures are also proposed for consideration at the detailed design stage.

7.1.8 Following implementation of the mitigation measures, there are considered to be no on or off-site impacts as a result of the Proposed Development in relation to this residual flood risk.

Fluvial Sources

7.1.9 The majority of the Proposed Development Site is located in Flood Zone 3, with a small area in Flood Zone 2. Modelled fluvial peak water levels from the Tidal Trent SFRM (Mott MacDonald, 2013) demonstrate that during a 0.1% AEP (1 in 1000 year) event, fluvial water levels in the North and South Soak Drains could rise up to 1.69m AOD. This is above the raised embankment levels of 1.3m AOD, however, a raised strip of land (2m AOD) on the south side of the Proposed Development Site will be retained and act as a barrier to fluvial flooding on the Proposed Development Site from the drains. Fluvial levels in the Trent are lower than the tidal levels on which the Proposed Development Site assessment and mitigation has been based.

7.1.10 The SFRA states that the failure of the network of watercourses to drain the marshland surrounding the river is another main source of flooding.

7.1.11 Based on the information provided by the Environment Agency, it has been determined that the Proposed Development Site is at a ‘low’ risk of flooding from fluvial sources with the defences in place or resulting from overtopping of the defences during events that exceed a 0.5% AEP (1 in 200 chance) and 0.1% AEP.

Surface Water Runoff to the Proposed Development

7.1.12 The risk of surface water flooding within the Proposed Development Site from elsewhere (or generated within) is considered to be ‘low’ to ‘very low’.

7.1.13 Extensive drainage infrastructure already exists across the Proposed Development Site related to Keadby 1 and Keadby 2 Power Stations and the Proposed Development drainage would be kept separate from this. Attenuation would be installed within the Proposed PCC Site and discharge would be at the greenfield runoff rate, or if this cannot be accommodated by the IDB, at the agricultural runoff/ alternative rate agreed with the IDB. The preferred method of surface discharge would be to the existing IDB network. In the event that this network is unable to accommodate all surface water, alternative and/ or hybrid solutions would be considered including the alternative discharge route to the River Trent via the Water Discharge Corridor.

Groundwater

7.1.14 The risk of groundwater flooding within the Proposed Development area within the Site is considered to be 'low'.

7.1.15 Based on historical assessment as part of the Keadby 2 Power Station ES (ERM, 2016), groundwater flooding is currently understood to be effectively managed via a well-developed drainage system serving Keadby 1 and Keadby 2 Power Stations.

Artificial Sources

7.1.16 The Proposed Development Site is not considered at risk from reservoir flooding.

7.1.17 The Stainforth and Keadby Canal is close to the Proposed Development Site but given its' shallow gradient and that it drains into the River Trent by a sluice, the risk of flooding is likely to be low.

7.1.18 The Canal and River Trust has a licence to abstract water from the canal to supply cooling water for the Keadby 2 Power Station, once operational. The canal is also the preferred source of cooling water for the Proposed Development (Canal Water Abstraction Option) and licensing discussions are ongoing to determine the feasibility of supply for the Proposed Development.

7.1.19 If any overtopping of the canal were to occur, this would drain into the North and South Soak Drains located at a lower elevation on either side of the canal and drain away into the Three Rivers a short distance to the south, and to the River Trent via sluice gates at Keadby Pumping Station. The canal levels are monitored and maintained by the Canal & River Trust. As a result, overtopping is unlikely and so the Proposed Development Site is considered to be at low risk of flooding from the canal.

7.1.20 Overall, the risk of flooding from artificial waterbodies is therefore considered to be 'low'.

7.2 Management of Surface Water Runoff from the Site

7.2.1 As described in Section 7.1.2, in order to ensure that the Proposed Development does not increase the flood risk elsewhere, surface water discharge from the Proposed PCC Site will be restricted to the existing greenfield runoff rate or if this cannot be accommodated by the IDB, at the agricultural runoff/ alternative rate agreed with the IDB, in accordance with the requirements of the NPPF, EA and NLC.

7.2.2 Surface water runoff attenuation will be provided to ensure existing greenfield runoff rates are maintained up to the 1% AEP event plus a 40% allowance for climate change. In addition to the on-site attenuation pond, a range of SuDS solutions including filter drains and swales would be considered in the detailed drainage design and utilised to provide conveyance and attenuation across the Proposed Development Site, providing further benefits for surface water quality.

7.3 Residual Risk Mitigation Measures

7.3.1 A number of additional mitigation strategies will be considered during the design process for the Proposed Development to ensure the operation of the Proposed Development Site is maintained in the event of an extreme flood should the existing tidal defences fail in the vicinity of the Proposed Development Site, or in the event of heavy rainfall that could result in surface water flooding at the Proposed Development Site, should the design capacity of the drainage network be exceeded.

7.3.2 These strategies include:

- providing flood resistance and resilience measures including raising of critical operational infrastructure;
- flood emergency response plans;
- flood warnings and alerts;
- emergency access and egress;
- place of safe refuge; and
- design capacity exceedance.

8.0 REFERENCES

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ANNEX A ENVIRONMENT AGENCY CONSULTATION

Abbey Hewson

Our Ref: EMD-211130

Your Ref:

Date: 23/04/2021

Dear Abbey,

Enquiry regarding - Keadby 3 Power Station, DN17 3EF

Thank you for your enquiry which was received on 23/03/2021, apologies for the delay.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

The data is available from sharefile here:

[redacted]

Licencing
The following information is not available under the Open Government Licence but we may be able to license it to you under the Environment Agency Conditional Licence

However, you must first check the supporting information and the above link to determine if the conditions on use are suitable for your purposes. If they aren't, this information is not provided with a licence for use, and the data is provided for read right only.

- The Humber Strategy model is a 1D-only Flood Modeller Pro model developed to support the Humber 2100+ Strategy. It has been designed for strategic level modelling only. The model is set up for joint probability modelling of in-bank hydraulic factors only; it does not provide information regarding water on the floodplain.
- This dataset should be used in conjunction with the Tidal Trent 2014 Tidal Trent SFRM model outputs.
- It is important that users of the Humber model read and understand the limitations associated with the model and consider how these will impact the intended application of the model. These limitations are provided in the modelling reports.
- Work to develop the Humber 2100+ Strategy is ongoing. Until this work is complete, the Humber model and its outputs are subject to change if/when new information becomes available.
- The Humber 2100+ Strategy is based on a baseline year of 2021. Modelling undertaken to date has made assumptions about the completion of schemes by 2021. In the majority of cases, these schemes are now fully or substantially

complete. However, the below schemes are represented differently in the model to reality. Users of the model and its outputs should consider the impact of this on their own application of the data and, where appropriate, take actions to revisit the representation of these schemes;

- Lincolnshire Lakes Flood Defence Scheme (tidal River Trent) – scheme completed in 2018 but not represented in the model.
- Outstrays to Skeffling Managed Realignment Scheme (outer Humber estuary, north bank) – scheme not complete but fully represented in the model.
- Port of Immingham Flood Defence Improvements (outer Humber estuary, south bank) – Phase 1 of scheme complete, Phase 2 of scheme not complete, scheme fully represented in the model.

Conditions

1.0 You may use the Information for your internal or personal purposes and may only sublicense others to use it if you do so under a written licence which includes the terms of these conditions and the agreement and in particular may not allow any period of use longer than the period licensed to you.

2.0 Notwithstanding the fact that the standard wording of the Environment Agency Conditional Licence indicates that it is perpetual, this Licence has a limited duration of 5 years at the end of which it will terminate automatically without notice.

3.0 We have restricted use of the Information as a result of legal restrictions placed upon us to protect the rights or confidentialities of others. In this instance it is because of third party data. If you contact us in writing (this includes email) we will, as far as confidentiality rules allow, provide you with details including, if available, how you might seek permission from a third party to extend your use rights.

4.1 The Information may contain some data that we believe is within the definition of "personal data" under the Data Protection Act 1998 but we consider that we will not be in breach of the Act if we disclose it to you with conditions set out in this condition and the conditions above. This personal data comprises names of individuals or commentary relating to property that may be owned by an individual or commentary relating to the activities of an individual.

4.2 Under the Act a person who holds and uses or passes to others personal data is responsible for any compliance with the Act and so we have no option but to warn you that this means you have responsibility to check that you are compliant with the Act in respect of this personal data.

5.0 The location of public water supply abstraction sources must not be published to a resolution more detailed than 1km2. Information about the operation of flood assets should not be published.

6.1 Where we have supplied model data which may include model inputs or outputs you agree to supply to the Environment Agency copies of any assessments/studies and related outputs, modifications or derivatives created pursuant to the supply to you of the Information, all of which are hereinafter referred to as "the Data".

6.2 You agree, in the public interest to grant to the Environment Agency a perpetual royalty free non-exclusive licence to use the Data or any part thereof for its internal purposes or to use it in any way as part of Environment Agency derivative products which it supplies free of charge to others such as incorporation into the Environment Agency's Open Data mapping products.

Information Warnings

Please be aware that model data is not raw, factual or measured but comprises of estimations or modelled results based on the data available to us.

Attribution

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Data Available Online

Many of our flood datasets are available online:

- Flood Map For Planning (Flood Zone 2, Flood Zone 3 ,Flood Storage Areas, Flood Defences, Areas Benefiting from Defences, ,)
- Risk of Flooding from Rivers and Sea
- Historic Flood Map
- Current Flood Warnings

Please get in touch if you have any further queries or contact us within two months if you'd like us to review the information we have sent.

Yours sincerely,

Luke Radford
Customers & Engagement Officer
East Midlands

For further information please contact the Customers & Engagement Team on 02084 747770

Direct e-mail:- EMDenquiries@environment-agency.gov.uk

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aecom.com

7th July 2020

Our Reference
Keadby_Water & FRA

Environment Agency
Waterside House
Waterside North
Lincoln
LN2 5HA

Data Consultation Request: Land at Keadby Power Station, Trentside, Keadby, Scunthorpe DN17 3EF.

Dear Sirs

AECOM has been commissioned to undertake an Environmental Impact Assessment, including an Environmental Statement Water Resources Chapter, Water Framework Directive Assessment and a Flood Risk Assessment (including a conceptual drainage strategy) to support a Development Consent Order application for development on land located within the Keadby Power Station site, on the bank of the River Trent to the west of Scunthorpe. The proposed development, a proposed Low Carbon Combined Cycle Gas Turbine (CCGT) Generating Station, will be located within the red line boundary indicated on the attached location plan below.

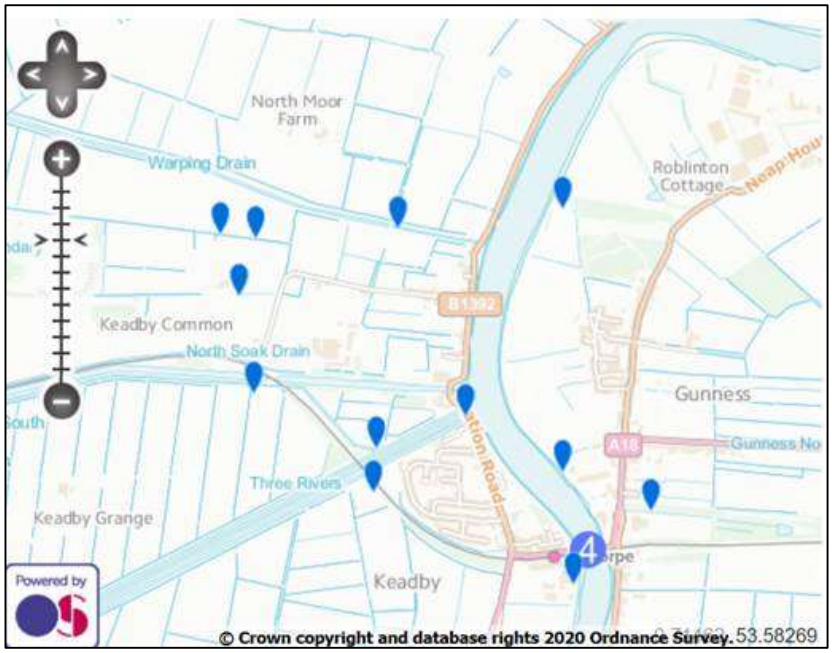
Water Quality, Resources, WFD and Biological Data Request

There are a number of surface water features in the vicinity of the proposed development Site for which we are in the process of gathering baseline information. These include:

- the River Trent (Humber Upper) (GB530402609203);
- Warping Drain (GB104028064300);
- the North and South Soak Drains (GB104028064350);
- the Three Rivers watercourse (GB104028064340);
- the Adlington Fleet Drain (GB104028064310); and
- Staintforth and Keadby Canal (fluvial) (GB70410281).

For a **1 km study area around the RLB** can you please provide, where possible, any data covering or relevant to the following points:

- Please confirm the specific WFD Water Body Typology for the above-named water bodies;
- Please provide copies of any WFD investigation reports that have been compiled for the above-named waterbodies (e.g. catchment walkovers, water quality/biological/NNIS risk assessments);
- Please provide details of any improvement/ mitigation measures being proposed by the Environment Agency to tackle existing pressures and risks and that are currently in place and those that are not in place for the above-named water bodies;
- Please provide copies of the latest survey data for biological quality elements for the nearest u/s and d/s monitoring points for the above-named waterbodies (especially fish).
- Please provide water quality and sediment quality data (including particle size and chemical composition) in an MS Excel format for the monitoring points in the vicinity of the site as available on WIMS, as shown in the image below:



- Active abstraction licences (groundwater and surface water) including location (NGR), user, and purpose;
- Active water activity permits (i.e. formerly discharge consents) including location (NGR) and effluent type;
- Any Category 3 or worse water pollution incidents within the past 5 years as recorded on NIRS (including location (NGR), pollution source, category and affected water body);
- Aquifer status and groundwater levels;
- Comments on any issues of concern regarding water resources, both surface and groundwater, in the study area;
- Details (including anecdotal observations) of any other water attribute or recreational / amenity activity that we should be aware of;
- Bathymetric survey of the Trent estuary bed;
- Topographic survey of intertidal areas (other than data available on the open source website);
- Fixed station measurements of water levels, current speed/direction, salinity, and temperature (spring and neap tides);
- Meteorology data including wind speed/direction and air temperature;
- River flow data - Time-series flow rates including yearly statistical data (min, max and average) at the River Trent at Humber Upper and Staintforth and Keadby Canal (fluvial) waterbodies;
- Water temperature measurements for the River Trent at Humber Upper and Staintforth and Keadby Canal (fluvial) waterbodies (for has high a sampling frequency as possible and preferably covering the past 5 years as a minimum). If there are any remotely sensed measurements of the plume temperature near the site from the previous sites operation that would also be useful; and;
- Copies of Environment Agency thermal maps if available.

Flood Risk Assessment

In line with the Environment Agency's standing advice, AECOM proposes to produce a Flood Risk Assessment that considers the risk to the site from all sources, rivers and the sea, streams, surface water run-off, sewers, groundwater, etc. AECOM will also make recommendations for managing surface water runoff according to sustainable drainage principles.

The Site lies entirely within Flood Zone 3a, as defined by the Environment Agency's online Flood Map for Planning. AECOM therefore requests the **Product 4 and Product 8 data packages**, including the following information, if available, to inform the FRA:

- Detailed maps of historical flood extents for the area and details of any other flood level or flood extent data related to the area that may be relevant, including any photographs or other anecdotal information;
- Details of existing flood defences for the area, their condition, anticipated lifetime and statutory flood defence levels;
- Details of proposed flood defence schemes planned for the area, specifically if relevant to the Site;
- Modelled water levels for the nearest adjacent model nodes in the River Trent (including the 1% AEP, 0.5% AEP, 0.5% AEP plus climate change and the 0.1% AEP event flood levels);
- The results of any modelling showing the inundation extents, depths and flood hazard resulting from breaching, overtopping (including the 1% AEP, 0.5% AEP, 0.5% AEP plus climate change and the 0.1% AEP event flood levels), or spray-over of the flood defences (for both the defended and undefended scenarios);
- Details of any tidal control structures in the vicinity;
- Details of any known surface water flooding problems in the area and confirmation of any designated critical drainage areas (CDAs);
- Provision of mapping showing the areas susceptible to surface water flooding and the flood map for surface water (AStSWF and FMfSW);
- Details of groundwater levels in the area and of the risk of rising groundwater levels and provision of mapping (AStGWF); and
- Outline flood risk mitigation measure requirements for the essential/critical infrastructure, including minimum floor levels, flood storage etc.

We realise that this is a large request for data and we understand that not all of this information will be available. However, we would be very grateful if you could please review this list and advise and send us what data you do hold.

I look forward to hearing from you.

Yours sincerely,

[redacted]

Jo Somerton
Principal Flood Risk Consultant
AECOM Limited
T: +44 (0) 113 204 5028
E: [redacted]@aecom

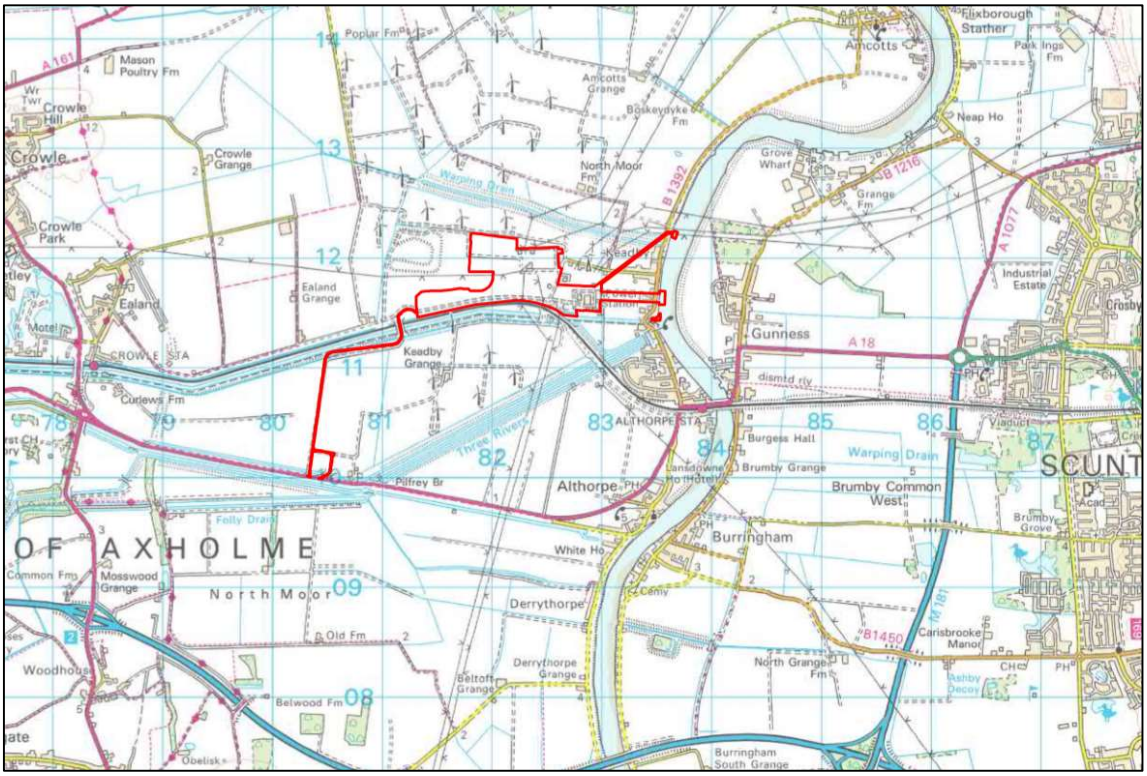
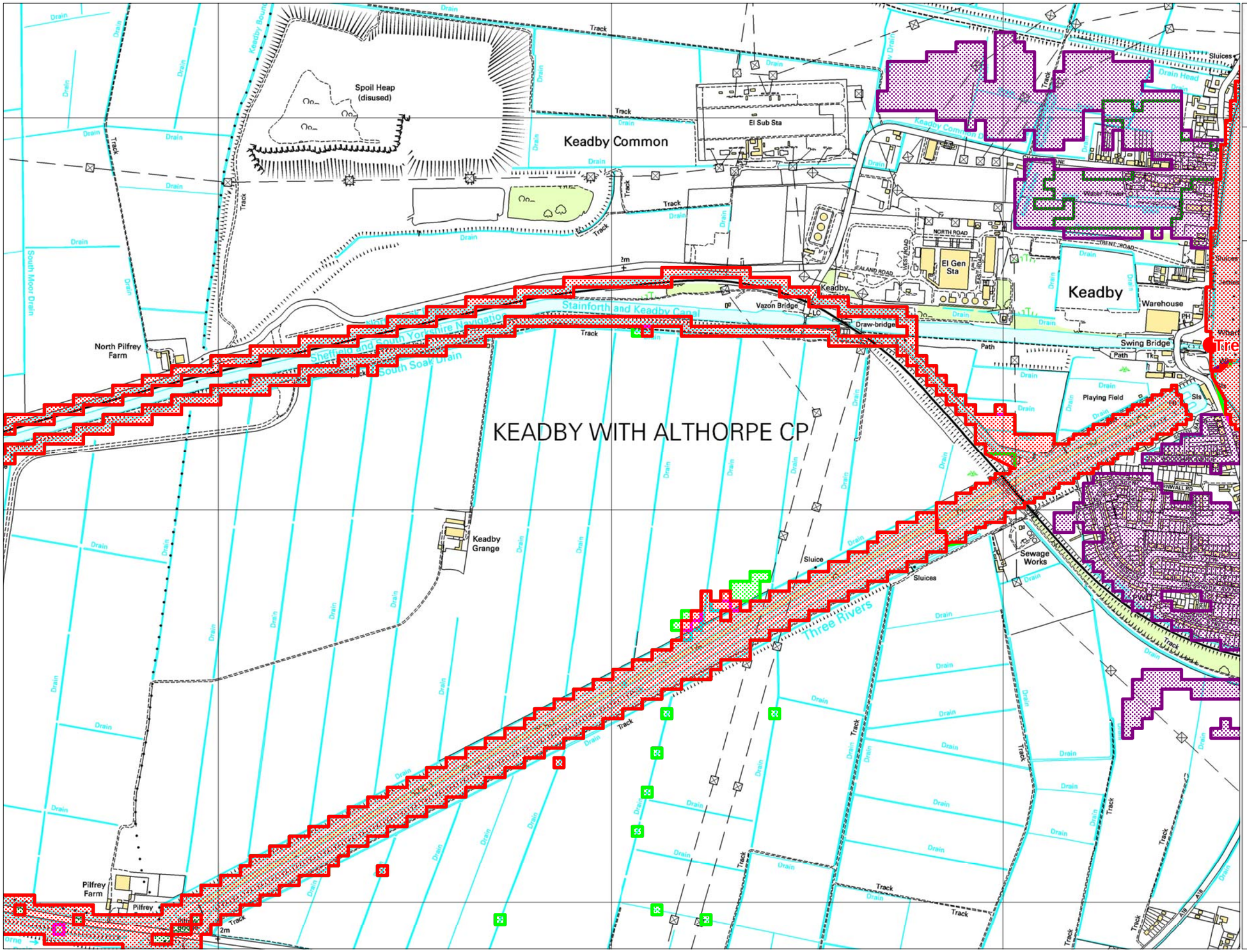


Figure 1: Keadby 3 Power Station (Development will be located within the red line boundary).

Modelled Extents Map centred on Keadby Power Station - created 25 August 2020 Ref: [EMD178614]



Environment Agency

Scale 1:10,000

N W E S

Legend

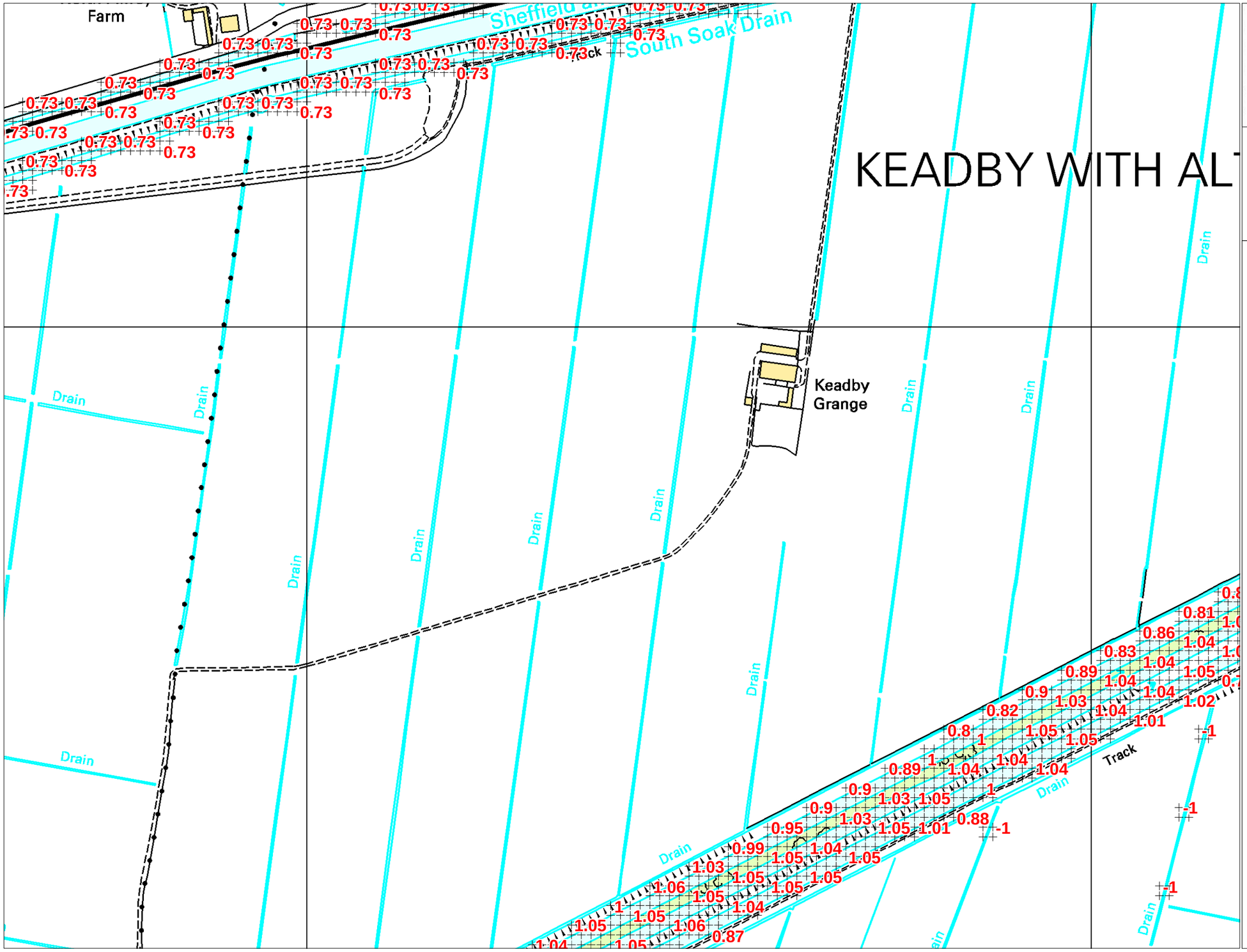
- 1 in 10 year Modelled Extent (with 2 year Fluvial flow)
- 1 in 20 year Modelled Extent (with 2 year Fluvial flow)
- 1 in 50 year Modelled Extent (with 2 year Fluvial flow)
- 1 in 100 year Modelled Extent (with 2 year Fluvial flow)
- 1 in 200 year Modelled Extent including climate change forecast (with 2 year Fluvial flow)
- 1 in 200 year Modelled Extent (with 2 year Fluvial flow)
- 1 in 1000 year Modelled Extent (with 2 year Fluvial flow)
- Modelled Node Location and Reference

Source:
Tidal Trent SFRM, Mott Macdonald, 2013 (includes updated 2014 interim water levels)

A Strategic Flood Risk Assessment may be available, providing further information for this site. Please contact your Local Planning Authority to access this information as it will need to be considered within any Flood Risk Assessment submission.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Floodplain Heights Map centred on Keadby Power Station - created 25 August 2020 Ref: [EMD178614]



Environment Agency

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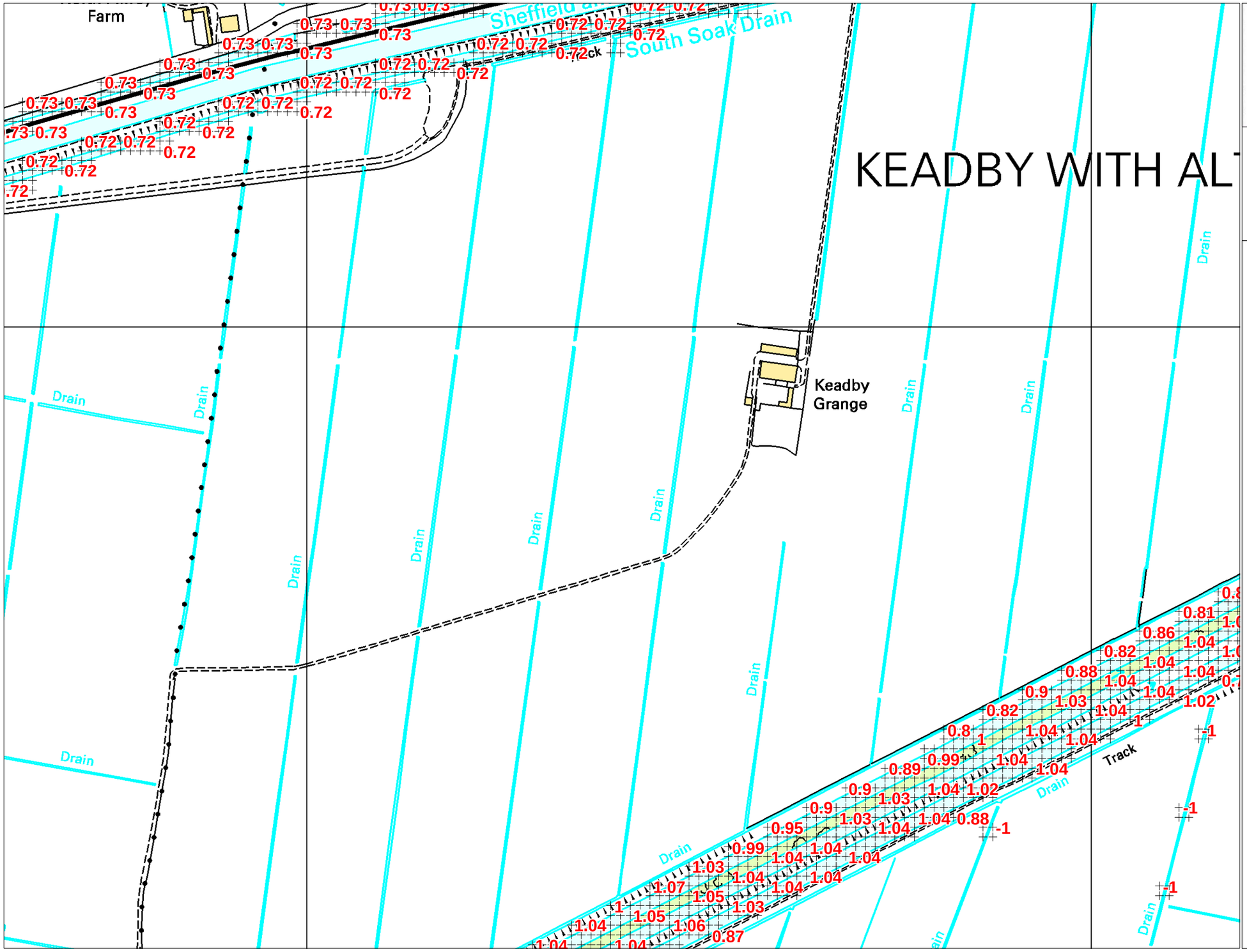
1 in 1000 year
Floodplain Level (mAOD)

Source:
Tidal Trent SFRM, Mott Macdonald, 2013
(includes updated 2014 interim water levels)

A Strategic Flood Risk Assessment may be available, providing further information for this site. Please contact your Local Planning Authority to access this information as it will need to be considered within any Flood Risk Assessment submission.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Floodplain Heights Map centred on Keadby Power Station - created 25 August 2020 Ref: [EMD178614]



Environment Agency

Scale 1:5,000

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Legend

x.xx

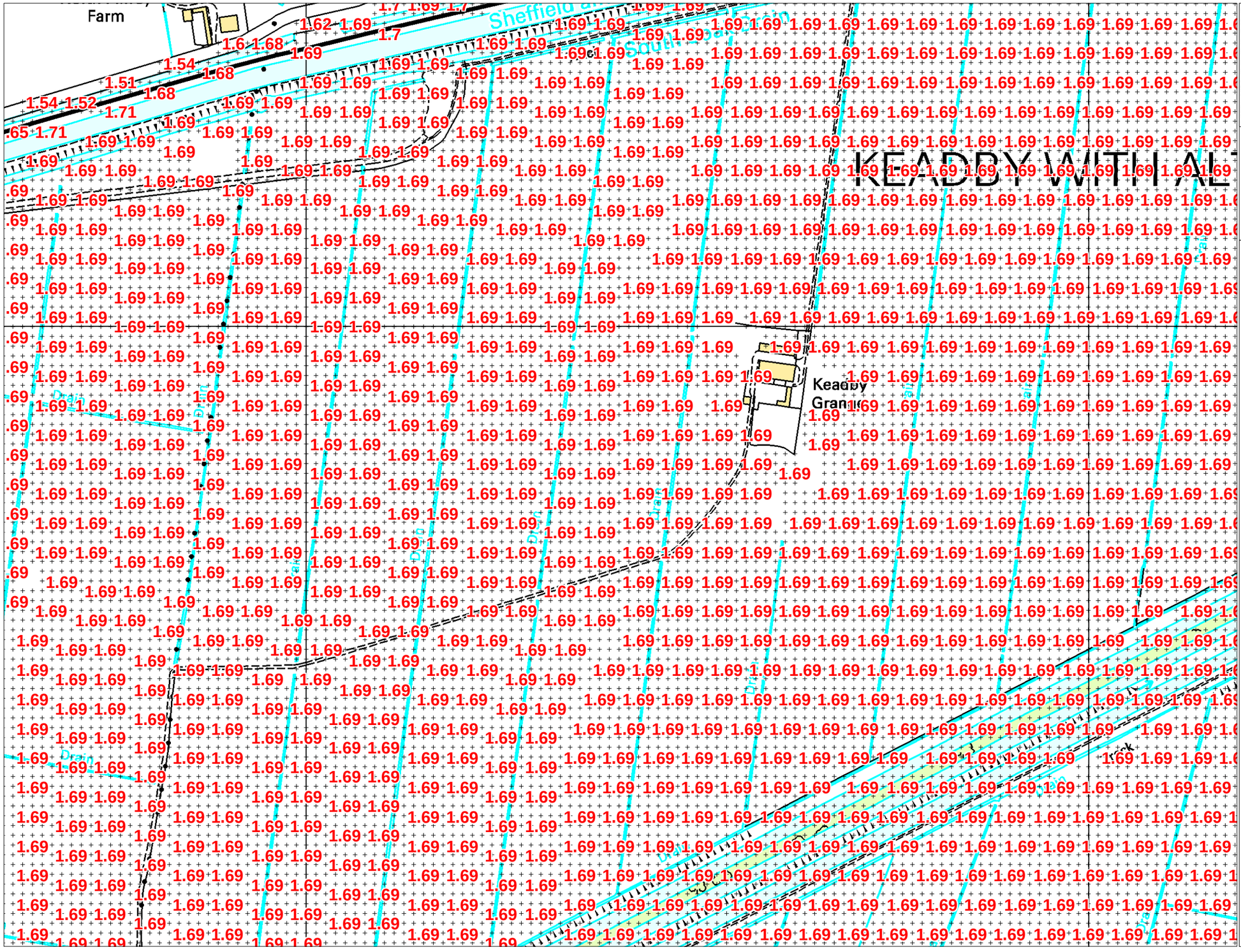
1 in 200 year
(including climate change forecast)
Floodplain Level (mAOD)

Source:
Tidal Trent SFRM, Mott Macdonald, 2013
(includes updated 2014 interim water levels)

A Strategic Flood Risk Assessment may be available, providing further information for this site. Please contact your Local Planning Authority to access this information as it will need to be considered within any Flood Risk Assessment submission.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Floodplain Heights Map centred on Keadby Power Station - created 25 August 2020 Ref: [EMD178614]



Environment Agency

Scale 1:5,000

N
W E
S

Legend

x.xx

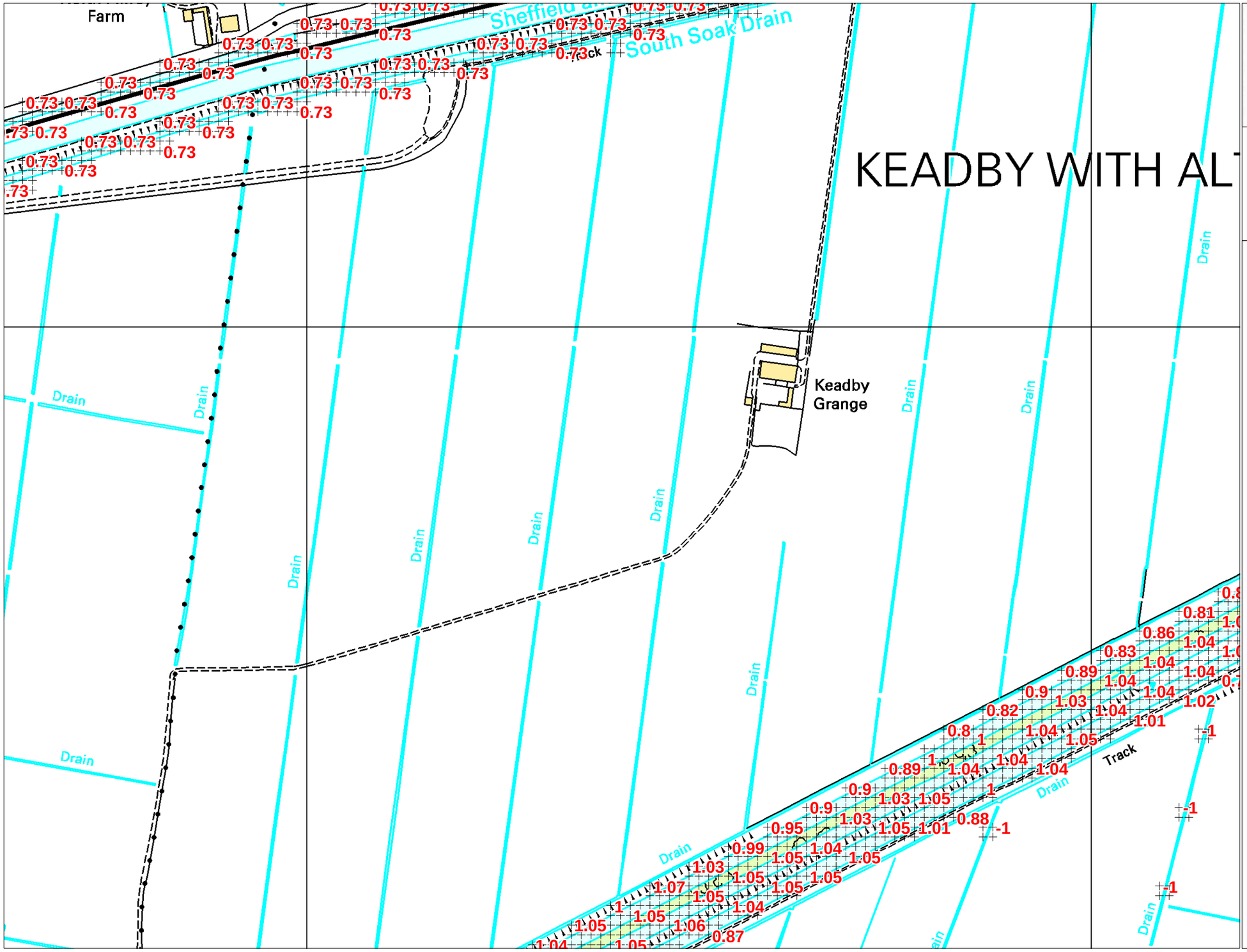
1 in 1000 year
Floodplain Level (mAOD)

Source:
Tidal Trent SFRM, Mott Macdonald, 2013
(includes updated 2014 interim water levels)

A Strategic Flood Risk Assessment may be available, providing further information for this site. Please contact your Local Planning Authority to access this information as it will need to be considered within any Flood Risk Assessment submission.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Floodplain Heights Map centred on Keadby Power Station - created 25 August 2020 Ref: [EMD178614]



Environment Agency

Scale 1:5,000

N
W E
S

Legend

x.xx

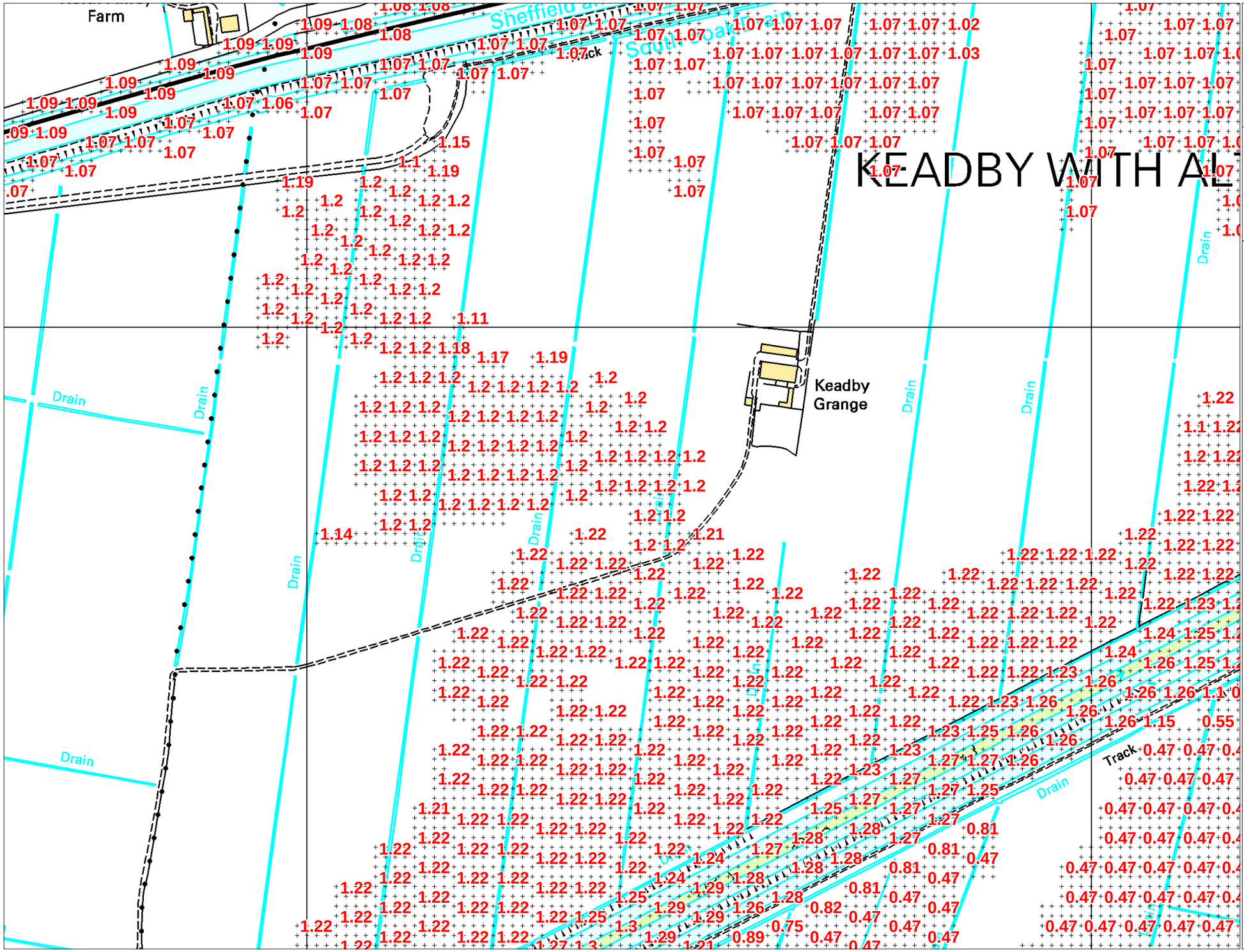
1 in 200 year
Floodplain Level (mAOD)

Source:
Tidal Trent SFRM, Mott Macdonald, 2013
(includes updated 2014 interim water levels)

A Strategic Flood Risk Assessment may be available, providing further information for this site. Please contact your Local Planning Authority to access this information as it will need to be considered within any Flood Risk Assessment submission.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Floodplain Heights Map centred on Keadby Power Station - created 25 August 2020 Ref: [EMD178614]



Environment Agency

Scale 1:5,000

N
W E
S

Legend

x.xx

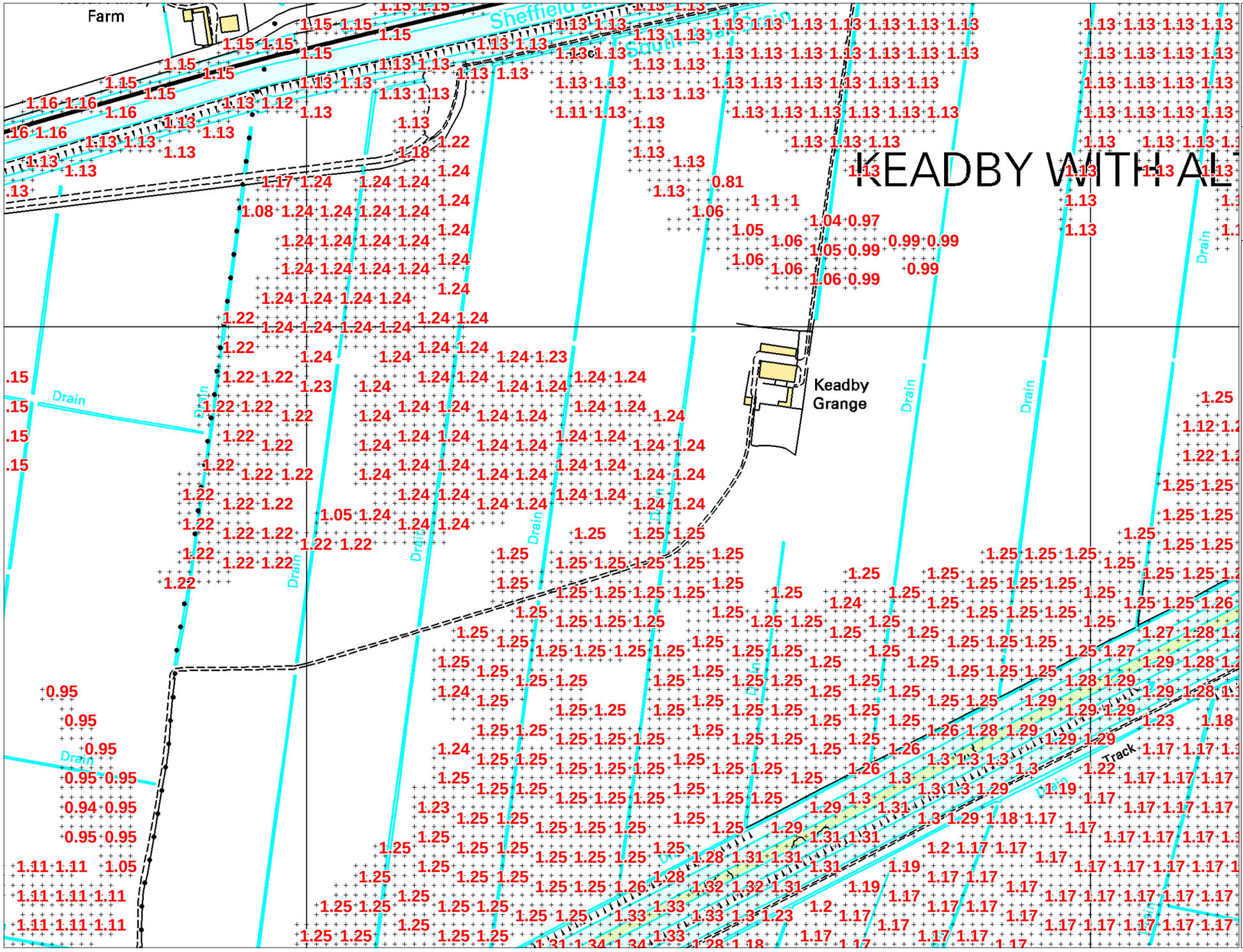
1 in 100 year
Floodplain Level (mAOD)

Source:
Tidal Trent SFRM, Mott Macdonald, 2013
(includes updated 2014 interim water levels)

A Strategic Flood Risk Assessment may be available, providing further information for this site. Please contact your Local Planning Authority to access this information as it will need to be considered within any Flood Risk Assessment submission.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Floodplain Heights Map centred on Keadby Power Station - created 25 August 2020 Ref: [EMD178614]



Environment Agency

Scale 1:5,000

N
W E
S

Legend

x.xx

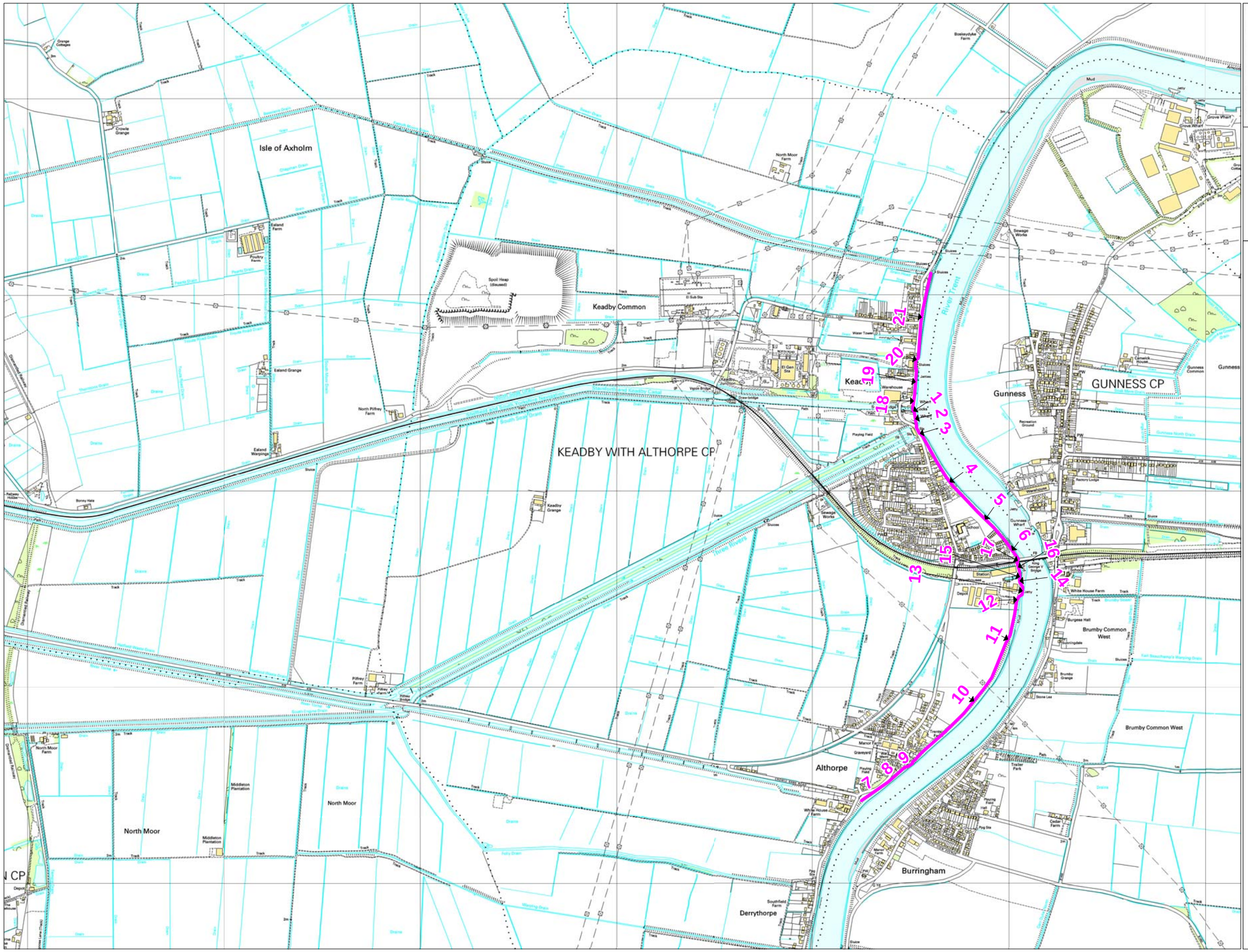
1 in 100 year
(including climate change forecast)
Floodplain Level (mAOD)

Source:
Tidal Trent SFRM, Mott Macdonald, 2013
(includes updated 2014 interim water levels)

A Strategic Flood Risk Assessment may be available, providing further information for this site. Please contact your Local Planning Authority to access this information as it will need to be considered within any Flood Risk Assessment submission.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Flood Defence Map centred on Keadby Power Station - created 25 August 2020 Ref: [EMD178614]



Environment Agency

Scale 1:20,000

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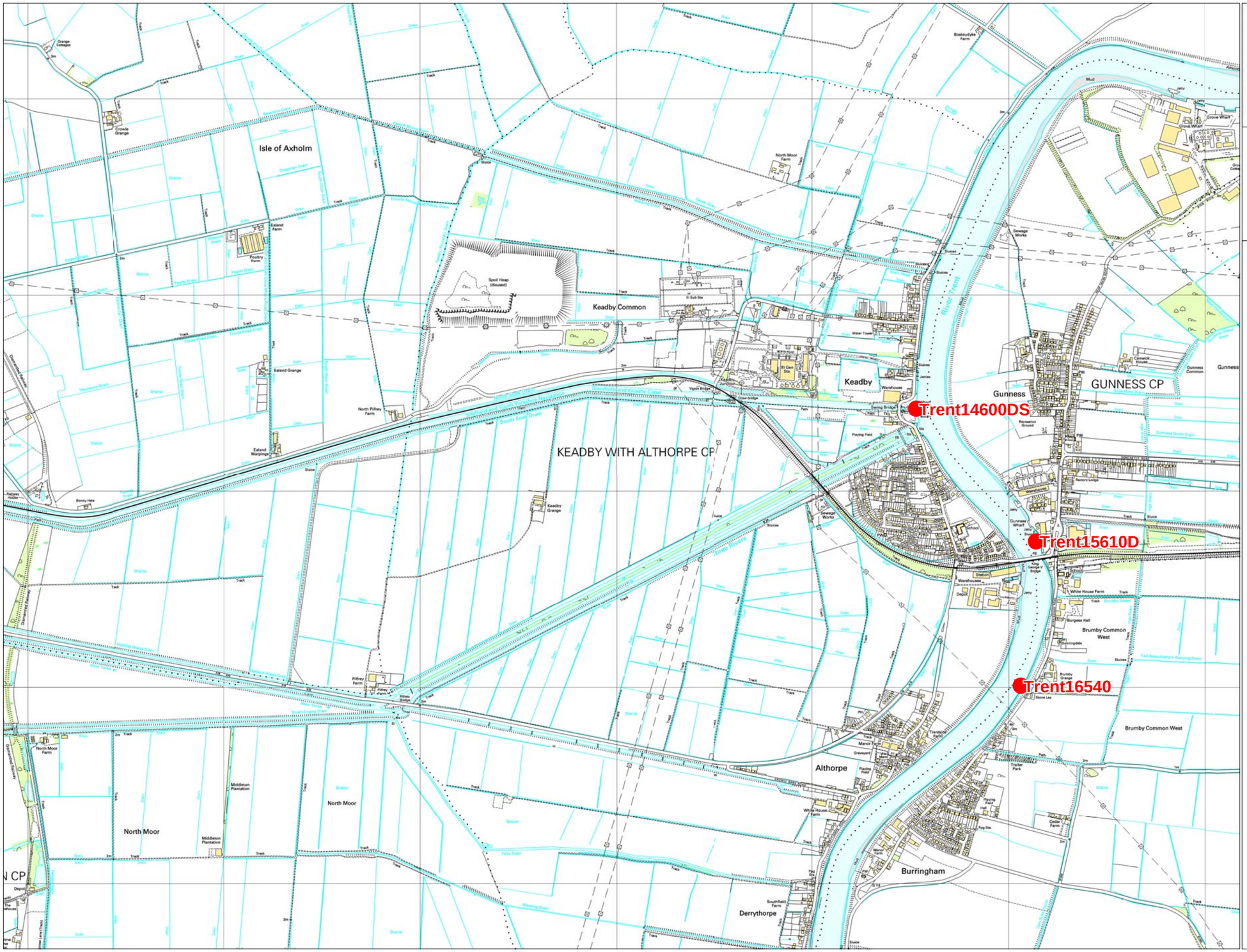
Legend

Flood Defence Locations

A Strategic Flood Risk Assessment may be available, providing further information for this site. Please contact your Local Planning Authority to access this information as it will need to be considered within any Flood Risk Assessment submission.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Modelled Nodes Map centred on Keadby Power Station - created 25 August 2020 Ref: [EMD178614]



Environment Agency

Scale 1:20,000

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Legend

- **Modelled Node Location and Reference**

Source:
Updated Tidal Trent SFRM Model (Mott Macdonald 2013 - includes updated 2014 interim water levels)

A Strategic Flood Risk Assessment may be available, providing further information for this site. Please contact your Local Planning Authority to access this information as it will need to be considered within any Flood Risk Assessment submission.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

EMD178614

Flood Map for Planning

The Flood Map for Planning is now classed as Open Data. As such it can be downloaded free of charge under an open data licence from the following address: [redacted]

Alternatively it can be viewed at the following address: [redacted]

Modelled Information

Node point reference	Location	50% (1 in 2 year) modelled level (mAOD)	50% (1 in 2 year) modelled flow (m^3/s)	20% (1 in 5 year) modelled level (mAOD)
Trent14600DS	SE 83530 11420	N/A	N/A	5.71
Trent15610D	SE 84142 10743	N/A	N/A	5.72
Trent16540	SE 84064 10008	N/A	N/A	5.73

Source: Tidal Trent SFRM Model, Mott Macdonald, 2013 (includes updated 2014 interim water levels)

Node point reference	Location	20% (1 in 5 year) modelled flow (m^3/s)	10% (1 in 10 year) modelled level (mAOD)	10% (1 in 10 year) modelled flow (m^3/s)
Trent14600DS	SE 83530 11420	1,115.69	5.76	N/A
Trent15610D	SE 84142 10743	1,072.21	5.77	N/A
Trent16540	SE 84064 10008	1,037.07	5.77	N/A

Source: Tidal Trent SFRM Model, Mott Macdonald, 2013 (includes updated 2014 interim water levels)

Node point reference	Location	5% (1 in 20 year) modelled level (mAOD)	5% (1 in 20 year) modelled flow (m^3/s)	4% (1 in 25 year) modelled level (mAOD)
Trent14600DS	SE 83530 11420	5.84	N/A	N/A
Trent15610D	SE 84142 10743	5.85	N/A	N/A
Trent16540	SE 84064 10008	5.85	N/A	N/A

Source: Tidal Trent SFRM Model, Mott Macdonald, 2013 (includes updated 2014 interim water levels)

Node point reference	Location	4% (1 in 25 year) modelled flow (m^3/s)	2% (1 in 50 year) modelled level (mAOD)	2% (1 in 50 year) modelled flow (m^3/s)
Trent14600DS	SE 83530 11420	N/A	5.92	
Trent15610D	SE 84142 10743	N/A	5.93	
Trent16540	SE 84064 10008	N/A	5.94	1,124.86

Source: Tidal Trent SFRM Model, Mott Macdonald, 2013 (includes updated 2014 interim water levels)

Node point reference	Location	1.33% (1 in 75 year) modelled level (mAOD)	1.33% (1 in 75 year) modelled flow (m^3/s)	1% (1 in 100 year) modelled level (mAOD)
Trent14600DS	SE 83530 11420			5.98
Trent15610D	SE 84142 10743			5.99
Trent16540	SE 84064 10008			6.00

Source: Tidal Trent SFRM Model, Mott Macdonald, 2013 (includes updated 2014 interim water levels)

Node point reference	Location	1% (1 in 100 year) modelled flow (m^3/s)	0.67% (1 in 150 year) modelled level (mAOD)	0.67% (1 in 150 year) modelled flow (m^3/s)
Trent14600DS	SE 83530 11420		N/A	N/A
Trent15610D	SE 84142 10743		N/A	N/A
Trent16540	SE 84064 10008		N/A	N/A

Source: Tidal Trent SFRM Model, Mott Macdonald, 2013 (includes updated 2014 interim water levels)

Node point reference	Location	0.5% (1 in 200 year) modelled level (mAOD)	0.5% (1 in 200 year) modelled flow (m^3/s)	0.1% (1 in 1000 year) modelled level (mAOD)
Trent14600DS	SE 83530 11420	6.01		6.09
Trent15610D	SE 84142 10743	6.02		6.08
Trent16540	SE 84064 10008	6.03		6.09

Source: Tidal Trent SFRM Model, Mott Macdonald, 2013 (includes updated 2014 interim water levels)

Node point reference	Location	0.1% (1 in 1000 year) modelled flow (m^3/s)	1% + 20% flow (1 in 100 year plus climate change) modelled level (mAOD)	1% + 20% flow (1 in 100 year plus climate change) modelled flow (m^3/s)
Trent14600DS	SE 83530 11420		N/A	
Trent15610D	SE 84142 10743		N/A	
Trent16540	SE 84064 10008		N/A	

Source: Tidal Trent SFRM Model, Mott Macdonald, 2013 (includes updated 2014 interim water levels)

Please note: The flows provided represent **in channel flow only** and do not take into account flow on the floodplain.

NODE_ID	X	Y	20% (1 in 5) modelled level	20% (1 in 5) modelled flow	10% (1 in 10) modelled level	10% (1 in 10) modelled flow	5% (1 in 20) modelled level	5% (1 in 20) modelled flow
NSOK_994	482751.3	411500.4	0.89	N/A	0.89	N/A	0.94	N/A
3R2A_27	483446.9	411301.6	0.81	N/A	0.81	N/A	0.84	N/A
3R2B_1577	482083.8	410563.3	0.84	N/A	0.84	N/A	0.89	N/A
SSOK_2886	480796.07	411238.55	0.88	N/A	0.87	N/A	0.93	N/A
NSOK_2095	481669.45	411521.77	0.92	N/A	0.92	N/A	0.97	N/A

NODE_ID	X	Y	2% (1 in 50) modelled level	2% (1 in 50) modelled flow	1.3% (1 in 75) modelled level	1.3% (1 in 75) modelled flow	1% (1 in 100) modelled level	1% (1 in 100) modelled flow
NSOK_994	482751.3	411500.4	N/A	N/A	0.97	N/A	0.97	N/A
3R2A_27	483446.9	411301.6	N/A	N/A	0.87	N/A	0.86	N/A
3R2B_1577	482083.8	410563.3	N/A	N/A	0.92	N/A	0.92	N/A
SSOK_2886	480796	411239	N/A	N/A	0.96	N/A	0.96	N/A
NSOK_2095	481669	411522	N/A	N/A	0.99	N/A	1.00	N/A

NODE_ID	X	Y	0.5% (1 in 200) modelled level	0.5% (1 in 200) modelled flow	0.1% (1 in 1000) modelled level	0.1% (1 in 1000) modelled flow
NSOK_994	482751.3	411500.4	0.98	N/A	N/A	N/A
3R2A_27	483446.9	411301.6	0.87	N/A	N/A	N/A
3R2B_1577	482083.8	410563.3	0.93	N/A	N/A	N/A
SSOK_2886	480796	411239	0.97	N/A	N/A	N/A
NSOK_2095	481669	411522	1.00	N/A	N/A	N/A

NODE_ID	X	Y	1% (100 year) plus 20% CC level	1% (100 year) plus 20% CC flow	1% (100 year) plus 30% CC level	1% (100 year) plus 30% CC flow	1% (100 year) plus 50% CC level	1% (100 year) plus 50% CC flow
NSOK_994	482751.3	411500.4	0.96	N/A	1.01	N/A	0.96	N/A
3R2A_27	483446.9	411301.6	0.86	N/A	0.88	N/A	0.87	N/A
3R2B_1577	482083.8	410563.3	0.91	N/A	0.93	N/A	0.91	N/A
SSOK_2886	480796	411239	0.95	N/A	1.01	N/A	0.95	N/A
NSOK_2095	481669	411522	0.99	N/A	1.04	N/A	0.99	N/A

Source: Derbyshire Trent, CH2MHill, 2019

All modelled levels in mAOD
All flows in m3/s

Updated Climate Change Guidance

On 19th February 2016, the Flood risk assessments: climate change allowances' was published on www.gov.uk website. It has replaced previous guidance Climate Change Allowances for Planners.

The climate change guidance can be found at: [redacted]
If your RFI is to assist with a Flood Risk Assessment (FRA) for a future planning application, please review this guidance to consider which allowances should be used for your site.

The climate change allowance provided with this RFI is a 20% increase in the peak river flow for the 1% Annual Exceedance Probability (1 in 100 year) scenario.

Breach Information

It should be noted that the breach location used to produce the modelled breach heights maps is approximately 3km to the east of the site and therefore does not give a true indication of the effect on the site. It is recommended that a site specific breach analysis is carried out for the site using the joint DEFRA/Environment Agency document Flood Risk Assessment Guidance for New Development (FD2320). This document can be downloaded directly using the following link (FD2320.pdf).

Defence Information

Defence ID	Asset Reference	Design Standard	D/S Crest Level (mAOD)	U/S Crest Level (mAOD)	Overall Condition Grade
1	23,792	100	6.2	6.2	2
2	24,834	100	6.2	6.2	3
3	23,793	100	6.2	6.2	2
4	24,285	100	6.32	6.32	3
5	24,835	100	6.2	6.2	3
6	23,593	100	6.2	6.2	2
7	77,608	100	6.4	6.4	1
8	50,711	100	6.4	6.4	2
9	22,642	100	6.4	6.4	3
10	23,881	100	6.4	6.4	2
11	23,880	100	6.46	6.46	3
12	22,641	100	6.4	6.4	3
13	23,879	100	6.4	6.4	3
14	51,435	100	6.4	6.4	2
15	22,091	100	6.4	6.4	3
16	22,090	100	6.4	6.4	3
17	51,393	100	6.2	6.2	2
18	24,833	100	6.2	6.2	3
19	23,791	100	6.3	6.3	3
20	23,790	100	6.25	6.25	3
21	51,392	100	6.3	6.3	2

Historic Information

We have records of historic fluvial flooding at this location in 2013. Please note that we may or may not hold the original records in question. We do not make any claim as to the reliability of recorded flood extents or that all flood events in the area have been recorded. Please also be aware that flood defences may have been built subsequent to these historic flood events. Note - This information relates to the area the above named property is in, and is not specific to the property itself - it ***does not*** provide an indicator of flood risk ***at individual property level***.

Open Data Information

The below datasets are now classed as Open Data and as such can be downloaded free of charge under an open data licence from the following address: [redacted]

- Risk of Flooding from Rivers and Sea (RoFRS) data
- LiDAR Data
- Flood Map for Planning (Rivers and Sea)
- Historic Flooding Data

Permitting Information

Under the Environmental Permitting (England and Wales) Regulations 2016, any permanent or temporary works in, over or under a designated main river will require an Environmental Permit for Flood Risk Activities from the Environment Agency.

Any permanent or temporary works within 8 metres of the top of bank of a designated main river, or landward toe of a flood defence may require an Environmental Permit for Flood Risk Activities from the Environment Agency. In addition, any permanent or temporary works within the floodplain of a designated main river may also require an Environmental Permit for Flood Risk Activities.

To find out whether your activity requires a permit or falls under a relevant exclusion, exemption or standard rule please follow the link below:
[redacted]

Please note that a permit is separate to and in addition to any planning permission granted.

Product Information

Below is a brief overview of which Product is likely to be most appropriate for your needs. This information will only be provided where it is available as we do not hold detailed information on all watercourses.

Product 4 – Producing a Flood Risk Assessment (FRA) where you:

- Require mapped and tabulated outputs from an Environment Agency model *e.g flood levels for a range of events*
- Require information on local defences and historic flooding events
- Do not need to undertake additional hydraulic modelling

Product 6 – Producing a Flood Risk Assessment (FRA) where you:

- Require raw modelling results files
- Require modelling results in GIS format

Product 7 - Producing a Flood Risk Assessment (FRA) where you:

- Do need to undertake additional hydraulic modelling using an existing Environment Agency model

In most instances to supply Product 6 and Product 7 data a hard drive will need to be supplied due to the large file sizes associated with this information. Please note that this information will require specialist modelling software to view and run.

A Product 5 (Model Report) will be supplied with all Product 6 and 7 requests and can also be requested separately.

DWDLLP
Sent via email only to:
consultation@keadby3.co.uk

Our ref: AN/2020/130468/02-L01
Your ref: EN010114

Date: 20 January 2021

Dear Sir/Madam

Keadby 3 Low Carbon Gas Power Station - Section 42 Preliminary Environmental Information Report Review
Keadby Power Station, Trentside, Keadby DN17 3EF

Thank you for consulting us on your Preliminary Environmental Information Report, on 24 November 2020.

We have considered the information in the Report and provide the following comments on it, in respect of topics that fall within our remit.

Chapter 11 – Biodiversity
We have reviewed Chapter 11 from the perspective of assessing risks to biodiversity, and initial protective and mitigation measures proposed are acceptable. Additional documents (i.e. Water Vole Mitigation Strategy, Fish management Plan), to ensure legislative compliance is proposed, and we look forward to reviewing these in due course.

Reference is made to works to achieve compliance with the Eels Regulations, which is welcomed. As this is the development of a new site we expect it will need to be screened/measures implemented to protect eel to best-practice and will be please to advise further regarding this when more details are provided/available.

Chapter 12 – Water Environment
Water quality
We have reviewed Chapter 12 and considered the proposal from a water qualilty/water resources perspective; providing relevant requirements from the Environment Permitting Regulations 2016 and Water Industry Act 1991 are adhered to this is acceptable. In particular, we would draw attention to ensuring (during both the construction and operational phases of the proposal):

- No polluting material shall enter any controlled water or groundwater without the benefit of an Environmental Permit.
- No more than 20 cubic meters shall be abstracted from any controlled water or groundwater per day without the benefit of an Abstraction Licence.

Ceres House, Searby Road, Lincoln, LN2 4DW
Customer services line: 03708 506 506
Email: LNplanning@environment-agency.gov.uk
www.gov.uk/environment-agency

Flood risk
We have also reviewed Chapter 12 from the flood risk perspective, and more particularly Appendix 12A, the Flood Risk Assessment (FRA).

In its current format the submitted FRA does not comply with the requirements for site-specific flood risk assessments, as set out in the Planning Practice Guidance (PPG) Flood Risk and Coastal Change section. The FRA does not yet adequately assess the flood risks posed by the development. In summary, the FRA currently fails to:

- Take into account the Critical Flood Level for North Lincolnshire, as described in the North Lincolnshire Strategic Flood Risk Assessment (SFRA);
- Provide details of the site-specific breach assessment which is being used for the site to assess the risk of the Trent defences breaching adjacent to the site during a severe flood event;
- Provide details of how the provided climate change flood levels for the Trent have been calculated and applied;
- Propose finished floor levels for the development in metres above Ordnance Datum.

<u>Critical Flood Level – North Lincolnshire SFRA</u>
Our previous response to the Keadby 3 Low Carbon Gas Power Station Scoping Opinion consultation included comments on flood risk, which have not been addressed in the FRA. The FRA includes a section on the North Lincolnshire SFRA (page 18), however it does not mention the Critical Flood Level. The Critical Flood Level is stipulated within the North Lincolnshire SFRA for new development within the Isle of Axholme Flood Risk Area. As the proposed power station is within the Isle of Axholme the finished floor level of the development, and any critical operational infrastructure should be raised 300mm above the critical flood level, so to a height of 4.4mAOD.

The Isle of Axholme is an area of land (the historic flood plain of the River Trent), which has been artificially drained, with water levels managed by a network of pumping stations. The Isle of Axholme critical flood level of 4.1metresAOD is an estimated flood level following a prolonged breakdown of the pumping station network and high water levels on the River Trent. The North Lincolnshire SFRA states that finished floor levels in this area should be set no lower than 4.4mAOD; 300mm above the critical flood level.

<u>Site specific breach assessment</u>
Aside from the Critical Flood Level in the SFRA, the greatest risk to the site for rapid-onset flooding is a breach of the River Trent defences in line with the site during a severe flood event. On page 24 of the FRA there is reference to a site specific breach model undertaken for the Keadby 2 development in 2015. The FRA states that a breach was assessed during a 0.5%AEP event including a "*50 year allowance for climate change*". We are not clear what climate change allowance this refers to, for example which percentile (H++/Upper End/Higher Central/Central). We would also like to review the location of the modelled breach and details of the calculation methods: we request that the full report for the site specific breach model and any accompanying calculations are submitted to us so we can check that it is relevant to the Keadby 3 site and uses the correct data.

<u>Climate change flood data</u>
On page 15 the FRA gives the new climate change sea level rise allowances up to 2065. There is also an assessment of the fluvial climate change allowances, which states that due to the proposed lifespan of the development, the plus 30% climate change allowance is applicable.

Cont/d..

The application should also assess the H++ climate change scenario. Information from the Gov.uk website is given below [redacted]:

> *Using H++ allowances for nationally significant infrastructure projects, new settlements or urban extensions*
> *Nationally significant infrastructure projects (NSIPs) are major infrastructure projects such as new harbours, roads, power stations and power lines. If you develop NSIPs you may need to assess the flood risk from a credible maximum climate change scenario. Check the relevant national policy statement.*
>
> *In other cases, such as new settlements or significant urban extensions, you may also need to assess the flood risk from a high impact climate change scenario. In these circumstances you should use the H++ climate change allowances.*
>
> *You should treat this as a 'sensitivity test'. It will help you assess how sensitive your proposal is to changes in the climate for different future scenarios. This will ensure your development can be adapted to large-scale climate change over its lifetime.*

On page 23 of the FRA Table 9 gives flood levels (presumably in-channel) for the River Trent during a 0.5%AEP event, with a range of climate change allowances. This data does not appear to be Environment Agency data that we are aware of. The Environment Agency Mott Macdonald 2014 data only includes a plus 20% climate change allowance, it also does not include the latest (2019) sea level rise data. Please could you explain where the data in Table 9 has been obtained from, or how it has been calculated.

The flood levels in Table 9 do not appear to have been assessed within the FRA in relation to the development site. You should include the relevant climate change allowances when assessing the site specific breach flood levels and also any overtopping of defences flood scenarios which affect the site.

Proposed finished floor levels and mitigation measures

The FRA does not appear to propose any specific flood mitigation measures for the proposed development. Proposed finished floor levels should be given in metres above Ordnance Datum (mAOD). The site is complex with a number of different uses. When deciding on the flood mitigation measures required you should always ensure that critical operational infrastructure is above modelled flood levels, including the SFRA Critical Flood Level plus 300mm, so above 4.4mAOD. The development must also be set no lower than the Breach Scenario plus 300mm freeboard.

The development must be safe for the designed lifetime, it must not increase flood risk to others and should be designed/constructed to remain operational in times of flood (PPG para 067, Table 3 notes for essential infrastructure in FZ3a).

Where areas of the site are below the critical flood level or breach flood level, the FRA should propose alternative mitigation measures such as flood resilience measures and safe refuges for occupants of the site above the maximum flood levels. It may be necessary to raise the platform level of the site in order to raise buildings and critical infrastructure above the Critical Flood Level and breach flood level. If large areas of the site are to be raised the FRA must take into account the impact on flow paths. For example during an overtopping or breach of defences flood, would flood water be diverted onto neighbouring properties?

Cont/d..

Further information/advice
In our previous correspondence we recommended contacting our Humber Strategy Team. This has not been mentioned in the FRA and so we would highlight our previous comments on this as follows:

Maintenance of Flood Defences (Humber 2100+) - The Environment Agency confirms it cannot guarantee that the flood defences will be maintained at the current standard of protection into the future, at this location. Some assets within this area are approaching the end of their designed life and require further investment for improvements, which are also in line with the impacts of climate change. This is highlighted within the Humber Flood Risk Management Strategy (2007). However, large areas across the Humber Basin found further improvements were uneconomical and as sea level rises the standard of protection provided will diminish.

A new Humber Strategy is currently under development known by the name of "Humber 2100+". The strategy will review the future approach of flood risk management within the Humber Basin. I would advise discussing your proposed development with the Humber Strategy Team, they are contactable by emailing the following address; HStrategy@environment-agency.gov.uk. and further information can be found on the following website; [redacted]

Flood Risk Permits
Several parts of the proposed development are close to Environment Agency main rivers and flood defences, including the Stainforth and Keadby Canal, the Three Rivers and the River Trent. Development in these areas will require Flood Risk Activity Permits. Flood Risk Activity Permits assess the impact of the proposals during both the construction and lifetime of the proposed development. The Environment Agency will require further detail of the proposed works and how the main rivers and flood defences may be affected.

The Environmental Permitting (England and Wales) Regulations 2016 require a permit or exemption to be obtained for any activities which will take place:

- On or within 8 metres of a main river (16 metres if tidal)
- On or within 8 metres of a flood defence structure or culverted main river (16 metres if tidal)
- On or within 16 metres of a sea defence
- Involving quarrying or excavation within 16 metres of any main river, flood defence (including a remote defence) or culvert
- In a floodplain more than 8 metres from the river bank, culvert or flood defence structure (16 metres if it's a tidal main river) and you don't already have planning permission.

For further guidance please visit [redacted] or contact our National Customer Contact Centre on 03708 506 506 (Monday to Friday, 8am to 6pm) or by emailing enquiries@environment-agency.gov.uk.
You should not assume that a permit will automatically be forthcoming once planning permission has been granted.

Chapter 13 – Geology, Hydrogeology and Contaminated Land
We have reviewed Chapter 13 and considered your proposal for assessing risks to controlled waters from the previous uses of the site and construction of the new power station. The proposed approach is acceptable. Additional intrusive site investigation work is proposed and we look forward to reviewing this in due course.

Cont/d..

Environment Permitting Regulations 2016
The proposed combustion installation will require a permit under Section 1.1 Part A of the Environmental Permitting Regulations, as previously advised in our response to your Scoping Opinion, made to the Planning Inspectorate. We have no further comments to add to those made previously in respect of a permit.

Should you require any additional information, or wish to discuss these matters further, please do not hesitate to contact me on the number below.

Yours faithfully

Annette Hewitson
Principal Planning Adviser

Direct dial 02030 254924
Direct e-mail [redacted]@environment-agency.gov.uk

End

Mr Richard Lowe
AECOM
2 City Walk
Leeds
LS11 9AR

Our ref: AN/2020/130468/03-L01
Your ref: EN010114

Date: 23 March 2021

(via email only)

Dear Richard

Keadby 3 Low Carbon Gas Power Station - Flood Risk Assessment proposal

Thank you for providing the Technical Note, outlining your proposed approach to flood risk and bridges, in connection with the Keadby 3 Development Consent Order application.

We have reviewed the Technical Note (dated 23 February 2021, Rev0), alongside the meeting note of 22 February 2021, and provide the following comments.

1. *The Flood Risk Assessment (FRA) should take into account the Critical Flood Level for North Lincolnshire, as described in the North Lincolnshire Strategic Flood Risk Assessment (SFRA)*

The critical flood level (CFL) is considered the height flood water would reach during a breach and prolonged failure of the complex drainage network (e.g. pumping stations) of the Isle of Axholme. The proposed breach assessment undertaken will only assess the breach scenario and not the failure of the Isle of Axholme drainage network. The proposed development will always have the residual flood risk that flood heights could reach 4.1m AOD during its lifetime.

If the FRA identifies difficulties in achieving mitigation to the CFL (4.1m AOD plus 300mm freeboard), the Environment Agency will consider this and provide feedback. If a lower finished floor level has to be proposed, the FRA should look to include other forms of flood mitigation measures up to the CFL.

We remain of the view, which aligns with the Planning Practice Guidance (PPG), that essential infrastructure should be designed to remain operational and safe during times of flood, and this should include consideration of the residual risk to the development.

2. *Provide details of the site-specific breach assessment which is being used for the site to assess the risk of the Trent defences breaching adjacent to the site during a severe flood event*

We will be pleased to review the proposed methodology in respect of the site specific breach assessment when available/received. We may require up to 28 days to provide our comments on this, and any prior notice you are able to give us in respect of its receipt would be appreciated to enable us to ensure resources are available to undertake the review.

We acknowledge the site is within a tidally dominant location along the River Trent. However, you should assess the breach during the fluvial 1% AEP plus 30% climate change allowance and the tidal 0.5% AEP plus climate change allowance. The fluvial scenario will need to be assessed due to the duration of the peak flow being longer than that of the tidal. By assessing both you will be able to determine which scenario will have the greatest impact on the proposed development.

The breach assessment should use the data from the Tidal Trent detailed hydraulic model (Mott Macdonald 2014), as this is still considered the latest available information. However, you should also undertake a scenario using the extreme Humber water levels as a sensitivity test.

3. *Climate Change Flood Data*

Each development is individually assessed, with historic and local developments being considered when we provide our response to the application. We note the development lifetime proposed is 35 years; this should be used as the basis for the assessment.

As detailed in section 1, the FRA should consider all flood risk as identified above, which includes the extremes (residual risk). The CFL considers the failure of the complex drainage network within the Isle of Axholme, unlike the site specific breach assessment. To meet current planning requirements the proposed development will need to be safe for its designed lifetime, this means it will need to implement appropriate flood mitigation measures up to 4.1m AOD plus 300mm freeboard.

4. *Propose finished floor levels for the development in metres above Ordnance Datum.*

We have no further comments to make on this issue at the current time.

5. *Humber Strategy*

No comments.

6. *Flood Risk Permits*

We welcome the acknowledgement of the permitting requirements for works close to Main Rivers and flood defences. For further guidance on our permitting requirements please visit [redacted] or contact our National Customer Contact Centre on 03708 506 506 (Monday to Friday, 8am to 6pm) or by emailing enquiries@environment-agency.gov.uk.

The Environment Agency has reviewed Appendix A. Based on the limited information provided we would expect the bridge to be set no lower than the existing soffit level.

Cont/d..

Should you require any additional information, or wish to discuss these matters further, please contact Chris Barton on 02030 251030.

Yours sincerely

Annette Hewitson
Principal Planning Adviser

Direct dial 02030 254924
Direct e-mail [redacted]@environment-agency.gov.uk

End

ANNEX B NORTH LINCOLNSHIRE COUNCIL CONSULTATION

AECOM Limited
5th Floor, 2 City Walk
Leeds LS11 9AR
United Kingdom

T: +44 (0)113 391 6800
aecom.com

7th July 2020

Our Reference
Keadby_FRA

North Lincolnshire Council,
Church Square House,
30-40 High St,
Scunthorpe
DN15 6NL

Data Consultation Request: Land at Keadby Power Station, Trentside, Keadby, Scunthorpe DN17 3EF. .

Dear Sirs

AECOM has been commissioned to undertake an Environmental Impact Assessment, including an Environmental Statement Water Resources Chapter, Water Framework Directive Assessment and a Flood Risk Assessment (including a conceptual drainage strategy) to support a Development Consent Order application on land located within the Keadby Power Station site on the bank of the River Trent to the west of Scunthorpe. The proposed development, a proposed Low Carbon Combined Cycle Gas Turbine (CCGT) Generating Station, will be located within the red line boundary, (encompassing an area of approximately 70.1 hectares (ha) and is indicative at this stage), indicated on the attached location plan below.

Water Quality, Resources, WFD and Biological Data Request

For a **1 km study area around the Red Line Boundary** can you please provide where possible any data covering or relevant to the following points:

- Please provide the locations (NGR) of any Private Water Supplies (PWS) and confirm whether they are a surface or groundwater source?

Depending on your response to the point above we may also be interested in the following information but would wish to discuss the need for this data in advance of it being provided:

- copies of water quality sampling results up to and including the last 5 years for any known PWS.
- a map or list indicating which households/businesses are supplied by the PWS.

Flood Risk Assessment

In line with the Environment Agency's standing advice, AECOM proposes to produce a Flood Risk Assessment that considers the risk to the site from all sources, rivers and the sea, streams, surface water run-off, sewers, groundwater, etc. AECOM will also make recommendations for managing surface water runoff according to sustainable drainage principles.

The Site lies within Flood Zone 3a, as defined by the Environment Agency's online Flood Map for Planning and North East Lincolnshire Council's Strategic Flood Risk Maps. The site is in an area that benefits from flood defences.

AECOM would like to request the following information from North Lincolnshire Council:

- Confirmation that the proposed development would be classified as 'Essential Infrastructure' under the NPPF Flood Risk Vulnerability Classification;
- Historical records of flooding from local sources (ordinary watercourses, surface water, groundwater etc.) for the area in proximity to/ at the site;

- Details of any known surface water flooding problems in the area and known Critical Drainage Areas as well as any associated Local Flood Risk Zones;
- Details of any known groundwater flooding problems in the area;
- Information on any Council owned flood assets,(e.g. flood defences, culverts etc.) located in proximity to the Site;
- Details of any proposed future flood defence schemes/ works to assets located in proximity to the Site;
- Any requirements the Council may have with regards surface water management at the proposed development;
- Any preferred SuDS techniques;
- Specific mitigation measures likely to be required by the Council for the proposed development; and
- Any further information required to be taken in to account as part of an FRA.

I look forward to hearing from you.

Yours sincerely,

[redacted]

Jo Somerton
Principal Flood Risk Consultant
AECOM Limited
T: +44 (0) 113 204 5028
E: [redacted]@aecom

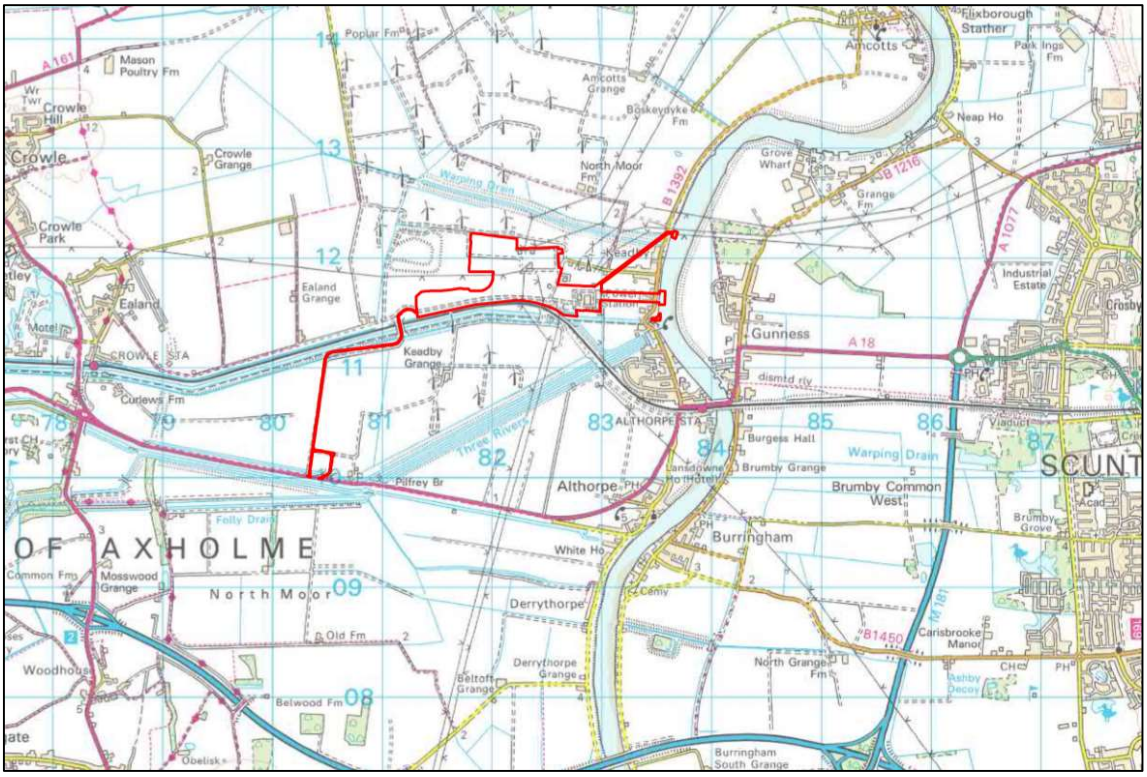
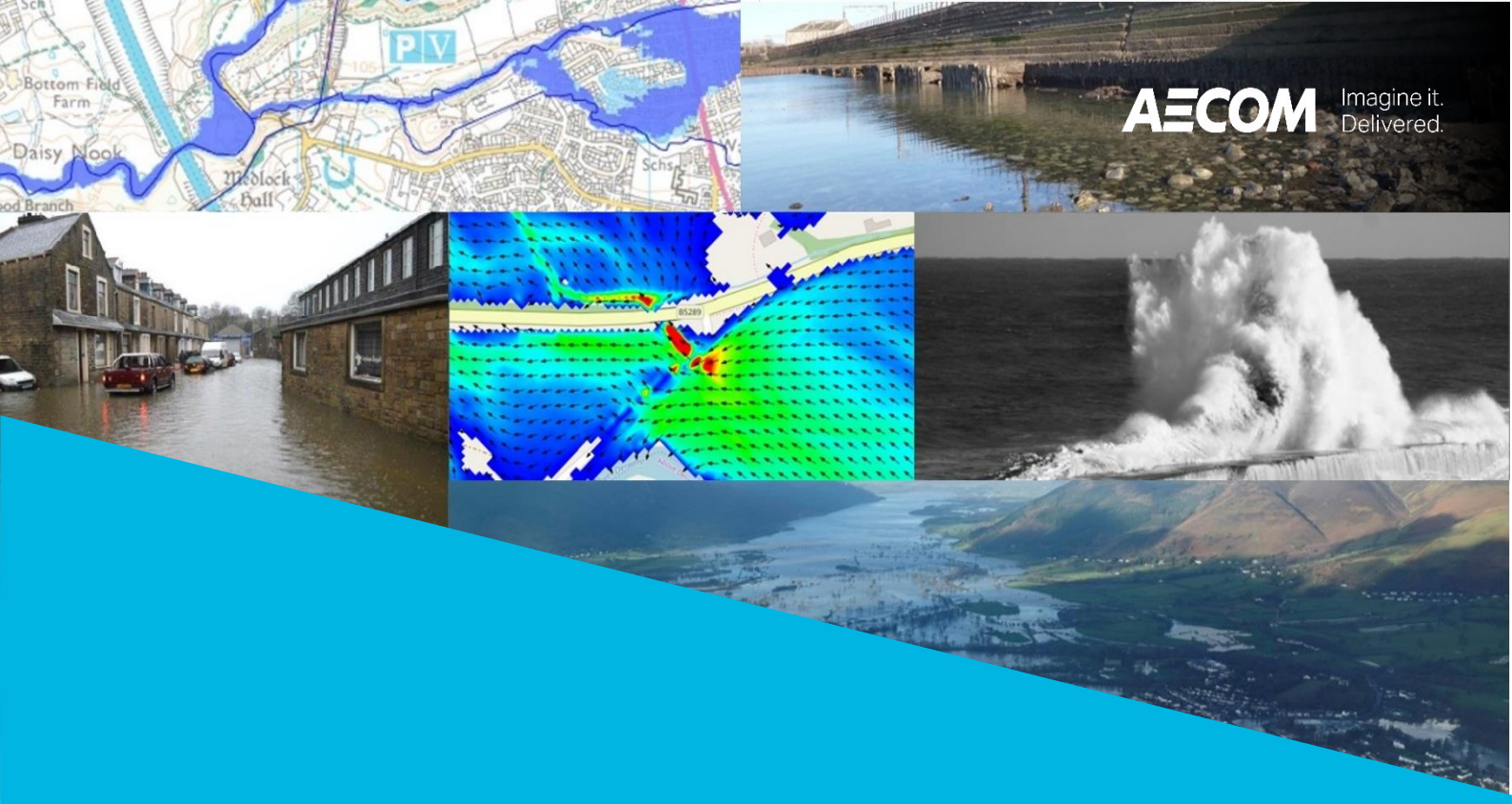


Figure 1: Keadby 3 Power Station (Development will be located within the red line boundary).

ANNEX C BREACH MODELLING TECHNICAL NOTE



Keadby 3 Low Carbon Gas Fired Generating Station

Breach Modelling Report Addendum

Keadby Generation Ltd

60625943

July 2021

Quality information

Prepared by	Checked by	Verified by	Approved by
Abbey Hewson	Katie Pearson	Ruth Goodall	
Graduate Consultant	Technical Director	Technical Director	

Revision History

Revision	Revision date	Details	Authorized	Name	Position

Distribution List

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Document overview

AECOM has been commissioned by Keadby Generation Ltd to prepare a Flood Risk Assessment (FRA) in support of a Development Consent Order (DCO) application for a proposed low carbon gas fired generating station on the Keady Power Station site at Keadby, Scunthorpe DN17 3EF. As part of the FRA, hydraulic modelling has been carried out in order to assess the risk to the proposed development from a breach in the River Trent tidal defences.

Prepared by:

Abbey Hewson

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Table of Contents

Figures

Tables

1.0 INTRODUCTION

1.1 Overview

1.1.1 AECOM has been commissioned to prepare a Flood Risk Assessment (FRA) in support of a Development Consent Order (DCO) application for a proposed low carbon gas fired generating station ('the Proposed Development') on land in the vicinity of Keady Power Station at Keadby, Scunthorpe DN17 3EF ('the Proposed Development Site'). As part of the FRA, hydraulic modelling has been carried out in order to assess the risk to the Proposed Development from a breach in the River Trent tidal defences.

1.1.2 An initial Model Report was prepared and submitted with the draft FRA to the Environment Agency in April 2021 which presented the initial approach taken. The modelling was reviewed by the Environment Agency in June 2021 and this Addendum has been prepared to respond to the comments raised by the Environment Agency in that review. The Addendum also includes the results of additional sensitivity testing undertaken using the model.

2.0 BREACH SETUP

2.1 Overview

2.1.1 The Environment Agency review queried the setup of the breach within the hydraulic model. The breach polygon in the model reviewed by the Environment Agency was lowering a section of defences significantly but was not resulting in a flat area all set at the 2.8m above ordnance datum (AOD) breach base level. Some cells in the polygon were at 2.8m AOD, some were higher and some were lower.

2.1.2 To respond to this query, a revised breach setup has been used in the updated model (July 2021) which makes the whole breach polygon base 2.8m AOD. A Variable Z Shape layer has been used, with a 'NO MERGE' option to ensure a flat level of 2.8m AOD applies across the breach.

2.1.3 The Environment Agency commented that the breach set up left the breach open throughout the model runs and did not close after 30 hours had elapsed as intended. However, this has remained unchanged in the updated model as allowing the breach to remain open for longer than 30 hours is a conservative approach and is not unrealistic given the potential difficulty in closing a breach in this location during high water. However, in response to this comment we have run a sensitivity test which closes the breach at 30 hours. Due to the occurrence of the peak water levels on the Proposed Development Site (occurring at ~74 hours) shortly after the breach start (at 71.75 hours) the timing of breach closure (at 101.75 hours) has no noticeable impact on the peak flood levels on site.

2.1.4 The Environment Agency had no further comments relating to the breach location and assumptions, other than those detailed above, about breach width and trigger level and opening times are unchanged from previous modelling.

2.1.5 The updated model was run with the revised breach setup and the same Head Time (HT) boundary conditions previously used (F02-T200CC from the Updated Tidal Trent SFRM Model (Mott MacDonald 2013/2014) with a peak water level at the breach of 6.23m AOD.

2.1.6 The updated model with the revised breach setup was run for a baseline scenario and with the development platform on which the main combined cycle gas turbine (CCGT) and carbon capture plant (CCP) is proposed to be developed (the Main Site and associated buildings within the Proposed PCC Site) raised (Development Scenario).

2.1.7 The results for maximum depth of inundation are shown on Figure 1 and 2 below.

Table 1 - Modelling Scenarios - updated breach geometry

Modelling Scenario	TUFLOW files (tcf)	Description	Water level at Keadby Power Station
Baseline F02 T200CC	Keadby_Breach_F02-T200CC_Breach_005.tcf	200-year tidal event plus climate change combined with a 2-year fluvial event pre-construction	2.41m AOD.

Development Scenario F02 T200CC	Keadby_Breach_F02-T200CC_Dev_Breach_005.tcf	200-year tidal event plus climate change combined with a 2-year fluvial event post power station construction	2.47m AOD.

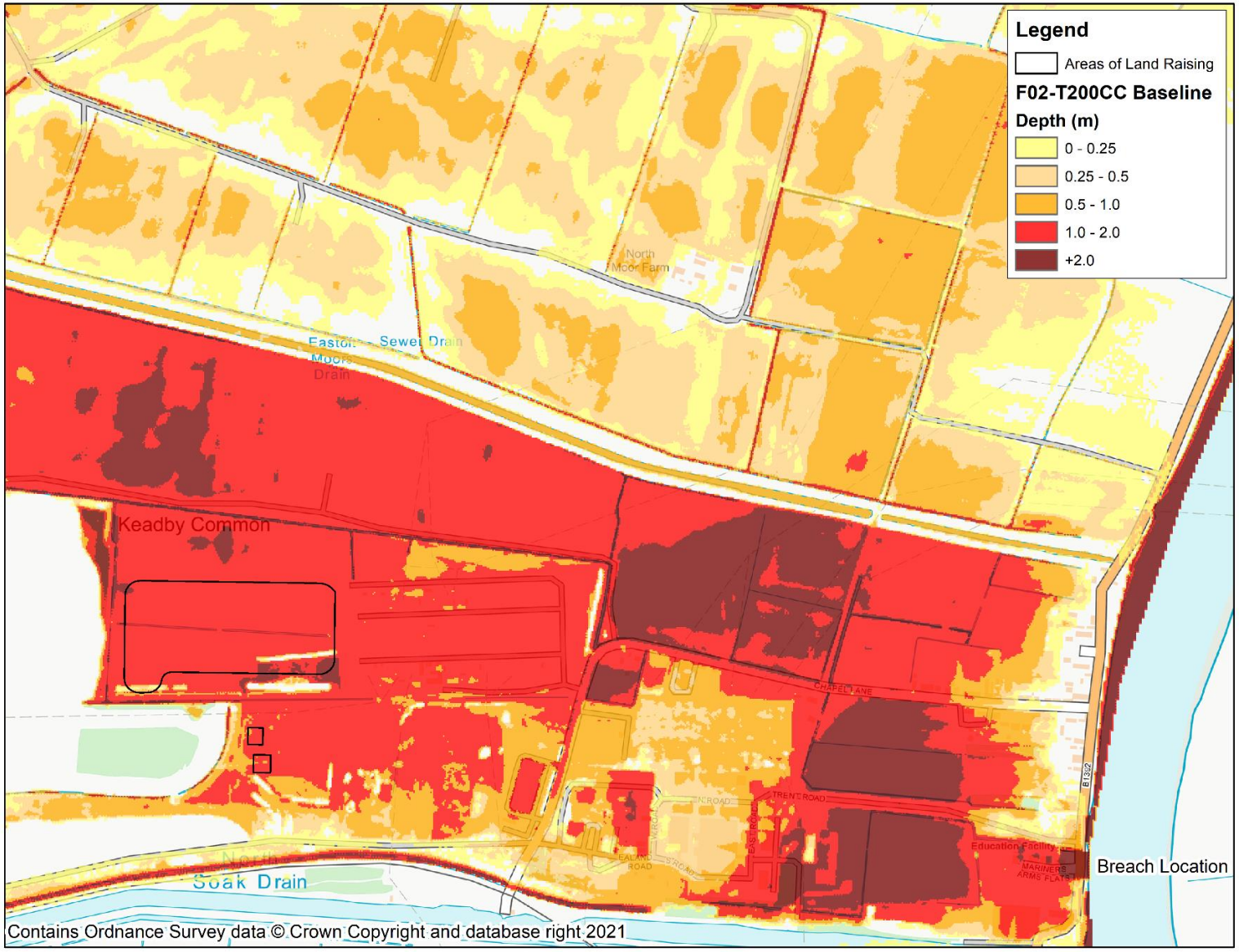


Figure 1 Maximum depth of inundation (defence breach, 200y tidal event with CC combined with 2y fluvial event) - Baseline

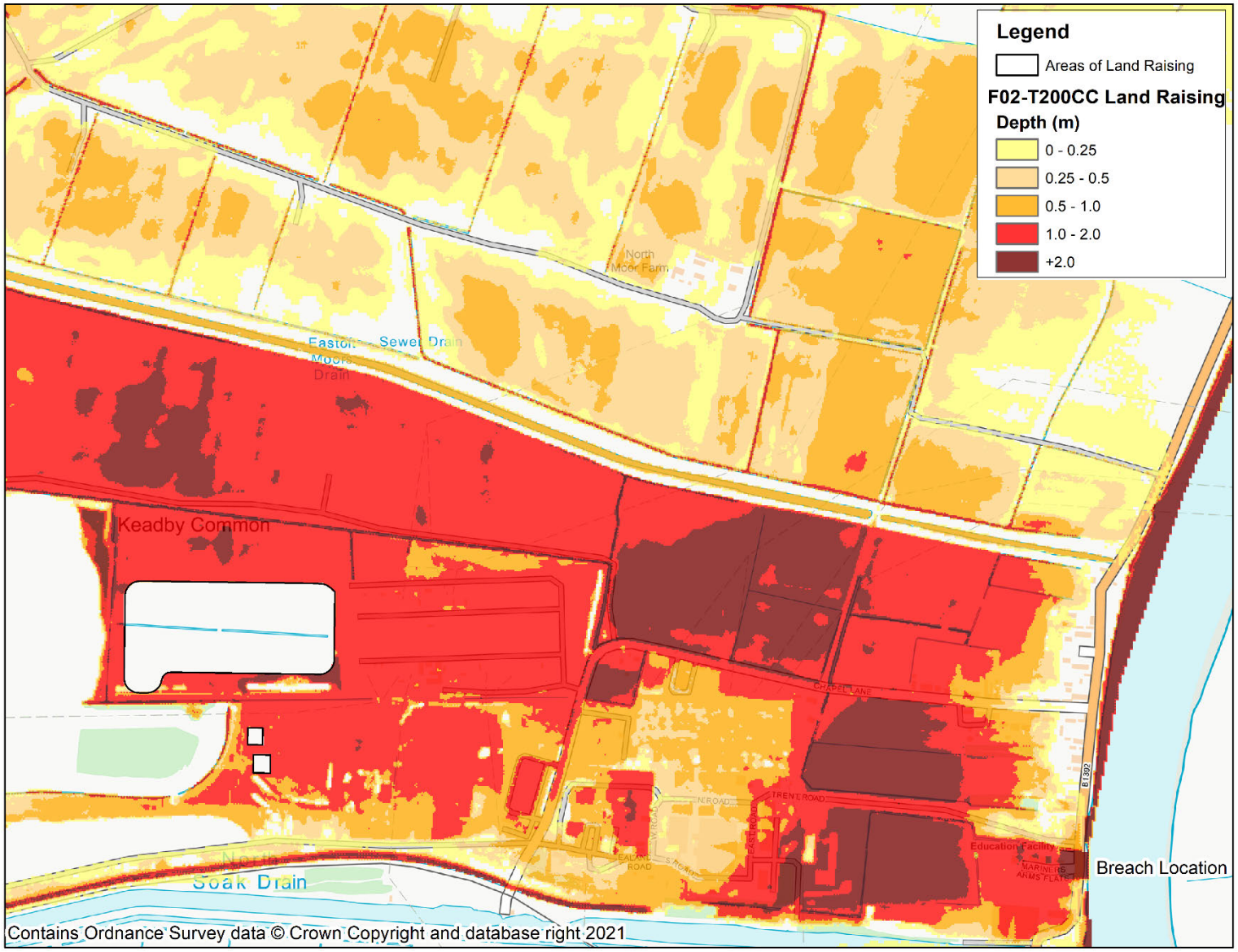


Figure 2 Maximum depth of inundation (defence breach, 200y tidal event with CC combined with 2y fluvial event) – Development platform raised

2.1.8 Results demonstrate that raising the development platform results in an increase in the maximum water level by 0.06m on average across the Main Site and Proposed PCC site buildings (Table 1). The locations used to determine an average water level (and depth) across the site are presented in Appendix B. All results are presented in Appendix C.

2.1.9 Figure 1 and Figure 2 demonstrate maximum depth grids generated from the TUFLOW modelling output files. The baseline model demonstrates that prior to any land raising, the majority of the Proposed PCC Site buildings is subject to flood depths between 1.0-2.0m. Following land raising of the necessary site components above the baseline breach water level, these areas are no longer flooded. Flood waters displaced by the land raising do not result in large scale changes to the depth of flooding across the Proposed Development Site, however the area of flooding in the 1.0-2.0m depth band increases a small amount on the 400kV National Grid electricity substation to the immediate east of the Main Site.

2.1.10 Further inspection of results has determined that the change in depth is greatest on the south side of the Proposed PCC Site (Appendix C), to the south of the Main Site (a large raised platform). To the immediate north and west of the Main Site, the water level increases by 0-10mm following platform raising. To the south and east of the raised platform, the water level increases by 70-100mm following platform raising.

2.1.11 In the wider Proposed Development Site and beyond, results (Appendix C) show that water levels increase by a maximum of 4mm in the post development breach scenario, with most results showing no increase in water levels at the edge of the maximum flood extents. As such, the model shows that off-site impacts as a result of land raising for the development are negligible.

3.0 SENSITIVITY TESTING

3.1 Extreme Water Levels

3.1.1 The Environment Agency review requested that the breach model was run with updated boundary conditions in the Tidal Trent based on the Extreme Still Water Levels from the Humber 2100+ Project (referred to as Humber Extreme Water Levels (HEWL) in Environment Agency reporting and the Keadby breach model) and provided data and reporting from that study to facilitate this. This data was not available when the initial modelling (April 2021) was completed to accompany the DCO application.

3.1.2 Two climate change scenarios from the HEWL model outputs have been run as highlighted on the extract from the Humber EWL User Guide below. The 2071 epoch has been selected to best represent the design life of the Proposed Development and a High (H) Upper End and a Extreme (HPP) H++ scenario has been used to represent significant sea level rise.

	2021	2040	2046	2071	2121
Medium (M) Higher Central	0.02m SLR +15% flows	0.14m SLR +20% flows	0.19m SLR +20% flows	0.42m SLR +30% flows	1.02m SLR +30% flows
High (H) Upper End	0.03 SLR +20% flows	0.18m SLR +30% flows	0.23m SLR +30% flows	0.54m SLR +50% flows	1.38m SLR +50% flows
Extreme (HPP) H++	0.03 SLR +20% flows	0.28m SLR +35% flows	0.37m SLR +35% flows	0.97m SLR +65% flows	2.64m SLR +65% flows

Table 3: Climate change scenarios

Plate 1: Climate Change Scenarios from HEWL Model Outputs (source Humber EWL user guide)

3.1.3 Peak water levels for these two scenarios were extracted from the HEWL results for a 1% AEP (100y) event on the Tidal Trent at the model node Trent14600DS (the model node closest to the breach location and the same node used previously to extract results from the 2013/14 SFRM2 model).

3.1.4 The peak water levels extracted for this node for the 1% AEP (100y) event, 2071 epoch are 6.26m AOD for the High (H) scenario and 6.34m AOD for the Extreme (HPP) scenario, (these compare to 6.23 in the baseline case). The HEWL water levels are a result of joint probability analysis.

3.1.5 The HEWL results provided by the Environment Agency are maximum water levels only, not full stage-time curves of model results. A simple approach has been taken of shifting the stage-time boundary curve previously used (from the 2013/14 SFRM2 model results1) up by 3cm and 11cm respectively for the H and HPP scenarios. The resulting stage-time boundary conditions are shown in Figure 3.

3.1.6 The model was run using the revised breach setup (see Section 2.0) and HT boundary conditions based on the HEWL project outputs, for two different climate change scenarios. It is considered that these runs provide more accurate information on the level of residual risk due to climate change at the

[1] Max water level at Trent14600DS for the F02-T200CC scenario (2013/14 SFRM2 model) = 6.23m AOD.

Proposed Development Site than were available previously in the April 2021 model.

3.1.7 In these higher water level model scenarios, there is a potential for overtopping of the defences at locations north of the breach where the Environment Agency Asset Information Management System (AIMS) data contains defence heights lower than the HEWL peak water levels. Therefore, in the model setup, the boundary condition is applied along the whole extent of the model in the Tidal Trent and the results show two small, discrete lengths of overtopping. Model results suggest that in this scenario, inundation from the breach may combine with inundation from overtopping.

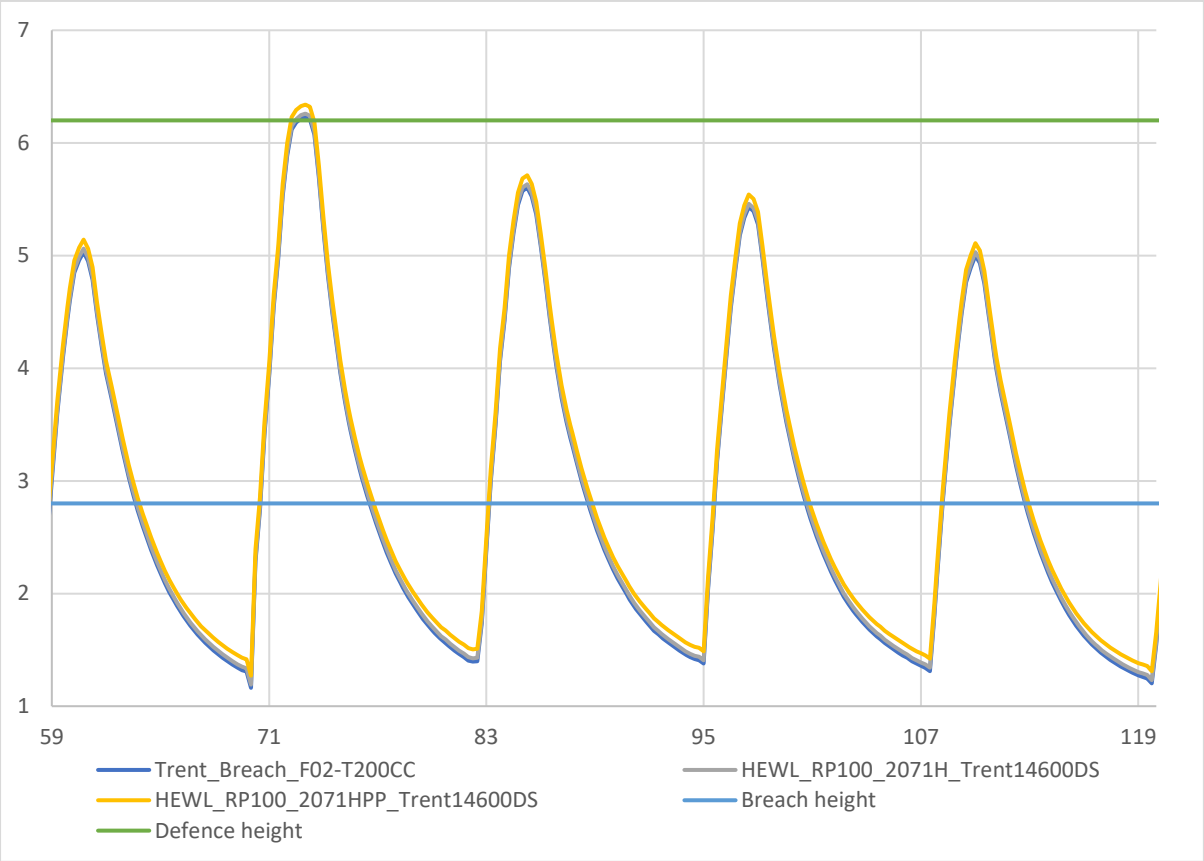


Figure 3 Boundary Conditions – HT curves at the breach location, with HEWL updates

Table 2 - Modelling Scenarios - HEWL

Modelling Scenario	TUFLOW files (tcf)	Description	Max water level at Keadby Power Station
Baseline 100y RP HEWL 2071 H Scenario	Keadby_Breach_HEWL_ RP100_2071H_005.tcf	Baseline event with stage hydrograph peak shifted to the HEWL 2071 (Upper End climate scenario) 100-year event peak. Pre-construction	2.43m AOD.
Baseline 100y RP HEWL 2071 HPP Scenario	Keadby_Breach_HEWL_ RP100_2071HPP_005.tcf	Baseline event with stage hydrograph peak shifted to the HEWL 2071 (Higher++ climate scenario) 100-year event peak. Pre- construction	2.47m AOD.

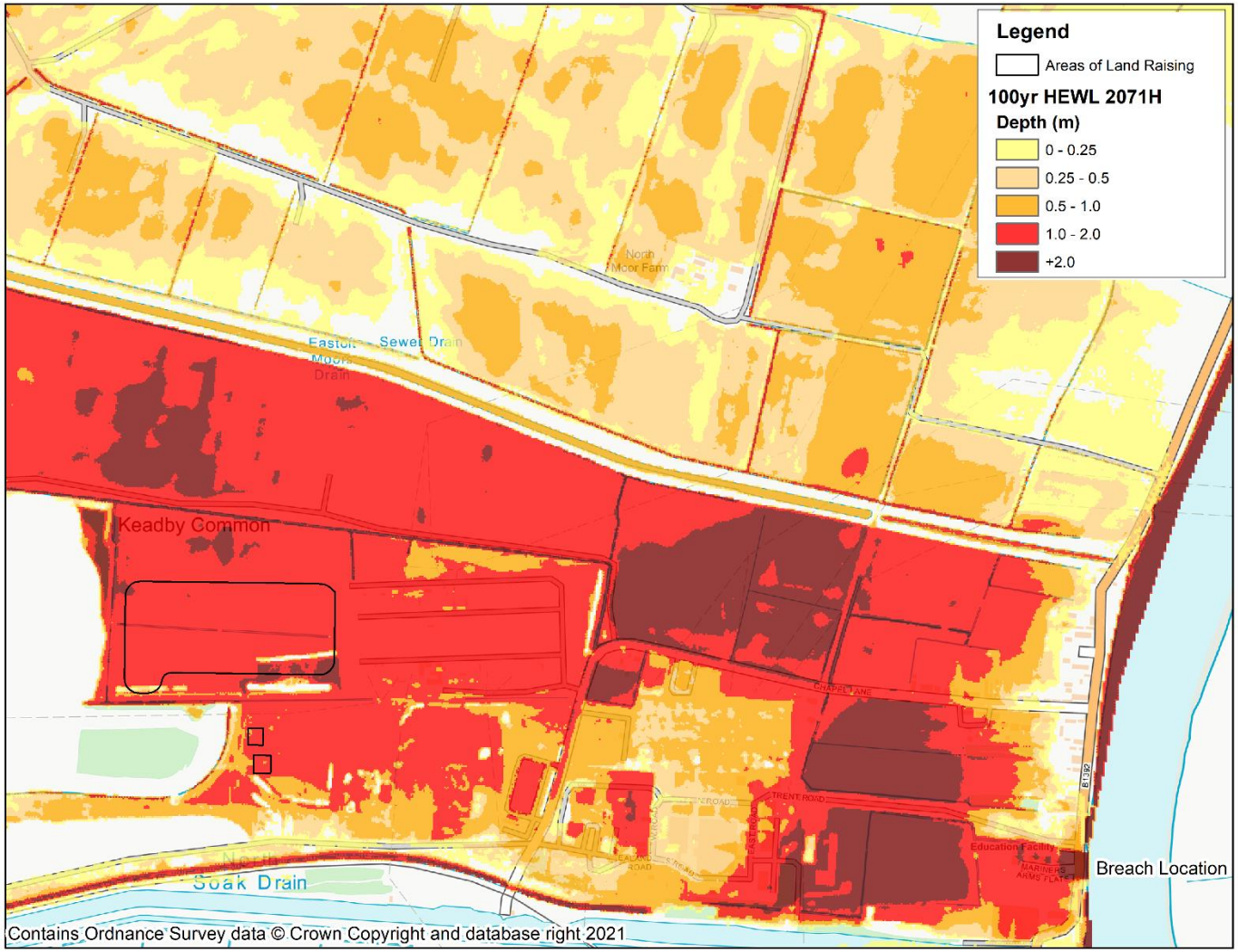


Figure 4 Maximum depth of inundation (defence breach, HEWL 'H' Scenario 2071 100y RP) - Baseline

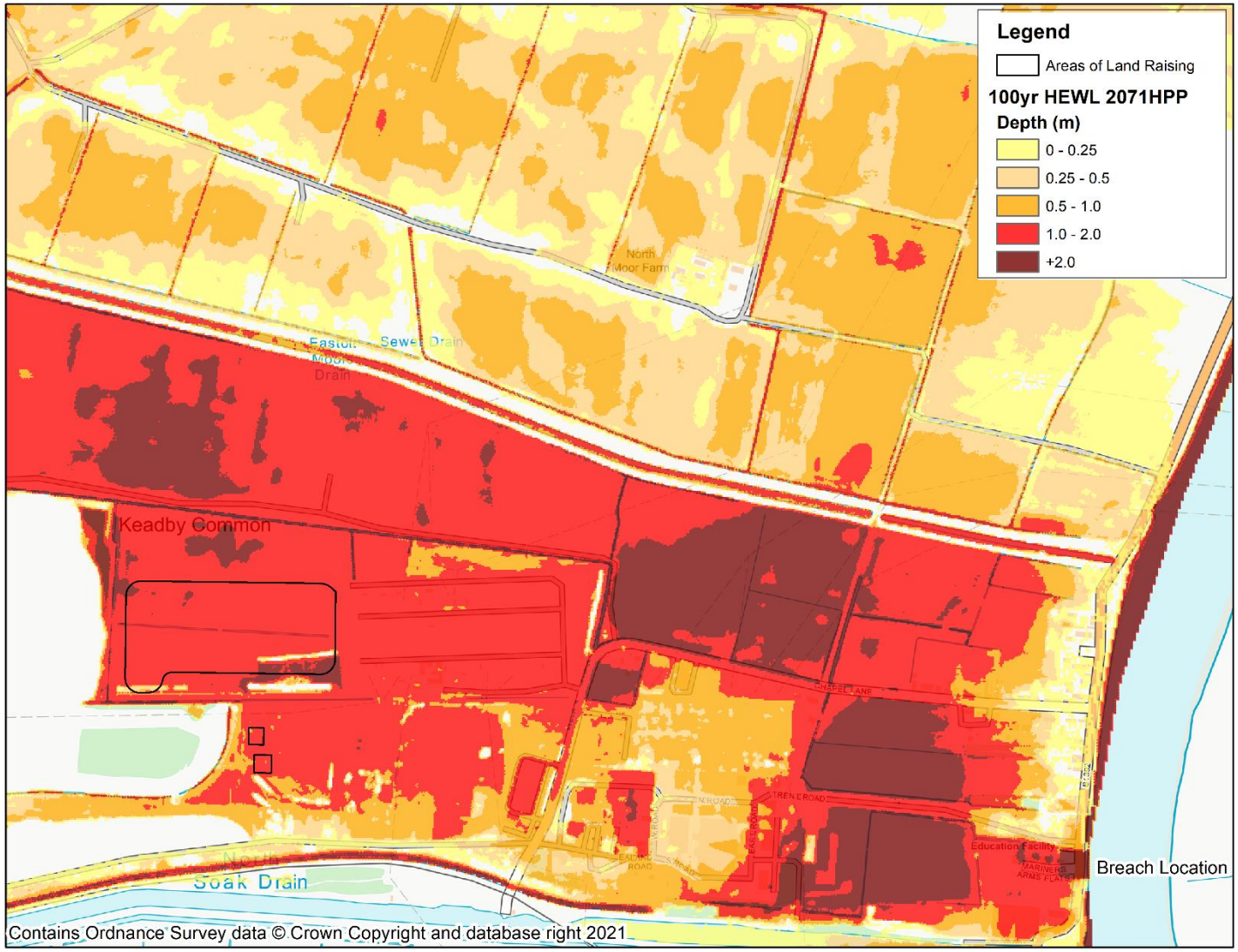


Figure 5 Maximum depth of inundation (defence breach, HEWL 'HPP' Scenario 2071 100y RP) – Baseline

3.1.8 The figures above show the maximum depth grids generated from model scenarios that used the Humber Extreme Water Levels in the breach boundary conditions. The 'H' and 'HPP' scenarios result in an increase in water levels by 20mm and 60mm respectively across the Main Site and Proposed PCC Site buildings during a breach when the HEWL levels in the Trent are used. As can be seen in Figure 4 and Figure 5, in comparison to the present day results, this does not result in any large scale changes in depth across the Proposed PCC Site. However, there is a small increase in the area of inundation >2m in depth within the Main Site (to the north of the development platform for the CCGT and CCP) and immediately north of the Main Site, in both the H and HPP scenarios.

3.2 Manning's n

3.2.1 The Environment Agency review requested that sensitivity testing was undertaken to understand the sensitivity of model results to the assumptions made regarding Manning's n roughness values in the 2D domain. The original Manning's n values applied in the modelling are described in the April Modelling Report accompanying the FRA (Appendix 12A - Annex C). Three sensitivity tests have been undertaken.

Table 3 -Modelling scenarios – Manning's n sensitivity

Modelling Scenario	TUFLOW files (tcf)	Description	Water level at Keadby Power Station
Baseline F02 T200CC Manning's n for buildings at 0.3	Keadby_Breach_F02-200CC_Breach_Mannings_Buildings_Sens_005.tcf	Manning's n for buildings reduced to 0.3 (from 1.0) Other Manning's n same as previous runs Pre-construction	2.51m AOD.
Baseline F02 T200CC Manning's n + 20%	Keadby_Breach_F02-T200CC_Breach_Mannings_1.2_005.tcf	All 2D Manning's n values increased by 20% Pre-construction	2.42m AOD.
Baseline F02 T200CC Manning's n - 20%	Keadby_Breach_F02-T200CC_Breach_Mannings_0.8_005.tcf	All 2D Manning's n values reduced by 20% Pre-construction	2.38m AOD

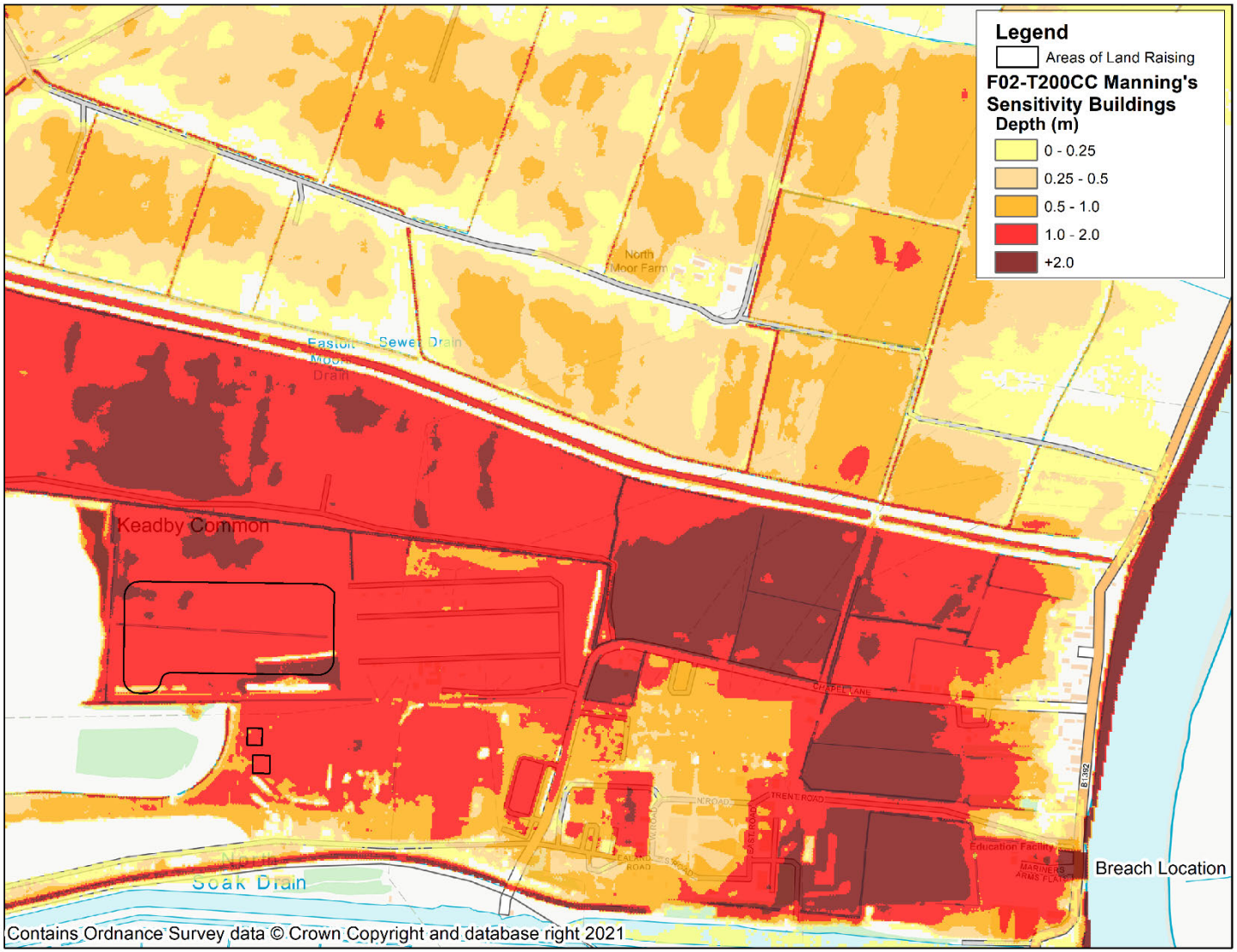


Figure 6 Maximum depth of inundation (defence breach, 200y tidal event with CC combined with 2y fluvial event) – Manning's n for buildings = 0.3

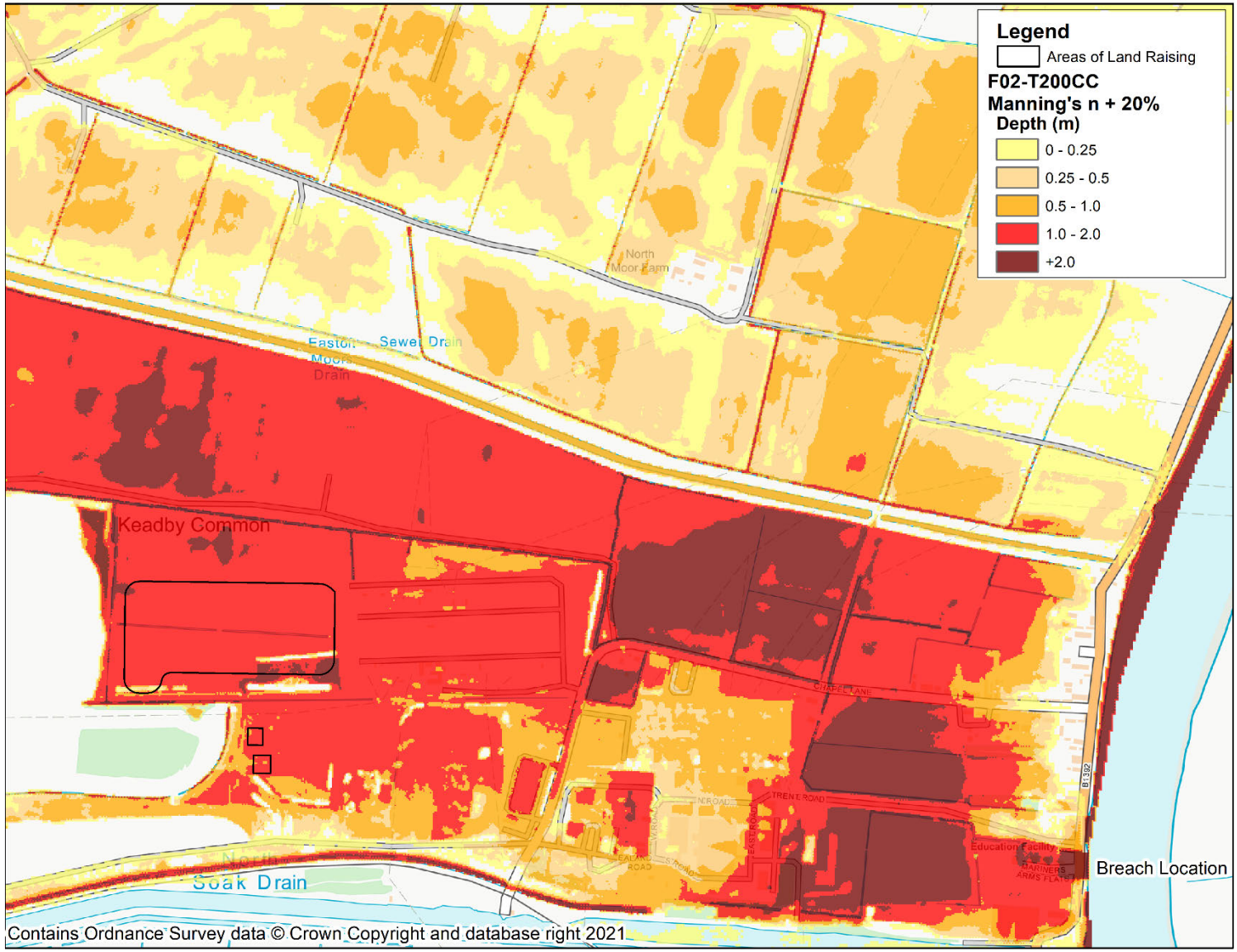


Figure 7 Maximum depth of inundation (defence breach, 200y tidal event with CC combined with 2y fluvial event) – Manning's n +20% (all 2D land-uses)

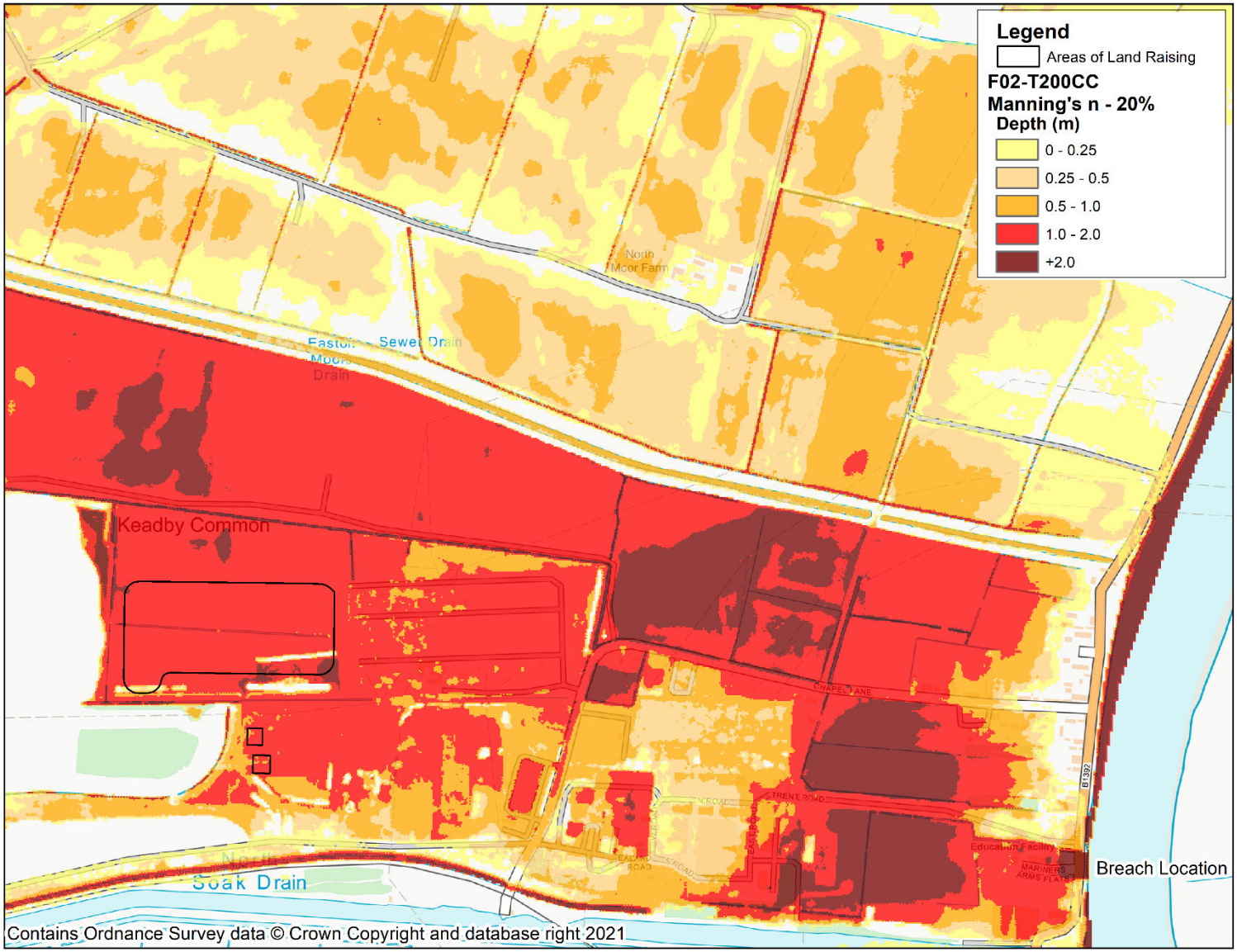


Figure 8 Maximum depth of inundation (defence breach, 200y tidal event with CC combined with 2y fluvial event) – Manning's n -20% (all 2D land-uses)

3.2.2 The model results show sensitivity to the assumptions made in the representation of buildings along the flow path between the breach and the Proposed PCC Site. When the Manning's n used for buildings is changed from 1.0 to 0.3 the predicted depth of flooding increases by 100mm across the site (with flood depths of 0.83-1.86m).

3.2.3 When all Manning's n values are increased by 20%, the average flood depth across the site increases by 10mm and when Manning's n is decreased by 20%, flood depth decreases by 30mm. This depth variation is <2% compared to the baseline flood depths of 1.55 m.

3.2.4 This demonstrates that the maximum water level is not very sensitive to varying Manning's n values across the whole 2D domain but does show sensitivity to the Manning's n values assigned to the buildings. The maximum level from the sensitivity runs will be considered in setting freeboard levels at the Proposed PCC Site.

3.3 Breach Duration

3.3.1 The Environment Agency commented that the breach set up left the breach open throughout the model runs and did not close after 30 hours had elapsed as intended. However, this has remained unchanged in the updated model as allowing the breach to remain open for longer than 30 hours is a conservative approach and is not unrealistic given the potential difficulty in closing a breach in this location during high water. However, a sensitivity check has been carried out to verify this assumption.

3.3.2 A sensitivity test which closes the breach at 30 hours has been tested. Due to the occurrence of the peak water levels on the Proposed Development Site (at ~74 hours) shortly after the breach start (at 71.75 hours) the timing of breach closure (at 101.75 hours) has no noticeable impact on the peak flood levels on site. Results from this sensitivity test are shown in Appendix C. These results determine that the closure of the breach has no impact on peak water levels or depths at the Proposed Development Site.

Table 4 - Modelling scenarios – Breach timing sensitivity

Modelling Scenario	TUFLOW files (tcf)	Description	Water level at Keadby Power Station
Baseline F02 T200CC	Keadby_Breach_F02-T200CC_Breach_005.tcf	200-year tidal event plus climate change combined with a 2-year fluvial event pre-construction	2.41m AOD.
F02 T200CC Breach Closure Test	Keadby_Breach_F02-T200CC_Breach_005_breach_test.tcf	200-year tidal event plus climate change combined with a 2-year fluvial event pre-construction, with breach closure after 30 hours.	2.41m AOD.

4.0 UNCERTAINTY

4.1 Overview

4.1.1 The Environment Agency has requested that AECOM undertake and present uncertainty analysis with the hydraulic modelling and has clarified this request as shown below.

> Additional information on this issue is required to ensure that the analysis and reporting you have undertaken has been open and clear about any uncertainty within the model assessment and quantifying this. For this project the biggest uncertainty is the water levels used, and what impact this has on the depths of flooding.
>
> We would suggest running a sensitivity with an increased water level to cover any potential uncertainty within these values, and to understand what impact that has on the model results. The uncertainty analysis should report on how the different sensitivity tests undertaken (roughness etc) have affected the results, and what the overall uncertainty within the results is, based on this. Whatever the design results show, there will be inherent uncertainty within them, and so identifying this and reporting on how this may affect the proposal/design is key.

Plate 2: Extract from Environment Agency Correspondence (9.7.21)

4.1.2 The two main sources of uncertainty in the breach modelling undertaken here are in the stage-time boundary conditions applied at the breach and in the application of Manning's n values to represent the roughness of the 2D domain. There were no other notable assumptions made during the modelling process which would affect the level of confidence in the model results. The information presented in Section 3.0 and Section 3.1.8 demonstrates, through sensitivity testing, the level of uncertainty associated with the hydraulic modelling of this breach.

4.1.3 There is no evidence or records of a breach in the Tidal Trent defences ever having caused flooding at the Keadby Power Station site so there is no calibration or verification data available. Therefore, the assessment of uncertainty can only be undertaken using sensitivity testing results.

4.2 Uncertainty – stage-time boundary

4.2.1 Three different stage-time boundary conditions have been tested in the model with peak levels at the breach of 6.23 m AOD, 6.26 m AOD and 6.34m AOD. The same shaped stage-time curve is used in each of the three cases. Table 5 shows the variation in modelled peak level at the power station for these different water levels.

Table 5 - Uncertainty analysis - boundary conditions

Peak level in stage-time boundary	Peak level at Keadby Power Station site
6.23m AOD	2.41 m AOD
6.26m AOD	2.43 m AOD
6.34m AOD	2.47 m AOD

4.2.2 As the difference in modelled peak levels at the power station is in the same order as the variation in the peak level in the stage-time boundary, the model would not be considered as overly sensitive to the boundary condition. However, this testing does show that the potential depth of flooding at the Proposed PCC Site is directly related to the water level in the Tidal Trent at the breach location and that any uncertainty in predicted levels in the Tidal Trent will correspond to uncertainty in the modelling results at the Proposed PCC Site.

4.2.3 The original stage-time boundary used in the modelling, for a F02-T200CC scenario from the 2013/14 SFRM2 project was the best available information at the time this modelling exercise began. Since this time, the Environment Agency has provided more recent information from the HEWL project which has been used in the sensitivity testing reported herein. It is noted in the documents provided with the HEWL outputs that the Environment Agency is undertaking other modelling projects in the Tidal Trent which may generate a different set of maximum water levels in the river Trent at the Keadby breach location.

4.2.4 The proposed development platform levels at the Proposed PCC Site include significant freeboard. As a result, the proposed floor levels are above the highest flood level of the three breach scenarios run (Table 5) and the levels set for the Critical Operating Infrastructure are higher again. The sensitivity analysis confirms that the freeboard depths already allowed for are proportionate to the risk.

4.3 Uncertainty – Manning's n roughness values

4.3.1 Four different model geometry scenarios have been tested in the updated model with different 2D Manning's n roughness values, shown in Table 6. These four model runs were all undertaken with the 'original' boundary condition of the F02-T200CC scenario, with a peak level in the stage-time boundary of 6.23m AOD.

Table 6 - Uncertainty analysis – Manning's n roughness

Manning's n roughness values	Peak level at Keadby Power Station site
Original (as per April 2021 Model Report)	2.41 m AOD
Buildings Manning's n = 0.3 (all other land uses as original model)	2.51 m AOD
All 2D Manning's n values +20% compared to original	2.42 m AOD
All 2D Manning's n values -20% compared to original	2.38 m AOD

4.3.2 The difference in modelled peak levels at the Proposed PCC Site across these four scenarios is 0.13m.

4.3.3 The proposed development platform levels at the Proposed PCC Site include significant freeboard. As a result the proposed floor levels are above the highest flood level of the four roughness tests (Table 6) and the levels set for the Critical Operating Infrastructure are higher again. The sensitivity analysis confirms that the freeboard depths already allowed for are proportionate to the risk.

5.0 SUMMARY AND CONCLUSIONS

5.1 Summary

5.1.1 A flood risk assessment including a hydraulic model (April 2021) accompanied a DCO Application for the Proposed Development and was submitted to the Planning Inspectorate on 1 June 2021. The application was accepted for examination by the Planning Inspectorate on 28 June 2021.

5.1.2 The original (April 2021) breach model for the Proposed Development has been reviewed by the Environment Agency and updated following comments received (July 2021). For the purposes of updated modelling, all previous (April 2021) model runs were re-run as well as new sensitivity analyses.

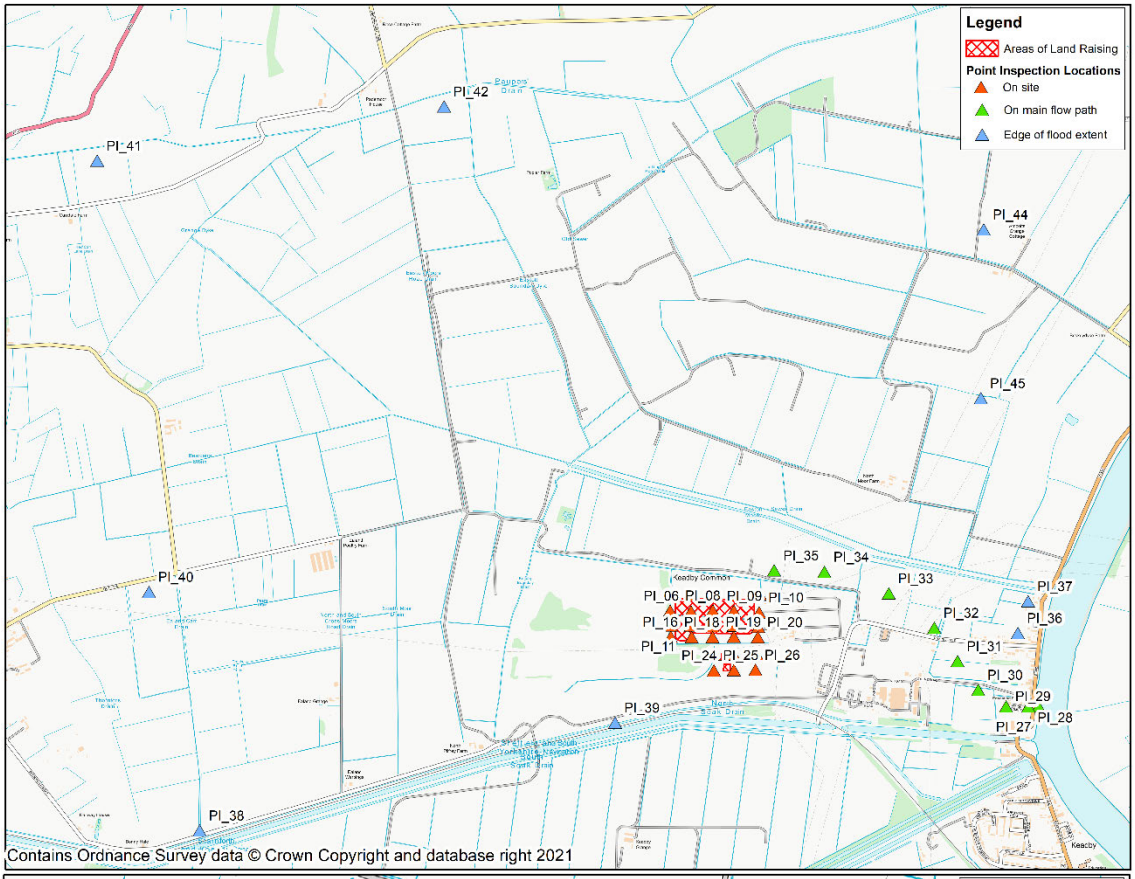
5.1.3 Results have determined that during the baseline scenario, the maximum water level at the Main Site/ Proposed PCC Site buildings is 2.41m AOD. This increases by 0.06m (60mm) to 2.47 m AOD following land raising for the Proposed Development platform. Flood waters are locally displaced by the Proposed Development platform. Results show that water levels increase by a maximum of 4mm (within the site boundary), with most results showing no increase in water levels at the edge of the maximum flood extents (Appendix C). As such, it is considered that the off-site impacts of the proposed land raising for the Proposed development platform are negligible.

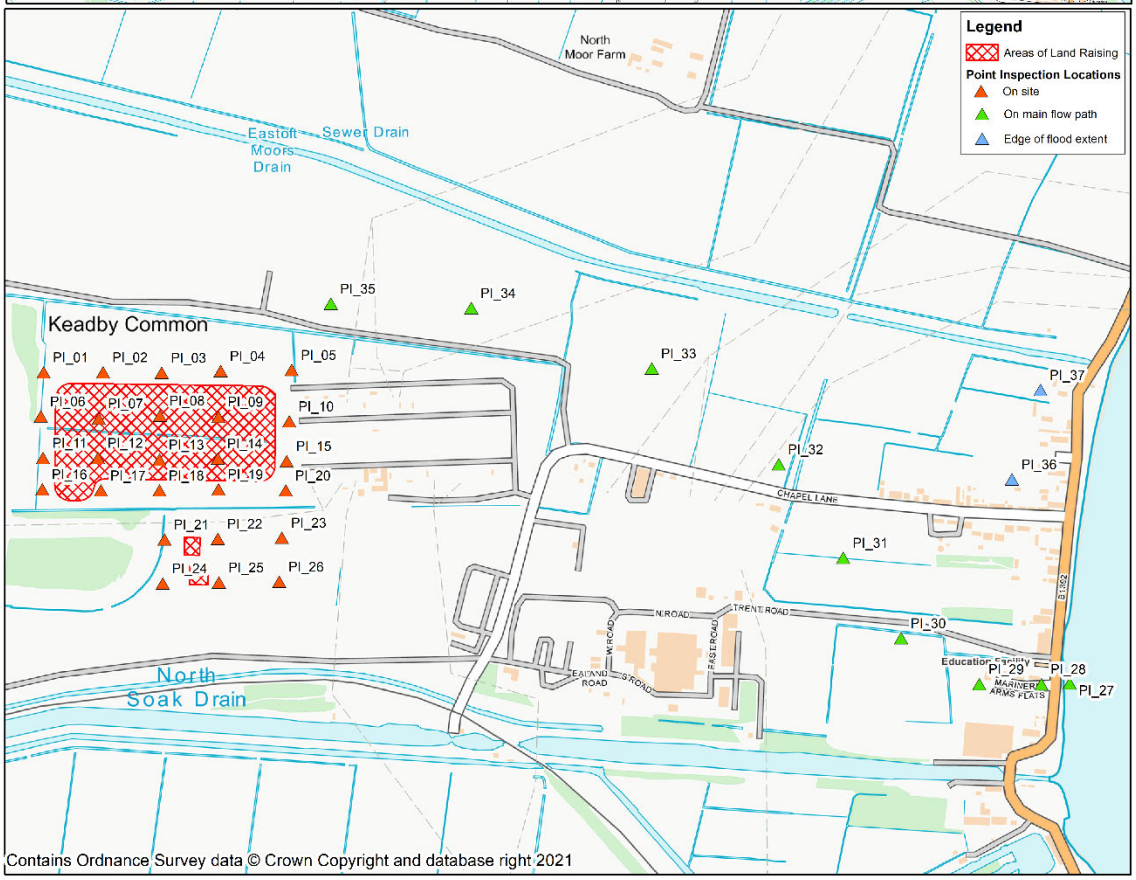
5.1.4 Sensitivity testing of the stage-time boundary using the HEWL has determined that water levels increase by 20mm and 60mm respectively in the H and HPP scenarios in comparison to the baseline scenario. This has determined that the model is not overly sensitive to the boundary condition, however the depth of flooding at the Proposed PCC Site is directly related to the water level in the Tidal Trent at the breach location. The HEWL HPP level will be used to inform proposed freeboard levels.

5.1.5 Sensitivity testing of Manning's n has determined that flood depth increases by 100mm when a Manning's n of 0.3 is used for buildings in comparison the value of 1.0 used in the baseline scenario. In addition, the depth variation compared to the baseline flood depths of 1.55m is <2% when all Manning's n values are increased and decreased by 20%. This has determined that the model is not overly sensitive to Manning's n. The sensitivity results will be used to inform the proposed development platform levels and freeboard.

Appendix A Environment Agency Model Review

Appendix B Locations of Point Inspection





Appendix C Point Inspection Results

On/near site (Water level mAOD)

Label	Baseline	Development	HEWL RP100 2071H	HEWL RP100 2071HPP	Mannings Buildings Sens	Mannings 1.2	Mannings 0.8	Breach closure test
PI_01	2.39	2.39	2.40	2.45	2.48	2.40	2.36	2.39
PI_02	2.39	2.39	2.41	2.45	2.48	2.40	2.36	2.39
PI_03	2.39	2.40	2.41	2.45	2.49	2.40	2.36	2.39
PI_04	2.40	2.41	2.42	2.46	2.49	2.41	2.37	2.40
PI_05	2.41	2.45	2.43	2.47	2.51	2.42	2.38	2.41
PI_06	2.39	2.40	2.41	2.45	2.49	2.40	2.36	2.39
PI_07	2.39	N/A	2.41	2.45	2.49	2.40	2.37	2.39
PI_08	2.40	N/A	2.41	2.45	2.49	2.40	2.37	2.40
PI_09	2.40	N/A	2.42	2.46	2.50	2.41	2.37	2.40
PI_10	2.41	2.48	2.43	2.47	2.51	2.42	2.38	2.41
PI_11	2.40	2.41	2.41	2.46	2.49	2.40	2.37	2.40
PI_12	2.40	N/A	2.41	2.46	2.49	2.40	2.37	2.40
PI_13	2.40	N/A	2.42	2.46	2.50	2.41	2.37	2.40
PI_14	2.40	N/A	2.42	2.46	2.50	2.41	2.37	2.40
PI_15	2.42	2.50	2.44	2.48	2.52	2.43	2.39	2.42
PI_16	2.40	2.41	2.41	2.46	2.49	2.41	2.37	2.40
PI_17	2.40	2.50	2.41	2.46	2.49	2.41	2.37	2.40
PI_18	2.40	2.50	2.42	2.46	2.50	2.41	2.37	2.40
PI_19	2.41	2.50	2.42	2.47	2.50	2.42	2.38	2.41
PI_20	2.43	2.51	2.44	2.49	2.53	2.44	2.39	2.43
PI_21	2.43	2.51	2.45	2.50	2.53	2.44	2.40	2.43
PI_22	2.44	2.51	2.45	2.50	2.54	2.44	2.41	2.44
PI_23	2.44	2.51	2.45	2.50	2.54	2.45	2.41	2.44
PI_24	2.44	2.51	2.45	2.50	2.54	2.45	2.41	2.44
PI_25	2.44	2.51	2.45	2.50	2.54	2.45	2.41	2.44
PI_26	2.44	2.51	2.46	2.50	2.54	2.45	2.41	2.44
Average	**2.41**	**2.47**	**2.43**	**2.47**	**2.51**	**2.42**	**2.38**	**2.41**

Along main flow path (Water level mAOD)

Label	Baseline	Development	HEWL RP100 2071H	HEWL RP100 2071HPP	Mannings Buildings Sens	Mannings 1.2	Mannings 0.8	Breach closure test
PI_28	5.46	5.46	5.49	5.55	5.28	5.47	5.46	5.46
PI_29	3.15	3.15	3.16	3.18	3.29	3.28	2.98	3.15
PI_30	2.86	2.86	2.87	2.91	2.91	2.92	2.77	2.86
PI_31	2.80	2.82	2.82	2.86	2.86	2.85	2.74	2.80
PI_32	2.67	2.69	2.68	2.72	2.76	2.70	2.61	2.67
PI_33	2.61	2.65	2.63	2.67	2.70	2.63	2.57	2.61
PI_34	2.47	2.51	2.48	2.53	2.57	2.48	2.43	2.47
PI_35	2.42	2.45	2.43	2.47	2.51	2.43	2.38	2.42

Around edge of flood extent (Water level mAOD)

Label	Baseline	Development	HEWL RP100 2071H	HEWL RP100 2071HPP	Mannings Buildings Sens	Mannings 1.2	Mannings 0.8	Breach closure test
PI_36	2.69	2.72	2.71	2.75	2.79	2.73	2.65	2.69
PI_37	2.69	2.72	2.71	2.75	2.79	2.73	2.65	2.69
PI_38	1.57	1.58	1.59	1.62	1.62	1.55	1.60	1.57
PI_39	2.48	2.51	2.49	2.51	2.53	2.48	2.48	2.48
PI_40	1.61	1.62	1.62	1.64	1.64	1.60	1.62	1.61
PI_41	1.41	1.41	1.43	1.49	1.47	1.38	1.43	1.38
PI_42	1.40	1.41	1.43	1.49	1.47	1.37	1.43	1.36
PI_43	1.40	1.40	1.42	1.48	1.47	1.37	1.42	1.35
PI_44	1.40	1.40	1.42	1.49	1.47	1.37	1.42	1.35
PI_45	1.40	1.40	1.42	1.49	1.47	1.37	1.42	1.34

On/near site (Depth mAOD)

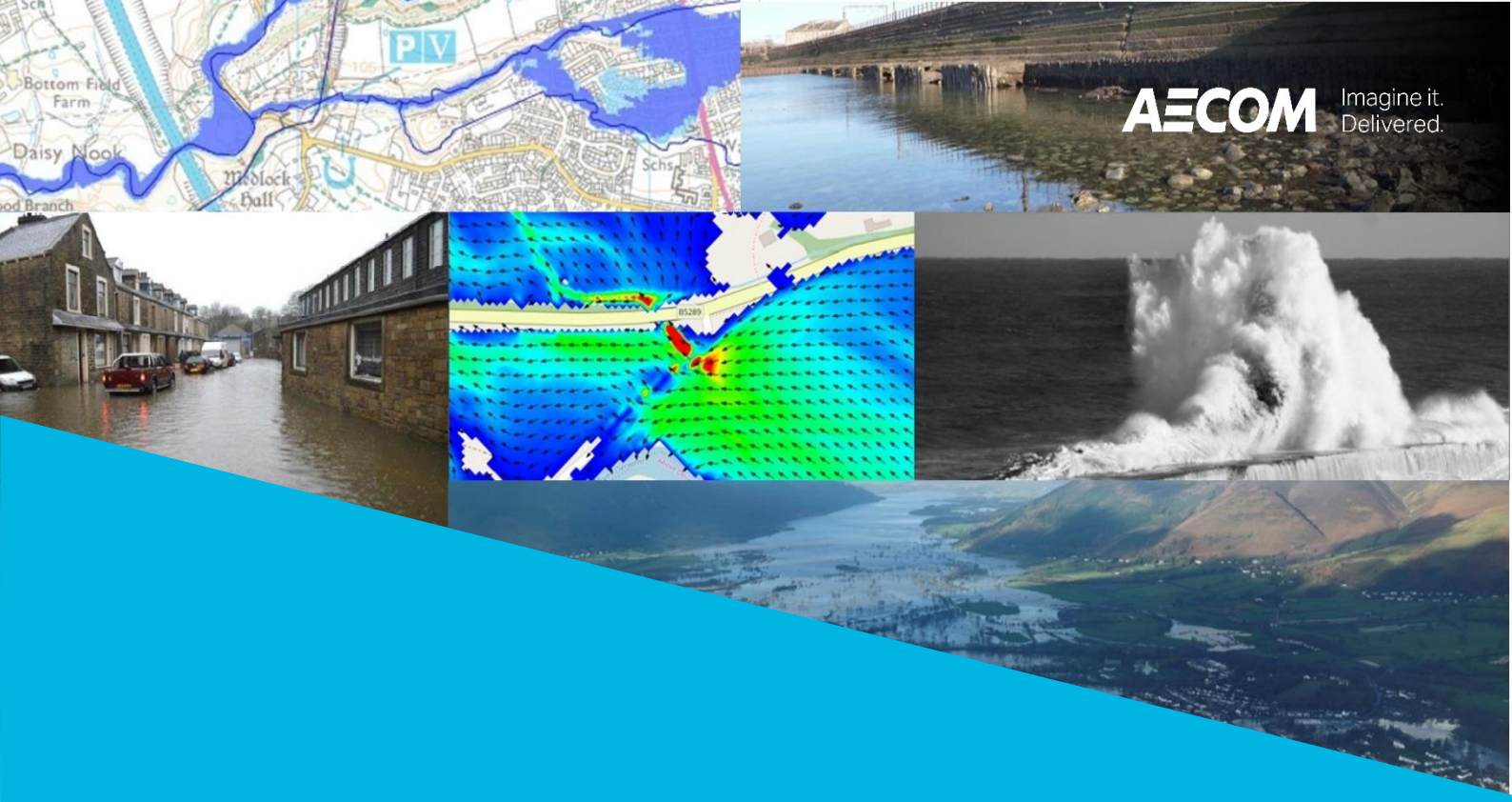
Label	**Baseline**	**Development**	**HEWL RP100 2071H**	**HEWL RP100 2071HPP**	**Mannings Buildings Sens**	**Mannings 1.2**	**Mannings 0.8**	Breach closure test
PI_01	1.81	1.82	1.83	1.87	1.91	1.82	1.78	1.81
PI_02	1.56	1.56	1.58	1.62	1.65	1.57	1.53	1.56
PI_03	1.84	1.85	1.86	1.90	1.94	1.85	1.81	1.84
PI_04	1.66	1.67	1.67	1.72	1.75	1.67	1.63	1.66
PI_05	1.79	1.83	1.81	1.85	1.89	1.80	1.76	1.79
PI_06	1.57	1.57	1.58	1.62	1.66	1.57	1.54	1.57
PI_07	1.83	N/A	1.85	1.89	1.93	1.84	1.80	1.83
PI_08	1.57	N/A	1.59	1.63	1.67	1.58	1.54	1.57
PI_09	1.66	N/A	1.67	1.72	1.76	1.67	1.63	1.66
PI_10	1.23	1.30	1.25	1.29	1.33	1.24	1.20	1.23
PI_11	1.69	1.70	1.71	1.75	1.79	1.70	1.67	1.69
PI_12	1.63	N/A	1.65	1.69	1.73	1.64	1.60	1.63
PI_13	1.58	N/A	1.60	1.64	1.68	1.59	1.55	1.58
PI_14	1.50	N/A	1.51	1.56	1.59	1.51	1.47	1.50
PI_15	1.79	1.87	1.81	1.86	1.89	1.80	1.76	1.79
PI_16	1.66	1.67	1.67	1.72	1.76	1.67	1.63	1.66
PI_17	1.86	1.96	1.88	1.92	1.96	1.87	1.83	1.86
PI_18	1.68	1.78	1.69	1.74	1.77	1.69	1.65	1.68
PI_19	0.83	0.92	0.84	0.89	0.92	0.84	0.80	0.83
PI_20	1.74	1.82	1.76	1.80	1.84	1.75	1.71	1.74
PI_21	1.19	1.27	1.21	1.25	1.29	1.20	1.16	1.19
PI_22	1.35	1.43	1.37	1.41	1.45	1.36	1.32	1.35
PI_23	1.53	1.61	1.55	1.60	1.63	1.54	1.50	1.53
PI_24	1.21	1.29	1.23	1.27	1.31	1.22	1.18	1.21
PI_25	1.27	1.34	1.28	1.33	1.37	1.28	1.24	1.27
PI_26	1.13	1.20	1.15	1.19	1.23	1.14	1.10	1.13
Average	**1.545**	**1.572**	**1.561**	**1.605**	**1.642**	**1.554**	**1.514**	**1.545**

Along main flow path (Depth mAOD)

Label	Baseline	Development	HEWL RP100 2071H	HEWL RP100 2071HPP	Mannings Buildings Sens	Mannings 1.2	Mannings 0.8	Breach closure test
PI_28	2.66	2.66	2.68	2.75	2.48	2.67	2.66	2.66
PI_29	1.19	1.19	1.20	1.23	1.33	1.32	1.02	1.19
PI_30	2.33	2.34	2.35	2.39	2.39	2.39	2.25	2.33
PI_31	2.46	2.48	2.47	2.52	2.52	2.51	2.40	2.46
PI_32	2.01	2.03	2.02	2.06	2.10	2.04	1.95	2.01
PI_33	2.26	2.29	2.27	2.31	2.35	2.28	2.21	2.26
PI_34	1.64	1.68	1.66	1.70	1.74	1.66	1.60	1.64
PI_35	1.58	1.61	1.59	1.64	1.68	1.59	1.54	1.58

Around edge of flood extent (Depth mAOD)

Label	Baseline	Development	HEWL RP100 2071H	HEWL RP100 2071HPP	Mannings Buildings Sens	Mannings 1.2	Mannings 0.8	Breach closure test
PI_36	0.45	0.48	0.47	0.51	0.55	0.49	0.41	0.45
PI_37	0.70	0.72	0.71	0.75	0.79	0.73	0.65	0.70
PI_38	0.01	0.02	0.02	0.03	0.03	0	0.02	0.01
PI_39	0.85	0.88	0.86	0.88	0.90	0.85	0.85	0.85
PI_40	0.16	0.16	0.16	0.18	0.18	0.15	0.17	0.16
PI_41	0.84	0.84	0.86	0.92	0.90	0.81	0.86	0.82
PI_42	0.73	0.73	0.75	0.81	0.79	0.70	0.75	0.69
PI_43	0.56	0.57	0.59	0.65	0.63	0.53	0.59	0.51
PI_44	0.36	0.36	0.38	0.44	0.43	0.33	0.38	0.31
PI_45	0.15	0.15	0.17	0.24	0.22	0.12	0.17	0.09



Keadby 3 Power Station

Breach Modelling Report

SSE Ltd

60625943

27th April 2021

Quality information

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Revision History

Revision	Revision date	Details	Authorized	Name	Position

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Document overview

AECOM has been commissioned by SSE Ltd to prepare a Flood Risk Assessment (FRA) in support of a Development Consent Order (DCO) application for a proposed low carbon gas fired generating station on the Keady Power Station site at Keadby, Scunthorpe DN17 3EF. As part of the FRA, hydraulic modelling has been carried out in order to assess the risk to the proposed development from a breach in the River Trent tidal defences.

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Table of Contents

Figures

Tables

1 Introduction

AECOM has been commissioned to prepare a Flood Risk Assessment (FRA) in support of a Development Consent Order (DCO) application for a proposed low carbon gas fired generating station on the Keady Power Station site at Keadby, Scunthorpe DN17 3EF. As part of the FRA, hydraulic modelling has been carried out in order to assess the risk to the proposed development from a breach in the River Trent tidal defences. This document presents the approach taken.

1.1 Site Overview

The Keadby Power Station Site centred on national grid reference (NGR) 482351, 411796 encompasses an area of approximately 88.1ha, of which approximately 17.7ha of land is currently under evaluation to determine the suitability for potential construction laydown. The site currently encompasses the operational Keadby 1 Power Station (decommissioned) and Keadby 2 Power Station (under construction). The Keadby 3 development site is proposed to be to the west of these (Figure 1-1).

The Site is bordered by the tidal River Trent to the east, by Stainforth and Keadby Canal to the south, by agricultural land and Keadby Wind Farm to the north, and by the former Keadby Ash Tip and scrubland to the west. The Proposed Development Site is surrounded on all sides by numerous drains including the Keadby Boundary Drain and North and South Soak Drains. Tidal defences on the River Trent bordering the site are approximately 6.2m AOD.

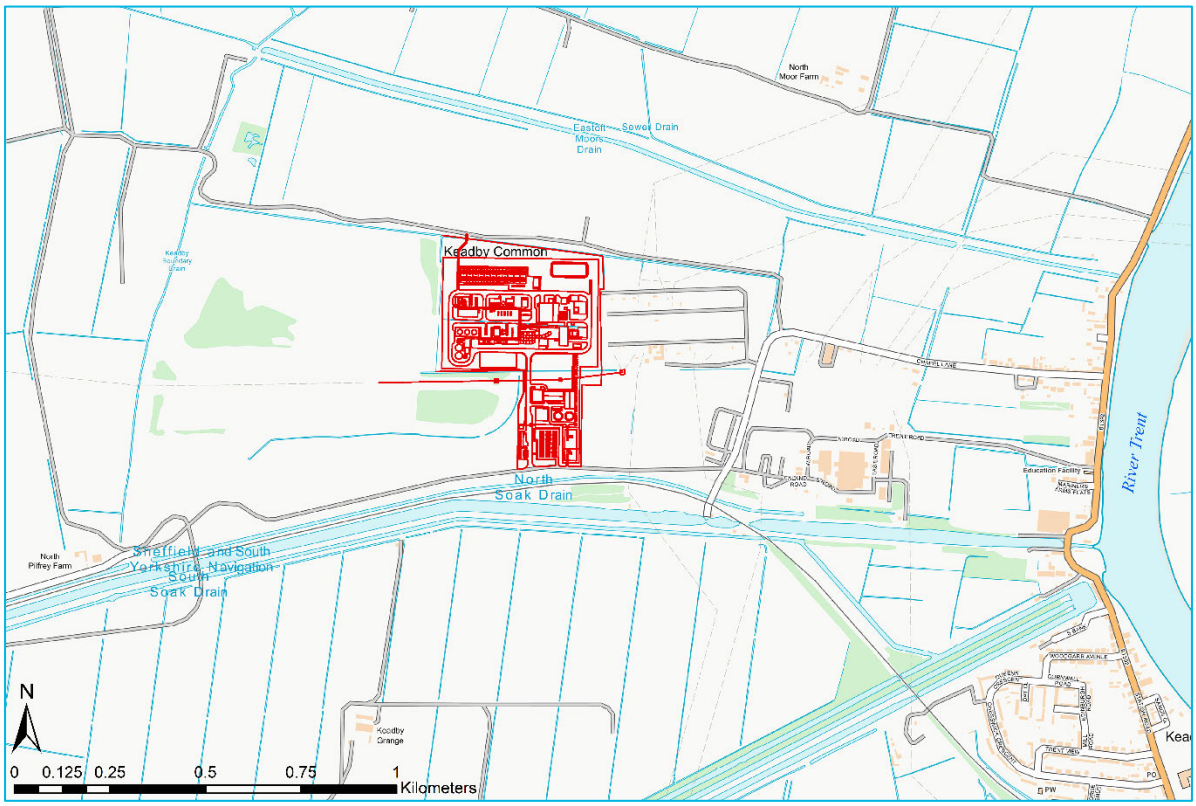


Figure 1-1 Indicative Site Layout in red

1.2 Data Review

Table 1-1 outlines the data sources used in this study. Further detail on several of these sources is given in the following sections.

Table 1-1 Data sources

Data source	Description
LiDAR data	LiDAR DTM data was sourced freely, the 2019 1m DTM is used.
Hydrologic data	Level time hydrographs to be used as boundary conditions for breach modelling were provided by the Environment Agency from the 2014 Tidal Trent hydraulic model (defended scenario).
EA Asset Register Data	Defence heights on the River Trent were provided by the EA. Further information on this can be found in Appendix A.

1.2.1 LiDAR Data

LIDAR data (2019 1m DTM composite) has been obtained from data.gov.uk (Figure 1-2). This was used to understand and represent the topography of the land at and surrounding the study site.

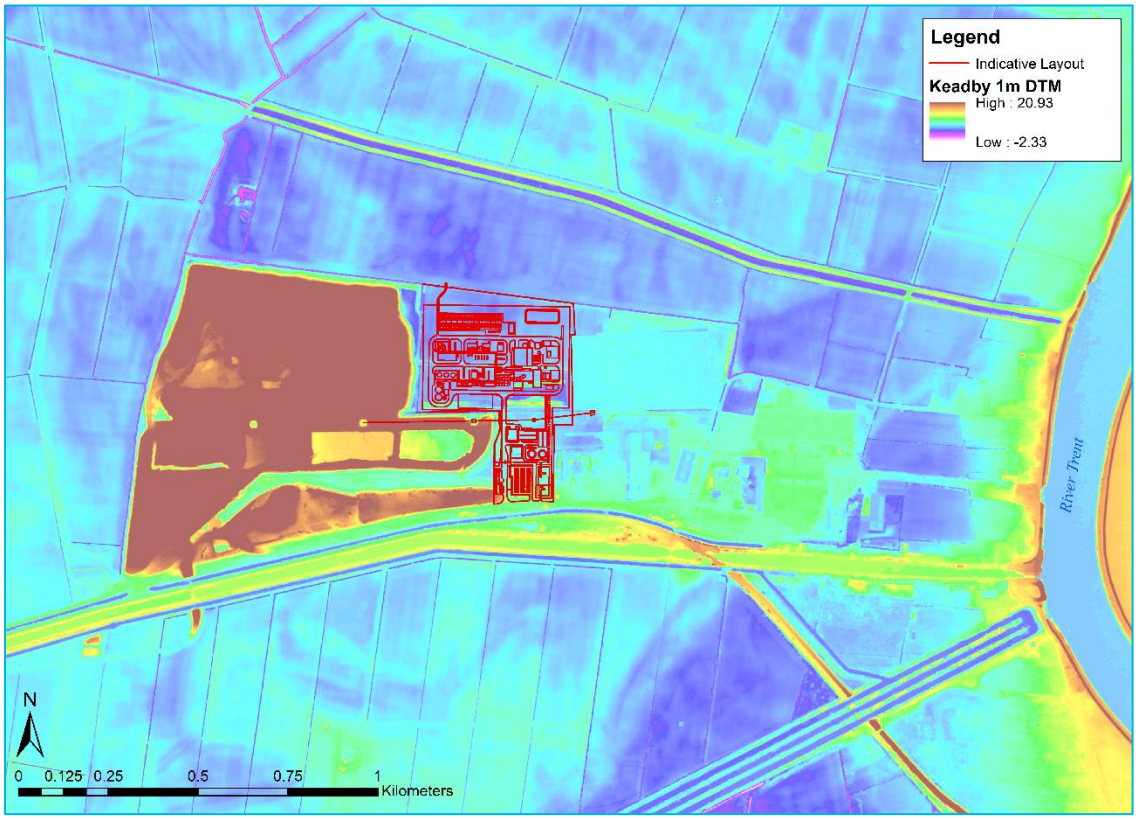


Figure 1-2. LiDAR obtained from data.gov.uk

2 Hydraulic Modelling

2.1 Model Schematisation

A new 2D hydraulic model has been developed in this project, using TUFLOW software (version 2020-10-AA-iSP-w64). This was a HPC-GPU model with sub-grid sampling. The approach to model development is summarised in the following paragraphs.

2.1.1 Model Development

A TUFLOW 2D domain has been created to represent the floodplain and tidal defences on the west bank of the River Trent at the breach location. Ground levels in the 2D model have been set using the 2019 DTM LIDAR composite and 2D hydraulic roughness values are linked to OS mapping feature codes and set based on published values and previous examples as shown in Table 2-1.

Table 2-1 Land use type and associated Manning's n coefficient in the 2D model

Land use	Material number	Manning's n coefficient
Road	10172	0.02
Buildings	10021	1
Tidal Water	10210	0.035

The breach location was determined through analysis of LIDAR and the defence heights provided by the Environment Agency (Appendix A). The breach location was placed in close proximity to the power station where embankments are at a level of 6.2m AOD; the lowest along this section of river bank (Figure 2-3).

Several refinements were made to the topography using 2D Z lines. A Z line was applied which raised land to 10m AOD at the breach location. This was to ensure that the inflow did not flow backwards towards the Trent following the breach. A 2D Z line was added to the south west of the breach location to reinforce the bank heights (5m AOD) of the embankment along the Three Rivers.

A 2D variable Z shape was used to set a trigger level for the breach. As recommended in the Environment Agency Breach of Defences Guidance for a river or 'non wave' tidal situation, the breach was set to occur when water level reached ¾ of the defence height. Using a datum of 2.8m AOD from LiDAR at the toe of the defences, and a defence height of 6.2m AOD, the trigger level was set to 5.35m AOD. At the time of breach, the variable Z shape is set to reduce elevation in front of the breach location to 2.8m AOD. Also using Table 2 from the Environment Agency Breach of Defences Guidance (Figure 2-1), the breach width was 50m and was set to be open for 30 hours.

This model setup is demonstrated by Figure 2-2 and Figure 2-3.

Source	Defence Type	Breach Width (m)	Time to close – urban (hrs)	Time to close – rural (hrs)
Estuary/Tidal River	Earth Bank	50	30	30
	Reinforced Concrete	20	18	18
Open Coast	Earth Bank	200	44	56
	Earth Bank with facing	100	44	56
	Dunes	100	44	56
	Shingle Bank	100	30	30
	Reinforced Concrete	50	18	30
River	Earth Bank	40	30	56
	Reinforced Concrete	20	18	18
Tidal/Coastal	Tidal Gates	Gate width	Gates fail on low tide preceding the peak level with emergency closure effected during the following low tide	

Figure 2-1 Recommended breach parameters to be applied for different types of defences

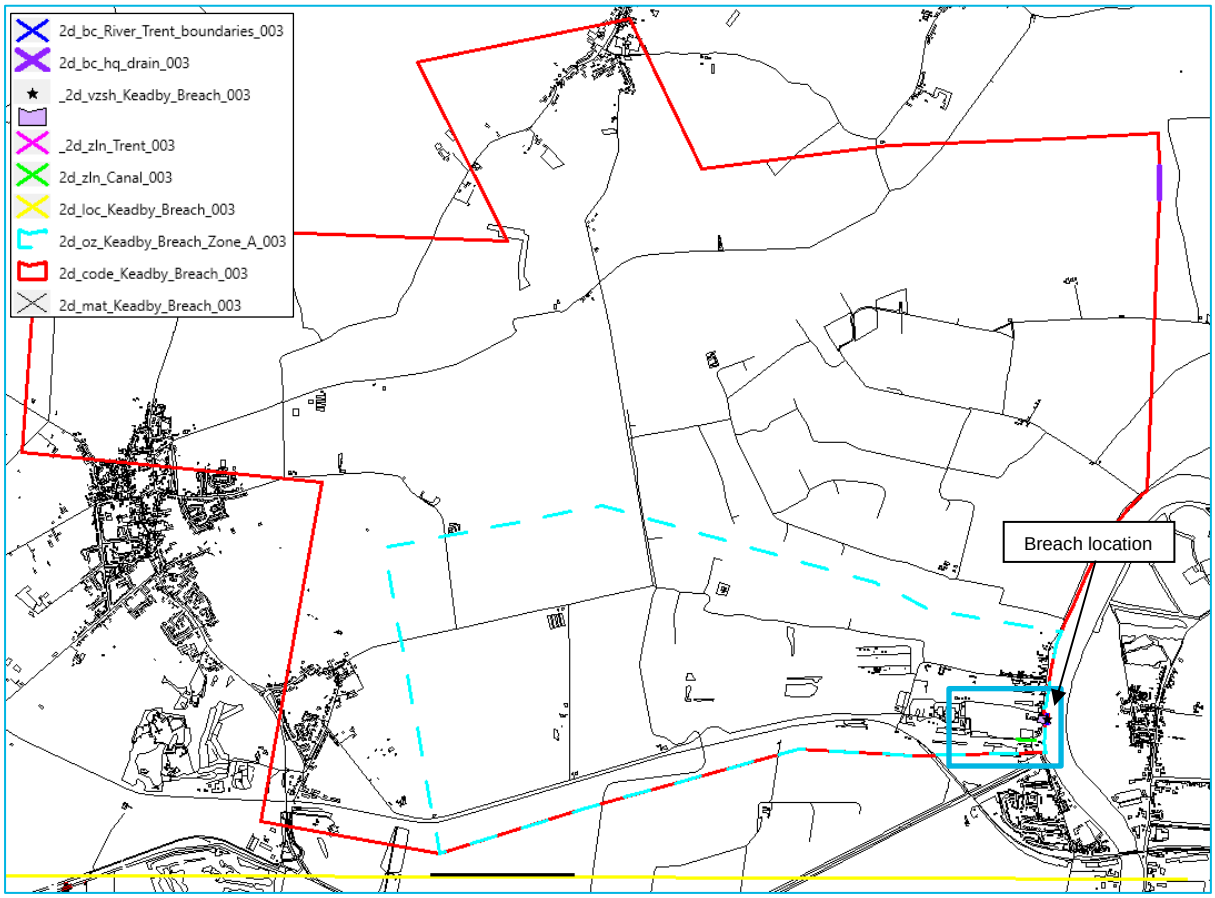


Figure 2-2 TUFLOW Model setup. Inset below.

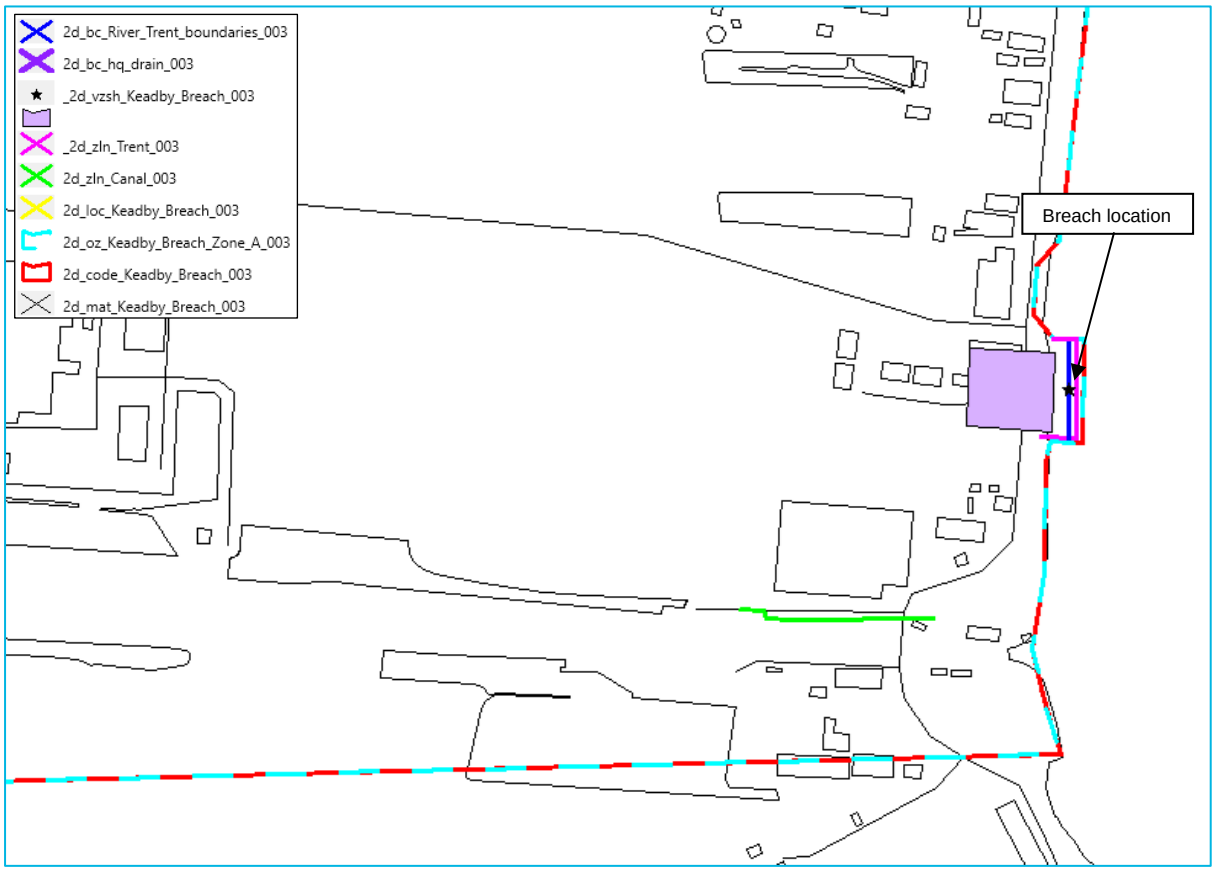


Figure 2-3 Model set up around breach location

2.1.2 Development Scenario

A 2D Z shape was used to represent the elevation of the development site following construction. This land was raised to 2.5m AOD which is based on the elevation of the breach flood waters at the site +300mm freeboard. This would determine whether land raising for the construction of the power station would impact or worsen flooding elsewhere in proximity to the site. The areas raised (main power plant, control room and admin building) are shown in Figure 2-4.

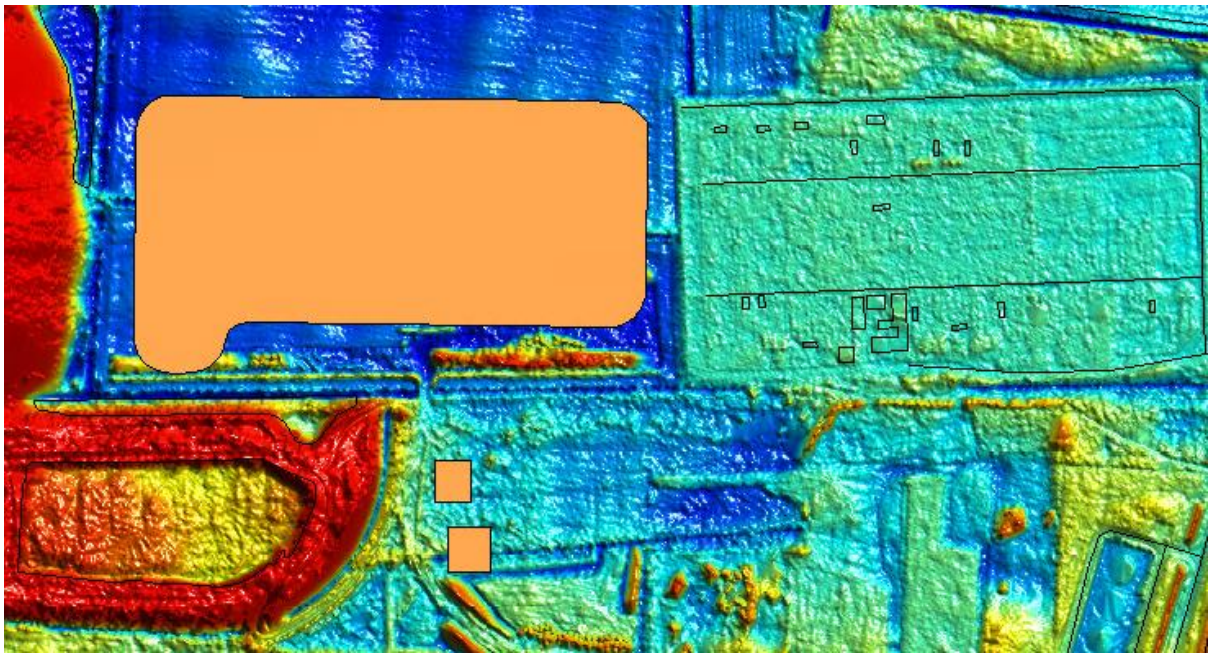


Figure 2-4 Location of Z shape land raising shown in orange

2.2 Model Structure and Naming Convention

Model files are organised within a standard folder structure as shown in Table 2-2.

Table 2-2: Flood Modeller folder structure

Folder	Sub-Folder	Contents
TUFLOW	checks	TUFLOW check files
	bc_dbase	TUFLOW boundary conditions
	model	TUFLOW boundary control file (tbc), geometry control file (tgc) and materials file (tmf), ground model (i.e. LIDAR DTM) and all GIS layers forming part of the TUFLOW model
	runs	TUFLOW control files (tcf), log files (tlf) and diagnostic messages files
	results	TUFLOW results files (2dm, xmdf, asc, mass balance, csv etc.)

2.3 Model Boundaries

The critical boundary condition required for the breach model is water level in the River Trent at the location of the breach in defences. At this location there is a combined fluvial and tidal influence on the levels in the River Trent. The Environment Agency provided model results from the Updated Tidal Trent SFRM Model (Mott MacDonald 2013, including updated 2014 interim water levels) for several scenarios for use in this breach modelling.

Figure 2-5 shows the results of the Environment Agency updated Tidal Trent SFRM Model at node Trent14600DS, closest to the breach location chosen for this modelling. The scenario chosen for use in this breach modelling is a combination of a 2 year (50% AEP) fluvial event and a 200 year (0.5% AEP) tidal surge event, including an allowance for climate change. The documentation provided by the Environment Agency with the model data does not explicitly state what the climate change uplift was and how this has been applied in the model but it is assumed that this has previously been approved by the Environment Agency, prior to these model results being released for use in third party modelling. The maximum level reached in this combined scenario, at this model node, is 6.23m AOD and the breach trigger level of 5.35m AOD is exceeded on 3 high tides (including at the peak of the event).

It is noted that climate change guidance for modelling and flood risk assessment has been updated since the 2013/14 SFRM model and that extreme tidal surge levels in the Humber Estuary have also been revised since that modelling was undertaken. Extreme water levels for the Humber Estuary were requested from the Environment Agency in March 2021 but have not been received at the time of writing this Modelling Report. Given the complex mechanisms within the Humber Estuary and the fluvial and tidal interactions in this reach of the River Trent, it would not be possible for AECOM to derive updated climate change levels at this breach location without undertaking joint fluvial and tidal modelling of the Tidal Trent. Undertaking new combined fluvial and tidal event modelling on the Tidal Trent to derive new boundary conditions for this breach assessment would be beyond the scope of this FRA. It is understood that the Environment Agency have another modelling and mapping project underway to update the Tidal Trent model but the outputs of that project would not be available within the time frame of this FRA.

The Environment Agency also requested that the breach risk was assessed for a 100 year (1% AEP) fluvial event, including an allowance for climate change. The breach model has therefore also been run for this scenario (combined with a 5 year (% AEP) tidal surge event), but as shown in Figure 2-5 the levels in this scenario are lower and a breach event during this scenario would not pose as greater risk to the power station site as in a 200 year tidal surge event. Therefore, it was considered more appropriate to assess risk in the higher 200-year tidal surge event. However, this event was still run for completeness.

Previous breach modelling undertaken by Wallingford HydroSolutions that has been used in earlier versions of the Keadby 3 FRA and Keadby 2 FRA also used the combined scenario of a 2 year (50% AEP) fluvial event and a 200 year (0.5% AEP) tidal surge event.

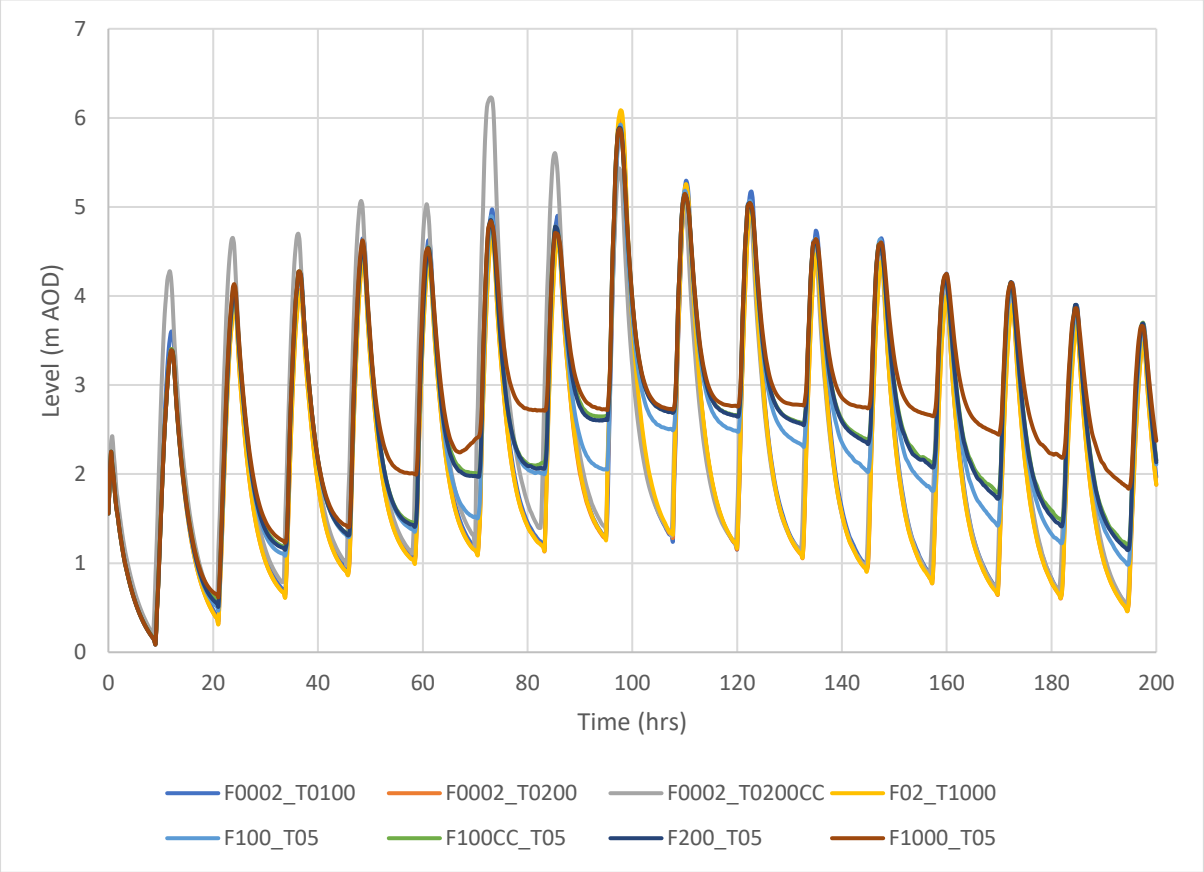


Figure 2-5 Level time hydrographs from the tidal Trent model at node Trent14600DS

The inflow (level time hydrograph) supplied from the Tidal Trent model was applied as a HT boundary across the 2d_bc_River_Trent_boundaries layer.

As early model results showed that flooding was reaching the edge of the 2D domain on a drain in the north east corner, a HQ boundary was applied here to avoid any glass walling (Figure 2-2). The gradient was set to that of the drain where the waters were reaching the edge of the domain (0.001m/m).

2.4 Model Outputs

The models were set up to generate the following outputs:

- TUFLOW map outputs (xmdf format) including depth (d), water level (h), velocity (v), unit flow (q), mass balance (MB1) and hazard (ZUK0). Map outputs were generated at 5-minute intervals for an output zone focused around the site and at 10-minute intervals for the wider model to allow the results to be animated while keeping results files to a manageable size.
- TUFLOW grid outputs (ASCII format) generated for peak depth, water level, velocity, unit flow and hazard.
- TUFLOW mass balance output and other standard diagnostic and log files.

3 Model Runs

The following scenarios were modelled in Flood Modeller (Table 3-1).

Table 3-1 Modelling scenarios in Flood Modeller

Modelling Scenario	TUFLOW files (tcf)	Description
Baseline F02 T200CC	Keadby_Breach_F02-T200CC_Breach_003.tcf	200-year tidal event plus climate change combined with a 2-year fluvial event pre-construction
Baseline F100CC T05	Keadby_Breach_F100CC-T05_Breach_003.tcf	100-year fluvial event plus climate change combined with a 5-year tide event pre-construction
Development Scenario F02 T200CC	Keadby_Breach_F02-T200CC_Dev_Breach_003.tcf	200-year tidal event plus climate change combined with a 2-year fluvial event post power station construction
Development Scenario F100CC T05	Keadby_Breach_F100CC-T05_Dev_Breach_003.tcf	100-year fluvial event plus climate change combined with a 5-year tide event post power station construction

Following examination of the provided Tidal Trent level hydrographs, it was determined that the 200-year tidal event plus climate change combined with a 2-year fluvial event would have the worst impact on the development site as there was three tidal peaks that were above the trigger value of 5.35m AOD.

The models were set to start at the low tide prior to the first time the breach trigger value would be reached and run for approximately 60 hours.

It should be noted that it is not possible to assign a probability to the likelihood of a breach occurring in the Tidal Trent defences at this location. The modelling and results shown here demonstrate the potential impacts of a breach in the defences occurring during a combined fluvial and tidal event on the River Trent at Keadby, for two different combinations of events. There is no history of breach flooding at this location.

4 Results

Maximum water level, depth and velocity results are presented below for the worst-case breach scenario modelled – the 200-year tidal event plus climate change combined with a 2-year fluvial event.

The maximum water level grid generated from the TUFLOW modelling output demonstrates that baseline water level at the development is approximately 2.20m AOD. This remains unchanged around the site following land raising, however, the raised platform is now above the breach water level. No figure is presented as the water level remains flat across the site and surrounding area.

Figure 4-1 and Figure 4-2 demonstrate maximum depth grids generated from the TUFLOW modelling output files. The baseline model demonstrates that prior to any land raising, the majority of the site is subject to flood depths between 1.0-2.0 m. Following land raising of the necessary site components above the baseline breach water level, these areas are no longer flooded. On the agricultural land to the east of the development site, the area of flooding in the 1.0-2.0 m depth band increases a small amount from an area of approximately 0.007km² to 0.015km², however flood depth around the Keadby 2 Power Station and village is not worsened.

Figure 4-3 and Figure 4-4 demonstrate the maximum velocity grids generated from the TUFLOW modelling output files. The highest velocities are located closest to the breach location. The baseline results demonstrate that floodwaters flow across the site in a westerly direction with velocities up to 1m/s. Following land raising, the flood waters are directed in both a northerly and southerly direction around the raised platform. Velocities remain at 0.3-1.0m/s surrounding the raised areas of the site with the exception of a small area at the southern boundary of the main site where velocity increases to 1.57m/s following diversion around the raised platform. However, this is a very small area affected, and the larger area surrounding the site and village remains unaffected.

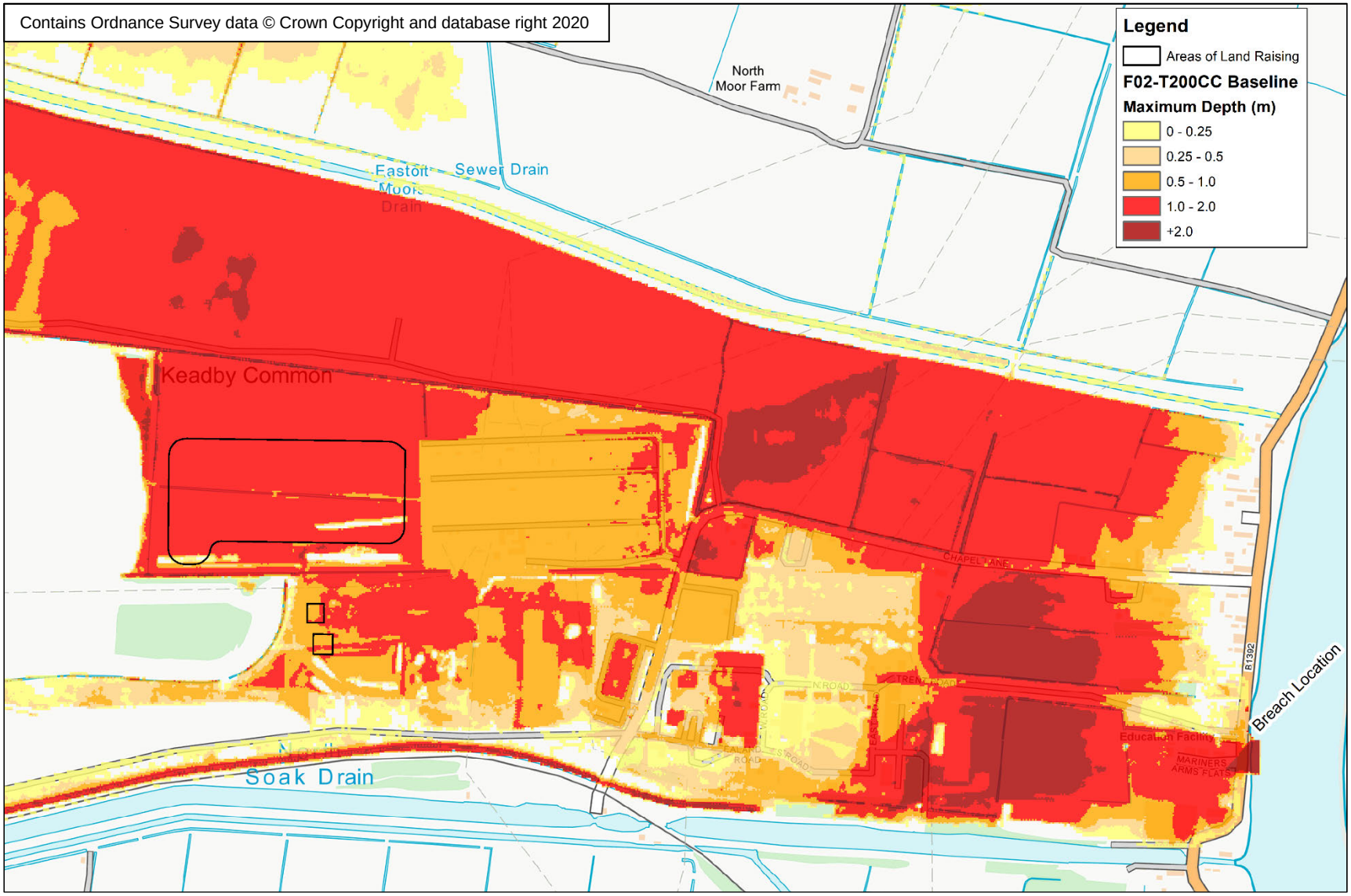


Figure 4-1 Maximum depth of inundation (defence breach, 200y tidal event with CC combined with 2y fluvial event) - Baseline

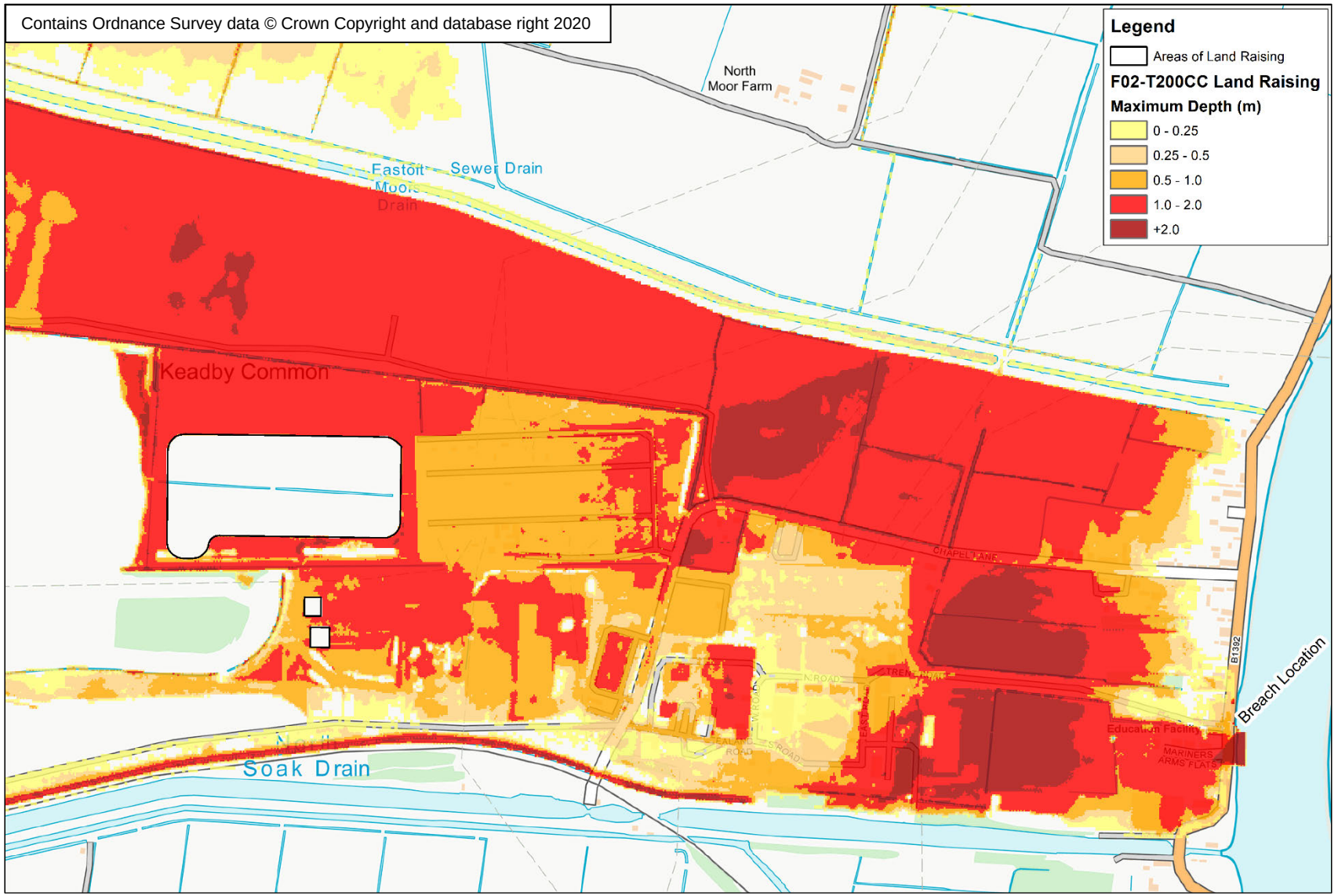


Figure 4-2 Maximum depth of inundation (defence breach, 200y tidal event with CC combined with 2y fluvial event) – with development raised

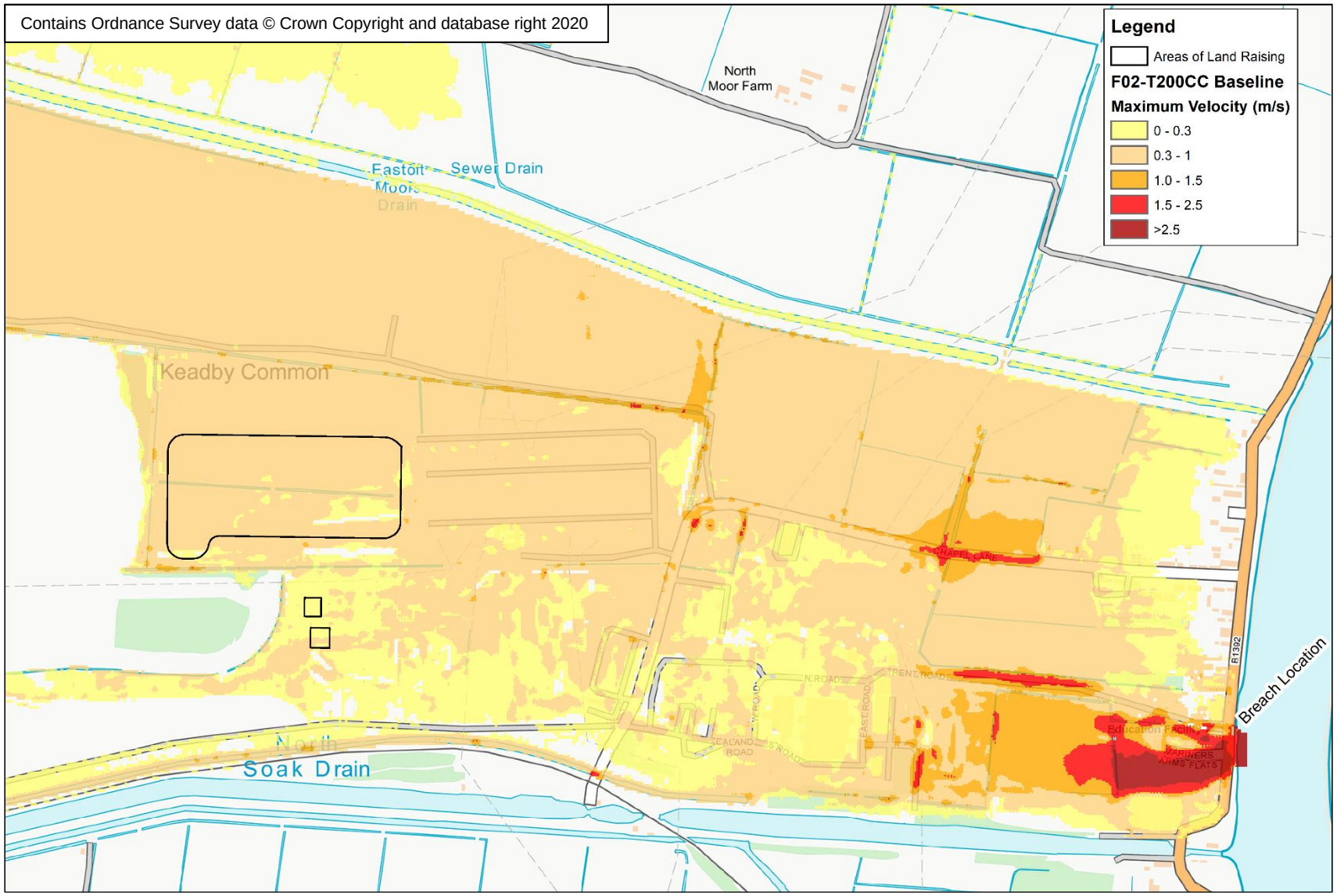


Figure 4-3 Maximum velocity of flood water (defence breach, 200y tidal event with CC combined with 2y fluvial event) - Baseline

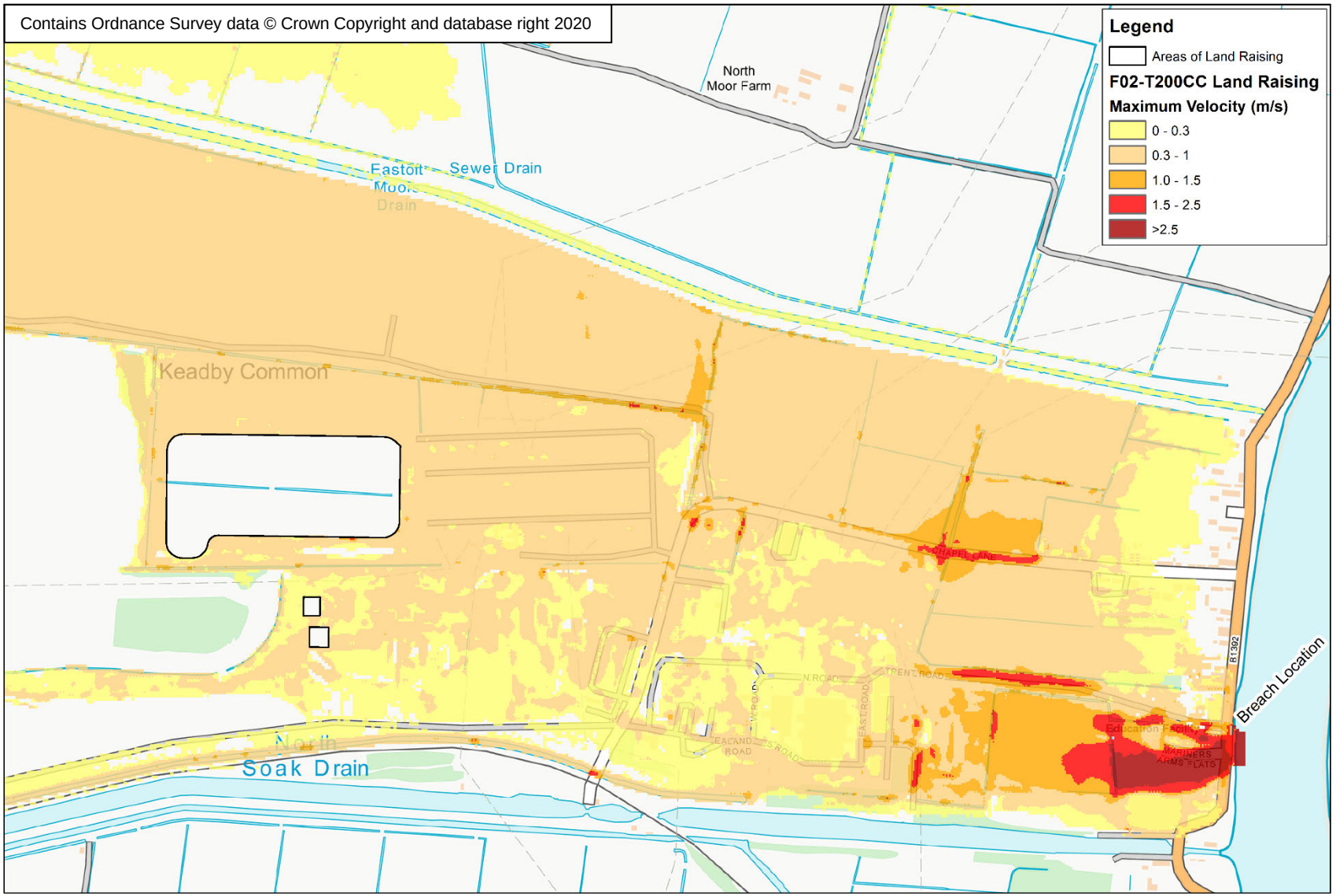


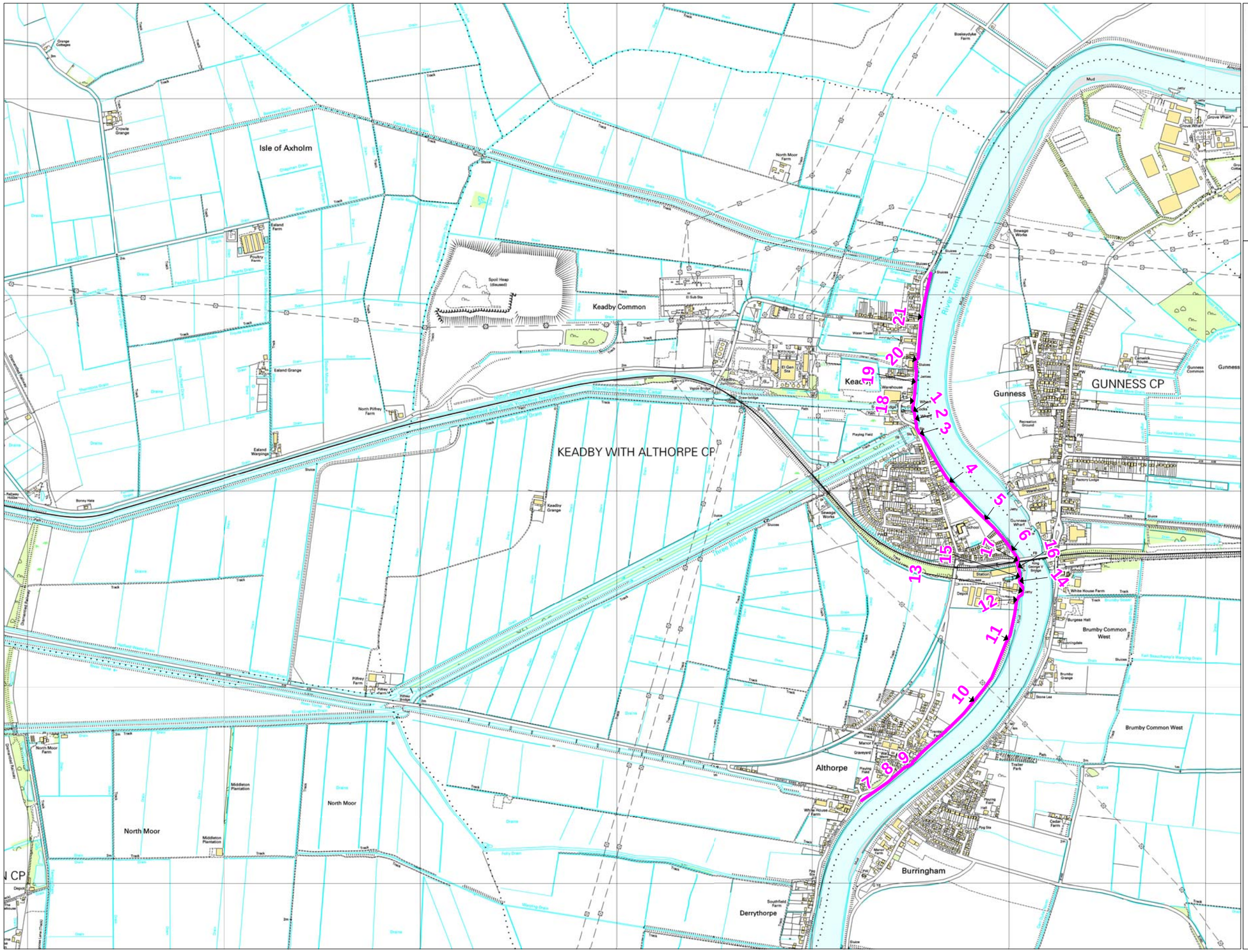
Figure 4-4 Maximum velocity of flood water (defence breach, 200y tidal event with CC combined with 2y fluvial event) – with development raised

Appendix A Trent Defence Heights

Defence Information

Defence ID	Asset Reference	Design Standard	D/S Crest Level (mAOD)	U/S Crest Level (mAOD)	Overall Condition Grade
1	23,792	100	6.2	6.2	2
2	24,834	100	6.2	6.2	3
3	23,793	100	6.2	6.2	2
4	24,285	100	6.32	6.32	3
5	24,835	100	6.2	6.2	3
6	23,593	100	6.2	6.2	2
7	77,608	100	6.4	6.4	1
8	50,711	100	6.4	6.4	2
9	22,642	100	6.4	6.4	3
10	23,881	100	6.4	6.4	2
11	23,880	100	6.46	6.46	3
12	22,641	100	6.4	6.4	3
13	23,879	100	6.4	6.4	3
14	51,435	100	6.4	6.4	2
15	22,091	100	6.4	6.4	3
16	22,090	100	6.4	6.4	3
17	51,393	100	6.2	6.2	2
18	24,833	100	6.2	6.2	3
19	23,791	100	6.3	6.3	3
20	23,790	100	6.25	6.25	3
21	51,392	100	6.3	6.3	2

Flood Defence Map centred on Keadby Power Station - created 25 August 2020 Ref: [EMD178614]



Environment Agency

Scale 1:20,000

N
W E
S

Legend

Flood Defence Locations

A Strategic Flood Risk Assessment may be available, providing further information for this site. Please contact your Local Planning Authority to access this information as it will need to be considered within any Flood Risk Assessment submission.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk