Steel House Flood Risk Assessment

Final Report

January 2021

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Revision History

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Contract

This report describes work commissioned by John McNicholas, on behalf of South Tees Site Company, by an email dated 30 October 2020. South Tees Site Company's representative for the contract was John McNicholas of South Tees Site Company. Alice Gent, Heather Kerr, Joy Kean, Samantha Cogan and René Dobson of JBA Consulting carried out this work.

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Purpose

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Acknowledgements

JBA wishes to thank Redcar and Cleveland Council and the Environment Agency for supply for flood history records.

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Abbreviations

AEP	Annual Exceedance Probability
ALTBAR	Mean catchment altitude (m above sea level)
ASCII	American standard character set for information interchange
BFIHOST	Base Flow Index estimated from soil type
BGS	British Geological Survey
DEFRA	Department of the Environment, Food and Rural Affairs (formerly MAFF)
DPLBAR	Index describing catchment size and drainage path configuration
DPSBAR	FEH index of mean drainage path slope
DTM	Digital Terrain Model
EA	Environment Agency
EIA	Environmental Impact Assessment
FARL	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
FRA	Flood Risk Assessment
LiDAR	Light Detection And Ranging
mAOD	metres Above Ordnance Datum
NGR	National Grid Reference
NPPF	National Planning Policy Framework
OS	Ordnance Survey
OS NGR	Ordnance Survey National Grid Reference
PDF	Portable Document Format
PPG	Planning Policy Guidance
PROPWET	FEH index of proportion of time that soil is wet
Ramsar	The intergovernmental Convention on Wetlands, signed in Ramsar, Iran, in 1971
SAAR	Standard Average Annual Rainfall (mm)
SFRA	Strategic Flood Risk Assessment
SPRHOST	Standard percentage runoff estimated from soil type
SSSI	Site of Special Scientific Interest

Definitions

FARL	Flood Attenuation by Reservoirs or Lakes. This provides a guide to the degree of flood attenuation by reservoirs or lakes in the catchment which will have effect on flood response. A value of 1 indicates no attenuation, whereas 0.8 and under indicates substantial attenuation.

1 Introduction

1.1 Scope of Works

The South Tees Development Corporation (STDC) commissioned JBA Consulting on 30 October 2020 to prepare the Water Management and Flooding chapter of the Environmental Impact Assessment (EIA) for the outline planning application for one of the sites within the STDC area on the south bank of the River Tees, near Redcar. The chapter will comprise an assessment of water management and flooding, as well as examining drainage and hydrogeology.

This Flood Risk Assessment (FRA) study has been undertaken to provide details that inform the Water Management and Flooding chapter. The study is necessary to meet the requirements of the National Planning Policy Framework[1] (NPPF) and to support the outline planning application in relation to assessing flood risk.

This FRA will comprise the following:

- Data review – including:
  - Request for flood records from Redcar and Cleveland Council and the Environment Agency,
  - Review of Phase 1 Data Collection and Baseline Assessment report for the wider STDC development,
- Review of baseline risk for water management and flooding and assess the impacts of the proposed development,
- Discuss flood, surface water and groundwater receptors and identify appropriate mitigation and enhancement measures,
- Assess impacts of proposed development.

1.2 Reporting Guidelines and Legislation Context

This Flood Risk Assessment (FRA) is consistent with the reporting requirements detailed within the National Planning Policy Framework (NPPF).

The aim of this FRA is to present relevant information pertaining to flooding in a clear format that can be reviewed by the Planning Authority and the Environment Agency. It does not guarantee that the proposed development will be acceptable to the Planning Authority and the Environment Agency in terms of flood risk and water management.

1 NPPF https://www.gov.uk/government/publications/national-planning-policy-framework--2 [accessed 11 November 2020]

2 Flood Risk Assessment

2.1 Site Details and Location

The proposed development site is located in the STDC area as part of the North East Industrial Zone (NEZ1) – hereafter referred to as the site – and is centred at Ordnance Survey National Grid Reference (OS NGR) NZ 57709 24179. The site is 24.4ha (244,000m2) in size and comprises brownfield land at the River Tees estuary, located 5km to the west of Redcar. Current vehicular access to the site is from the south along the A1085 (Trunk Road).

The site is immediately bound by:

- The A1085 Trunk Road to the south and a roundabout providing access to the local road network. Redcar Gate is located at the south of the site,
- An STDC access road to the east,
- STDC access roads to the west and beyond this lies the Wilton Sempcorp utilities corridor; and,
- The network rail corridor to the north.

STDC's internal access roads, which are partly described above, provide access to the offices and they also run along the former Hot Metals Transfer Rail line. This rail line runs through the western part of the site from south west to north.

The Darlington to Saltburn Railway line, which provides the northern boundary of the site is an operational passenger railway line and, the Redcar British Steel station is located on the boundary of the site, just to the west of the intersection between the two railway lines.

A mains power transmission line crosses under the site in a south west to north east direction under the route of the internal road network and Hot Metals Transfer line. A live substation is located at Steel House.

The operational RWE Breagh high pressure gas pipeline runs along the southern boundary of the site before crossing the Long Acre site in a north-west south-east direction. Water infrastructure present on the site comprises potable water supply pipes and an NWL water main, both of which are located near Steel House.

2.1.1 Catchment Hydrology

The site lies within the catchment of the River Tees to which The Fleet and Dabholm Beck flow into. The River Tees is approximately 4km to the north of the site.

It is also within the catchments of four waterbodies and Steel House Lake – The Ash Gill Beck which drains into the centre of the site as Ash Gill culvert. The culverted Mill Race watercourse drains to the western boundary of the site. The Mill Race watercourse originates in the Cleveland Hills before flowing along the eastern boundary of the Wilton Works to the south of the development site. The watercourse is then subject to a series of short culverts before briefly flowing open in the south west corner of NEZ1 where it is an open channel approximately 3m wide. From this point the watercourse enters a culvert approximately 500m in length which flows below the south west of the NEZ1 to its confluence with The Fleet. Steel House Lake is currently supplied by the Ash Gill which flows from Dormanstown under the A1085 into a short open channel before discharging into the lake. The Fleet drains along the northern boundary of the site and into which the Dabholm Beck drains. The Dabholm Beck becomes tidal within the Dabholm Gut before flowing into the River Tees. Both channels discharge to the River Tees. The 1m Lidar DTM shows the elevations at the site are between 3mAOD and 16mAOD. The site is relatively flat with lower elevations within The Fleet.

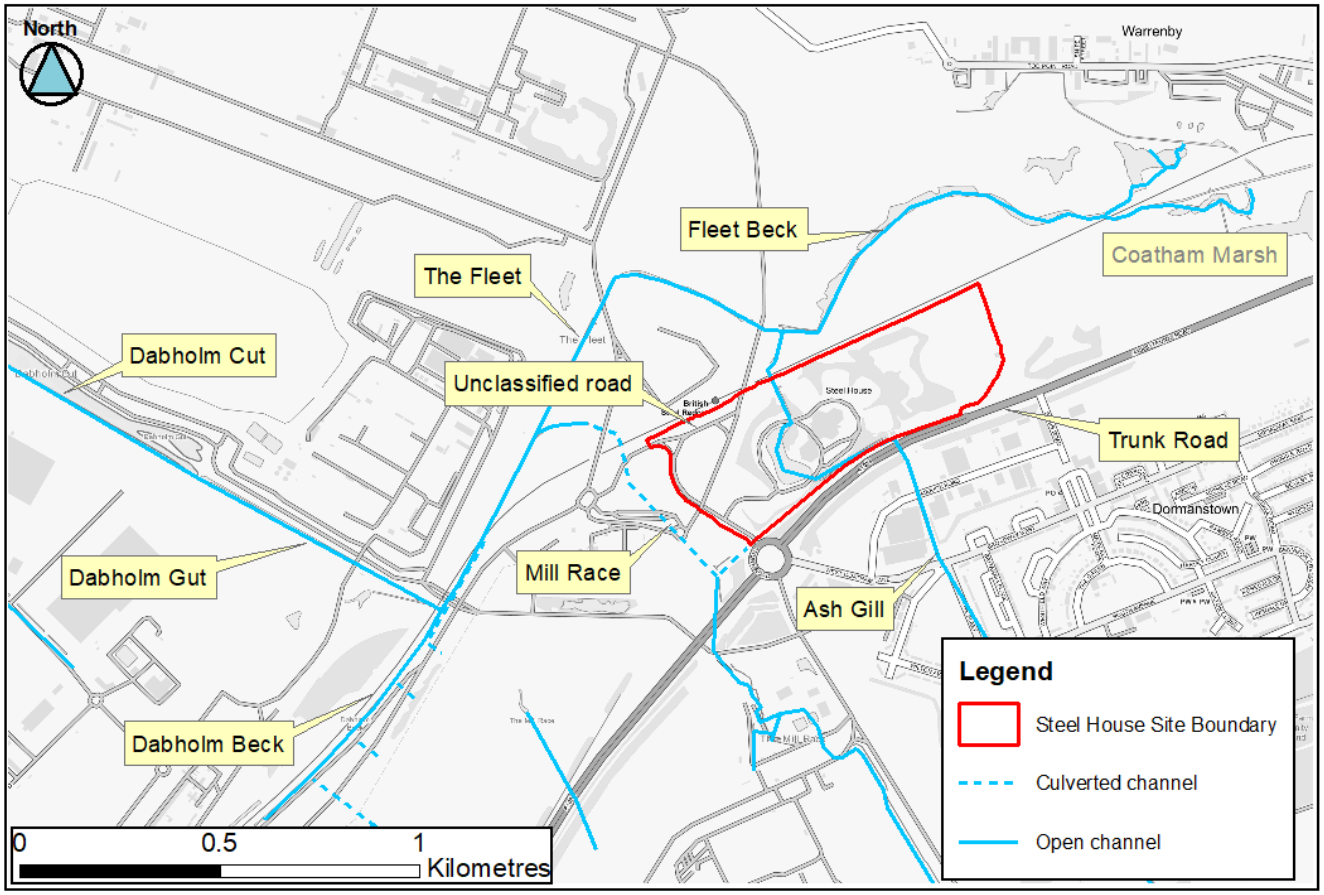

Figure 2-1: Map showing watercourses on site

The catchment of The Fleet (up to OS NGR NZ 57002 24231) drains an area of 10.0km^2 in a north westerly direction. The catchment topography slopes from south to north, with ground levels within the catchment dropping from an elevation of 202mAOD to 3.6mAOD at the site. The Mill Race watercourse flows into The Fleet after point NZ 57002 24231 but before the confluence with Dabholm Beck via a culvert.

The catchment of Dabholm Beck (up to OS NGR NZ 56135 24005) drains an area of 20.3km^2 in a northerly direction while the channel of Dabholm Beck flows in a north easterly direction. Numerous land drains discharge into the Dabholm Beck, likely used to drain run-off from the A1085. The catchment of Dabholm Beck includes the sub-catchment of The Fleet. The catchment topography slopes from south to north, with ground levels within the catchment dropping to 2.20mAOD from an elevation of 234mAOD at the top of the catchment.

The FARL values for both The Fleet and Dabholm Beck catchments range between 0.94-0.95 which indicates that, while there may be some reservoir influence within both catchments, the influence is not considered major. URBEXT values of 0.1-0.2 also indicates that urban cover within the catchment is not considered extensive in hydrological terms. Both catchments are shown in Figure 2-2.

Table 2-1: Catchment descriptors for both catchments draining to the site

Catchment Descriptor	Fleet Catchment	Dabholm Beck Catchment
AREA (km^2)	10.02	20.29
ALTBAR (m above sea level)	31	31
BFIHOST	0.33	0.35
DPLBAR (km)	4.57	4.8
DPSBAR (m/km)	27.3	29.7
FARL	0.953	0.943
PROPWET	0.32	0.32
SAAR (mm)	614	615
SAAR4170 (mm)	633	630
SPRHOST (%)	38.92	38.03
URBEXT1990	0.1687	0.2374
URBEXT2000	0.1499	0.2649

The British Geological Survey[2] online viewer indicates the underlying bedrock geology is Triassic Rock which comprises of sandstone, siltstone and mudstone. The superficial geology is raised Marine deposits, comprising of sand and gravel.

2 http://mapapps,bgs.ac.uk/geologyofbritain/home.html [accessed 11 November 2020]

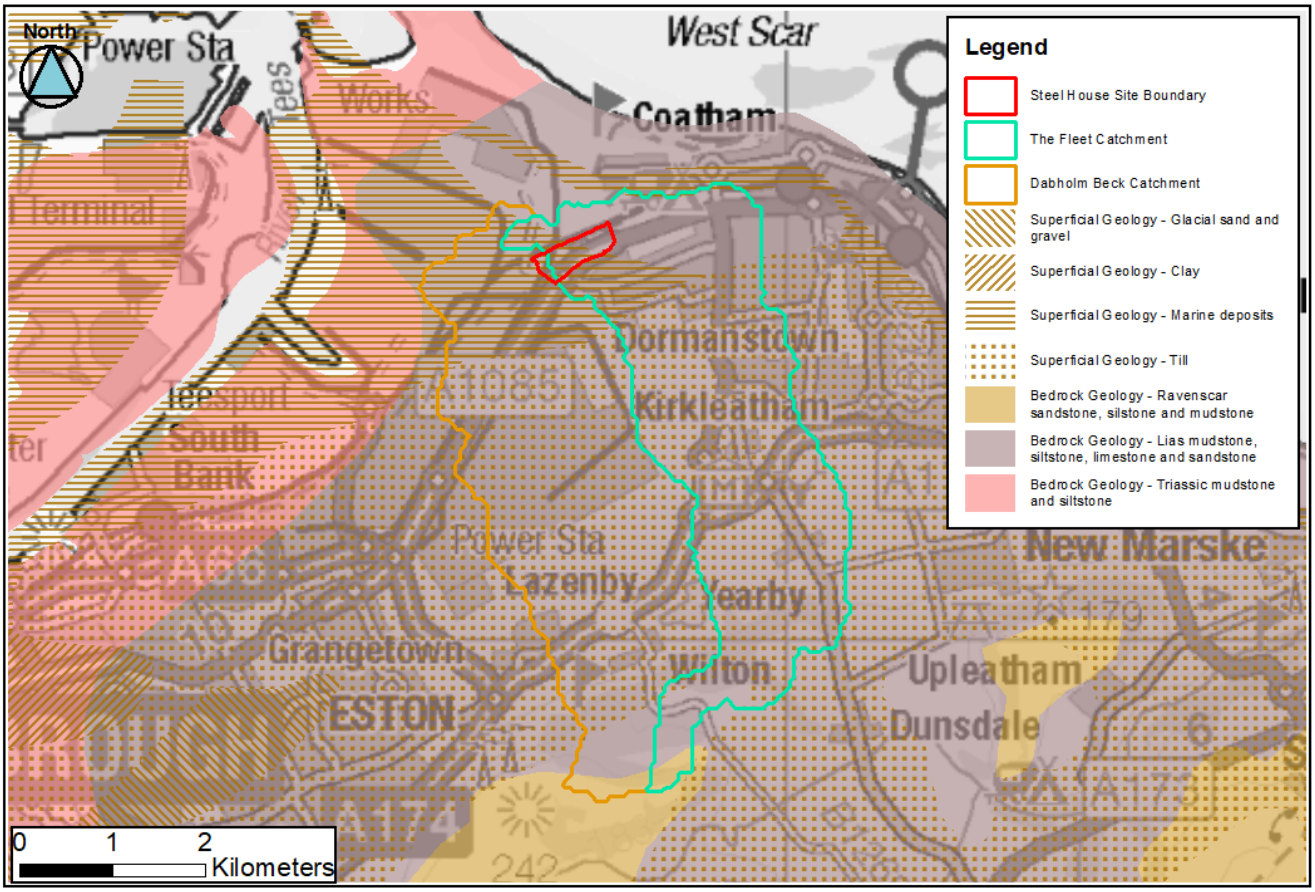

Figure 2-2: Map showing the hydrological catchments and geology at the site

2.1.2 Designations Within or in Proximity to the Site

A search for designations within 2km of the site has been completed using the Defra MAGIC portal[3]. Based on the available data and Defra mapping, the site itself is not located within a designated SSSI. While the Teesmouth and Cleveland Coast SSSI does extend across the whole of the River Tees estuary, the boundary of the SSSI lies within 100m of the site boundary (to the north eastern site corner). Due to the proximity of the site to the boundary of the Teesmouth and Cleveland Coast SSSI, the site is mapped within an area designated as a SSSI Impact Risk Zone.

This is in place to protect the coastal and freshwater habitats on the estuary. This includes areas of Jurassic and quaternary geology, notably the Redcar Rocks in the area of the site. Sand dunes, saltmarshes, mudflats, rocky and sandy shores, saline lagoons, grazing marshes, reedbeds and freshwater wetlands provide habitats for breeding and non-breeding birds as well as assemblage for invertebrates. The coastal habitat provides breeding areas for harbour seals. The site is located within the SSSI impact risk zone which requires planning applications to be assessed for likely impacts on the SSSI. The site is also located within a Wild Bird General Licence exclusion zone due to its adjacency with the SSSI protected site, requiring a special licence for any licensable actions to be carried out on site.

Located to the east of the site at Coatham Sands is a designated Ramsar site for the mudflats which provide a breeding ground for wetland birds. A proposed Ramsar site is located at Coatham Marsh. Considerations for Ramsar designated sites will be the same as

3 https://magic.defra.gov.uk/MagicMap.aspx

those for the SSSI impact risk zone. Within the site boundary, there is an area of designated community forest.

In addition to the SSSI and Ramsar designations, the coastline from Teesmouth to Redcar is part of the Teesmouth and Cleveland Special Protection Area (SPA) designated for ornithological importance (nationally and internationally) and presence of invertebrates. This also covers SSSI unit 25 (Dabholm Gut/ Cut). Designations are shown on Figure 2-3 below.

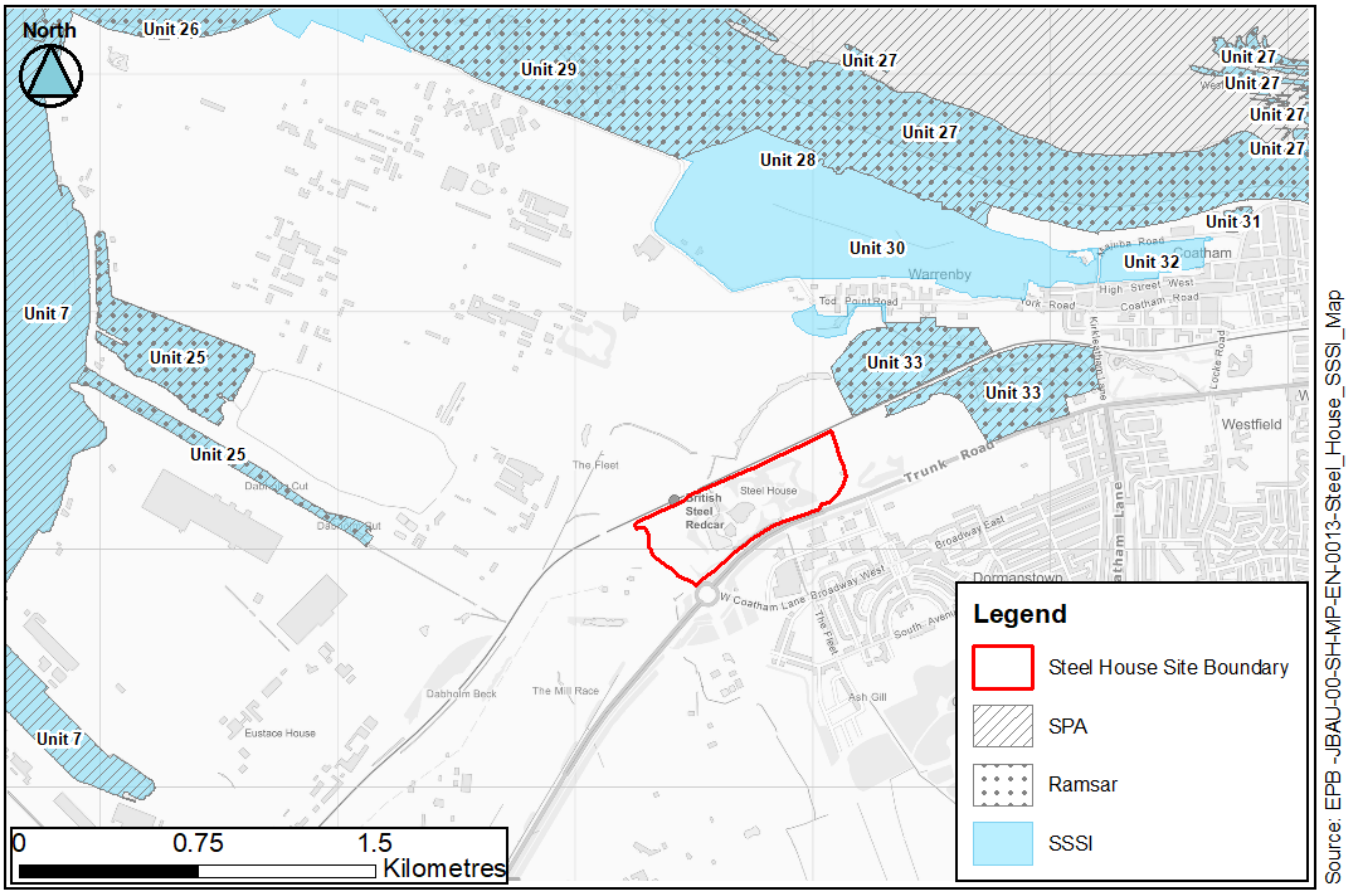

Figure 2-3: Designations in proximity to the site

2.2 Historical and Existing Land Use

The site currently lies unused as brownfield land. Steel House is in a previously landscaped area, where slag is the main component of the upper layer of ground. Generally, the extent of contamination is likely to be limited. The Made Ground deposits, mainly slag, will be of variable thickness with depths of 4m in some places. Heavy metal contamination has been found associated with the slag deposits.

Previous land use at the site includes the steel industry. Other usage of the site has been for the storage of materials and freight rail infrastructure uses.

2.3 Proposed Development

The proposed outline development is for a general Use Class E development of almost 15,800m^2. This is classed as office accommodation and incubator space together. The development will also include associated land uses such as ancillary office accommodation, HGV and car parking and associated works including works to watercourse, potentially involving their realignment. It is noted the planning application will not be specifically linked to the offshore wind industry so it can be promoted to general manufacture occupiers. However, the development parameters will be set to allow use by this specific industry if the

opportunity arises. The initial development parameters have been developed by the client and are specified in Table 2-2 below.

Table 2-2: Initial development parameters

Development Parameter	Amount/use
Use Class	E (Office and Incubator Space)
Maximum Floorspace	170,000 sqft / circa 15,794 sqm
Maximum Development Height	33.8m
Finished Floor Level	Minimum 5.03m AOD
Developable Area	The footprint of the proposed buildings will dependent on market demand. The Parameters Plan will include developable areas which show a distinction between those area where buildings will be located and those designated for hard and soft landscaping.
Access	Access is reserved and details will be submitted at the Reserved Matter stage of the planning process. An indicative location is shown on the Parameters Plan.

The proposed development is being submitted as an outline planning application to Redcar and Cleveland Borough Council.

2.4 Sources of Flood Risk

There are a number of potential sources of flooding that could impact any site; these are fluvial (originating from a watercourse), coastal, groundwater, surface water (pluvial), sewers and blocked culverts and infrastructure failure. The purpose of this report is to provide an assessment of flood risk to the site from these sources.

Within England, the Flood Risk and Coastal Change Planning Practice Guidance (FRCC-PPG)[4] sits alongside the NPPF and sets out detailed guidance on how this policy should be implemented. It has a three-stage approach: assess flood risk, avoid flood risk and manage / mitigate flood risk.

The flood probabilities used to describe Flood Zones as defined in the FRCC-PPG are noted below:

Flood Zone	Annual Probability of Flooding
1	This zone comprises land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding in any year (<0.1%).
2	This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year
3a	This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding

4 Flood risk and coastal change https://www.gov.uk/guidance/flood-risk-and-coastal-change [accessed 11 November 2020]

	(>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
3b	This zone comprises land where water has to flow or be stored in times of flood. This includes land that would flood with an annual probability of 1 in 20 (5%) or 1 in 25 (4%) or greater in any year, or is designed to flood in an extreme (0.1%) flood. Also referred to as functional floodplain.

As part of the avoidance of flood risk, the Sequential Test is applied which entails steering the development to a location which is in Flood Zone 1 (areas with a low probability of river or sea flooding). If the proposed development is located within Flood Zone 2 then the Exception Test is applied which requires demonstration that the proposed development will a) 'provide wider sustainability benefits to the community that outweigh flood risk and b) that the proposed development will 'be safe for its lifetime without increasing flood risk elsewhere and where possible reduce flood risk overall'

2.4.1 Fluvial and Coastal Flooding

The EA flood map for planning[5], in Figure 2-3, shows the combined flood extents from rivers and the sea at the site.

The site is located within Flood Zone 1, meaning it has a less than 1 in 1000-year annual probability of flooding from river or sea. The northern boundary of the site lies adjacent to areas located in Flood Zone 2 (source of flooding is The Fleet) however EA WMS mapping shows that the extent of Flood Zone 2 does not encroach into the proposed development site[6]. The flood extents for this mapping are created using coarse scale UK wide fluvial modelling, and incorporates more detailed modelling of specific rivers done for the EA. It should be noted that, due to the coarse scale used for the development of the extents for Flood Zones 2 and 3, the watercourses through the site (Ash Gill Beck and Steel House Lake) are too small to be included in the coarse modelling and will not have previously been modelled by the EA so any fluvial flooding from these will not be captured in this mapping. Therefore, any potential fluvial flooding from Ash Gill Beck and Steel House Lake which is within the site boundary map has not been represented. Flood levels for the area included within the Environment Agency Flood Zone 2 extent have not been obtained at this stage of the assessment.

5 Environment Agency Flood map for planning. https://flood-map-for-planning.service.gov.uk/confirm-location?easting=460152&northing=525139&placeOrPostcode=redcar [Accessed 11 November 2020]

6 Environment Agency Flood Map for Planning (Rivers and Sea) - Flood Zone 2 and Environment Agency Flood Map for Planning (Rivers and Sea) - Flood Zone 3 WMS service. Flood Zone 2 and Flood Zone 3 extents last updated 07/09/2020. Flood Zone 2 and Flood Zone 3 extents obtained from www.data.gov.uk on 26/11/2020.

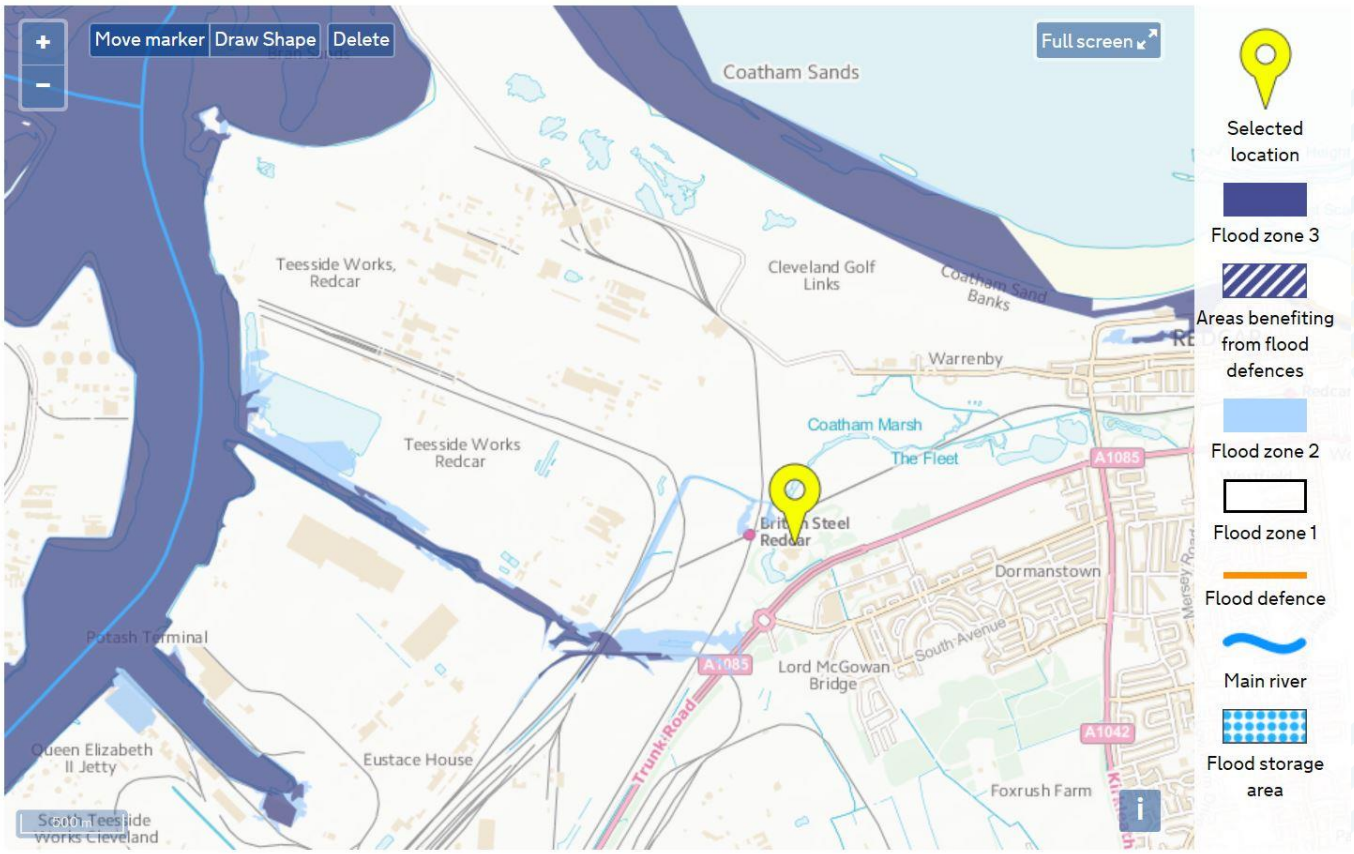

Figure 2-4: Extract from Environment Agency flood map for planning at the site

The EA flood maps combine the risk of flooding from river and seas. The EA flood warning information service long term flood risk map shows the risk split into very low, low, medium and high-risk categories:

- Very low risk – less than 1 in 1000-year probability
- Low risk – Between 1 in 1000 and 1 in 100-year probability
- Medium risk – Between 1 in 100 and 1 in 30-year probability
- High risk – Greater than 1 in 30-year probability.

Figure 2-5 shows the development site is in an area of very low risk. The Tees Estuary is an area of high risk, and due to the tidal influence in this location is most likely to be from tidal rather than fluvial flooding.

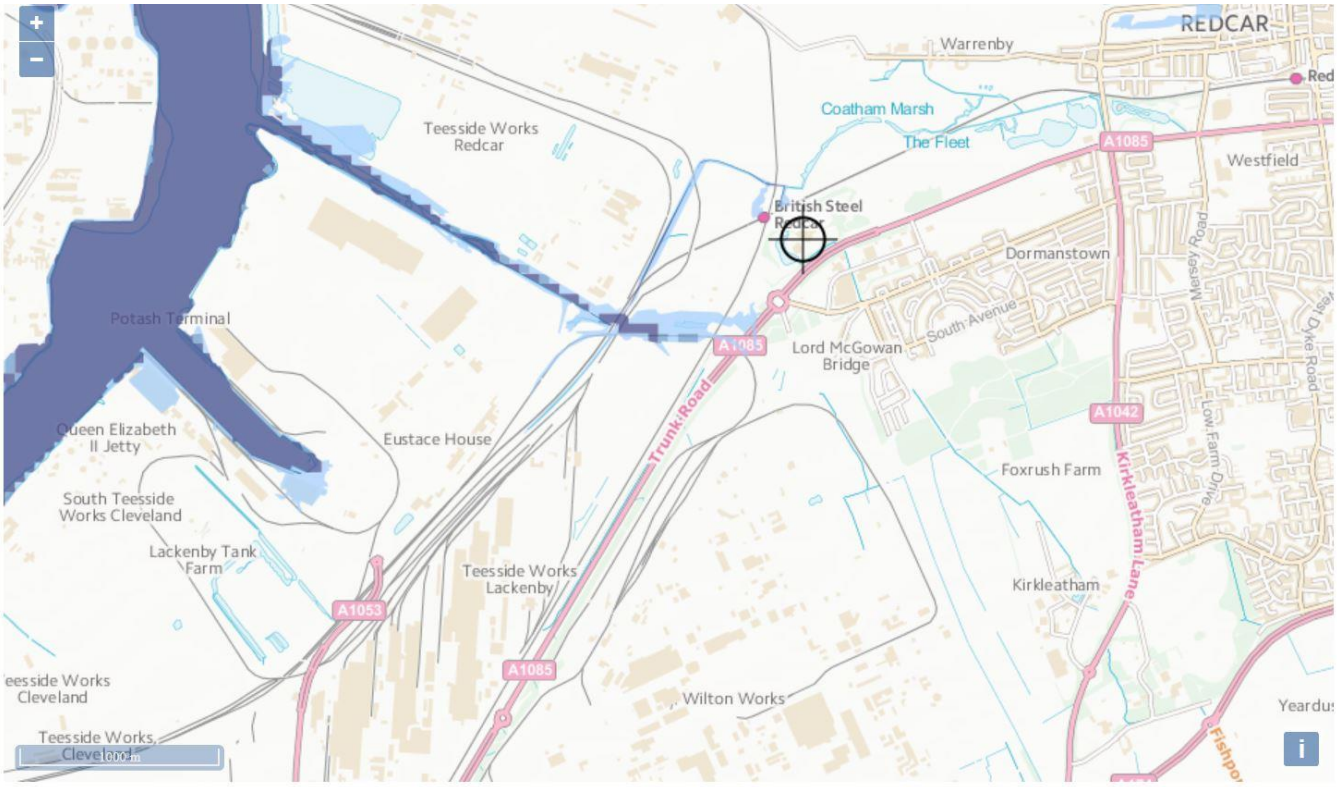

Figure 2-5: Extract from EA map of long term flood risk flood extent from rivers or the sea[7]

2.4.1.1 Climate Change - Fluvial

NPPF notes that there should be a "proactive approach to mitigating and adapting to climate change, taking into account the long-term implications for flood risk".

Peak river flow allowances show the anticipated changes to peak flow by river basin district. Redcar is located within the Northumbria river basin district. The application of allowance category is subject to the Flood Risk Vulnerability Classification (categorises development, considering whether it relates to essential infrastructure or, for example development for vulnerable groups in society e.g. hospitals / care homes) and the Flood Zone in which the site lies.

7 EA flood warning information service map of long term flood risk. https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=453987&northing=522641&address=10034526609&map=RiversOrSea [Accessed 11 November 2020]

Table 2-3: EA Peak flow allowances, Northumbrian River Basin District (use 1961 to 1990 baseline)[8]

Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper end	20%	30%	50%
Higher central	15%	20%	25%
Central	10%	15%	20%

2.4.1.2 Climate Change – Sea Level

There are a range of allowances for each epoch for sea level rise in Northumbria shown in Table 2-4 below derived from EA Table 3.

Table 2-4: EA Sea level allowance for each epoch for Northumbria[9]

Allowance	2000 to 2035 (mm)	2036 to 2065 (mm)	2066 to 2095 (mm)	2096 to 2125 (mm)	Cumulative rise 2000 to 2125 (metres)
Higher central	4.6 (161)	7.5 (225)	10.1 (303)	11.2 (236)	1.03
Upper end	5.8 (203)	10 (300)	14.3 (429)	16.5 (495)	1.43

Since the original Tees tidal model was developed in 2011/2013 and the above table was published, JBA have undertaken an update to the Tees coastal model on behalf of the EA as part of a separate project in 2019/2020 for Port Clarence / Greatham. The update to the model was based on the UKCP18 uplift values utilising 2017 for a base year for extreme sea levels. Table 2-5 below summarises the results of the updated modelling on the uplift (mm) per epoch.

Table 2-5: Tees Tidal UKCP18 Tees Tidal Uplift Value

Uplift	Epoch	Updated uplift value (mm)
Present day uplift	2017-2019	0.011
UKCP18 2070 uplift	2019-2070	0.488
UKCP18 2100 uplift	2019-2100	0.947
UKCP18 2030 uplift	2019-2030	0.071
UKCP18 2050 uplift	2019-2050	0.249

8 https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-1 [Accessed 11 November 2020]

9 https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-3 [Accessed 11 November 2020]

Table 2-6: Tees Tidal UKCP18 Tees Tidal Climate Change Uplift Levels

Events	2017-2019 (present day)	2030	2070	2100
T2 (2 year)	3.45	3.52	3.94	4.40
T100 (100 year)	3.98	4.05	4.47	4.93
T200 (200 year)	4.08	4.15	4.57	5.03
T1000 (1000 year)	4.33	4.40	4.82	5.28

2.4.1.3 Offshore Wind Speed and Extreme Wave Height Allowance

Wave heights may change because of increased water depths. The frequency, duration and severity of storms could also change. At this point wave modelling has not been included in EA models. If required at a future stage in the project an allowance of 10% should be applied to coastal modelling. Nationally available flood maps do not currently show the impact of waves.

Table 2-7: EA Offshore wind speed and extreme wave allowance

Applies around all the English coast	2000 to 2055	2065 to 2125
Offshore wind speed allowance	5%	10%
Offshore wind speed sensitivity test	10%	10%
Extreme wave height allowance	5%	10%
Extreme wave height sensitivity test	10%	10%

2.4.2 Pluvial Flooding

The Environment Agency's Risk of Flooding from Surface Water map considers flood risk from surface water (pluvial) sources. Flooding from pluvial sources can occur during times of heavy rainfall which exceeds the infiltration capacity of the ground and can also lead to exceedance in drainage capacity.

According to the Environment Agency's Risk of flooding from Surface Water map (Figure 2-5), the site is not at risk of flooding from pluvial sources for a 1 in 30-year pluvial flood event (representative of a high flood risk) and there are only three minor isolated areas mapped at risk for a 1 in 100 year pluvial flood event (representative of a medium flood risk) – likely due to localised depressions within the site boundary.

At high risk, the depths are below 900mm; whereas medium and low risk extents are over 900mm in some places. For high risk areas, the velocities are below 0.25m/s (towards the site). For medium and low risk areas of the site, velocities are above and below 0.25m/s, with notable areas in the west exceeding 0.25m/s. For low risk areas, the velocities are below 0.25m/s towards the centre of the site.

The A1085 access road has a more continuous area of surface water flood risk; this may cause access issues to site and presents a flow path for surface water flooding. Additionally, The Fleet acts as a continuous flow path within the northern boundary of the site.

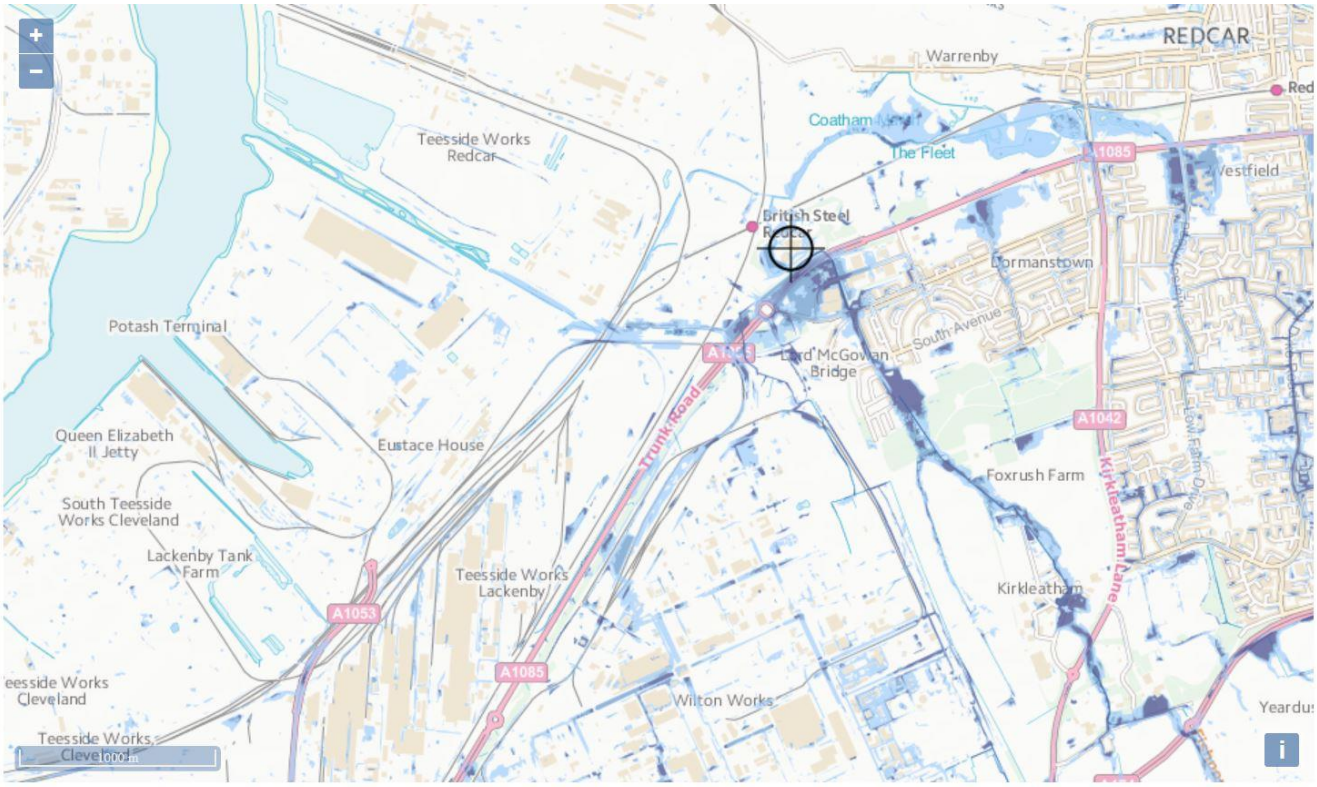

Figure 2-2-6: Extract from EA Long term surface water flood risk map[10]

2.4.2.1 Climate Change

With respect to surface water flood risk mapping and design of drainage systems (including blue-green networks and minor watercourses with a catchment of less than 5km^2) the allowances outlined in the table below should be used. As the development has a design life of 100 years the default design parameters are to design for the 20% and sensitivity check for the 40%.

Table 2-8: EA Peak rainfall intensity allowance in small and urban catchments (use 1961 to 1990 baseline)

Applies across all of England	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper end	10%	20%	40%
Central	5%	10%	20%

2.4.3 Groundwater Flooding

Groundwater flooding is flooding that is caused by unusually high groundwater levels or flow rates. During flooding, groundwater can emerge at the ground surface or within man-made

10 EA Long term flood risk for surface water. https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=453987&northing=522641&address=10034526609&map=SurfaceWater [Accessed 11 November 2020]

underground structures such as basements. There are various mechanisms of groundwater flooding, including clearwater flooding due to prolonged heavy rainfall on distant connected geology alluvial and coastal groundwater flooding, and that associated with minewater rebound or ground subsidence.

The EA alongside the BGS have developed a groundwater vulnerability map[11] accessed through the DEFRA MAGiC Map portal. This designates the site as in an area of Medium-High risk from groundwater. These risk levels are described on the BGS website as:

- High: areas able to easily transmit pollution to groundwater, characterised by high-leaching soils and the absence of low-permeability superficial deposits.
- Medium: areas that offer some groundwater protection. Intermediate between high and low vulnerability.

2.4.4 Sewers, Culverts and Bridges

The watercourses across and surrounding the site have been significantly modified and have either been culverted or straightened.

The main structures are:

- Culvert conveying the Ash Gill Beck under the A1085.
- Bridge/weir under internal road conveying Ash Gill Beck into Steel House Lake
- Culvert conveying the Ash Gill Beck/Steel House Lake under the Darlington to Saltburn Railway line.
- Culvert conveying The Mill Race watercourse.
- Culvert conveying Dabholm Beck under the major operations freight railway line after the confluence with The Fleet (to the west of the site).
- Key hydraulic structures including siphons within the western part of the site.

Ash Gill Beck enters the site from the south east via a culvert which diverts the channel under the A1085 (approximate culvert width is 2.6m). Within the site boundary, the Ash Gill Beck is flows underneath a internal access road into Steel House Lake. While the exact width of the culvert/bridge cannot be ascertained, it can be estimated to be over 6m wide based on the information available.

Ash Gill Beck/Steel House Lake flows over a fixed water level control weir (circa 0.5 – 1m high) located to the north of Steel House before exiting the site to the north to join with The Fleet via a culvert, underneath the Darlington to Saltburn Railway line. Approximate culvert width is 5.5m. The Fleet is fed underneath a second access road (culvert width approx. 2-3m) and the Darlington to Saltburn Railway line before the confluence with Dabholm Beck by a culvert that is approximately 6m wide.

Immediately downstream of the confluence of The Fleet into Dabholm Beck, the watercourse is fed into a culvert to divert flow underneath the major operations freight railway line and towards the River Tees (approximate culvert width 6.5m). Dabholm Beck is fed under an access road (approximate culvert width 3.5m) and subsequently underneath a vehicular bridge (60m width) and a foot/land bridge (8.4m width). Aerial imagery indicated there may also potentially be an outfall weir from Dabholm Gut into the River Tees.

The rail and final vehicular bridge have high clearance and are unlikely to affect channel flows in high conditions. Dabholm Beck tributaries are in culverts of unknown dimensions before the confluence of the tributaries downstream of the site. There does not appear to be any additional channel structures after the confluence of the two watercourses once flow enters Dabholm Gut.

11 BGS Groundwater vulnerability data. https://www.bgs.ac.uk/products/hydrogeology/GroundwaterVulnerability.html [Accessed 11 November 2020]

2.4.5 Additional structures

An additional study undertaken at the site[12], identified a weir downstream of Steel House Lake. The backwater effects of this weir were observed extending back to the south of the A1080. The weir will have a significant effect on flood levels and sediment deposition within the channel and structures. This influence will increase as the effects of climate change materialise. JBA modelling of The Fleet indicates that, during a 1 in 100-year fluvial flood event, waters are modelled to overtop the culvert diverting Ash Gill Beck underneath an access road, south of the existing Steel House Development and upstream of the weir. This modelling does not take into account tidal influence or fluvial flows in relation to climate change allowances and it is assumed that modelling does not take into account backwater effects from the weir. As the upstream culvert cannot accommodate flow during a 1 in 100 year fluvial flood event, it will not accommodate flow when additional factors are considered, which is likely to result in an increased flood extent within the site in comparison to the flood extent that has been modelled along Steel House Lake and Ash Gill Beck.

2.4.6 Reservoir Flooding / Breach

The risk of flooding from reservoirs is related to the breach of a large reservoir (a large reservoir is classified as a reservoir which can hold over 25,000m^3 of water) and is based on the worst-case scenario. Since mapping is a prediction of a credible worst-case scenario, it is unlikely that any actual flood would be as large as is predicted within the model.

According to the Environment Agency's Risk of Flooding from Reservoirs - Maximum Flood Extent map (Figure 2-6), most of the site is not at risk of flooding from reservoir sources. The Fleet channel, including the section of The Fleet located within the site boundary, is mapped to be at risk from flooding from the two small reservoirs which lie to the south east of the site (Brine Reservoir, Wilton No.1 (OS NGR NZ 58807 20741) and Brine Reservoir, Wilton No.1 (OS NGR NZ 58819 20515)).

12 JBA Consulting (2020) Phase 2: Strategic Flood Risk Assessment and Drainage Strategy.

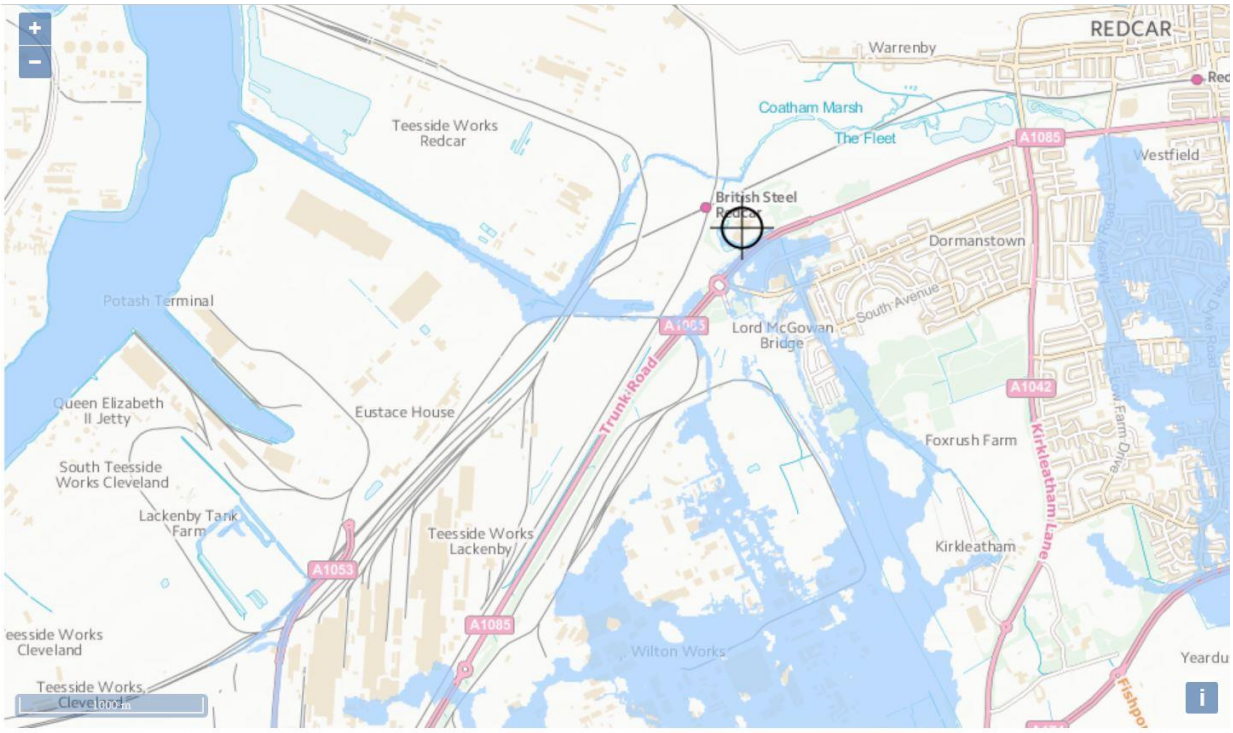

Figure 2-7 Extract from the EA Flood Maps for reservoir flooding

2.5 Flood History

The following sources were consulted:

- **Readily available archives** - internet based sources including the British Hydrological Society Chronology of British Hydrological Events[13] and Google Newspaper Archive[14]. No specific information for this area was available from these archives.
- **Environment Agency (Risk Management Authority under the Water Management Act and Flood Risk Regulations)** - open data records noted the occurrence of one flood event within the Tees Estuary on 05/12/2013 and was recorded to be due to operational failure/breach of defence and the source was coastal. This event did not breach onto the site. The flood event was due to a high spring tide mixed with the failure of the flood defence embankment at the south side of Greatham Creek (4.3km to the North-west of the site)[15]. Since this event, a new flood defence scheme has been completed at Port Clarence and Greatham South[16].
- **Redcar and Cleveland Borough Council (Lead Local Flood Authority and Risk Management Authority under the Water Management Act and Flood Risk Regulations)** - provided historic flood photographs for the wider STDC site,

13 Chronology of British Hydrological Events. http://cbhe.hydrology.org.uk/ [Accessed 11 November 2020].

14 Google Newspaper Archive. https://news.google.com/newspapers [Accessed 11 November 2020].

15 Stockton-on-Tees Borough Council LLFA Flood Investigation Report, Tees Tidal Flooding, March 2014

16 "Hartlepool public invited to opening of new £14.5m flood defence scheme", Hartlepool Mail , 16 October 2018

these were not georeferenced and lack name and date information which makes locating and using them difficult. One photo showed that Tees Dock Road was flooded in September 2015 (anticipated to be located north of the roundabout where Tees Dock Road is joined to the A66 and A1053, to the north east of the site). Further historic flood records were requested[17] but the RCBC had no records for the main site. This does not indicate that no incidents have occurred but that none have been recorded.

- **The SFRA reports from 2010**[18] **and 2016**[19] - use of existing data from these projects has been granted by RCBC for this project. The Level 1 report states that RCBC has little data on fluvial or tidal flooding. In this report NW provided their register on surface water flood events. These were concentrated in the main residential areas of Eston and Redcar and none were identified in the vicinity of the site.
- **Historical Mapping** – The online National Library of Scotland (NLS) archives have been reviewed. These show the north of the site was originally mudflats in the Tees estuary (Coatham Marshes). Iron work buildings was established to the south of the site and a railway network running adjacent to the western site boundary, circling around the north and through the Coatham Marshes between 1885-1900 (earlier maps are not available so the exact date of the Iron Works development cannot be established). Between 1892 and 1914, iron work buildings developed and spread further north. By 1937-1961, the site had been fully reclaimed from the River Tees. None of the historic mapping had any levels recorded.

2.6 Flood Estimation

Flood risk is a combination of the likelihood of flooding and the potential consequences arising. It is assessed using the source – pathway – receptor model.

Flood mapping for fluvial and coastal / tidal risk are available from previous studies undertaken. These studies extend across the site and the surrounding STDC area and which can be used to inform this high-level assessment of flood risk:

- Tidal: The Tees Estuary model developed for the EA by JBA documents coastal flood risk for entire site. This was recently updated by JBA to account for the UKCP18 climate change uplift values. Wave action is not accounted for however the protection offered by the existing sand dunes system and historic railway embankment have been included.
- Fluvial: The Fleet system comprising of the Fleet and its main tributaries were modelled for Redcar & Cleveland Borough Council by JBA in 2015. The study featured a detailed survey which included all of the in-channel structures within the STDC site.

No surface water modelling had been undertaken to date and since the EA flood maps indicated that there were pockets of pluvial flooding across the site, a preliminary surface water model was run to give a high-level overview of pluvial flood risk as part of the Data Collection and Baseline Assessment[20] undertaken as Phase 1 of the Water Management

17 Email from Nigel Hill, Drainage & Flood Risk Manager of Council flood team, received 30 January 2020

18 Redcar and Cleveland Borough Council Level 2 Strategic Flood Risk Assessment, August 2010

19 Redcar and Cleveland Borough Council Level 1 Strategic Flood Risk Assessment Update, May 2016

20 Phase 1 – Data Collection and Baseline Assessment, JBA Consulting for Faithful & Gould on behalf of STDC, May 2020

Strategy for the STDC development. Details of the pluvial modelling and analysis of flow pathways and potential flood receptors are provided below.

2.6.1 Approach to Peak Flow Estimation

Preliminary hydrological data for the high level assessment of pluvial flooding was based upon Flood Estimation Handbook (FEH) catchment areas (shown in Figure 2-2) and FEH13 rainfall, which were downloaded from the FEH web-service tool along with the catchment descriptors (tabulated in Table 2-1).

2.6.2 Hydraulic Modelling

The preliminary surface water flood maps were generated using InfoWorks Integrated Catchment Modelling (ICM) software version 9.5. InfoWorks ICM is an advanced integrated catchment modelling software used to model complicated hydrological and hydraulic systems efficiently. It also allows the user to combine natural solutions with piped (network) modelling to suggest improvements to capacity and create scenarios to optimise flood risk management. The inputs required were a Digital Terrain Model (DTM) to represent the ground of the area of interest and FEH13 rainfall.

The DTM was created using LiDAR 2m spatial resolution DTM data. Denser LiDAR data is available but was not utilised at this high-level stage in the project. DTM processing was completed using 3D analyst tools in ArcMap 10.4 with ASCII files exported and added to InfoWorks ICM to create the ground model.

The modelling directly applied the FEH13 rainfall from the Lackenby Channel catchment over the 2m LiDAR DTM. The model was run for the 100-year and 100-year plus climate change scenarios.

The model results were exported into geodatabases for analysis within ArcMap 10.4 which was used to create the following flood risk screening maps:

- 100yr surface water
- 100yr +20%cc surface water
- 100yr+ 40%cc surface water
- 100yr fluvial (Fleet Model)
- 200yr coastal +SLR
- 200yr coastal +SLR, 100yr surface water, Fleet 100yr
- 200yr coastal +SLR, 100yr+40%cc

2.6.3 Assumptions and Limitations of the Modelling

The modelling undertaken was for the preliminary stage of the water management strategy and due to the high-level nature of the preliminary flood risk screening exercise it was necessary to make a number of key assumptions and apply limitations for the modelling as follows:

- Limited to 2 scenarios 100yr and 100yr plus climate change.
- A 20% and 40% climate change uplift has been applied to the rainfall hyetographs in line with EA guidance.
- The model was run as a full blockage scenario. This highlights potential flood risk and details areas within the development suitable for conveyance. It can also inform more detailed modelling.
- The model does not include any losses to account for interception into existing surface water drainage systems or infiltration into the ground. A value of 70-75% is applied.
- The model does not account for flooding of the sewer network.

- FEH Catchment data from the surrounding areas were used to allow direct application of rainfall on LiDAR within the sites of interest.
- A 2m resolution DTM was utilised.
- A storm duration of 60 minutes was used to allow high level assessment of overland flow paths.

N

Fleet Beck

Steel House

British Steel Redcar

The Mill Race

Ash Gill

A1085

LIMERICK ROAD

BROADWAY

0 0.125 0.25 0.5 km

Legend

Steel House Boundary

100-year Surface Water Extents

Depth (m)

High : 5.70

Low : 0.10

Culverted Watercourses

Rev.	Modifications	Date	Drawn	Checked	Approved

Unit 2.1, Quantum Court
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South Tees Development Corporation

FLOOD RISK SCREENING MAPS
1:100YR SURFACE WATER FLOOD RISK

Scale: 1 : 5,000 @ A1	Drawn	HK 12/11/2020
	Checked	RD
	Approved	RD

Digital File Name: EPB-JBAU-00-SH-MP-EN-0003-Steel_House_100yr_SW

Drawing Number:	Sheet No.:	Status:	Rev.:
0001	1 of 7	S3	P02

N

Fleet Beck

Steel House

British Steel Redcar

The Mill Race

A1085

Ash Gill

LIMERICK ROAD

BROADWAY

0 0.125 0.25 0.5 km

Legend

Steel House Boundary

100-year + 20% CC Surface Water Extents

Depth (m)

High : 5.76

Low : 0.10

Culverted Watercourses

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South Tees Development Corporation

FLOOD RISK SCREENING MAPS
1:100YR + 20% CC SURFACE WATER FLOOD RISK

Scale: 1 : 5,000 @ A1	Drawn	HK 12/11/2020
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	Approved	RD

Digital File Name: EPB-JBAU-00-SH-MP-EN-0004-Steel_House_100yr_20CC_SW

Drawing Number:	Sheet No.:	Status:	Rev.:
0002	2 of 7	S3	P02

N

Fleet Beck

Steel House

British Steel Redcar

The Mill Race

A1085

Ash Gill

LIMERICK ROAD

BROADWAY

0 0.125 0.25 0.5 km

Legend

Steel House Boundary

100-year + 40 % CC Surface Water Extents

Depth (m)

High : 6.91

Low : 0.10

Culverted Watercourses

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FLOOD RISK SCREENING MAPS
1:100YR + 40%CC SURFACE WATER FLOOD RISK

Scale: 1 : 5,000 @ A1	Drawn	JK 12/11/2020
	Checked	RD
	Approved	RD

Digital File Name: EPB -JBAU-00-SH-MP-EN-0005-Steel_House_100yr_40CC_SW

Drawing Number:	Sheet No.:	Status:	Rev.:
0003	3 of 7	S3	P02

N

Fleet Beck

Steel House

British Steel Redcar

Ash Gill

A1085

LIMERICK ROAD

BROADWAY

The Mill Race

0 0.125 0.25 0.5 km

Legend

Steel House Boundary

200-year Coastal Risk + Sea Level Rise Allowance

Value

High : 7.43

Low : 0

Culverted Watercourses

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FLOOD RISK SCREENING MAPS
1:200YR COASTAL FLOOD RISK + SEA LEVEL RISE ALLOWANCE TO 2100 (5.03mAOD)

Scale:		
1 : 5,000 @ A1	Drawn	HK 12/11/2020
	Checked	RD
	Approved	RD

Digital File Name: EPB-JBAU-00-SH-MP-EN-0006-Steel_House_200yr_C

Drawing Number:	Sheet No.:	Status:	Rev.:
0004	4 of 7	S3	P02

N

Fleet Beck

Steel House

British Steel Redcar

The Mill Race

A1085

Ash Gill

LIMERICK ROAD

BROADWAY

0 0.125 0.25 0.5 km

Legend

Steel House Boundary

100-year Surface Water Extents

Depth (m)

High : 5.70

Low : 0.10

200-year Coastal Risk + Sea Level Rise Allowance

Depth (m)

High : 7.42

Low : 0

Culverted Watercourses

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FLOOD RISK SCREENING MAPS
1:200YR COASTAL WATER FLOOD RISK +
1:100YR SURFACE WATER FLOOD RISK

Scale: 1 : 5,000 @ A1	Drawn	JK 12/11/2020
	Checked	RD
	Approved	RD

Digital File Name: EPB -JBAU-00-SH-MP-EN-0007-Steel_House_200yr_C_100yr_SW

Drawing Number:	Sheet No.:	Status:	Rev.:
0005	5 of 7	S3	P02

N

Fleet Beck

Steel House

British Steel Redcar

A1085

Ash Gill

LIMERICK ROAD

The Mill Race

BROADWAY

0 0.125 0.25 0.5 km

Legend

Steel House Boundary

100-year + 40 % CC Surface Water Extents

Depth (m)

High : 6.91

Low : 0.10

200-year Coastal Risk + Sea Level Rise Allowance

Depth (m)

High : 7.42

Low : 0

Culverted Watercourses

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FLOOD RISK SCREENING MAPS
1:200YR COASTAL RISK + SEA LEVEL RISE ALLOWANCE TO 2100 (5.03mAOD) AND
1:100YR SURFACE WATER FLOOD RISK + 40% CC

Scale: 1 : 5,000 @ A1	Drawn	JK 12/11/2020
	Checked	RD
	Approved	RD

Digital File Name: EPB -JBAU-00-SH-MP-EN-0008 Steel_House_200yr_C_100yr_40CC_SW

Drawing Number:	Sheet No.:	Status:	Rev.:
0006	6 of 7	S3	P02

N

Fleet Beck

Steel House

British Steel Redcar

Ash Gill

The Mill Race

A1085

LIMERICK ROAD

BROADWAY

0 0.125 0.25 0.5 km

Legend

- Steel House Boundary
- Fleet Model 100-year Flood Extents
- Culverted Watercourses

Rev.	Modifications	Date	Drawn	Checked	Approved

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South Tees Development Corporation

FLOOD RISK SCREENING MAPS
1:100YR FLEET MODEL RESULTS

Scale: 1 : 5,000 @ A1	Drawn	JK 12/11/2020
	Checked	RD
	Approved	RD

Digital File Name: EPB -JBAU-00-SH-MP-EN-0009-Steel_House_100yr_Fleet_Model

Drawing Number:	Sheet No.:	Status:	Rev.:
0007	7 of 7	S3	P02

2.6.4 Pre-Development Scenario

Findings from previous studies and the surface water modelling described above have been used to summarise flood risk to the site from different sources.

At the flood risk screening stage, it is necessary to assign a preliminary flood risk to each of the development areas. Flood risk is typically classed based on likelihood of flooding to occur combined with the severity and consequence of the flooding. At this stage in the process information is limited to the return periods available during the data gathering process and preliminary surface water modelling. Hence in order to give preliminary flood risk categories the following scoring system has been adopted.

- High: Substantial coverage of proposed development area by flooding of one or more flooding sources. Flow paths are often clear and linked with flood water ponding at substantial depths (1m>).
- Moderate: Moderate cover of the proposed development area by one or more flooding sources. Flow paths maybe less clear with areas of ponding typically between 0.3m-1m deep.
- Low: Only a small portion of the proposed developable land is affected by ponding of shallow depths typically up to 0.3m deep. Isolated areas of shallow ponding are frequent typically related to the demolition of industrial buildings.
- Very Low: Little to no flooding within developable area. Any flooding is typically isolated to localised low points at depths of <0.3m. Isolated areas of shallow ponding are frequent typically related to the demolition of industrial buildings

2.6.4.1 Fluvial Flood Risk

The Environment Agency's Flood Map for Planning Purposes places the site at very low risk from fluvial flooding. There are areas adjacent to the northern site boundary which are located within Flood Zone 2 due to the presence of The Fleet. None of the site is mapped by the Environment Agency as being located within Flood Zone 3.

Ash Gill Beck and Steel House Lake are too small to be included in the EA fluvial flood extent modelling so any fluvial flooding from these sources will not be captured in this mapping. Flood levels for the area included within the Environment Agency Flood Zone 2 extent have not been obtained at this stage of the assessment.

The Fleet model comprising of The Fleet and its main tributaries (JBA, 2015) was assessed. Based on the 100yr fluvial (Fleet Model) extents, the majority of the site is not expected to be inundated from flows from Ash Gill Beck and Steel House Lake during an event of this magnitude as the extent of flooding is largely constrained in the channel of Ash Gill Beck/Steel House Lake. However, there are two sections where flood water is predicted to overtop watercourse channels:

- A section to the west where flood extents predict that flow could overtop the bank of the watercourse and inundate a section of the access road included within the site boundary,
- A section in the south, where waters are modelled to overtop the culvert diverting Ash Gill Beck underneath an access road, south of the existing Steel House Development.

At this stage it is assumed that, as The Fleet, Ash Gill Beck and Steel House Lake all receive flows from culverted watercourses, the inflows are limited to the capacity of the on-site and downstream culverts. However, modelling indicates that during a 1 in 100 year fluvial flood event, flood waters are modelled to overtop the culvert diverting Ash Gill Beck underneath an access road, south of the existing Steel House Development.

The main flood risk relates to the 1 in 100 year flood events with an allowance for climate change and the 1 in 1000 year event which have not been modelled, and on the performance of the on-site, upstream and downstream culverts particularly when under tidal influence in conjunction with a fluvial flood event.

2.6.4.2 Coastal and Tidal Flood Risk

The Environment Agency's Flood Map for Planning revealed that the site is at very low risk from coastal/tidal sources. However, as part of the Level 2 Strategic Flood Risk Assessment (SFRA), a detailed model was created to supersede the broad scale EA tidal flood risk mapping. The modelling revealed that there are areas of the site at moderate to high risk of tidal flooding.

Flood waters from a 1 in 200-year tidal flood event, with a Sea Level Rise Allowance, is expected to inundate the areas of the site close to the on-site watercourses, which includes both the existing development and road network on-site.

The following observations were made from the coastal modelling:

- The land to the south of the site (A1085 and Wilton Works) are particularly vulnerable to tidal flood events, although this is outwith the site boundary, this is likely to impact access and egress.
- The western area of the site is elevated and is at low risk from coastal flooding.
- The western half of the site is within Flood Zone 1 and is, therefore, suitable for development according to Table 3 of the FRCC-PPG.

As previously mentioned, the coastal flood modelling does not take into account the presence of tidal limiting structures such as flap valves and weirs. This includes the weir present at Steel House Lake. As such there is a lower confidence in the flood mapping of the inland areas.

2.6.4.3 Surface Water Flood Risk

The site is at low risk from surface water flooding. However, the back-water effect from The Fleet results in flooding on the A1085 and Dormanstown. The modelling revealed that there is a substantial issue with surface water flooding on the A1085 which is a major access route to the site. It is therefore likely to affect access and egress routes from the site (see Section 3.4). Other ponding on the site relates to small isolated shallow ponds which is reflected in the hummocky nature of the brownfield site. With redevelopment there is the opportunity to regrade the ground and provide positive overland flow paths to drainage channels where surface water can be managed.

2.6.4.4 Additional Structures

An additional study undertaken at the site, identified a weir downstream of Steel House Lake. The backwater effects of this weir were observed extending back to the south of the A1080. The weir will have a significant effect on flood levels and sediment deposition within the channel and structures. This influence will increase as the effects of climate change materialise. JBA modelling of The Fleet indicates that, during a 1 in 100-year fluvial flood event, waters are modelled to overtop the culvert diverting Ash Gill Beck underneath an access road, south of the existing Steel House Development and upstream of the weir. This modelling does not take into account tidal influence or fluvial flows in relation to climate change allowances and it is assumed that modelling does not take into account backwater effects from the weir. As the upstream culvert cannot accommodate flow during a 1 in 100 year fluvial flood event, it will not accommodate flow when additional factors are considered, which is likely to result in an increased flood extent within the site in comparison to the flood extent that has been modelled along Steel House Lake and Ash Gill Beck.

2.6.5 Post Development Scenario

In terms of planning and plot-based design it is likely that the tidal levels are to be the defining factor in terms of plot elevations. A tidal flood level of 5.03mAOD represents the 1:200yr Coastal Flood Risk + Sea Level Rise Allowance to 2100 design scenario. It is understood that the ground levels for the site will be set above 5.03mAOD and therefore above the level to which flooding is anticipated. It is assumes this level will also be sufficient for fluvial flood risk.

Whilst the straightened and culverted watercourses through and surrounding the site present constraints to development, they also provide significant opportunities to manage flood risk and improve biodiversity, linking a number of priority habitats and species with internationally important designations.

There is therefore an aspiration for a Water Sensitive Urban Design, which is a land planning and engineering design approach which integrates the urban water cycle, including stormwater, groundwater and wastewater management and water supply, into urban design to minimise the cost of infrastructure, environmental degradation, and improve aesthetic and recreational appeal. This could take the form of blue-green networks which would extend across the site.

3 Flood mitigation measures

3.1 Flood Warning System and Existing Alleviation

The site is not within an EA Flood Warning or Flood Alert area. Within the Tees Estuary and low-lying land surrounding it there is the Tidal River Tees flood alert area (code 121WAT926). The monitoring station for this area is the River Tees at Tees Dock, station ID 8372, located at the Teesport dock, 4.3km north east of the site boundary.

There are no flood alleviation schemes within the site or affecting the small watercourses through the site. The closest scheme is the Port Clarence and Greatham South scheme, mentioned in section 0. These are designed to protect homes and businesses in Port Clarence.

3.2 Asset Design and Protection

Any new development should be located outwith the functional floodplain with a minimum final floor level equivalent to the 0.5% (200 year) flood level plus allowances for climate change and freeboard.

It is understood that the ground levels proposed for the development are to be confirmed. The tidal flood level of 5.03mAOD represents the 200-year Coastal Flood Risk + Sea Level Rise Allowance to 2100 design scenario. It is assumed that this level will provide protection for a fluvial flood event.

There is a residual risk of groundwater flooding throughout the STDC site however, this is expected to be limited to basements and other below ground structures where flood resilience will rely on the performance of waterproofing and pumping systems.

This assessment has been undertaken as a high-level analysis of flood risk to the site. Further mapping and modelling of flood risk will be required as part of the reserved matters stage of the planning process in relation to the drainage design and this will further identify opportunities and constraints.

3.3 Surface Water and Drainage Management

One of the core principles of STDC's strategy for the area is to promote a low carbon circular economy development, reducing energy costs and waste minimisation. Key principles to achieve this are embodying a strategy of Water Sensitive Urban Design. Water sensitive urban design is a land planning and engineering design approach which integrates the urban water cycle, including stormwater, groundwater and wastewater management and water supply, into urban design to minimise the cost of infrastructure, environmental degradation, and improve aesthetic and recreational appeal. Considering this principle and the information about the site a drainage strategy has been devised using blue-green corridors which offer multiple benefits including habitat creation, place making, increased amenity benefit and re-naturalisation of watercourses.

Blue-green infrastructure is of importance within the drainage strategy and forms a key part of delivering a sustainable eco-industrial park. The preliminary drainage strategy has been created by analysing the overland flow paths, drainage catchments, topography and development parcels. Whilst the straightened and culverted watercourses surrounding the site present constraints to development, they also provide significant opportunities to manage flood risk and improve biodiversity, linking a number of priority habitats and species with internationally important designations.

There is therefore an aspiration for a Water Sensitive Urban Design, which is a land planning and engineering design approach which integrates the urban water cycle, including stormwater, groundwater and wastewater management and water supply, into urban design to minimise the cost of infrastructure, environmental degradation, and improve aesthetic and recreational appeal. This could take the form of blue-green networks which would extend across the site.

3.4 Safe Access and Egress

Whilst outwith the site boundary, the flood maps show that the main access route from the south along the A1085 (Trunk Road) is at risk from flooding from surface water sources to depth and velocities of under 0.9m and 0.25m/s (towards the site) at the high risk level. At a medium risk the depths increase to above 0.9m and flood velocities increase over 0.25 m/s in some locations and water flows towards a low spot. At a low risk (less than 0.1% AEP) the flood velocities are mostly over 0.25 m/s and depths reach over 0.9m for parts of the site. Modelling also indicates that egress routes will be susceptible to fluvial and tidal flood events. Large emergency vehicles may be able to operate in flood depths of up to 0.9m21, so in the instance of a large flood event, it is anticipated that emergency access would be possible to most of the site. Emergency access and egress routes shall be included as part of the site operations plan.

3.5 Potential Impact of the Proposed Development on Flood Risk Within and Outwith the Site

Since it is understood that ground levels will be above the 200-year Coastal Flood Risk + Sea Level Rise Allowance to 2100 design scenario, the proposed development is not anticipated to have an impact on fluvial flood risk within or outwith the site.

The site boundary at present is located at or greater than 20m from the Tees. An environmental permit is required for any activity that may pollute the air, water or land; increase flood risk; or adversely affect land drainage and work on or near main rivers requires a permit. The River Tees is designated as a main river but as the other watercourses (open and culverted) across the site are not main rivers, the EA guidelines advise contacting the local council or internal drainage board to check if land drainage consent is required. https://www.gov.uk/guidance/check-if-you-need-an-environmental-permit Permits are generally required for:

- Any activity within 8 metres of the bank of a main river, or 16 metres if it is a tidal main river,
- Any activity within 8 metres of any flood defence structure or culvert on a main river, or 16 metres on a tidal river.

Once the design for the site is developed, consultation should be undertaken with the Flood Risk Management Authorities.

21 Defra/Environment Agency Flood and Coastal Defence R&D Programme: R&D Outputs: Flood Risks to People, FD2321/TR2 Guidance Document, 2006.

4 Conclusions

This high-level FRA has been prepared in accordance with NPPF for the proposed development at part of the Steel House (NEZ1) site that is part of the wider STDC area. The Environment Agency's Flood Map for Planning Purposes places the site at very low risk from fluvial flooding. The proposed development lies within Flood Zone 1 which means it has a chance of flooding of less than 0.1% - equivalent to the 1000-year event. However Ash Gill Beck and Steel House Lake are too small to be included in the EA fluvial flood extent modelling.

Detailed modelling of the watercourses, including Steel House Lake and Ash Gill Beck, indicates that the majority of the site is not expected to be impacted during a 1 in 100 year fluvial flood event. The extent of flooding is largely constrained in the channel of Ash Gill Beck/Steel House Lake however there are sections to the west and to the south of the watercourses which are modelled to overtop the watercourse channels.

Flood risk to the proposed development could also increase due to the weir via backwater effects to Steel House Lake/Ash Gill Beck when the impact of tidal influences and climate change is accounted for. There is also potential for an additional increase in flood risk at the culvert diverting Ash Gill Beck south of the existing Steel House Development. The main fluvial flood risk to the site relates to the 1 in 100 year flood events with an allowance for climate change and the 1 in 1000 year event which have not been modelled, and on the performance of the on-site, upstream and downstream culverts particularly when under tidal influence.

A tidal flood level of 5.03mAOD represents the 1:200yr Coastal Flood Risk + Sea Level Rise Allowance to 2100 design scenario and modelling indicated that flood waters are expected to inundate the areas of the site close to the on-site watercourses, which includes both the existing development and road network on-site. The proposed finished floor levels for the site is to be a minimum of 5.03mAOD which is equivalent to the 1 in 200 year coastal flood risk and sea level rise allowance to the 2100 design scenario. It should be noted that the modelling takes account of recent climate change scenarios which are representative of a worst-case scenario.

Surface water modelling indicates that, while the majority of the site is at very low risk of surface water flooding, there are areas of moderate-higher risk due to pooling of water in low spots on the site and because of the presence of The Fleet, which acts as an overland flow path for surface water through the site. Furthermore, there is a back-water effect from the Trunk Road which causes flooding on the main site. The aspiration for the development of a sustainable drainage strategy and aspiration for blue-green networks will create flow paths for this water to reduce the risk at the site.

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