

Havant Thicket Reservoir Project

Environmental Statement Volume 4 - Appendices

Appendix A15 Water

A15.5 Flood Risk Assessment Addendum (Pipeline)

Portsmouth Water Ltd.

23/05/2024

Atkins Doc No.: HTR-ATK-XX-XX-RP-Z-0091

Atkins Revision No.: C01

Flood Risk Assessment Addendum

Havant Pipeline

Rev.	Date	Reason for issue	Prepared	Reviewed	Approved
[1]	12/05/23	Draft	RV	JB	JB
[2]	12/05/23	Draft	RV	JB	JB
[3]	24/05/23	Issued to EA 1 st Review	RV	JP	JB
[4]	17/08/23	Draft	RV	JB	JP
[5]	09/11/23	Issued to Client	RV	JP	JP
[6]	18/01/23	Issued to EA 2 nd Review	RV	JP	JP
[7]	08/05/24	FOR PLANNING	RV	ASi	ASm

Project Name: Havant Pipeline
Project Number: 65209354
Client: Ward & Burke
Date: 29/05/2024
Author: Richard Vivian
Document Reference: HTR-SWE-PI-XX-RP-C-0001

Table of contents

1	Introduction	6
1.1	Background	6
1.2	Site location	7
1.2.1	Havant Thicket Reservoir location	7
1.3	Detailed design changes	7
1.3.1	Site overview	9
1.3.2	Study sections	11
1.4	Previous Studies.....	13
1.5	Assessing flood risk.....	15
1.6	Scope	16
2	Planning Policy	17
2.1	Background	17
2.2	Flood Zones.....	17
2.3	Vulnerability classification	18
2.4	Flood risk assessment.....	19
2.5	Sequential Test.....	19
2.6	Exception Test.....	19
2.7	Other policy and legislation	19
3	Baseline flood risk	23
3.1	Data	23
3.2	Historical flooding	23
3.3	Fluvial and tidal flooding	23
3.3.1	Hydraulic modelling	25
3.3.2	Model outputs	26
3.4	Surface water flooding.....	33
3.5	Flooding from groundwater	34
3.6	Other sources of flood risk / artificial sources	35
3.7	Summary of flood risk.....	35
4	Proposed Development.....	37
4.1.1	Permanent elements	38
4.1.2	Construction Works	41
5	Operation flood risk impacts	43
5.1	Havant Thicket Reservoir	43
5.1.1	Fluvial	43
5.1.2	Tidal.....	48
5.1.3	Surface Water	49
5.2	Pipeline	49
6	Construction flood risk impacts	51
7	Managing flood risk	54
7.1	Drainage management plan	54
7.2	Construction Environment Management Plan.....	54
7.3	Environmental permits.....	54
7.4	Operational maintenance	55
8	Residual risk	56
8.1	Embankment failure.....	56
8.2	Emergency drawdown strategy	56

8.3 Access and egress conditions, flood warning and evacuation.....60

9 Summary and Conclusions 61

9.1 Fluvial flood risk.....62

9.2 Surface water flood risk.....62

9.3 Residual risk.....62

9.4 Application of planning policy 63

Appendix A- Flood Maps

Appendix B- Hydraulic Modelling Report

Executive Summary

This FRA has assessed the flood risk to the changes at detailed design of the Havant Thicket Pipeline only and for the purposes of this assessment, no adverse changes have been made to the reservoir design since the 2020 FRA and subsequently there are no changes to the reservoir volume or predicted top water levels. Based on the original 2020 FRA, the Proposed Development, information made available or created by the Environment Agency and the FRA hydraulic modelling work, this assessment concluded that:

- There is no increase in fluvial flood risk compared to the 2020 FRA from the Proposed Development.
- Minor elements of the Proposed Development, namely the emergency discharge access road, will increase the hardstanding area, and as such without adequate drainage design, the Proposed Development has the potential to increase this surface water flood risk. A Drainage Management Plan will be developed and will apply SuDS principles, where appropriate, to ensure there is no increase in surface water flood risk up to and including the 1% AEP including an allowance for climate change;
- The risk of flooding from groundwater sources remains low;
- The risk of flooding from tidal sources remains low;
- The increase in residual risk remains the same as that concluded in the 2020 FRA. One industrial property and 2-3 gardens / outbuildings are at risk of flooding as a consequence of the emergency drawdown strategy.

1 Introduction

This Flood Risk Assessment (FRA) Addendum supports the Havant Thicket Reservoir FRA (HTR-ATK-XX-XX-RP-Z-0042¹), hereby referred to as the '2020 FRA'. The 2020 FRA was produced as part of the 2020 planning application for the Havant Thicket Reservoir project.

This FRA addendum (2024) supports a new planning application for the pipeline only and should be read in conjunction with the 2020 FRA. This FRA structure follows that of the 2020 FRA and provides updates, where applicable, under each section heading.

The reader will be referred to the corresponding 2020 FRA report section where no updates have been made to conclusions and findings.

This FRA has assessed the flood risk associated with the pipeline and for the purposes of this assessment, has assumed the design of the reservoir structure, control house, visitor centre and any ancillaries related to the reservoir itself are fixed. Information from the outline design of the reservoir has been used to inform this FRA.

The hydraulic modelling carried out for this assessment used the same model events and scenarios as in the 2020 FRA modelling and has directly compared results shown in flood maps (Appendix A) to assess the change in flood risk between the outline and detailed design stages.

1.1 Background

The responsible organisation for the project is Portsmouth Water. The aim of the Havant Thicket Reservoir is to provide a new resource to supply drinking water in the water-stressed South-East of England, while maximising the community and environmental benefits of a new raw water reservoir. The Havant Thicket Reservoir site and associated pipeline was granted planning permission in 2021 to ensure that there will be adequate provision to meet the water supply needs during the plan period and to secure sub-regional supplies in the medium and longer term.

The reservoir will provide improved resilience for existing Portsmouth Water customers and support additional housing growth in the Portsmouth Water supply area. The development will create new habitats, including a wetland, woodland and parkland habitat and enhance existing habitats through woodland management.

Construction of an underground twin pipeline will link the reservoir with the existing pumping station at Bedhampton (approximately 3.39km long) to fill the reservoir. The pipeline will also be used as an emergency drawdown pipeline if the reservoir needs to be drained down in emergency conditions in accordance with Environment Agency safety guidance².

¹ Atkins, *Havant Thicket Reservoir Project*, Environmental Statement Volume 4 -Appendices, Appendix A15 Water, A15.2 Flood Risk Assessment Report, 2020

² Environment Agency, 2021. Available online at: <https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/guide-to-drawdown-capacity-for-reservoir-safety-and-emergency-planning>

1.2 Site location

1.2.1 Havant Thicket Reservoir location

The site for the Havant Thicket Reservoir is located to the north of the town of Havant in the county of Hampshire. The reservoir site is split along a north-south alignment between two local planning authorities: Havant Borough Council and East Hampshire District Council. The reservoir site lies within a shallow valley located between the residential settlements of Leigh Park and Rowlands Castle and covers an area of approximately 160 hectares. The current site is predominantly open grassland with some woodland, hedgerows and ditches.

1.3 Detailed design changes

A site location map is shown in Figure 1-2 which shows the red line boundary for this planning application and for the reservoir planning application. The following changes concerning the pipeline have been made since the 2020 FRA:

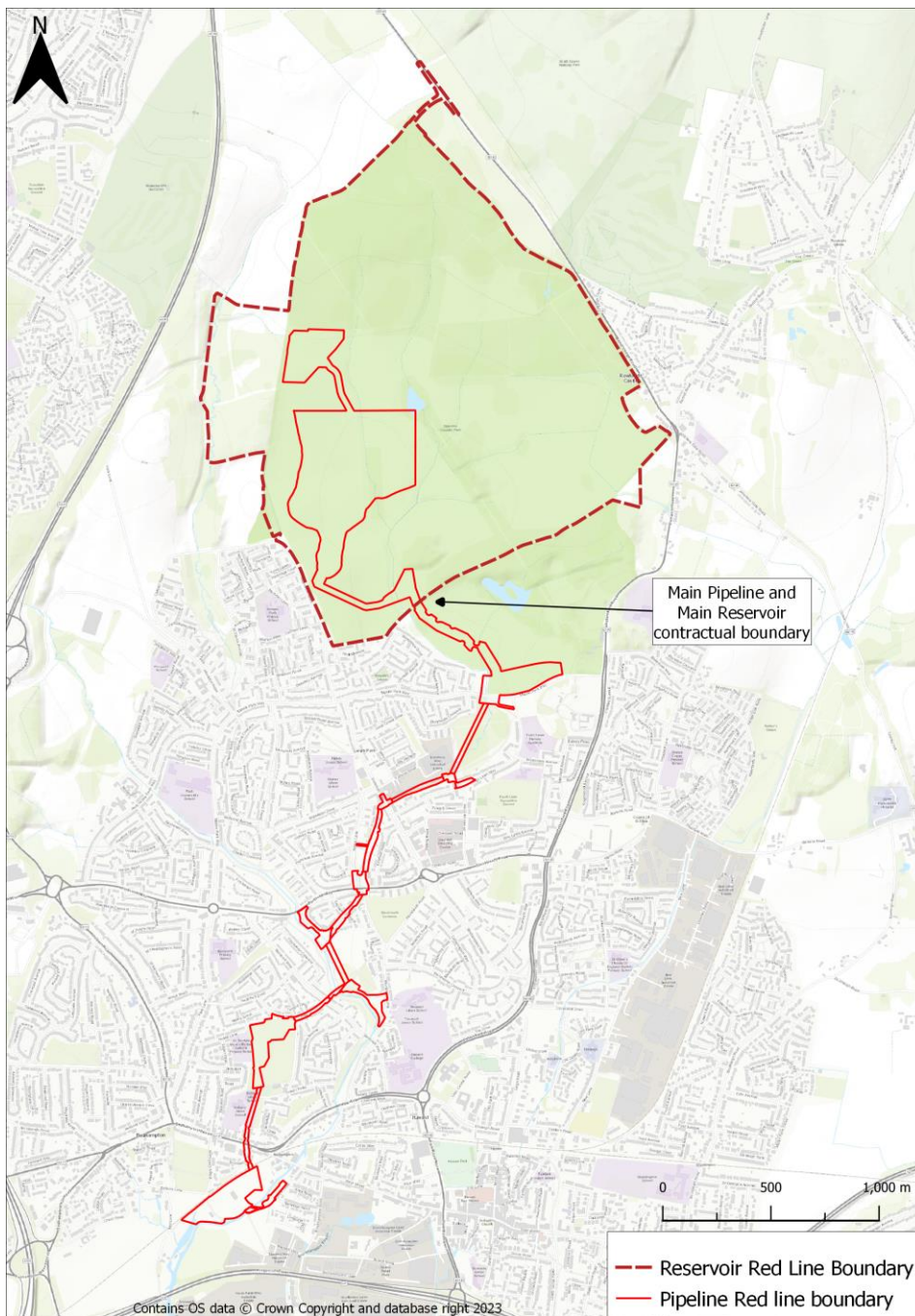
- The single bi-directional pipeline has been replaced by a twin pipeline, one inlet pipe for filling the reservoir and one outlet pipe for emergency drawdown.
- The inlet pipeline extends north of the reservoir embankment beyond the contractual boundary of the main pipeline.
- The development boundary has changed, and the pipelines now closely follows the course of the Riders Lane and Hermitage Streams.
- The pipeline construction methodology has changed from open cut trench to a combination of open cut trench and tunnelling.
- The number of construction areas has increased from five to eight to accommodate the change in construction methodology.
- The position of the emergency discharge into the Hermitage Stream has moved from downstream of Middle Park Way to the Hermitage Stream and Riders Lane Stream confluence adjacent to Corhampton Crescent.

For the purposes of this report, the twin pipeline is referred to as 'the pipeline'.

It should be noted that there are no changes to the locations for culvert upgrades to mitigate against the emergency drawdown strategy and the. Detailed design for the culvert upgrades remains ongoing.

From the reservoir site the inlet pipe will pass through the north-west corner of the reservoir embankment and be installed via open cut construction (Pipeline Section P10). Associated infrastructure contained in Section P10 will be constructed by the Main Reservoir Contractor. The toe of the reservoir embankment located on Riders Lane Stream forms the contractual boundary between the Main Pipeline Contractor and the Main Reservoir Contractor. The contractual boundary for the Main Pipeline Contractor contains Pipeline Sections P0 – P9).

Figure 1-1: Site location plan

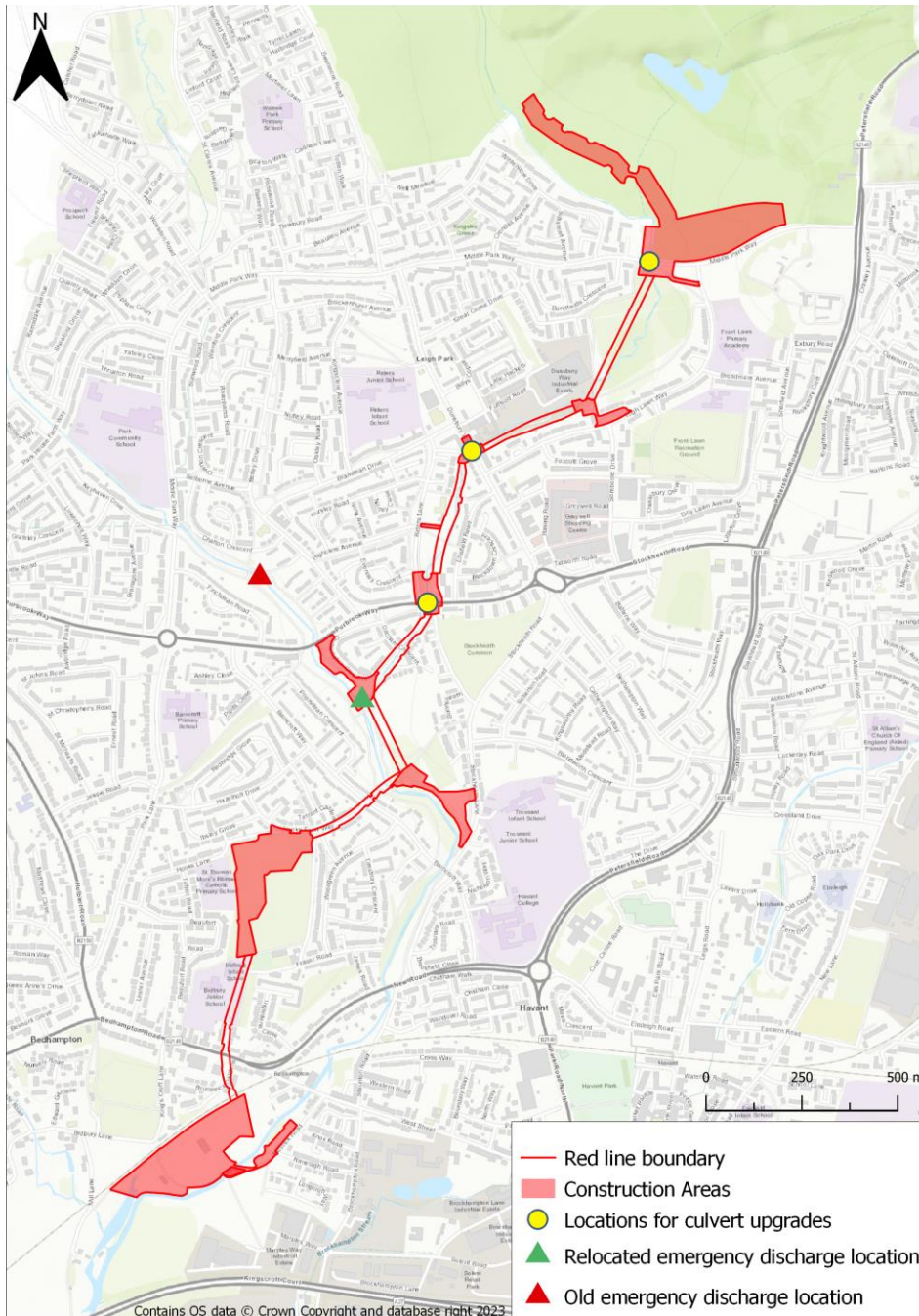


The reservoir embankment is to be constructed before the pipeline which would result in severance of surface water flow pathways and attenuation of water upstream of the embankment. The flood risk to both the reservoir and pipeline were assessed in the 2020 FRA. As such there is no requirement for this FRA to consider the impacts of the pipeline on the flood risk upstream of the reservoir embankment.

This FRA, therefore, assesses the flood risk as a result of the updates to the pipeline design downstream of the reservoir, only. The extents of the red line

boundary which are assessed in this FRA are shown in Figure 1-2, this extent is referred to as ‘the Proposed Development’ within this FRA.

Figure 1-2: Proposed Development pipeline plan



1.3.1 Site overview

Within the study area there are two Environment Agency designated main rivers, the Hermitage Stream and Riders Lane Stream, as shown on Figure 1-3.

Main rivers are usually larger rivers and streams, on which, the Environment Agency are responsible for overseeing maintenance and improvement works. Smaller rivers are referred to as ordinary watercourses, and the flood risk

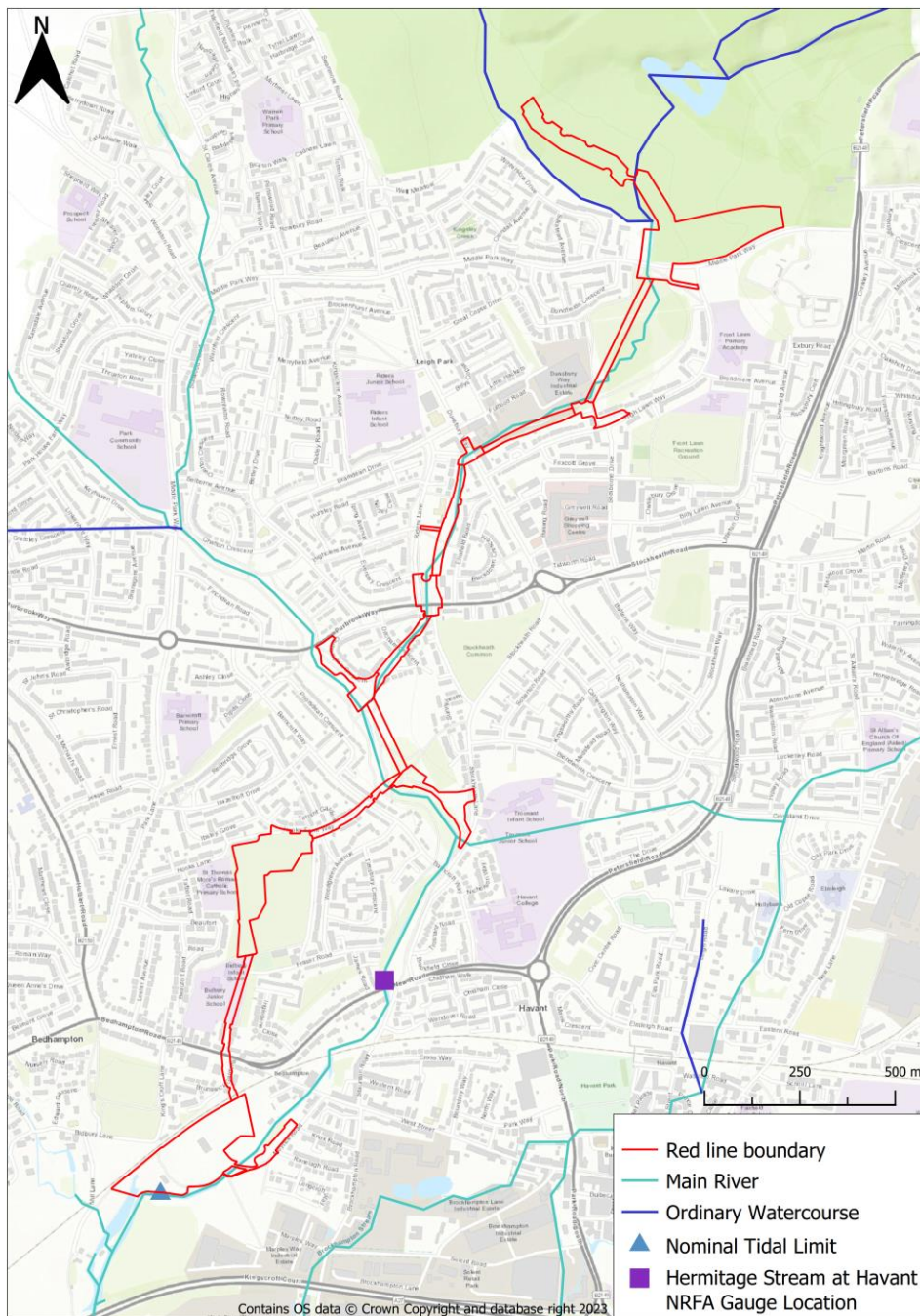
management of these watercourses is overseen by Lead Local Flood Authorities (LLFAs). The Hermitage Stream has an approximate catchment size of 20km², however 4.5km² of that area is attributed to the Riders Lane Stream catchment. The upper catchment of the Riders Lane Stream includes five ordinary watercourses, which are ephemeral in nature and often run dry. The Riders Lane Stream also has a pond feature called 'Upper Lake' at National Grid Reference (NGR) SU 7142110030.

To the west of the reservoir site are the headwaters of Park Lane Stream (part of the Hermitage Stream catchment). The Park Lane Stream is classed as an ordinary watercourse until it is culverted under the urban area, where it becomes a main river. The confluence of the Park Lane Stream with the Hermitage Stream is just upstream of the confluence of the Hermitage Stream with the Riders Lane Stream.

The Nominal Tidal Limit (NTL) is at NGR SU 70511 06237 on the Hermitage Stream, just south of Meyrick Road. The Hermitage Stream flows over a weir at this point, after which it becomes a transitional waterbody, Langstone Harbour.

Figure 1-3 also shows the location of the National River Flow Archive (NRFA) gauge; Hermitage Stream at Havant (NRFA no. 42017).

Figure 1-3: Map showing main rivers and ordinary watercourse in proximity to Havant Thicket Reservoir



1.3.2 Study sections

For the purpose of this FRA and to ensure consistency with the 2020 FRA, the surface waterbodies have been divided up into study sections for comparison of flood risk. The eight sections are set out in Table 1-1 below.

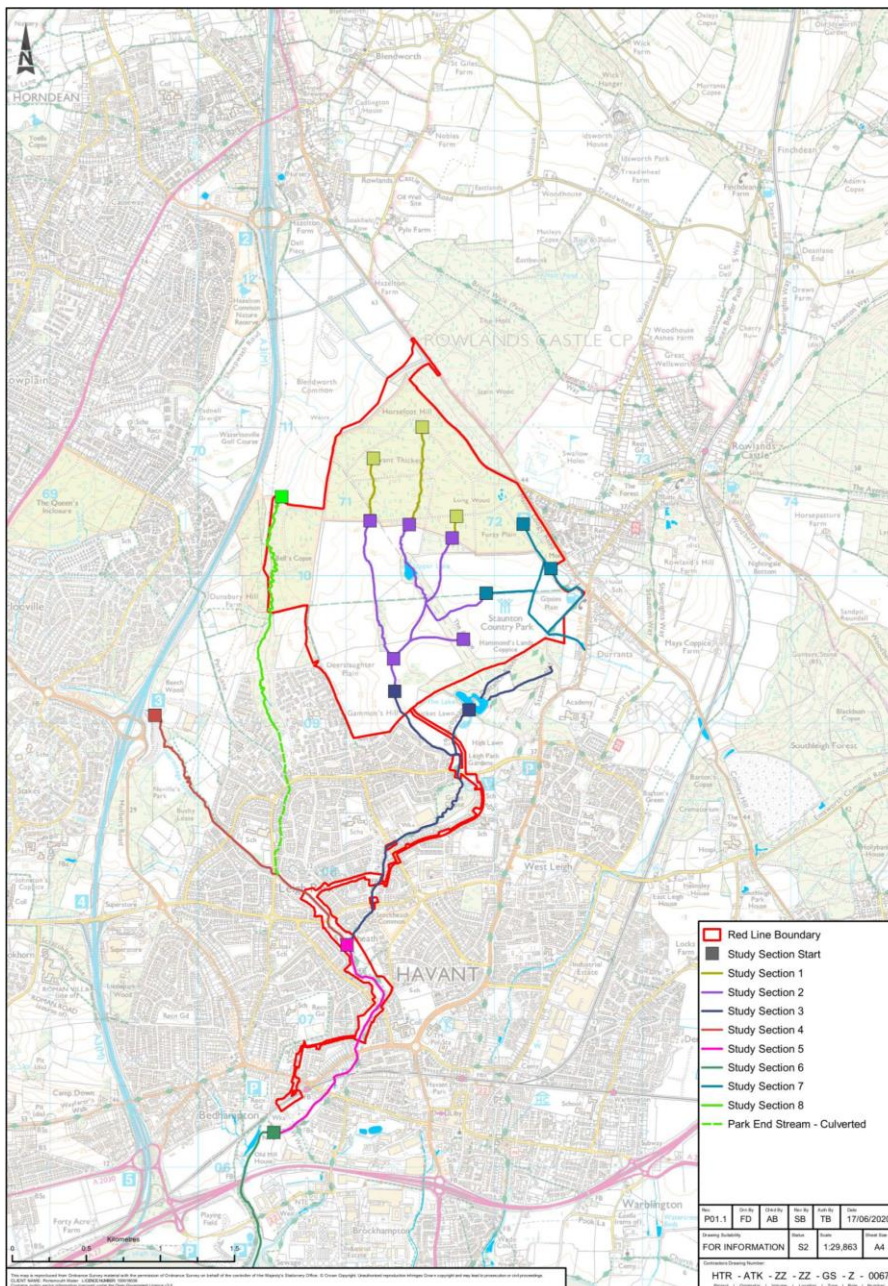
Table 1-1: Study sections used for flood risk analysis

Study section	Description	Grid reference – upstream	Grid reference - downstream
1	Headwater Streams 1, 2 and 3 up to Reservoir footprint	HS1 - SU 71178 10789 HS2 - SU 71520 11000 HS3 - SU 71743 10398	HS1 - SU 71160 10368 HS2 - SU 71421 10346 HS3 - SU 71713 10253
2	Headwater Streams 1, 2, 3, 4, 5, Upper Lake and short section of Riders Lane Stream (RLS) all under Reservoir footprint	HS1 - SU 71160 10368 HS2 - SU 71421 10346 HS3 - SU 71713 10253 HS4 - SU 71828 09793 HS5 - SU 71621 09697 RLS - SU 71314 09436	HS1 - SU 71314 09436 HS2 - SU 71537 09816 HS3 - SU 71537 09816 HS4 - SU 71621 09697 HS5 - SU 71475 09570 RLS - SU 71319 09440
3	RLS between Reservoir footprint up to Hermitage Stream confluence. The Lake Stream (TLS) joining Riders Lane Stream from Leigh Lake.	RLS - SU 71319 09440 TLS - SU 71836 09095	RLS - SU 71007 07503 TLS – SU 71747 08787
4	Hermitage Stream – between A3(M) and confluence with Riders Lane Stream	SU 69631 09096	SU 71007 07503
5	Hermitage Stream – between confluence with Riders Lane Stream and Nominal Tidal Limit	SU 71007 07503	SU 70511 06237
6	Langstone Harbour	SU 70511 06237	SU 68652 00138
7	Headwater Streams draining east towards River Lavant	SU 71947 09871	SU 72613 09497
8	Park Lane Stream	SU 70563 10531	SU 70513 09001

As outlined above, this FRA only assesses the risk downstream of the proposed reservoir embankment, therefore, the hydraulic model used to define the baseline flood risk in Section 3 only covers study sections 3-6.

A map of the 2020 FRA study sections is shown in Figure 1-4. The same study sections are used in this report. Any reference to the red line boundary in the figure are superseded.

Figure 1-4: Map showing study sections used for analysis in 2020 FRA, red line boundaries now superseded.



1.4 Previous Studies

The 2020 FRA has formed the basis of this assessment and is referred to throughout this report. A Flood Risk Management Inception Report was undertaken by Atkins in 2019 for the Havant Thicket Reservoir Project. The report summarised the work undertaken previously, gathered information relating to flood risk management and assessed its usefulness for the design development. Table 1-2 from the 2020 FRA details the most relevant documents with findings relevant to flood risk and is also presented in Table 1-2 below.

Table 1-2: Previous Studies (Extract of the 2020 FRA)

Report	Year	Finding
Environment Agency Flood Report Information	2008	Details the (now superseded) Havant InfoWorks RS flood model reports and results.
Public consultation	2008	Records that the general public were concerned about flood risk and climate change, specifically noting concerns at Whichers Gate area of Rowland's Castle and Leigh Park.
Panel of Experts Report	2008	Refers to the need for embankment failure to be assessed and for a Flood Plan.
Local Planning Authority (LPA) Environmental Impact Assessment (EIA) Scoping Opinion	2009	Identifies the need for a FRA in compliance with PPS25 (now superseded by the NPPF), and additionally considering: • The testing and operation of the reservoir • emergency drawdown system; • Embankment failure; • Applying the Sequential Test to demonstrate no suitably available alternatives at lower flood risk • and • Satisfying the Havant Borough Council (BC) Local Plan policies on development and flood risk. Subsequent documents indicate that a formal Sequential Test is not required, as discussed below.
Arup Environmental Handover Note	2009	Refers to the need for a FRA in compliance with PPS25 (now superseded by NPPF), and additionally considering: • The testing and operation of the reservoir • emergency drawdown system; and • Embankment failure. Appendix B of the handover note provides further detail with areas at possible flood risk identified as Middle Park Way, Great Copse, Durrants Road, Redhill Road/College Close, Finchdean Road, Woodberry Lane, Dean Lane End, Ashcroft Lane.
Arup Engineering Handover Note	2009	Refers to the need for embankment failure to be assessed and for a Flood Plan.
Arup Planning Handover Note	2009	Refers to the need for a FRA with reference to PPS25 (now NPPF), CIRIA C624 and ICE 'Floods and Reservoir Safety'. This states that a formal Sequential or Exception Test would not need to be undertaken as HTR is completely within Flood Zone 1, although evidence should be provided of alternatives considered and rejected.

Report	Year	Finding
Portsmouth Water Feedback Reports	2009	These note that the 2009 FRA scoping is largely complete. Key remaining issues were as follows: • Need for summary text in relation to the Sequential Test. The Environment Agency at the time indicated that the Sequential Test would need to be applied, but that this could be covered by reference to the historic 1960s-2000s range of studies rather than formal application of the Test. • The Environment Agency also noted the need to refer to the Probable Maximum Flood (PMF) and the 0.01% (1 in 10,000) Annual Exceedance Probability (AEP) event and seepage/lining failure events relating to reservoir safety and design. • Portsmouth Water needed clarity on future testing time scale (6 or 12 months) of emergency drawdown system; why low flows (less than 7m³/s at Hermitage Stream) are noted as a concern; whether the emergency drawdown discharge can be contained by Riders Lane and/or Hermitage Streams.
Arup Alternatives and Needs Assessment, and Portsmouth Water Feedback	2011	Notes the Environment Agency's request for the greater use of the historic options studies since the 1960s to set out the reasoning for selecting the Havant Thicket site. The document also notes that the Environment Agency requested the Sequential Test information prior to the FRA being submitted.
Portsmouth Water HTR Risk Register and Vision	2018	Note the need for a FRA and to consider the risk of embankment failure.
Havant Borough Council Local Plan	2019	
Atkins Lavant Link Pipe and Extreme Tidal Levels Study	2019	Findings described within FRA.
Atkins Emergency Drawdown Study	2019	

No studies concerning the Havant Thicket Reservoir project or pipeline have been completed between 2020 and 2024.

1.5 Assessing flood risk

A FRA should consider all types of flooding to satisfy the following three key objectives:

- to assess flood risk to the Proposed Development and to demonstrate that any residual risks to the development and its users would be acceptable;
- to assess the potential impact of the Proposed Development on flood risk elsewhere and to demonstrate that the development would not increase flood risk elsewhere; and,

- to satisfy the requirements of the National Planning Policy Framework (NPPF).

Flood risk should be considered alongside other spatial planning issues such as transport, housing, economic growth, natural resources, regeneration, biodiversity, the historic environment and the management of other hazards. Throughout this document, the risk of flooding will be described using Annual Exceedance Probability (AEP). For example, a 1% AEP, has a 1 in 100 chance of occurring in any given year.

1.6 Scope

The scope remains the same as that in the 2020 FRA. The scope has been designed to include a thorough assessment of baseline flood risk, the potential impact on flood risk of the operation of the Proposed Development, the potential impact on flood risk of the construction of the Proposed Development, and an assessment of the residual risk posed, principally by emergency rapid drawdown of the reservoir.

2 Planning Policy

2.1 Background

The National Planning Policy Framework (NPPF³), published in 2012 and most recently updated in 2023, is the overarching document in relation to development and flood risk and sets out the Government's policy on development relating to flood risk. The aim of the NPPF is to ensure that development is not at an unacceptable risk of flooding.

Where development is unavoidable in areas at risk from flooding, the NPPF ensures that the development is safe without increasing flood risk elsewhere and where possible reducing flood risk overall.

In accordance with the NPPF, a site-specific FRA should be provided for all development in Flood Zones 2 and 3. In Flood Zone 1, a FRA should accompany all proposals involving sites of 1 hectare or more; land which has been identified by the Environment Agency as having critical drainage problems; land identified in a Strategic Flood Risk Assessment (SFRA) as being at increased flood risk in the future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.

2.2 Flood Zones

The Environment Agency's Flood Map is divided into three separate Flood Zones. These Flood Zones are used by the NPPF in determining the appropriateness of proposed developments when considering flood risk through the application of the Sequential Test. They represent the probability of flooding without flood defences in place.

The Flood Zones are defined in Table 2-1.

Table 2-1: Environment Agency Flood Zones

Flood Zone	Definition
Flood Zone 1: Low Probability	Land where the annual chance of flooding is lower than 0.1% for either fluvial or sea flooding.
Flood Zone 2: Medium Probability	Land where the annual chance of flooding is between 0.1 and 1.0% for fluvial flooding. Or, land where the annual chance of flooding is between 0.1 and 0.5% for flooding from the sea.
Flood Zone 3a: High Probability	Land where the annual chance of flooding is 1.0% or greater for fluvial flooding. Or, land where the annual chance of flooding is 0.5% or greater for flooding from the sea.

³ Ministry of Housing, Communities and Local Government, 2012. National Planning Policy Framework. Available at <https://www.gov.uk/government/publications/national-planning-policy-framework--2>

Flood Zone	Definition
Flood Zone 3b: Functional Floodplain	Land where water has to flow or be stored in times of flooding. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. Local planning authorities identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. Functional floodplain will normally comprise: Land where the annual chance of flooding is 3.3% or greater for fluvial. Or, land that is designed to flood, even if it would only flood in more extreme events

2.3 Vulnerability classification

The NPPF assigns vulnerability type to land use in terms of vulnerability to the impact of flooding. The definitions for vulnerability type, and Flood Zone compatibility, is available on the gov.uk website⁴. The pipeline is classified as essential infrastructure under the vulnerability classifications.

Table 2-2 sets out the NPPF flood risk vulnerability and flood zone compatibility assessment, as taken from Table 2 of the NPPF Flood Risk and Coastal Change Planning Practice Guidance⁵.

The table indicates which development types are appropriate within each Flood Zone.

Table 2-2: Flood Risk Vulnerability Classification

Flood Zones	Flood Risk Vulnerability Classification				
	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test Required	✓	✓	✓
Zone 3a †	Exception Test Required †	✗	Exception Test Required	✓	✓
Zone 3b	Exception Test Required*	✗	✗	✗	✓*

† In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

* In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

- Remain operational and safe for users in times of flood;
- Result in no net loss of floodplain storage; and,
- Not impede water flows and not increase flood risk elsewhere.

⁴ Environment Agency, 2021. Available at: <https://www.gov.uk/guidance/national-planning-policy-framework/annex-3-flood-risk-vulnerability-classification>

⁵ Environment Agency, 2022. Available at: <https://www.gov.uk/guidance/flood-risk-and-coastal-change>

2.4 Flood risk assessment

In accordance with the NPPF, in order to reduce the risk of flooding, all developments greater than one hectare in size, or sites within Flood Zones 2 or 3, must submit a FRA or comply with the Environment Agency's Flood Risk Standing Advice where relevant.

The red line boundary of the pipeline is greater than one hectare. This, and the fact that there are areas of Flood Zones 2 and 3 within the red line boundary, means that a FRA is required for this development.

If required, dependent on the Proposed Development type and vulnerability classification, the FRA should demonstrate that the Proposed Development passes the Sequential Test and / or Exception Test.

2.5 Sequential Test

As the proposed development was granted planning consent in 2021, the Sequential Test is deemed to be passed. The basis of the Sequential test was that Havant Thicket has been determined as the most appropriate and safe location for the new Havant Reservoir, and subsequently pipeline infrastructure, as outlined in paragraph 2.17 of the 2020 FRA. I

2.6 Exception Test

As the proposed development was granted planning consent in 2021, without the requirement for the Exception Test, as it is noted in the Havant SFRA Local Plan Sites document⁶, that the Havant Thicket Reservoir and pipeline does not require an Exception Test owing to the nature of the development.

2.7 Other policy and legislation

The 2020 FRA summarises the national and local policies that have been considered throughout the scheme development. These policies, including those that are updated are shown in Table 2-3.

Table 2-3: National and local policies

Guidance	Region	Description
Floods Directive (2007/60/EC)	UK & Europe	The aim of this Directive is to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. It sets the strategic level for flood risk that any development will need to comply with.
Flood and Water Management Act ⁷	National	The key areas covered by this Act are: Roles and responsibilities for flood and coastal erosion risk management and, improving reservoir safety.
National Planning Policy Framework (NPPF)	National	The NPPF (as discussed in previously in this section) sets strict tests to protect people and property from flooding which all local planning authorities are expected to follow. It forms the basis of assessment of flood risk for projects.

⁶ Havant Borough Council, 2018. Strategic Flood Risk Assessment (Local Plan Sites).

⁷ UK Government, 2010. Flood and Water Management Act 2010. Available at: <http://www.legislation.gov.uk/ukpga/2010/29/contents>

Guidance	Region	Description
Reservoirs Act	National	In England, reservoirs that are capable of holding 25,000m ³ or more of water are regulated under the Reservoirs Act 1975. The undertakers (owners or operators) of these reservoirs are required to register them with the Enforcement Authority (the Environment Agency) following which a designation of 'high-risk' or 'not high-risk' will be given. Those designated high-risk will be subject to inspection and supervision by reservoir. engineers. Havant Thicket Reservoir will be designated as 'high-risk' and therefore will fall under the requirements of the Reservoirs Act (1975).
Environment Agency Guide to risk assessment for reservoir safety management ⁸	National	This report outlines the preferred drawdown capacity for reservoirs in the UK. This guidance is intended for reservoir inspection engineers, required by UK reservoir legislation to review the drawdown capacity of reservoirs.
Environment Agency Guide to drawdown capacity for reservoir safety and emergency planning ⁹	National	This report outlines the preferred drawdown capacity for reservoirs in the UK. This guidance is intended for reservoir inspection engineers, required by UK reservoir legislation to review the drawdown capacity of reservoirs.
Environmental Permitting regulations (Defra / EA, 2016)	National	Permitting guidelines for activities that are regulated by the Environment Agency. An Environmental Permit is required if you do an activity that could: • pollute the air, water or land • increase flood risk • adversely affect land drainage
Havant Borough Local Plan 2036 (Pre-Submission)	Local	This has not yet been adopted as is still undergoing consultation. However, it sets out the vision and a framework for the future Development, growth and prosperity of Havant Borough. It is influenced by the National Planning Policy Framework (NPPF). The Local Plan outlines Havant Thicket Reservoir as a Key Project (KP9). However, it does set out criteria for planning permission to be granted. For example, sustainable, cost-effective, providing environmental and community benefits, conserving natural, rural and historic character, assessing impacts on watercourses etc. Policies of note within this Local Plan include: • Policy E19: Managing flood risk in a new development • Policy E20: Drainage infrastructure in new development.

⁸ Environment Agency, 2013. Risk assessment for reservoirs. Available online at <https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/risk-assessment-for-reservoirs>

⁹ Environment Agency, 2021. Guide to drawdown capacity for reservoir safety and emergency planning. Available online at <https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/guide-to-drawdown-capacity-for-reservoir-safety-and-emergency-planning>

Guidance	Region	Description
Havant Borough Local Plan (Core Strategy) ¹⁰	Local	The core strategy forms part of the Havant Borough Local Development Framework (HBLDF) by outlining the broad detail and direction of development within the borough. Havant Thicket Reservoir is an allocated strategic site within Policy CS18. It also identified criteria for planning permission to be granted. For example, sustainable, cost-effective, deliver environmental and community benefits, assess risk of flooding within storm events etc. Another policy of note within this Local Plan is Policy CS15: Flood and Coastal Erosion Risk.
East Hampshire District Council Local Plan 2017-2036 (Draft)	Local	A new Local Plan (2017-2036) is currently undergoing consultation and thereby still in draft form. This allocates Havant Thicket Reservoir site (Policy S31) and identifies it as key infrastructure. It also identifies criteria for planning permission to be granted. For example, sustainable, cost-effective, providing environmental and community benefits, assessing risk of flooding during storm events within a flood risk assessment etc. Policies of note within this Local Plan include: • Policy S25: Managing Flood Risk • Policy S24: Planning for climate change
East Hampshire District Council Local Plan: Joint Core Strategy ¹¹	Local	The Joint Core Strategy purpose is to provide a policy framework for new development within the District Council area as well as allocating development areas. Policies of note within this Local Plan include: • CP25: Flood Risk • CP26: Water resources/ Water quality – this safeguards the site identified for the Havant Thicket Reservoir from development.
Hampshire County Council Local Flood Risk Management Strategy (LFRMS) ¹²	Local	The Flood and Water Management Act 2010 requires LLFAs (Hampshire County Council) to develop a strategy for local flood risk management as well as being responsible for flood risk management relating to groundwater, surface water or ordinary watercourses. This document aids individuals, communities, businesses and authorities to understand the flood risk within Hampshire and how to manage it. The main focus is on local sources of flooding for example, surface water or ordinary watercourses (e.g. streams and ditches).

¹⁰ Hampshire County Council, 2011. Hampshire County Council Preliminary Flood Risk Assessment.

¹¹ East Hampshire District Council, 2014. East Hampshire District Local Plan: Joint Core Strategy.

¹² East Hampshire District Council, 2014. East Hampshire District Local Plan: Joint Core Strategy.

Guidance	Region	Description
Hampshire County Council Preliminary Flood Risk Assessment (PFRA) ¹³	Local	The PFRA provides an overview of flood risk within Hampshire. This includes flood risk from multiple sources, for example, surface water, groundwater, main rivers, ordinary watercourses, tidal flooding and reservoirs. This informs Local Flood Risk Management Strategies and Surface Water Management Plans. The report also includes the impact of climate change on future flooding and the impact on long term developments.
Partnership for Urban South Hampshire (PUSH) Strategic Flood Risk Assessment (SFRA) ¹⁴	Local	A SFRA is an assessment which aims to inform Local Planning Authorities (e.g. Havant Borough Council) on flood risk within the area in order for site allocations and strategic planning to be undertaken.
East Hampshire District Council Strategic Flood Risk Assessment (SFRA) ¹⁵	Local	This assessment assesses the flood risk within East Hampshire in order to inform the Local Plan, and site-specific flood risk assessments. It is an update to the 2018 SFRA.

¹³ Hampshire County Council, 2011. Hampshire County Council Preliminary Flood Risk Assessment.

¹⁴ PUSH, 2016. Strategic Flood Risk Assessment 2016 Update.

¹⁵ EHDC, 2022. East Hampshire Level 1 SFRA.

3 Baseline flood risk

The NPPF states that all types of flooding should be considered in the development framework. This section assesses the baseline flood risk to the study area and compares the baseline flood risk to the conclusions drawn in the 2020 FRA baseline assessment.

3.1 Data

To inform the baseline assessment of flood risk, the following available information has been used (accessed April 2023):

- Environment Agency Flood Zones¹⁶
- Environment Agency Surface Water Mapping¹⁷
- InfoWorks ICM (Integrated Catchment Model) Hydraulic River Model

3.2 Historical flooding

The 2020 FRA summarised the historical flooding within the catchment and noted the damage caused by the September 2000 fluvial event. It concluded that the Lavant and Havant catchments flood in different storm event types and a flood occurring on one of the two streams will not usually result in a flood of similar magnitude on the other stream. This is caused by the varying catchment response times caused in part by characteristics such as the surface type, geology and topography.

The 2020 FRA noted that there has not been significant flooding experienced in the Hermitage Stream since the 1970s.

The Hermitage Stream at Havant (gauge number 42017) forms part of the National River Flow Archive (NRFA) dataset¹⁸, it is classed as only being suitable for QMED. The flow records show that no significant flooding has been observed in the catchment in the intervening period (i.e. the 2020 FRA).

As such there is no additional information on historical flooding.

3.3 Fluvial and tidal flooding

The Environment Agency publish mapping showing Flood Zones that cover the Environment Agency designated main rivers (Figure 3-1). There are negligible differences in the extents of the Flood Zones between the 2020 FRA and this assessment.

For the Riders Lane Stream fluvial flooding occurs mostly in bank, or within areas of open land. There is limited flooding to properties. The same trend is seen downstream of the Hermitage Stream. The flood maps indicate an abrupt change in flood risk along a straight line on Hermitage Stream, upstream of Middle Park Way.

¹⁶ Environment Agency, 2023. Available online at: <https://flood-map-for-planning.service.gov.uk/>

¹⁷ Environment Agency, 2023. Available online at: <https://www.gov.uk/check-long-term-flood-risk>

¹⁸ Centre for Ecology and Hydrology, 2023. Available online at: <https://nrfa.ceh.ac.uk/data/station/peakflow/42017>

The 2020 FRA identified that this abrupt change has led to uncertainty in the reliability of the Flood Zones and deemed them unsuitable for defining the baseline flood risk to the study area alone.

The risk of flooding was therefore refined through the development of a detailed hydraulic model for the 2020 FRA.

The nominal tidal limit is located at a series of weirs situated south of Meyrick Road. Upstream of this point the flood risk is fluvial, however below this point the Flood Zones also indicate tidal influences. The 2020 FRA identified that under changing climate predications, it is expected that the tidal limit will migrate upstream to between the bridges located at Meyrick Road and West Street.

There is no significant tidal flood risk to the study area with flows staying largely in bank, or within areas of open land.

Figure 3-1: Environment Agency Flood Zones



3.3.1 Hydraulic modelling

An InfoWorks (v9.0.2) ICM hydraulic model was built to inform the baseline flood risk in the catchment for the 2020 FRA. The hydraulic model was reviewed by the Environment Agency in 2020 and deemed suitable in assessing flood risk to the Scheme.

This assessment has used the same hydraulic model to assess the baseline fluvial flood risk for the present day.

The model was updated to the latest software release (v2023.2.0) and minor changes were made to the baseline model as described in Appendix B. The model boundaries remain the same as those described in paragraph 3.15 of the 2020 FRA. The reader is referred to Figure 3-2 of the 2020 FRA for a model overview. The red line boundary within this figure should be ignored. The hydraulic model used to inform the 2024 FRA was approved by the Environment Agency on 18 July 2023.

A full hydrological assessment of the catchment was completed for the 2020 FRA. The hydrology proforma can be found in Appendix C of HTR-ATK-XX-XX-RP-Z-0042 (2020 FRA). A hydrological assessment was completed for this FRA (as requested by the Environment Agency) and the proforma can be found in Appendix A of Appendix A- Hydraulic Modelling Report. The hydrology assessment concluded that the FEH (Flood Estimation Handbook) Statistical and ReFH2.3 (Revitalised Flood Hydrology) methods produced very similar results. Considering that the ReFH2.3 default estimates were the final choice of method in the 2020 FRA, and the ReFH2.3 estimates have remained the same since the 2020 FRA, no updates to the original hydrology were made. The Environment Agency approved the 2024 FRA hydrological assessment on 18 July 2023.

Current climate change estimates for peak river flow allowances are based on the UK Climate Projections 2018 and were updated in 2021 based on the latest Environment Agency guidance¹⁹. The development at the site, comprising the proposed pipeline, is classified as 'essential infrastructure' under Annex 3 of the flood risk vulnerability classification⁴.

The following climate change allowance scenarios for the East Hampshire Management Catchment and for a time horizon of 2080s are given below:

- central – 37%
- higher – 51%
- upper – 88%

As the site is essential infrastructure within Flood Zone 3a, the peak flow 'higher' climate change allowance of 51% has been used to uplift the inflow hydrographs.

The upper allowance of 88% has been used as a sensitivity check as confirmed by the Environment Agency on 2 May 2023.

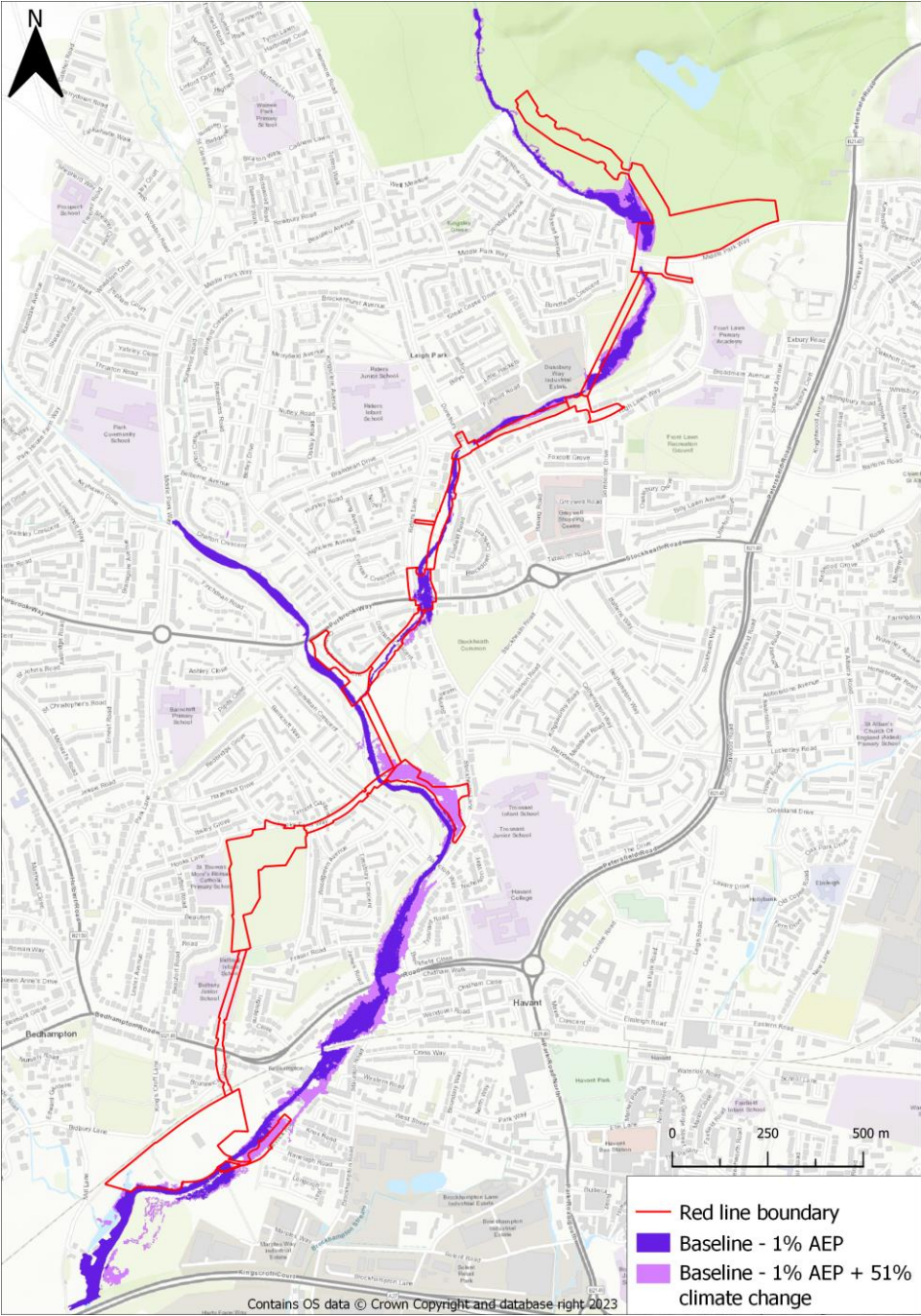
No updates were made to the tide curves in the hydraulic model. The reader is referred to Appendix B for further detail on the hydraulic model inflow updates.

3.3.2 Model outputs

The baseline flood extents defined by the ICM results are shown in Figure 3-2 for the 1% AEP and 1% AEP plus 51% climate change events.

¹⁹ Environment Agency, 2022. Available online at: <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>

Figure 3-2: Baseline flood risk (1% AEP and 1% AEP plus 51% CC)



The baseline model outputs to be used for comparison to the Proposed Development scenario are given in Table 3-1.

Table 3-1: Baseline model outputs

Study Section	AEP	u/s peak level (mAO D)	d/s peak level (mAO D)	u/s peak flow (m³/s)	d/s peak flow (m³/s)
1	No river data available, assessment will be qualitative				

Study Section	AEP	u/s peak level (mAOD)	d/s peak level (mAOD)	u/s peak flow (m³/s)	d/s peak flow (m³/s)
2	No river data available, assessment will be qualitative				
3	3.33% AEP	20.80	7.86	3.09	5.46
	1% AEP	20.86	8.07	3.84	6.62
	1% AEP + CC	21.00	8.46	5.80	9.13
	0.1% AEP	21.01	8.52	6.38	9.72
4	3.33% AEP	9.99	7.86	11.77	13.51
	1% AEP	10.10	8.07	14.53	16.68
	1% AEP + CC	10.36	8.46	21.94	25.16
	0.1% AEP	10.42	8.52	23.90	27.31
5	3.33% AEP	7.86	2.96	18.91	17.98
	1% AEP	8.07	3.04	23.28	22.53
	1% AEP + CC	8.46	3.28	34.29	34.61
	0.1% AEP	8.52	3.52	37.03	36.52
6	3.33% AEP	2.96	2.72	18.16	25.19
	1% AEP	3.04	2.72	22.54	29.79
	1% AEP + CC	3.28	2.72	34.63	42.37
	0.1% AEP	3.32	2.72	36.55	44.28
7	No river data available, assessment will be qualitative				
8	No river data available, assessment will be qualitative				

The baseline 1% AEP results from the 2020 FRA were compared to the baseline 1% AEP results from this assessment (Table 3-2). Study sections 3 through 6 shown in Figure 1-4 have been used.

Table 3-2: Comparison of the 1% AEP event to the 2020 FRA

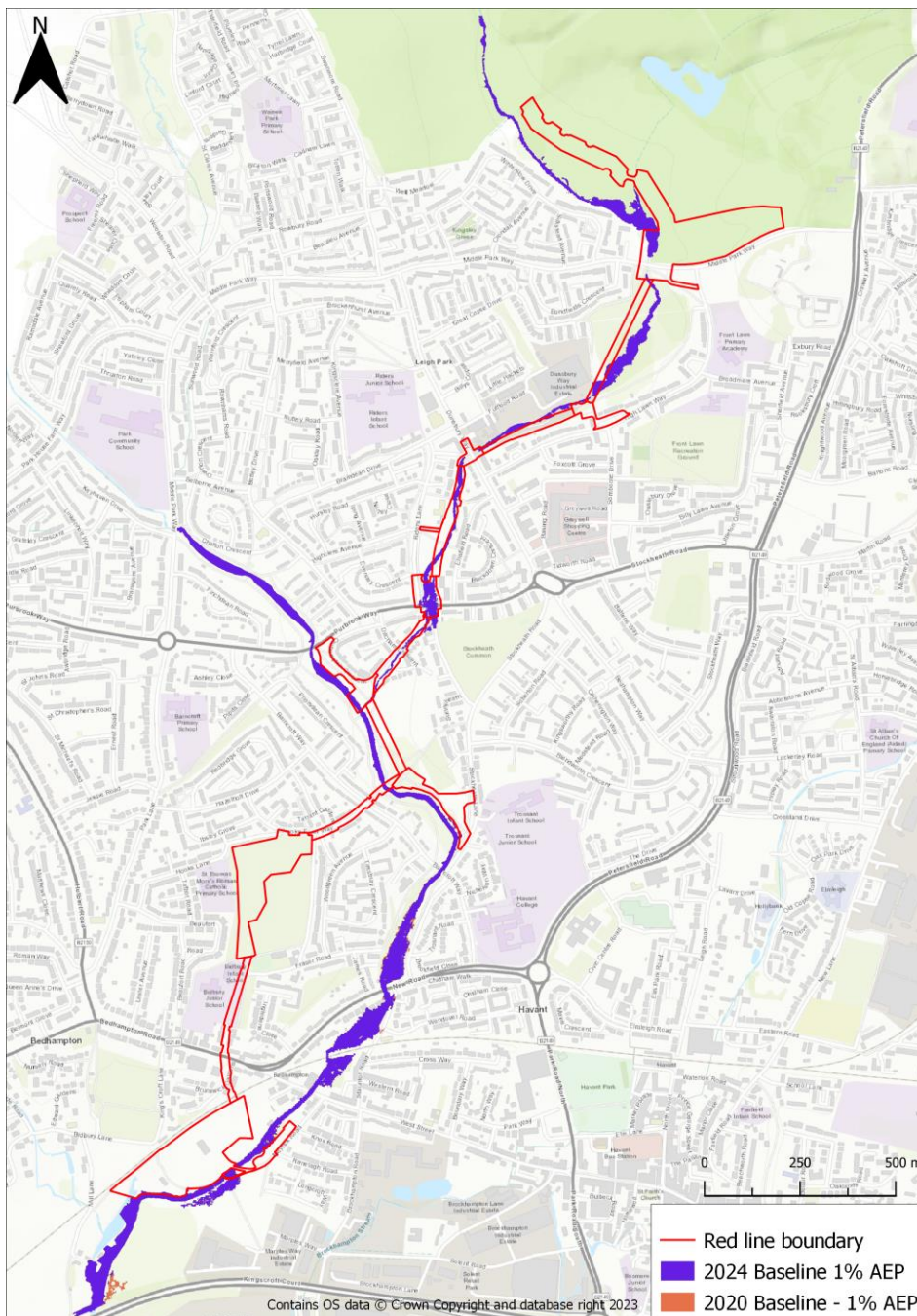
Study section	Assessment	u/s peak level (mAOD)	d/s peak level (mAOD)	u/s peak flow (m³/s)	d/s peak flow (m³/s)
Study section 3	2020 FRA	20.86	8.06	3.84	6.62
	2024 FRA	20.86	8.07	3.84	6.62
Study section 4	2020 FRA	10.10	8.06	14.53	16.68
	2024 FRA	10.10	8.07	14.53	16.68

Study section	Assessment	u/s peak level (mAOD)	d/s peak level (mAOD)	u/s peak flow (m ³ /s)	d/s peak flow (m ³ /s)
Study section 5	2020 FRA	8.06	3.04	23.26	22.70
	2024 FRA	8.07	3.04	23.28	22.53
Study section 6	2020 FRA	3.04	2.72	22.70	29.91
	2024 FRA	3.04	2.72	22.54	29.79

The results in the baseline scenario produced negligible differences compared to the 2020 FRA baseline results. Any changes are attributed to a combination of updating the hydraulic model to the latest software release, the minor changes made to the model build and rounding to two decimal places when reporting. Further details on the changes made in the hydraulic model between the two assessments can be found in Appendix B.

The 1% AEP results in this assessment showed changes in peak level of no more than 10mm compared to the 1% AEP 2020 FRA results. The largest difference in peak flow occurred at the downstream extent of the model. The flood extents between the two baseline scenarios are compared in Figure 3-3. The changes in peak level and flow had negligible impacts on flood extents. The only notable change to flood extent occurred near the downstream extent of the model boundary upstream of the A27.

Figure 3-3: Baseline flood extent comparison between 2020 and 2024 FRA



The baseline results were compared by overlaying the 0.1% AEP and 1% AEP flood extents with the Environment Agency Flood Zone 2 flood map (Figure 3-4) and Flood Zone 3 flood map (Figure 3-5) respectively.

Figure 3-4: Flood Zone 2 comparison

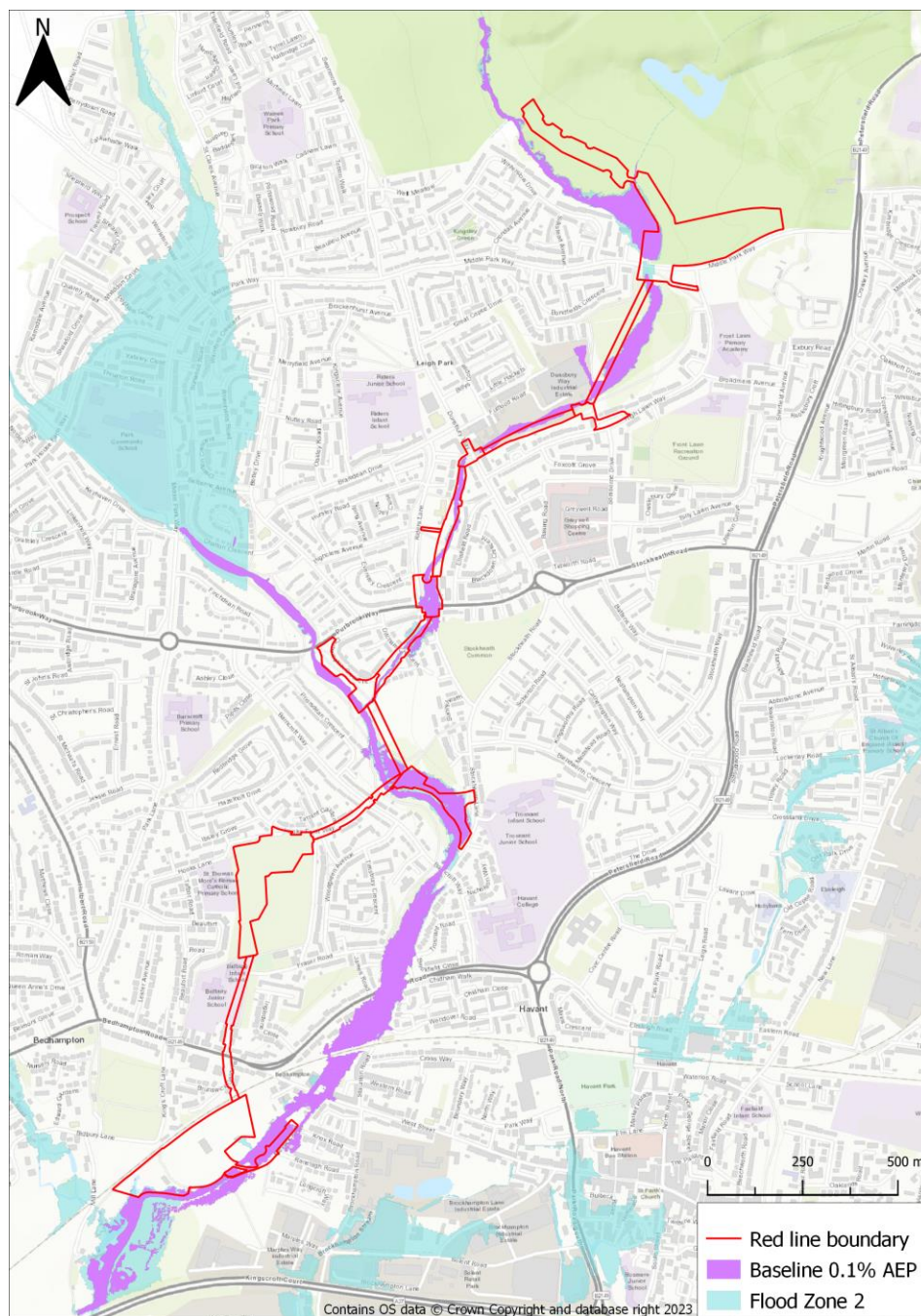
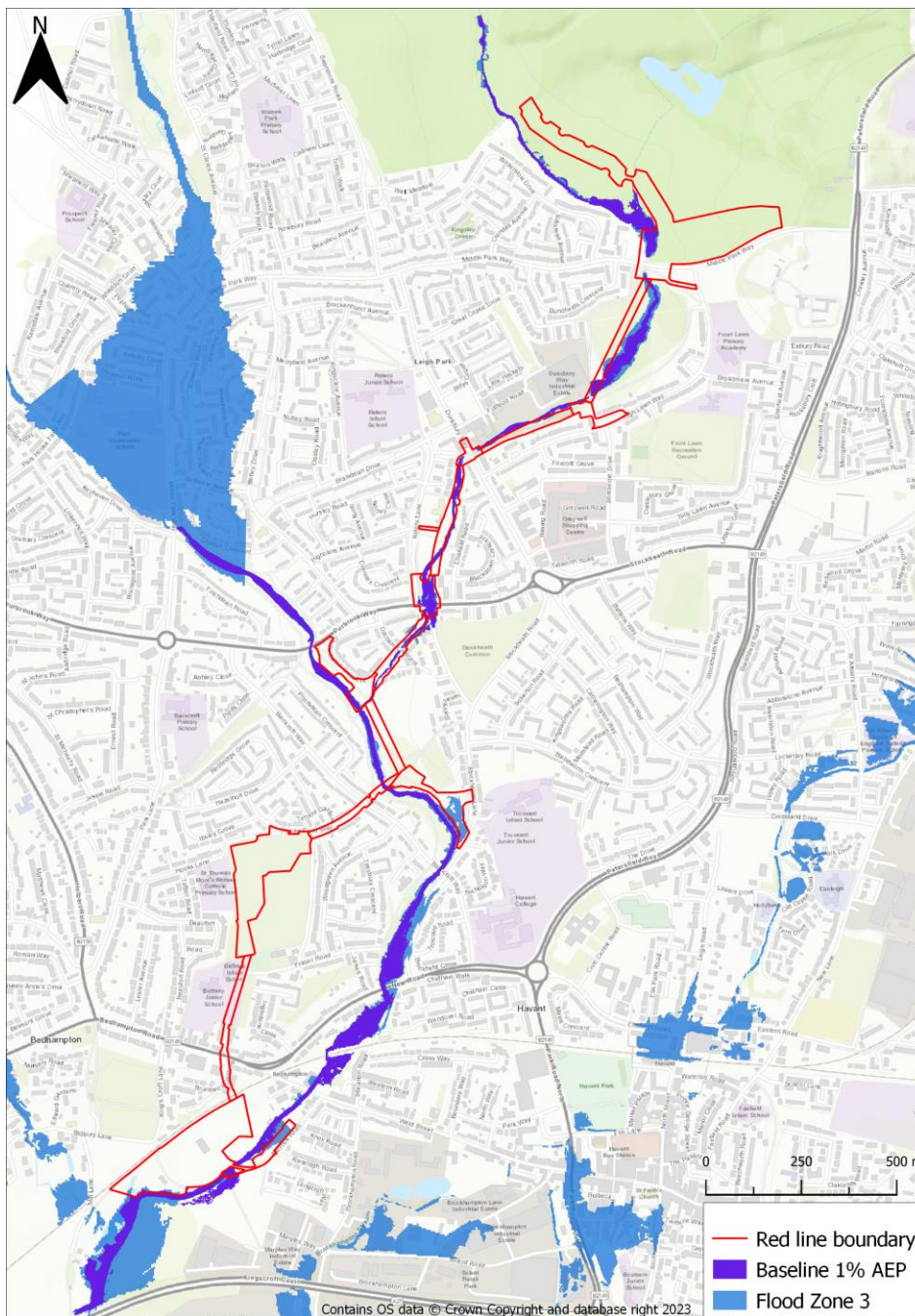


Figure 3-5: Flood Zone 3 comparison



The detailed ICM hydraulic model provides a more refined extent of the flood risk within the catchment, as it removes the anomaly in the floodplain extent at the northern end of Leigh Park on the Hermitage Stream. The flood extent produced by the hydraulic model is considered a more robust estimate of flood risk as it was calibrated to recorded high flows for use in the 2020 FRA and has derived from an updated hydraulic model.

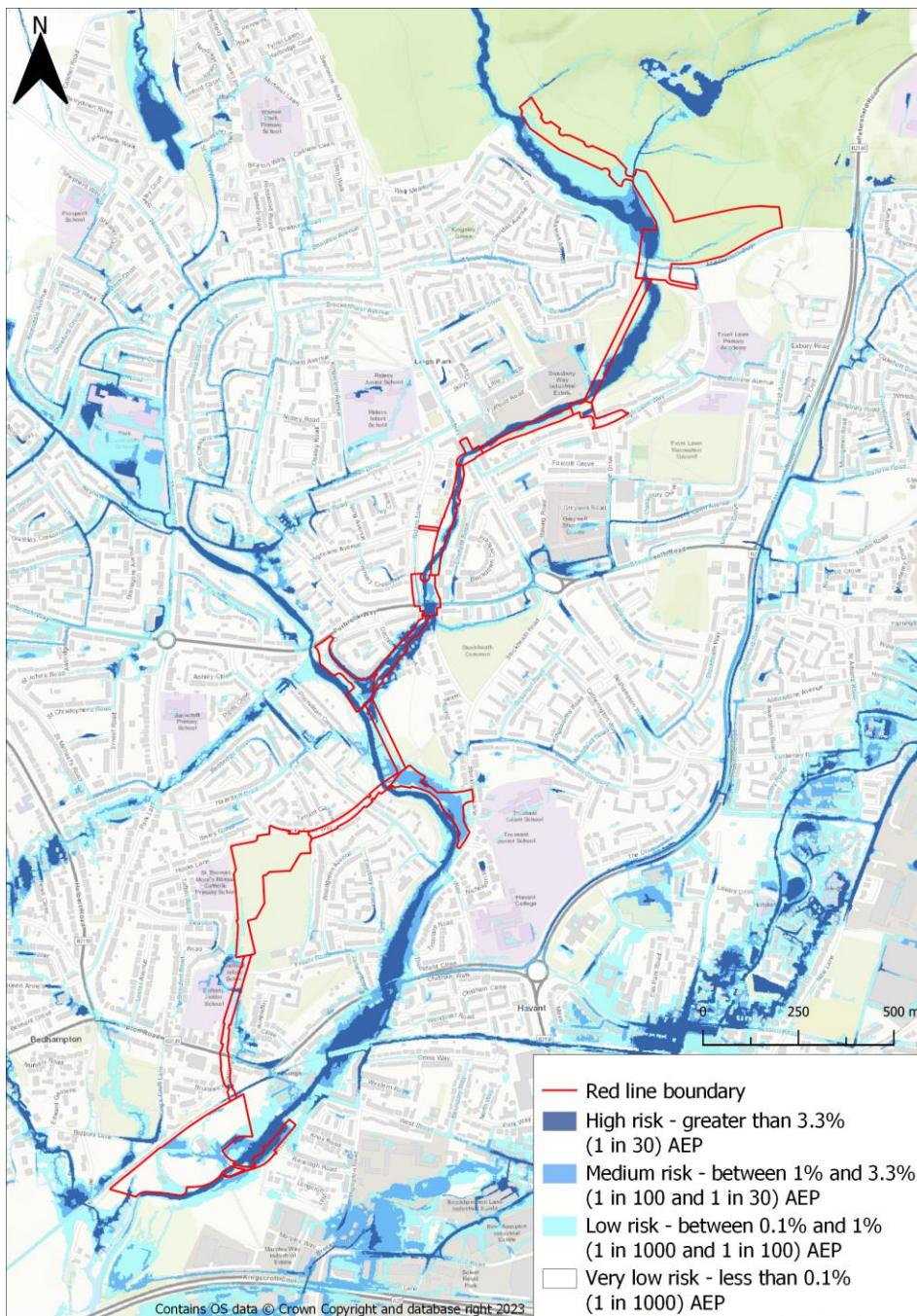
3.4 Surface water flooding

The Environment Agency Risk of Flooding from Surface Water (RoFSW)¹⁷ maps indicate the estimated risk of flooding from surface water (Figure 3-6). There are negligible differences between the RoFSW maps presented in the 2020 FRA and those shown in this report.

Surface water flood risk generally follows the same flow pathway and trend when compared to the Environment Agency Flood Zones. There are, however, localised flow routes and localised areas of ponding caused by variations in topography.

There is varying probability of surface water flood risk within the study area ranging from greater than 3.33% AEP (high probability) to between 0.1% AEP and 1% AEP (low probability).

Figure 3-6: Baseline flood risk from surface water



3.5 Flooding from groundwater

The PUSH Strategic Flood Risk Assessment (SFRA) identified that although Havant has been susceptible to groundwater flooding historically, these events have been focussed around the upper parts of the Lavant Stream, north-east of the study area. The SFRA recommended that only site specific FRAs for sites within the upper reaches of the Lavant Stream should consider groundwater flows. The 2020 FRA concluded that groundwater flood risk within the study area is defined as negligible.

There are no changes to the 2020 FRA groundwater flood risk conclusions.

3.6 Other sources of flood risk / artificial sources

The study area was assessed for any new potential artificial sources of flood risk such as reservoirs, canals or lakes in the 2020 FRA.

No new artificial sources were found within the study area for this assessment. Consequently, there are no changes to the 2020 FRA artificial sources of flood risk conclusions.

3.7 Summary of flood risk

Table 3-6 of the 2020 FRA presents a summary of the flood risk sources to the study area. There are no changes to the conclusions presented in the table. These conclusions are presented in Table 3-3 below.

Table 3-3: Summary of flood risk sources taken from 2020 FRA

Source	Summary	Potential for change as a result of the Proposed Development
Fluvial flooding	Fluvial flooding occurs mostly in bank, or within area of open land on both the Riders Lane Stream and downstream on the Hermitage Stream after the confluence of the two. The model results, when compared to the Environment Agency Flood Zones, show that the detailed hydraulic modelling has further refined the flood extents, with noticeable decreases on the Hermitage Stream in Leigh Park and downstream of the NTL.	Yes
Tidal flooding	The NTL is situated on the Hermitage Stream at GR SU 70511 06237. Upstream of this point the flood risk is fluvial, however below this point flood risk also includes tidal influences. There is no significant tidal flood risk, with flows staying largely in bank, or within areas of open land.	Yes
Surface water flooding	Surface water flood risk generally follows the same path and trend as the Environment Agency Flood Zones, remaining in bank, or within areas of open space. There are, however, localised flow routes through the urbanised roads in the area and localised areas of surface water ponding caused by variations in topography.	Yes

Source	Summary	Potential for change as a result of the Proposed Development
Groundwater flooding	Groundwater levels and information from the PUSH SFRA indicate that groundwater flood risk is small within the catchment, with higher risk in the Lavant Stream catchment to the East. Therefore, groundwater will not be commented on further in this FRA.	No
Other	There is the potential for residual risk to increase with the operation of the reservoir, due to failure of the embankment.	Yes

4 Proposed Development

This chapter describes the key design information for the elements of the Havant Pipeline construction works. The Proposed Development in this report concerns the design of the pipeline only.

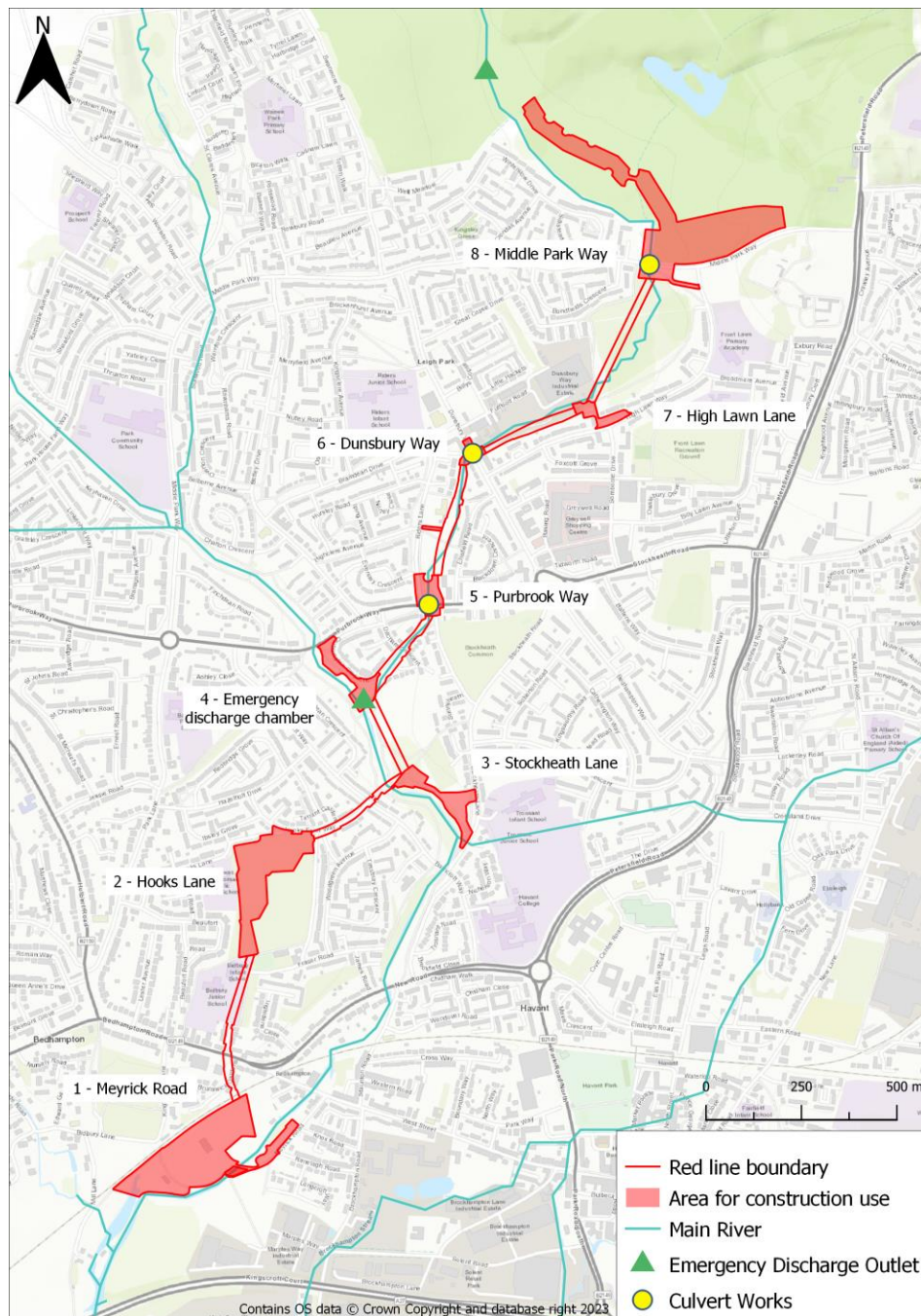
This assessment compares the results of the 'With Scheme' scenario in the 2020 FRA with the Proposed Development scenario in this assessment.

The key changes to the pipeline corridor since the 2020 FRA are given below:

- The single bi-directional pipeline has been replaced by a twin pipeline, one inlet pipe for filling the reservoir and one outlet pipe for emergency drawdown.
- The inlet pipeline extends north of the reservoir embankment beyond the contractual boundary of the main pipeline.
- The development boundary has changed, and the pipelines now closely follows the course of the Riders Lane and Hermitage Streams.
- The pipeline construction methodology has changed from open cut trench to a combination of open cut trench and tunnelling.
- The number of construction areas has increased from five to eight to accommodate the change in construction methodology.
- The position of the emergency discharge into the Hermitage Stream has moved from downstream of Middle Park Way to the Hermitage Stream and Riders Lane Stream confluence adjacent to Corhampton Crescent.

The red line boundary, construction compounds, emergency discharge outlets and proposed culvert works are shown in Figure 4-1. The construction compounds have been numbered for the purposes of this assessment.

Figure 4-1: Location of Proposed Development and the construction compounds



4.1.1 Permanent elements

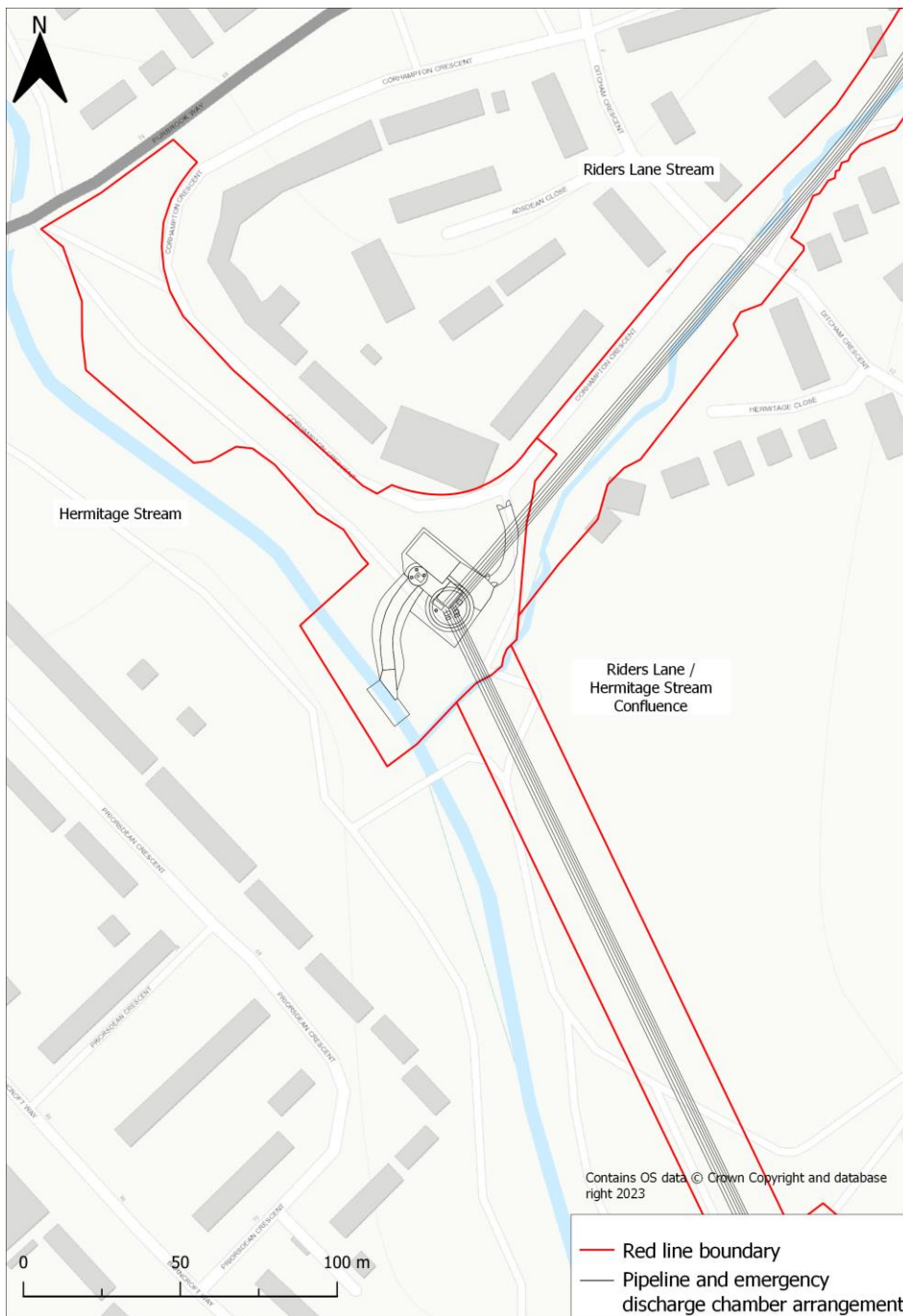
The Havant Thicket Reservoir will operate as a pumped storage reservoir utilising surplus water from the Havant & Bedhampton Spring source. A twin pipeline (3.39km) is therefore required to allow for the transfer and discharge of water between the Bedhampton Springs and the reservoir and from the reservoir to Riders Lane Stream.

Eight shafts are to be constructed to access the pipeline, these will be sealed post-construction.

The maximum emergency discharge rate from the reservoir in accordance with Environment Agency guidance has been calculated as 10.9m³/s. This maximum emergency discharge rate remains unchanged from the 2020 FRA, termed the Emergency Discharge Condition. The Emergency Discharge Condition from the reservoir is split to allow 7.05m³/s to the Riders Lane Stream directly downstream of the reservoir embankment, and 3.85m³/s to the Hermitage and Riders Lane Stream confluence.

The emergency discharge arrangement is shown in Figure 4-2. The arrangement comprises the discharge shaft, emergency discharge valve chamber, a weir and a spillway. At the base of the spillway is a stilling pond that dissipates the emergency discharge flow before entering the main Hermitage Stream channel.

Figure 4-2: Emergency discharge location



The pipeline includes one 1000mm diameter pipe for filling the reservoir with spring water from Bedhampton and a 1200mm diameter gravity main pipe for returning water to Bedhampton and to accommodate the Emergency Discharge Condition.

The pipeline route now follows beneath the Riders Lane Stream up to the confluence with the Hermitage Stream. The pipeline then deviates from the Hermitage Stream before finishing near Bedhampton train station.

In order for the Riders Lane Stream to receive the Emergency Discharge Condition without increasing flood risk, three changes to culverts along the river are required as part of the planning application as shown in Table 4-1. These culvert upgrades are shown in Figure 4-1.

Table 4-1: Alterations to existing culverts

Location	Existing configuration	Proposed configuration
Middle Way Park	1x1540mm circular concrete culvert	1x1540mm + 1x1200mm circular culverts
Dunsbury Way	1x1450mm circular culvert	1x1450mm + 1x1200mm circular culverts
Purbrook Way	3x900mm circular culvert	5x900mm circular culvert

It should be noted that there have been no changes to suggested culvert upgrades from the 2020 FRA.

4.1.2 Construction Works

The pipeline will, for the most part, adopt tunnelled construction methodology with sections of open cut trench.

Works will generally be outside of the 8m consenting boundary, however, where works need to take place within the 8m consenting boundary, a Flood Risk Activity Permit (FRAP) will be applied for from the Environment Agency.

Dry open cut trench methodology will be used at the crossing of the ordinary watercourse, the Lake Stream, downstream of the reservoir. This will entail the temporary damming of the watercourse. The methodology will require environmental permitting. The only other location where open cut trench methodology will be adopted is within the grounds of Havant Rugby Football club (see Figure 4-1 - construction compound 2), outside of the 8m consenting boundary.

The pipeline will be tunnelled beneath the Hermitage and Riders Lane Stream watercourses. There are no anticipated changes to ground levels due to the tunnelled pipeline.

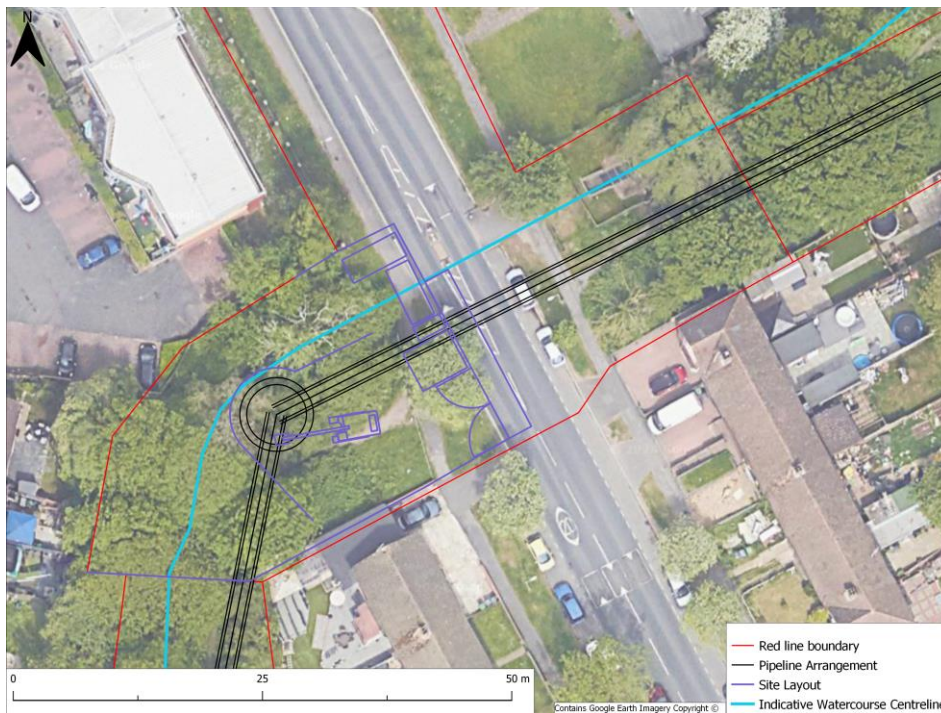
Construction compounds are planned adjacent to the Hermitage and Riders Lane Streams. Each individual pipe section will have a secured (fenced) area and welfare office for the duration of the works within that section. Temporary stockpiling of materials within construction compounds will be minimised as much as practicable. A dynamic risk assessment will be undertaken where any temporary stockpiling is required within the floodplain to ensure that the Proposed Development complies with the overall FRA requirements.

The construction of the emergency discharge chamber will result in limited in-channel works.

Construction of Shaft 6, located within construction compound 6, will result in significant in-channel works for an approximate duration of four months. The proposed shaft extent will lie adjacent to the left bank of Riders Lane Stream (Figure 4-3) Construction of the shaft requires a section of sheet piling that begins at the outlet of the Dunsbury Way culvert, wraps around Shaft 6 and ties into the riverbank. The sheet pile extents protrude into the Riders Lane Stream causing a 50% reduction in channel width. Fluming will be required during

construction to maintain the passage of flow around the site. Upon construction completion, the sheet piles will be removed, and the channel width restored to baseline conditions.

Figure 4-3: Proposed Shaft 6 arrangement



The flood risk implications of temporarily constricting flow at the Shaft 6 location have been assessed in Section 6 of this report.

5 Operation flood risk impacts

This chapter describes the flood risk impacts (as a result of the relocation of the emergency discharge outfalls and the proposed culverts only) to and from the permanent Proposed Development elements during the operation of the Havant Thicket Reservoir and pipeline.

The pipeline corridor is within Flood Zone 3, although it is underground when operational and has been designed to convey the required flows, therefore there is no associated flood risk.

5.1 Havant Thicket Reservoir

5.1.1 Fluvial

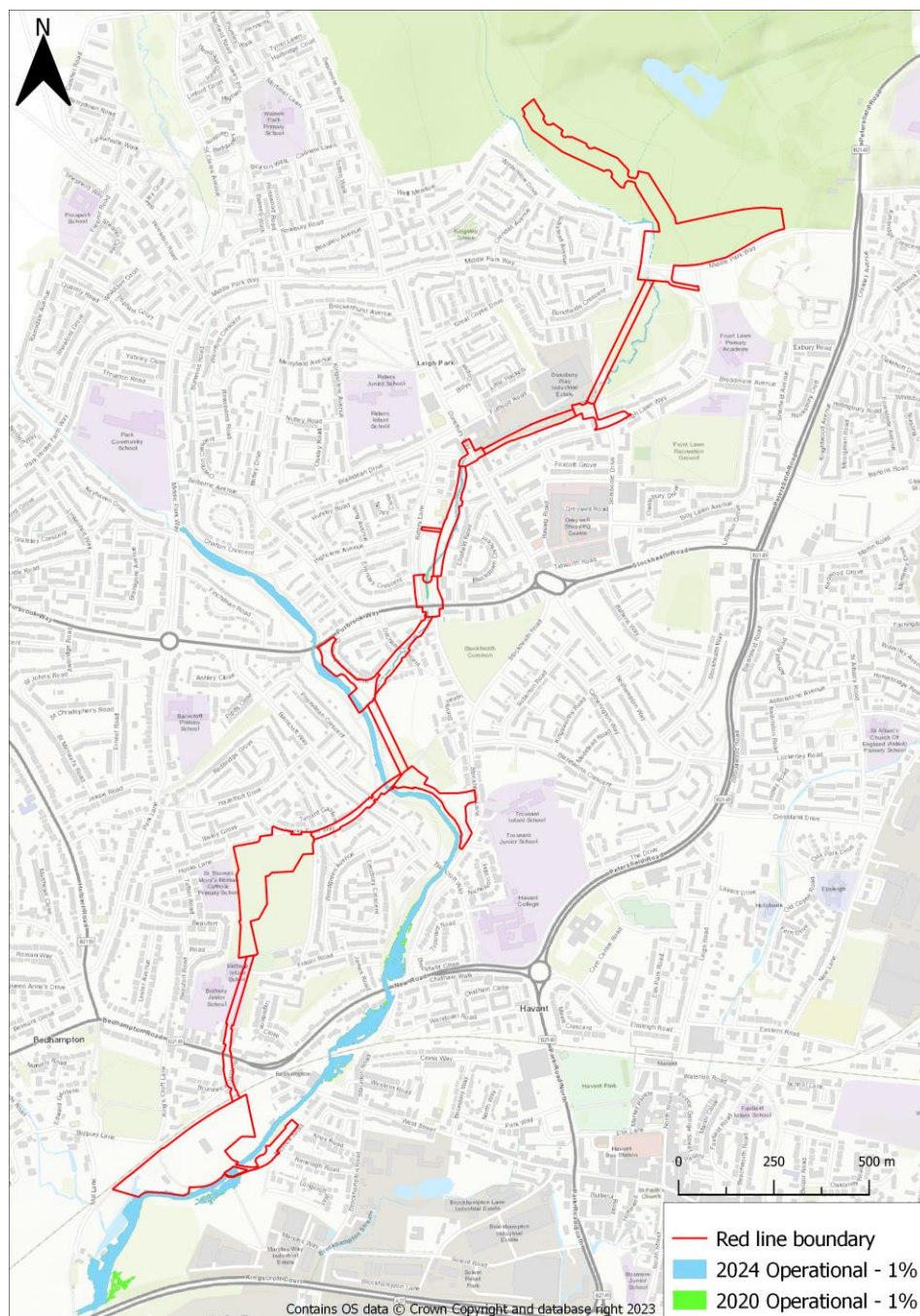
The baseline results in the 2020 FRA are shown to be comparable to the baseline results in this FRA (Table 3-2). The culvert upgrades used in the 2020 FRA are the same as those used in this assessment.

A comparison between the 'With Scheme' 2020 FRA results and the Proposed Development results from this assessment is shown in Table 7-1 of Appendix B.

Negligible differences were predicted between the two assessments. Any observed changes are attributed to a combination of updating the model to the latest software release, the minor changes made to the baseline model and rounding to two decimal places when reporting. Further detail on the changes made to the baseline hydraulic model can be found in Appendix B.

The differences in operational 1% AEP flood extents between the 2020 FRA and the results from this assessment are shown in Figure 5-1. As with the baseline scenario, the changes in peak level and flow had negligible impacts on flood extents. The only notable change to flood extent occurred near the downstream extent of the model boundary upstream of the A27.

Figure 5-1: Operational flood extent comparison between the 2020 and 2024 FRA



A summary of changes in fluvial flood risk as a result of the Proposed Development is given in Table 5-1 below.

Table 5-1: Summary of changes in fluvial flood risk due to Proposed Development

Study section	AEP	Proposed Development				Difference from baseline			
		u/s peak level (mAOD)	d/s peak level (mAOD)	u/s peak flow (m3/s)	d/s peak flow (m3/s)	u/s peak level (mAOD)	d/s peak level (mAOD)	u/s peak flow (m3/s)	d/s peak flow (m3/s)
1	No river data available, refer to Table 5-2 of the 2020 FRA conclusions								
2	No river data available, refer to Table 5-2 of the 2020 FRA conclusions								
3	3.33% AEP	20.19	7.71	0.16	2.64	-0.61	-0.15	-2.93	-2.82
	1% AEP	20.23	7.90	0.20	3.25	-0.63	-0.17	-3.64	-3.37
	1% AEP + CC	20.29	8.34	0.30	4.90	-0.71	-0.12	-5.50	-4.23
	0.1% AEP	20.34	8.42	0.39	5.41	-0.67	-0.10	-5.99	-4.31
4	3.33% AEP	9.99	7.71	11.77	13.51	0	-0.15	0	0
	1% AEP	10.10	7.90	14.53	16.68	0	-0.17	0	0
	1% AEP + CC	10.36	8.34	21.94	25.18	0	-0.12	0	0.02
	0.1% AEP	10.42	8.42	23.90	27.32	0	-0.10	0	0.01
5	3.33% AEP	7.71	2.90	16.01	15.45	-0.15	-0.06	-2.90	-2.53
	1% AEP	7.90	2.97	19.76	19.11	-0.17	-0.07	-3.52	-3.42
	1% AEP + CC	8.34	3.20	29.84	30.61	-0.12	-0.08	-4.45	-4.00
	0.1% AEP	8.42	3.23	32.49	32.36	-0.10	-0.29	-4.54	-4.16
6	3.33% AEP	2.90	2.72	15.45	22.45	-0.06	0	-2.54	-2.74
	1% AEP	2.97	2.72	19.11	26.29	-0.07	0	-3.43	-3.50
	1% AEP + CC	3.20	2.72	30.63	37.55	-0.08	0	-4.00	-4.82
	0.1% AEP	3.23	2.72	32.36	39.72	-0.09	0	-4.19	-4.56
7	No river data available, refer to Table 5-2 of the 2020 FRA conclusions								
8	No river data available, refer to Table 5-2 of the 2020 FRA conclusions								

The following flood maps are given below, in line with those shown in the 2020 FRA (noting in accordance with Table 5-1 the operational peaks are lower than the baseline):

- Figure 5-2 shows the Proposed Development fluvial flood extents for the 1% AEP and 1% AEP plus climate change;
- Figure 5-3 shows the Proposed Development change in fluvial flood risk from the Baseline for the 1% AEP;

- Figure 5-4 shows the Proposed Development change in fluvial flood risk from the Baseline for the 0.1% AEP.

Figure 5-2: Proposed Development fluvial flood extents

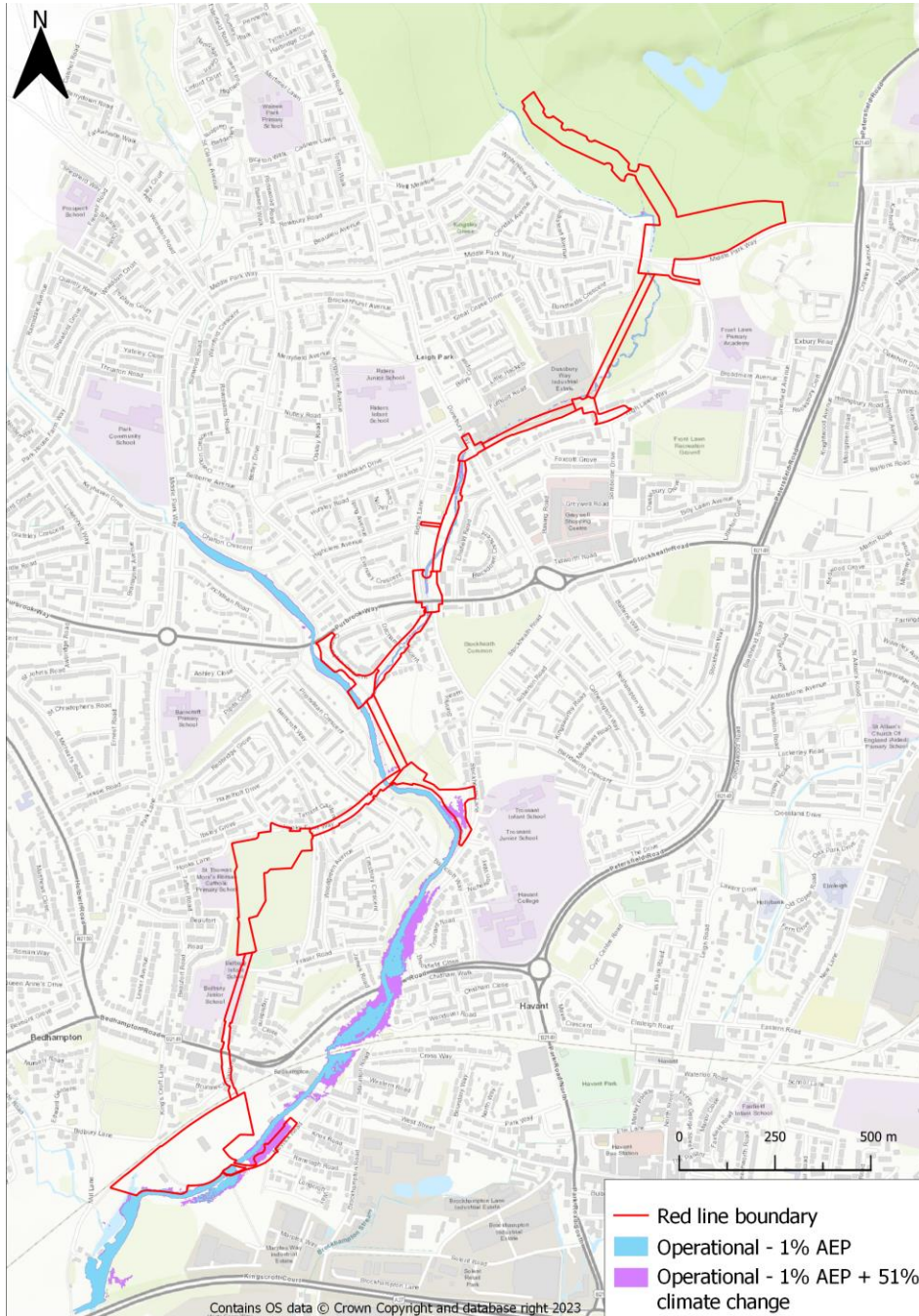


Figure 5-3: Proposed Development 1% AEP change in fluvial flood risk

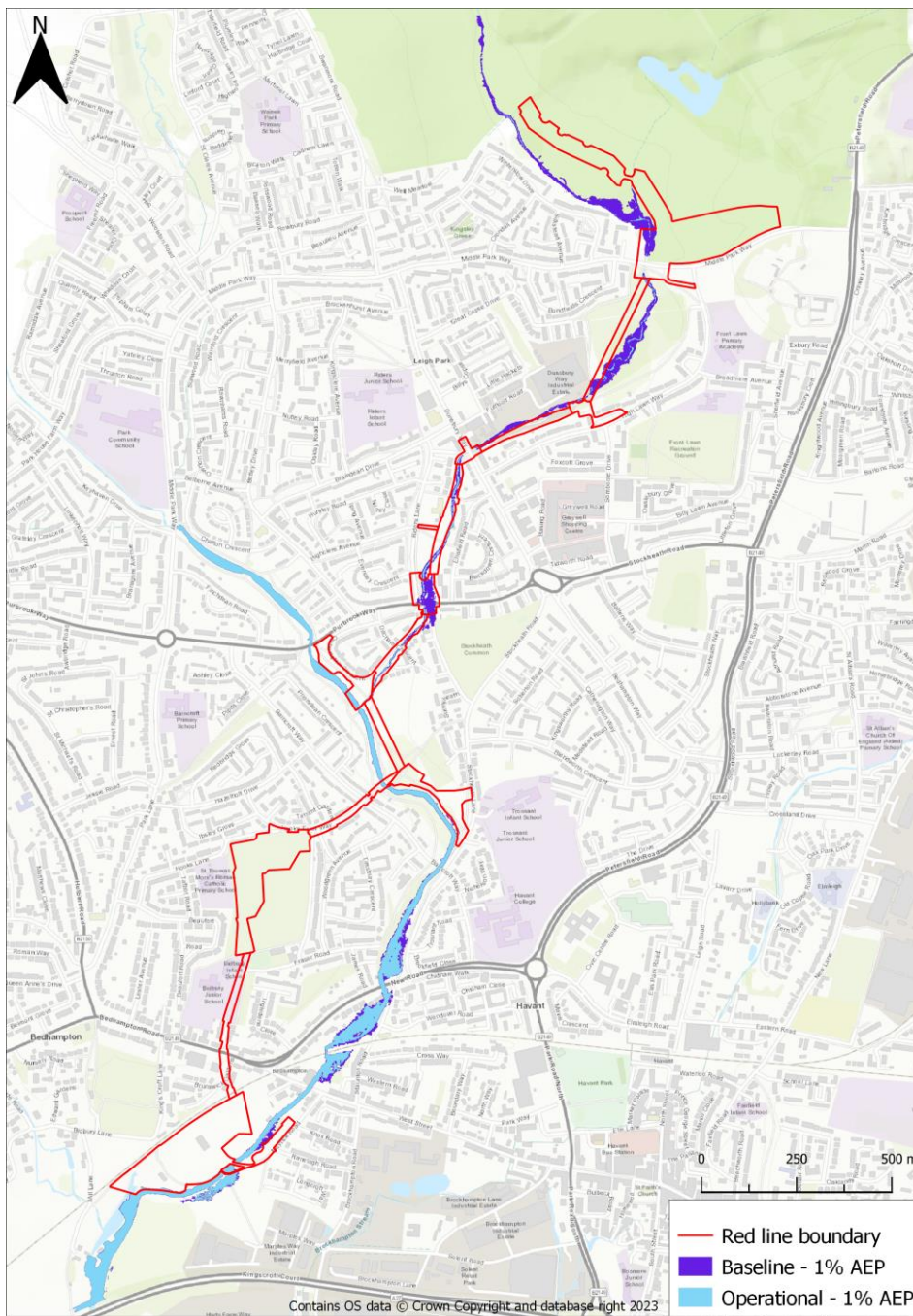
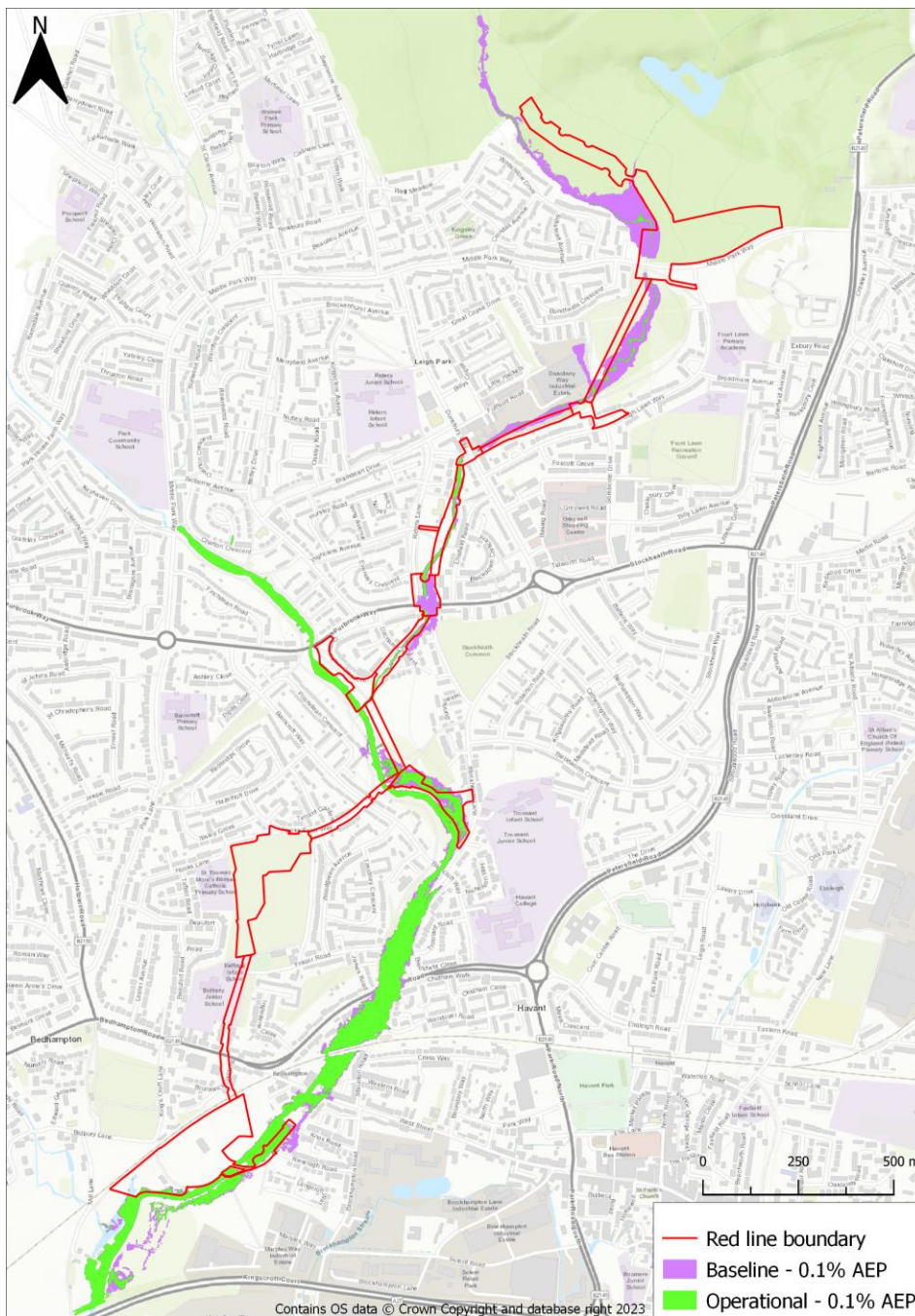


Figure 5-4: Proposed Development 0.1% AEP change in fluvial flood risk



5.1.2 Tidal

No changes were made to the tidal inflows from the 2020 FRA model. Negligible changes were observed between the Proposed Development and 'With Scheme' fluvial results.

The 2020 FRA concluded there was no change in extents between the baseline and the 'With scheme' results and that the construction of the scheme does not affect tidal flood risk.

No further assessment of tidal flood risk to the Proposed Development was carried out.

5.1.3 Surface Water

The 2020 FRA qualitatively assessed the changes in surface water flood risk as a result of the reservoir in Table 5-4. The assessment concluded that for study sections 3 to 6 there is no change in surface water flood risk as a result of the reservoir. Localised surface water flood risk is likely to reduce due to the reduction in peak levels and flows in the watercourses.

No further assessment of surface water flood risk to the Proposed Development was carried out.

5.2 Pipeline

The design of the pipeline along with its pumping operation, due to its construction underground, is not expected to have any impact on fluvial, tidal or surface water flood risk within any study sections.

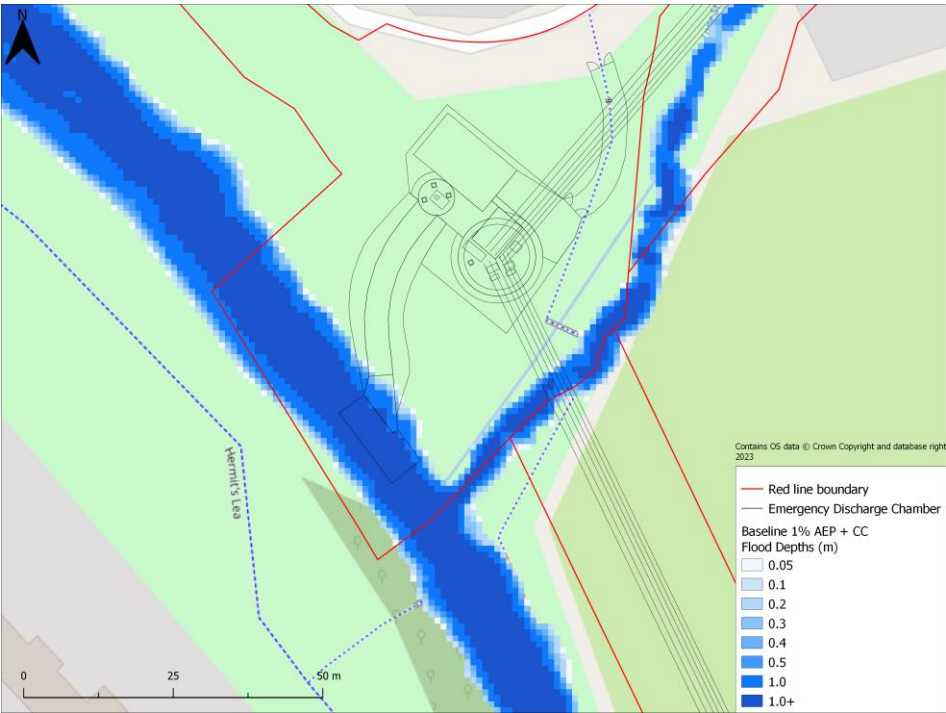
The pipeline, however, is also used as part of the drawdown operation. It is expected that the emergency drawdown system will be tested on commissioning up to the capacity of the watercourses. This is discussed further in Section 8.

For routine drawdown for maintenance, the system will be tested at the reservoir top water level. A testing programme will be developed to measure head and discharges at various openings, and at various stages of filling, and these can be compared with the manufacturer's performance data. Valves will be tested every six months individually with the reservoir at top water level to check they actuate correctly. During these tests, no flow will be discharged.

The culvert upgrade works to facilitate the Emergency Discharge Flow are designed to enhance discharge along the Riders Lane Stream, and thus have no impact on fluvial flood risk during normal operation, other than potentially improving conveyance at key pinch points and providing additional contingency capacity for culvert or trash screen blockage.

The emergency discharge shaft and valve chamber lie outside of the 1% AEP plus 51% climate change flood extent (Figure 5-5). The emergency discharge spillway protrudes out of the pipeline and into the Hermitage Stream. Flood depths are predicted above 1.0m in this area. The spillway is expected to be constructed within the reprofiled riverbank. No additional volume is occupied by the Proposed Development within the 1% plus climate change flood extent and so no flood compensation is required.

Figure 5-5: 1% AEP plus 51% climate change flood extent at the emergency discharge chamber



6 Construction flood risk impacts

The pipeline will mostly adopt tunnelled construction methodology with sections adopting dry open cut trench. There are eight construction compounds to accommodate the tunnelled pipeline and culvert upgrades (Figure 4-1).

Dry open cut trench methodology will be used at the crossing of the ordinary watercourse, the Lake Stream, downstream of the reservoir. The pipeline will be tunnelled beneath the Hermitage and Riders Lane Stream. There are to be no anticipated open cut trenches through any Environment Agency designated main rivers.

The open cut trench would entail the temporary damming of the Lake Stream. The construction design has assumed installation of a flume to ensure the downstream conveyance of flood flows up to and including the 1% AEP. No change in fluvial flood risk is expected within the Lake Stream.

A total of six of the eight construction compounds (Table 6-1) are within the predicted 1% AEP flood extent (indicative Flood Zone 3 extent). Construction related activities within flood zones could lead to a temporary loss of floodplain volume and potential flood storage. It should be noted that the fluvial flood risk exhibited at the compounds will reduce during construction from the risk associated with the baseline condition to that associated with the Havant Thicket Reservoir Scheme. To avoid temporary loss of floodplain storage within the construction compounds, temporary buildings, earthworks and material storage should be sited outside the areas of high flood risk (1% AEP), where practicable.

Table 6-1: Construction compounds

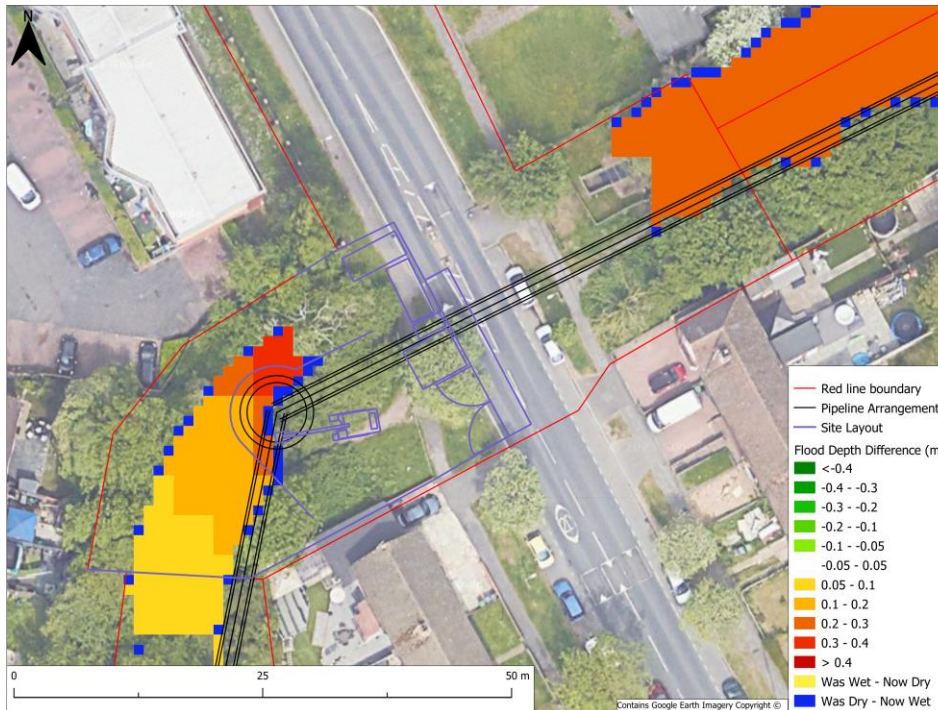
Construction compound number	Compound Area (m ²)	Area of Compound in 1% AEP Extent (m ²)	% of Compound in 1% AEP Extent
1	48,000	760	1.6
2	30,000	0	0
3	10,000	100	1.0
4	8,000	1,000	12.5
5	6,000	230	3.8
6	2,300	110	4.8
7	4,000	0	0
8	60,000	120	0.2

The proposed location for Shaft 6 lies adjacent to the left bank of Riders Lane Stream, immediately downstream of the proposed Dunsbury Way culvert upgrade. The construction of Shaft 6 will result in significant in-channel works for an approximate duration of four months. Sheet piling is required during construction to protect shaft and machinery. The extents of the sheet piling result in an approximate reduction in channel width of up to 50%. The flood risk implications of temporarily reducing channel widths for the duration of construction were assessed within the hydraulic model. Further information can be found in Appendix B.

Figure 6-1 shows the change in flood depths during a 1% AEP plus 51% climate change event due to the channel impingement. Construction of Shaft 6 is predicted to cause localised increases in flood depths within the area. The

greatest increase in depths are predicted to occur immediately downstream of Dunsbury Way culvert by up to 300mm. Depth increases are predicted to reduce moving downstream away from the construction site. No impacts to flood risk are predicted beyond 20m downstream of Shaft 6. This is however, a conservative assumption as the impacts of climate change will not occur during the construction phase.

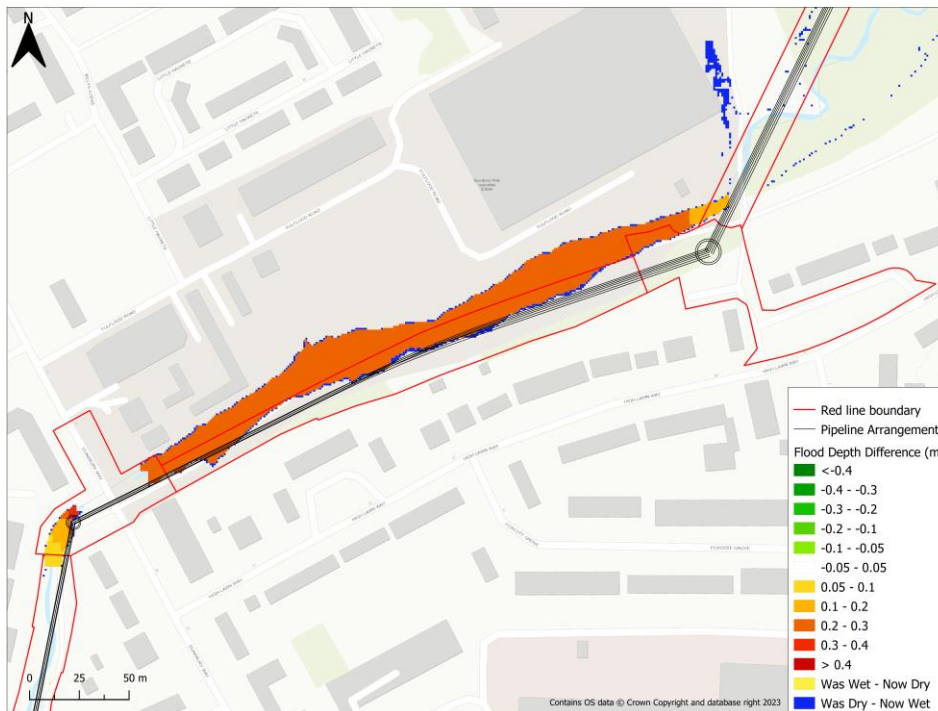
Figure 6-1: Shaft 6 construction flood risk impacts



The channel impingement is predicted to cause flood waters to back up through Dunsbury Way culvert resulting in an increase of 250mm flood depths between Dunsbury Way and High Lawn Lane (Figure 6-2). No flood risk impacts are predicted upstream of High Lawn Lane construction compound as any increase in depths fall within the hydraulic model tolerance of +/- 50mm.

Critically, construction of Shaft 6 is predicted to result in localised increases in flood depths only and result in no increase in flood risk to receptors, i.e. buildings or roads. The increase in flood risk would last for the duration of the construction of Shaft 6 only.

Figure 6-2: Shaft 6 construction flood risk backwater effects



Coffer dams are expected to be used within culvert upgrade construction compounds to minimise any localised flood risk to third parties, the construction workers and to protect the construction area.

All of the construction compounds are within areas of medium to high surface water flood risk, as shown in the Environment Agency RoFSW map (Figure 3-6). Again, it should be noted however, that surface water flood risk within the construction compounds is likely to reduce during the construction of the Havant Thicket Reservoir scheme.

During construction there is likely to be an increase in new hardstanding areas from access roads, welfare offices and machinery, which, if not mitigated, could increase the flow rate and volume of runoff from the construction sites. The surface water flow pathways in the study area largely resemble the Hermitage and Riders Lane Stream flood zones. An increase in volume of runoff from the construction sites could, in turn, result in the increased localised flooding to downstream receptors.

Extreme rainfall events during construction could lead to an increased risk of flooding where surface water flow pathways cross construction compounds. The presence of site buildings, temporary earthworks and material storage has the potential to divert surface water flood pathways onto others. To avoid this, placement of any material along a medium to high risk surface water flood pathway should be avoided. Stockpiling of materials within the construction sites will be minimised as much as practicable and so any increase in surface water flood risk to others would be slight.

The Construction Environmental Management Plan (CEMP) will include details of how the construction compounds will safely manage surface water flows in line with CIRIA and Environment Agency Pollution Prevention Guidance (PPG).

7 Managing flood risk

The culvert upgrade mitigation required to safely manage flood risk to the pipeline is already embedded in the Proposed Development design.

7.1 Drainage management plan

A drainage management plan will be prepared for the Proposed Development. It will include details of how increased surface water runoff from new areas of hardstanding (that is, the emergency discharge chamber access road) will be managed to ensure no increase in flood risk. Sustainable Drainage Systems (SuDS) will be included in the drainage design where practicable. The drainage design will follow the SuDS manual and guidance from the Local Plans and SFRAs.

It will also detail how the construction compounds will safely manage surface water flows in line with the Flood Risk and Coastal Change PPG and CIRIA guidance.

7.2 Construction Environment Management Plan

A CEMP will be developed for the Proposed Development. The plan will outline the process for managing the volume and quality of discharge of water for the construction compound, areas used for construction use and other areas of hardstanding and haulage roads.

It will make provision for attenuating surface water runoff generated as part of the pipeline construction.

Mitigation in line with best practicable measures and construction environmental management procedures will be described in the Outline Environmental Management Plan (OEMP) (Atkins reference: HTR-ATK-XX-XX-RP-Z-0069). The OEMP forms the basis of the production of the CEMP.

A Record of Environmental Actions and Commitments (REAC) identifying the commitments to address potential flood risk effects of the construction of the Proposed Development will be included in the OEMP.

7.3 Environmental permits

As the red line boundary includes Environment Agency designated main rivers and Flood Zones 2 and 3, FRAPs are likely to be required to permit the construction of any works within 8m of the top of riverbank and above or beneath the watercourse.

Permits for the Proposed Development will be applied for the following reasons:

- Construction works of the pipeline shafts within 8m of the riverbanks,
- Construction of the emergency discharge spillway within the Hermitage Stream,
- Temporary encroachments of the pipeline shafts into the Riders Lane Stream,
- Construction of culverts,
- Trenchless crossings of the Hermitage and Riders Lane Streams,
- Temporary bridge crossing over Riders Lane Stream,
- Ordinary watercourse consents for open cut crossings.

7.4 Operational maintenance

It is likely that testing of the emergency discharge valves will be undertaken twice per year, to be confirmed by the Construction Engineer appointed under the Reservoirs Act (1975).

Full testing of the 'emergency drawdown' system, up to the capacity of the watercourses, will be tested on commissioning of the reservoir.

8 Residual risk

8.1 Embankment failure

The consequence of a reservoir breach was modelled as part of the 2020 FRA to understand the flood risk associated with a failure of the reservoir embankment. The consequence of a reservoir breach was assessed for this assessment, as requested by the Environment Agency.

The 2020 FRA breach modelling assessed the 0.1% AEP fluvial event and the reservoir top water level. No changes have been made to the fluvial hydrology from the 2020 FRA and the 0.1% AEP remains the same. No adverse changes have been made to the reservoir design since the 2020 FRA and subsequently there are no changes to the reservoir volume or predicted top water levels.

The 2020 FRA used 1m Digital Terrain Model (DTM) LiDAR from the National Lidar Programme²⁰ (flown in 2020) to inform the 2D breach modelling. The latest version (2022) of 1m DTM LiDAR for the Havant urban area was downloaded from the National Lidar Programme. The two datasets were compared in terms of elevation differences that could infer land use changes between the years 2020 and 2022. No changes to the dataset were found north of Trosnant Infant and Junior school, near New Road. Minor changes to levels were found south of Trosnant Infant School which were largely associated with the Hermitage Stream. The discrepancies in LiDAR levels recorded at the streams can be attributed to differing water levels in the streams at the time of survey. The largest discrepancies in levels were noted within Langstone Industrial Park at the southern end of the reservoir breach extents. Changes to levels in this area are above the flood inundation level and not considered to impact on reservoir breach extents.

Google Earth imagery was used to assess the land-use changes between 2020 and present day. Other than Langstone Industrial Park, no significant new developments were observed that could impact on flood extents.

The culvert upgrade works in the 2020 FRA are the same as those in this assessment.

Considering the above, there would be no change to the breach modelling extent due to the Proposed Development and thus no change to the risk.

8.2 Emergency drawdown strategy

The 2020 FRA assessed an emergency discharge location of the Hermitage Stream at Middle Park Way. This FRA addendum assesses moving the emergency discharge location to the Hermitage Stream and Riders Lane Stream confluence.

The pipeline will also be used to provide an emergency drawdown facility to safely reduce the water level in the reservoir in line with the requirements of the Environment Agency Guide to Drawdown Capacity for Reservoir Safety and Emergency Planning⁹.

²⁰ <https://environment.data.gov.uk/DefraDataDownload/?Mode=survey>

The calculation of the emergency discharge condition in the 2020 FRA was informed by the capacity of the pipeline and the reservoir as outlined in the Preliminary Design Report²¹. No adverse changes have been made to the reservoir design since the 2020 FRA and subsequently there are no changes to the predicted top water levels. The capacity of the pipeline remains unchanged since outline design. No changes were therefore made to the calculation of the Emergency Discharge Condition from the 2020 FRA (10.9m³/s). The Emergency Discharge Condition has been defined in the hydraulic modelling report in Appendix B.

The emergency discharge is to be accommodated through outfall structures into the Riders Lane Stream and Hermitage Stream at the toe of the dam structure and into the Riders Lane and Hermitage Stream confluence.

The total discharge is split to allow:

- 7.05m³/s into the Riders Lane Stream; and,
- 3.85m³/s into the Hermitage Stream and Riders Lane Stream confluence.

The 2020 FRA proposed emergency discharge condition was modelled in combination with a base flow condition (Q₁₀) and 50% AEP (1 in 2 year) tidal condition, as agreed with the Environment Agency on 8 March 2019. The combination of these components formed the Emergency Discharge Flow, as defined in Appendix B. The same approach was agreed for this assessment in consultation between the EA and Sweco (12 January 2023).

Sensitivity tests were carried out to assess how the Emergency Discharge Flow interacts with:

- high flow fluvial events,
- the tidal boundary,
- a 20% uplift in model roughness.

These sensitivity tests reflected those used in the 2020 FRA.

Further information, including results of the sensitivity testing for the Emergency Discharge Flow are presented in Appendix B.

The model results of the Emergency Discharge Flow under baseline conditions resulted in:

- One property upstream of Middle Park Way culvert being at risk of flooding,
- minor flooding to one industrial unit
- minor flooding to 2-3 gardens / outbuildings
- inundation of Dunsbury Way road / bridge and
- inundation of Purbrook Way road / bridge.

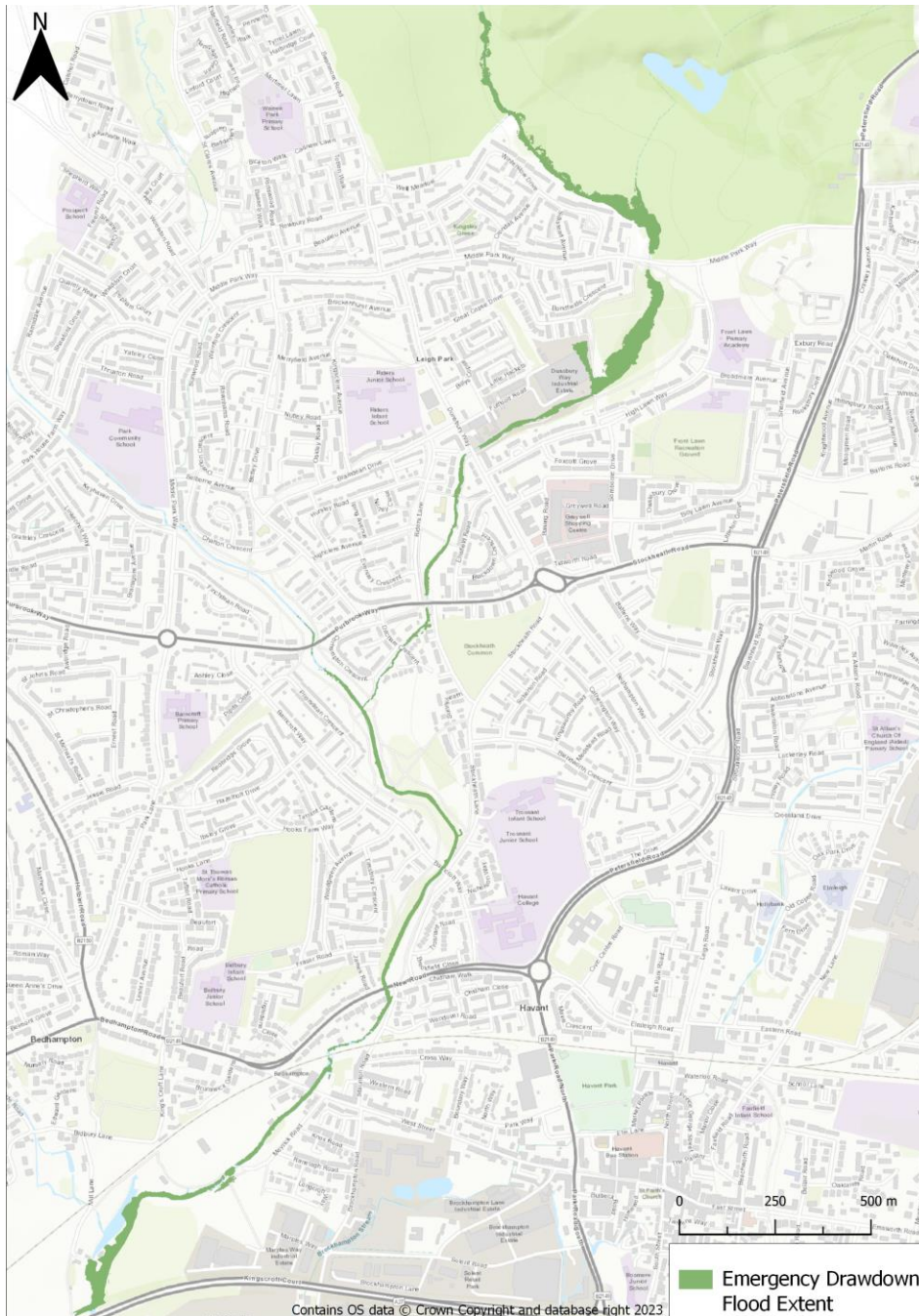
To mitigate this flooding, upgrades to culverts along the Riders Lane Stream (described in Table 4-1) have been included in the Proposed Development design. These upgrades are the same used as mitigation within the 2020 FRA.

The Emergency Discharge Flow extent is shown in Figure 8-1. The enhancements to culvert capacities resulted in no residential properties being at risk of flooding, however a small number of gardens / outbuildings (2-3) and one

²¹ Atkins reference HTR-ATK-ZZ-ZZ-RP-Z-0115

industrial unit are within the modelled extent, showing depths between 0.1m-0.2m. The strategy meets the requirement / planning condition set by the LPA of causing no flooding to residential properties.

Figure 8-1: Risk of flooding during an Emergency Discharge Flow



The peak flow within the Riders Lane Stream and Hermitage Stream during the Emergency Discharge Flow has been compared to baseline results and shown for each study section in Table 8-1. It should be noted that the Emergency Discharge Flow only affects study sections 3 to 6. This suggests that, for the Hermitage Stream (study sections 4-6), the Emergency Discharge flows are similar to an AEP event of 3.33% or greater. For the Riders Lane Stream (study

section 3), the flows represent a higher magnitude fluvial event. However, the emergency discharge modelling represents a residual risk, and does not cause residential property flooding.

Table 8-1: Peak Emergency Discharge Flows during

Study Section		Peak Flow (m ³ /s)	Comparative AEP within Baseline
3	U/S	7.19	Less than a 0.1% AEP
	D/S	7.19	Between a 1% and 0.1% AEP
4	U/S	0.43	Greater than a 3.33% AEP
	D/S	0.43	Greater than a 3.33% AEP
5	U/S	11.47	Greater than a 3.33% AEP
	D/S	9.21	Greater than a 3.33% AEP
6	U/S	9.21	Greater than a 3.33% AEP
	D/S	16.84	Greater than a 3.33% AEP

It should be noted that the Q₁₀ baseflow condition (0.43m³/s) within the Hermitage Stream was applied to the upstream extent of study section 4. Further detail on the baseflow condition can be found in Appendix B.

The 2020 FRA states that it was agreed in discussion with Hampshire County Council that the impact of the emergency drawdown on surface water drainage in Havant would be qualitatively considered by a comparison of flows with baseline conditions, shown on Table 8-1 above. It should be noted that under normal conditions, the operation of the pipeline is expected to have no impact on surface water drainage.

In the unlikely event of an emergency drawdown at full capacity, coinciding with a storm event in Havant, the storm water network discharging to the Hermitage Stream would respond in a similar manner to its current performance as the Emergency Discharge Flows in the watercourse would be greater than a 3.33% AEP event. Impact on surface water flood risk is therefore not anticipated.

The storm water network discharging to the Riders Lane Stream may be restricted however, as the Emergency Discharge Flow in the channel is predicted to be between a 1% and 0.1% AEP. Although, the likelihood of an emergency drawdown combining with a storm event is very low, there is a possibility of increased surface water flood risk in areas that discharge to the Riders Lane Stream. This FRA addendum agrees with the 2020 FRA recommendation that Portsmouth Water should work with the LLFA and Southern Water to determine whether the potential increase in surface water flood risk would require a plan for mitigation during a release of the Emergency Discharge Flow.

The Emergency Discharge Flow was also simulated in conjunction with higher magnitude fluvial events, to determine the approximate fluvial event which, if coinciding with the requirement for emergency drawdown, would cause flooding.

The model results show that for the Riders Lane Stream, the 50% AEP event would cause minor inundation of one residential property, and for the Hermitage Stream, the onset of flooding is the 20% AEP, with up to three residential properties also potentially affected. The flood outline for the Emergency Discharge Flow paired with the 3.33% AEP fluvial event is shown in Appendix A.

This FRA addendum has assessed moving the emergency discharge location to the Hermitage Stream and Riders Lane Stream confluence. Moving the emergency discharge to the confluence remains in line with the strategy set by the LPA of causing no flooding to residential properties.

8.3 Access and egress conditions, flood warning and evacuation

There are no concerns with regards to access and egress during an emergency discharge, with no residential properties at risk. Although the external areas of an industrial unit are potentially at risk of shallow flooding, there is an alternative route for access and egress via Dunsbury Way.

During the construction of the pipeline there needs to be consideration of flood evacuation and safe egress routes for construction workers. Consideration for this will be made in the CEMP.

A flood emergency response plan will be developed as part of CEMP to manage the flood risk impacts during construction and to ensure construction workers are not exposed to increased levels of risk.

9 Summary and Conclusions

This FRA addendum has been undertaken in accordance with the NPPF to assess flood risk from all sources for the Proposed Development.

The 2020 FRA concluded that:

- Once operational, the scheme will reduce existing fluvial flood risk along the Riders Lane and Hermitage Streams;
- Elements of the scheme contain areas of hardstanding that will increase the surface water flood risk without adequate drainage;
- The risk of flooding from groundwater sources was assessed as low;
- The risk of flooding from tidal sources is low;
- There is an increase in the residual risk of flooding to one industrial unit and 2-3 gardens/outbuildings as a consequence of the emergency drawdown strategy.

This FRA has assessed the flood risk to the changes at detailed design of the pipeline only and for the purposes of this assessment, no adverse changes have been made to the reservoir design since the 2020 FRA and subsequently there are no changes to the reservoir volume or predicted top water levels. The following changes have been made since the 2020 FRA that form the Proposed Development:

- The single bi-directional pipeline has been replaced by a twin pipeline, one inlet pipe for filling the reservoir and one outlet pipe for emergency drawdown.
- The inlet pipeline extends north of the reservoir embankment beyond the contractual boundary of the main pipeline.
- The development boundary has changed, and the pipelines now closely follows the course of the Riders Lane and Hermitage Streams.
- The pipeline construction methodology has changed from open cut trench to a combination of open cut trench and tunnelling.
- The number of construction areas has increased from five to eight to accommodate the change in construction methodology.
- The position of the emergency discharge into the Hermitage Stream has moved from downstream of Middle Park Way to the Hermitage Stream and Riders Lane Stream confluence adjacent to Corhampton Crescent.

Based on the original 2020 FRA, the Proposed Development, information made available or created by the Environment Agency and the FRA hydraulic modelling work, this assessment concludes that:

- There is no increase in fluvial flood risk compared to the 2020 FRA from the Proposed Development.
- Minor elements of the Proposed Development, namely the emergency discharge access road, will increase the hardstanding area, and as such without adequate drainage design, the Proposed Development has the potential to increase this surface water flood risk. A Drainage Management Plan will be developed and will apply SuDS principles, where appropriate, to ensure there is no increase in surface water flood risk up to and including the 1% AEP including an allowance for climate change;
- The risk of flooding from groundwater sources remains low;
- The risk of flooding from tidal sources remains low;

- The increase in residual risk remains the same as that concluded in the 2020 FRA. One industrial property and 2-3 gardens / outbuildings are at risk of flooding as a consequence of the emergency drawdown strategy.

9.1 Fluvial flood risk

The 2020 FRA concluded that the scheme would reduce the existing fluvial flood risk to the Hermitage and Riders Lane Streams. The pipeline corridor is underground and there is no associated operational flood risk. The Proposed Development does not change the fluvial flood risk findings concluded in the 2020 FRA.

The construction of the pipeline will cross two Environment Agency designated main rivers. A FRAP will be required for all construction activity within 8m of the main river and / or within the floodplain to ensure the risks can be safely managed.

The construction of shaft 6 will result in significant in-channel works at Dunsbury Way and cause an increase in localised flood risk during construction. Critically, construction works will result in no increase in flood risk to receptors.

9.2 Surface water flood risk

The Proposed Development is underground and there is no associated surface water flood risk during operation of the pipeline. The emergency discharge chamber access road will increase the area of hardstanding. A drainage management plan will be prepared for the Proposed Development. It will include details of how increased surface water runoff from new areas of hardstanding will be managed to ensure no increase in flood risk.

There is the potential for the Proposed Development to increase surface water flood risk during construction through the addition of hardstanding areas. A Construction Environment Management Plan will be developed for these elements and will apply SuDS principles, where appropriate, to ensure there is no increase in surface water flood risk up to and including the 1% AEP including an allowance for climate change.

9.3 Residual risk

The operation of the reservoir has the potential to increase the residual risk of flooding to the urban area of Havant, caused by a breach in the embankment. Risk of a breach of the reservoir was considered extremely low in the 2020 FRA and remains low in this FRA addendum.

To mitigate the unlikely possibility of embankment failure, an emergency drawdown strategy has been developed and modelled, in which an emergency discharge is routed into the Riders Lane Stream downstream of the reservoir embankment and into the Hermitage Stream and Riders Lane confluence.

Modelling of the Emergency Discharge Flow has demonstrated that with the suggested culvert upgrades in Table 4-1, the emergency drawdown can be enacted without risk of flooding to residential properties, however, one non-residential property does become at risk of shallow inundation (0.1 - 0.2m).

The 2020 FRA assessed an emergency discharge location of the Hermitage Stream at Middle Park Way. Moving the emergency discharge to the Hermitage

Stream and Riders Lane Stream confluence remains in line with the strategy set by the LPA of causing no flooding to residential properties.

9.4 Application of planning policy

The Proposed Development is classified as “essential infrastructure”, with permanent infrastructure in areas of Flood Zones 1, 2 and 3, and temporary construction in areas of Flood Zone 3. It is considered that the Proposed Development can satisfy the requirements of NPPF, is appropriate for the level of flood risk documented in this FRA addendum and will not increase flood risk at the site or to surrounding areas.

Appendix A – Flood Maps

Figure A1 - Baseline Flood Extents

Figure A2 - Baseline Flood Depth- 50% AEP

Figure A3 - Baseline Flood Depth- 20% AEP

Figure A4 - Baseline Flood Depth- 10% AEP

Figure A5 - Baseline Flood Depth- 3.33% AEP

Figure A6 - Baseline Flood Depth- 1% AEP

Figure A7 - Baseline Flood Depth- 0.1% AEP

Figure A8 - Baseline Flood Depth- 1% AEP Plus 51% Climate Change

Figure A9 - Baseline Flood Depth- 1% AEP Plus 88% Climate Change

Figure A10 - Baseline 2020 vs 2024 1% Comparison

Figure A11 - Operational Flood Extents

Figure A12 - Operational Flood Depth- 50% AEP

Figure A13 - Operational Flood Depth- 20% AEP

Figure A14 - Operational Flood Depth- 10% AEP

Figure A15 - Operational Flood Depth- 3.33% AEP

Figure A16 - Operational Flood Depth- 1% AEP

Figure A17 - Operational Flood Depth- 0.1% AEP

Figure A18 - Operational Flood Depth- 1% AEP Plus 51% Climate Change

Figure A19 - Operational Flood Depth- 1% AEP Plus 88% Climate Change

Figure A20 - Operational / Baseline 1% Comparison

Figure A21 - Operational / Baseline 1% + 51% CC Comparison

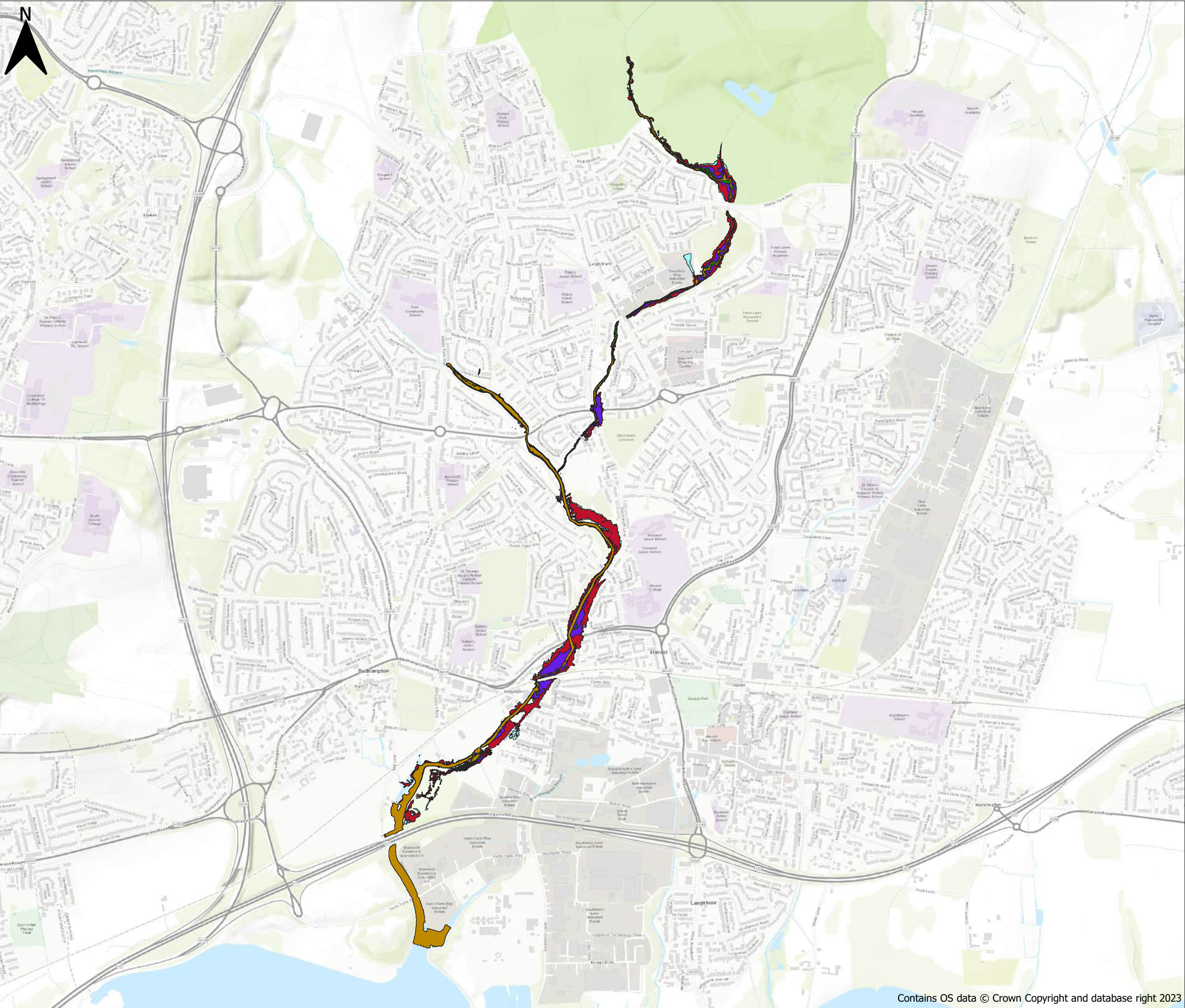
Figure A22 - 2020 vs 2024 Operational 1% Comparison

Figure A23 - Emergency Discharge Flood Extent

Figure A24 - Operational / Baseline Emergency Discharge Flood Extent

Figure A25 - 2020 vs 2024 Emergency Discharge Comparison

Figure A26 - Emergency Discharge Flood Extent + 3.33% AEP Fluvial



Havant Pipeline

Baseline Flood Extents

50% AEP

10% AEP

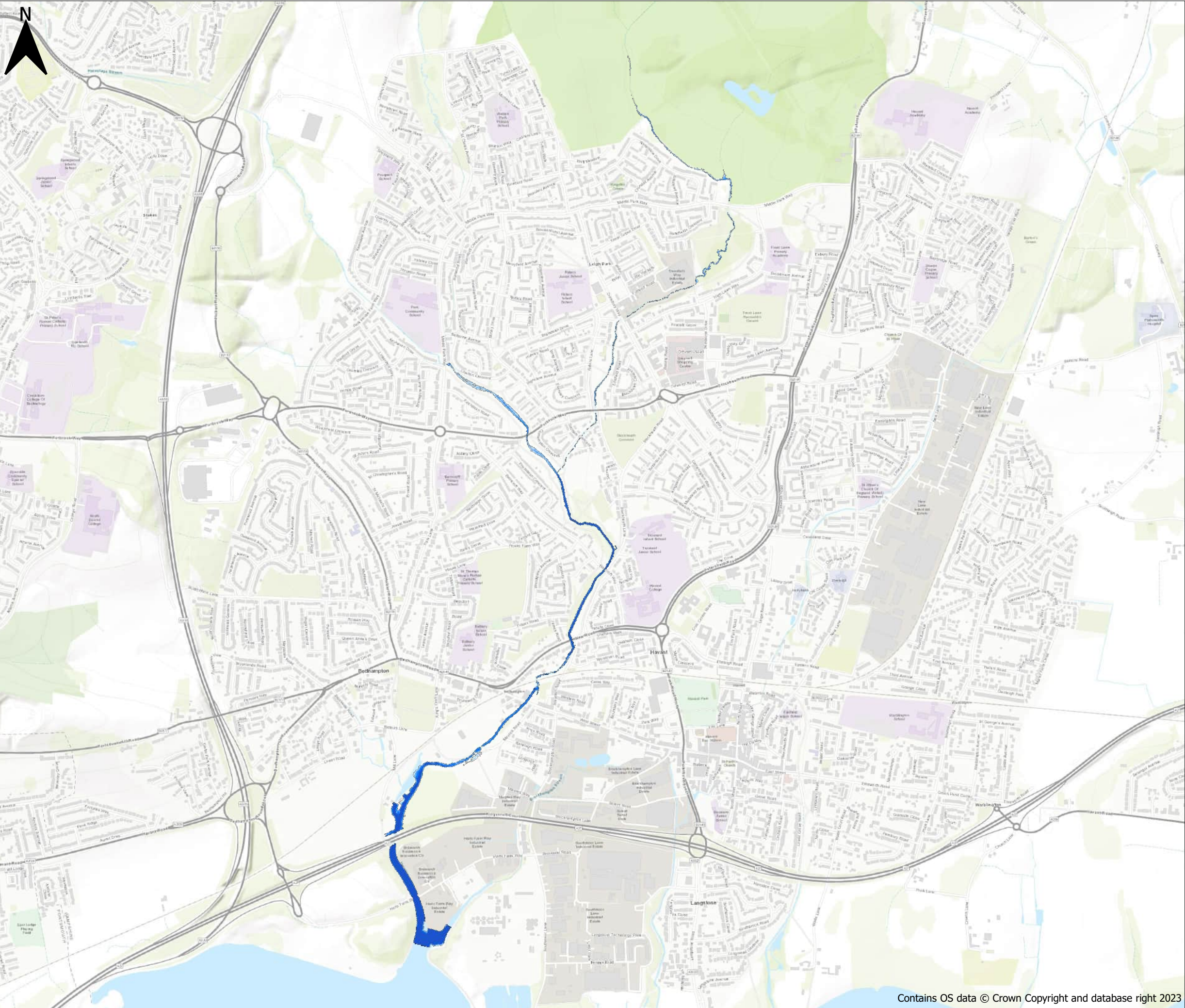
1% AEP

1% AEP + 51% CC

0.1% AEP

DRAWN RV	CHECKED JP	AUTHORISED 22/05/23
DESIGNER SWECO		
CONTRACTOR WARD & BURKE		
CLIENT 		
PROJECT TITLE HAVANT PIPELINE		
PROJECT STAGE DETAILED DESIGN		
PURPOSE OF ISSUE ISSUE TO CLIENT		
DRAWING NUMBER APPENDIX A - FIGURE A1		
SHEET SIZE A3	SCALE 1:16000 @ A3	REVISION P03
05001,000 m		

This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Baseline 50% AEP
Flood Depths (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

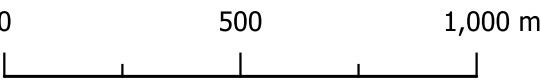
PURPOSE OF ISSUE

ISSUE TO CLIENT

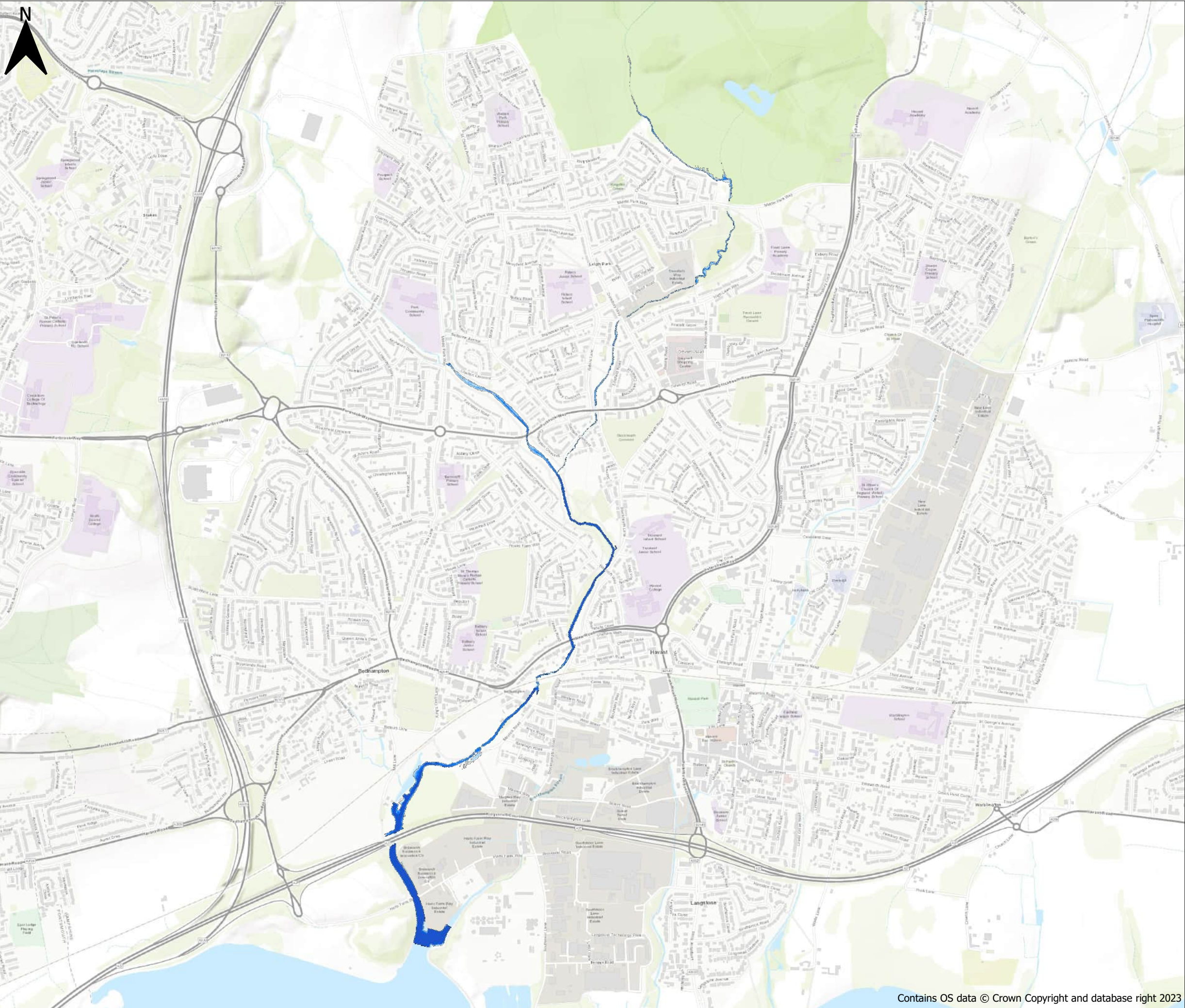
DRAWING NUMBER

APPENDIX A - FIGURE A2

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Baseline - 20% AEP
Flood Depths (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN RV	CHECKED JP	AUTHORISED 22/05/23
-------------	---------------	------------------------

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



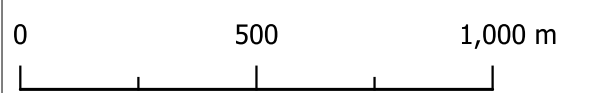
PROJECT TITLE
HAVANT PIPELINE

PROJECT STAGE
DETAILED DESIGN

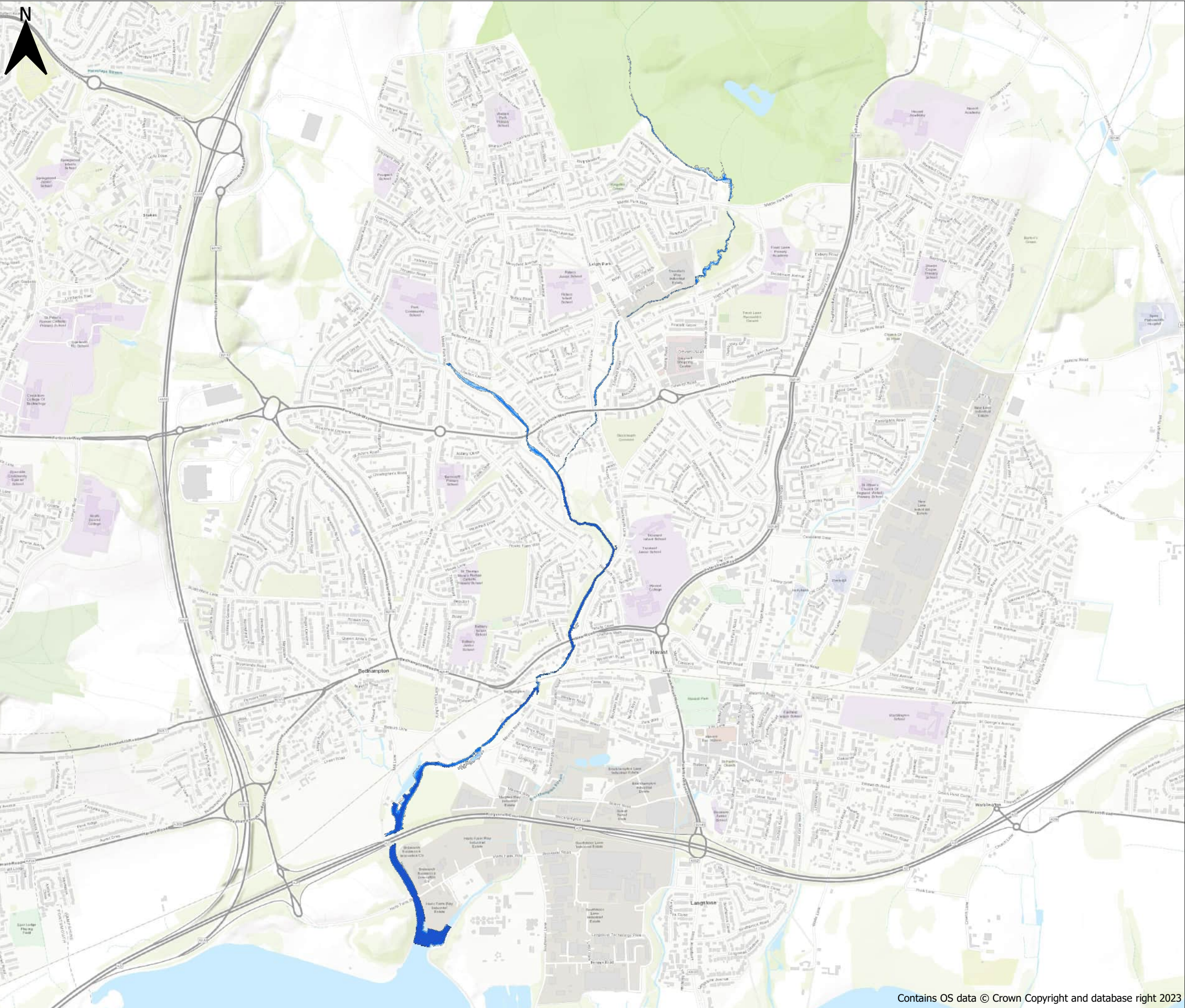
PURPOSE OF ISSUE
ISSUE TO CLIENT

DRAWING NUMBER
APPENDIX A - FIGURE A3

SHEET SIZE A3	SCALE 1:16000 @ A3	REVISION P03
------------------	--------------------------	-----------------



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Baseline - 10% AEP
Flood Depth (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN RV	CHECKED JP	AUTHORISED 22/05/23
-------------	---------------	------------------------

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

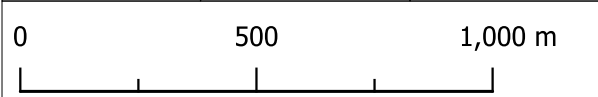
PURPOSE OF ISSUE

ISSUE TO CLIENT

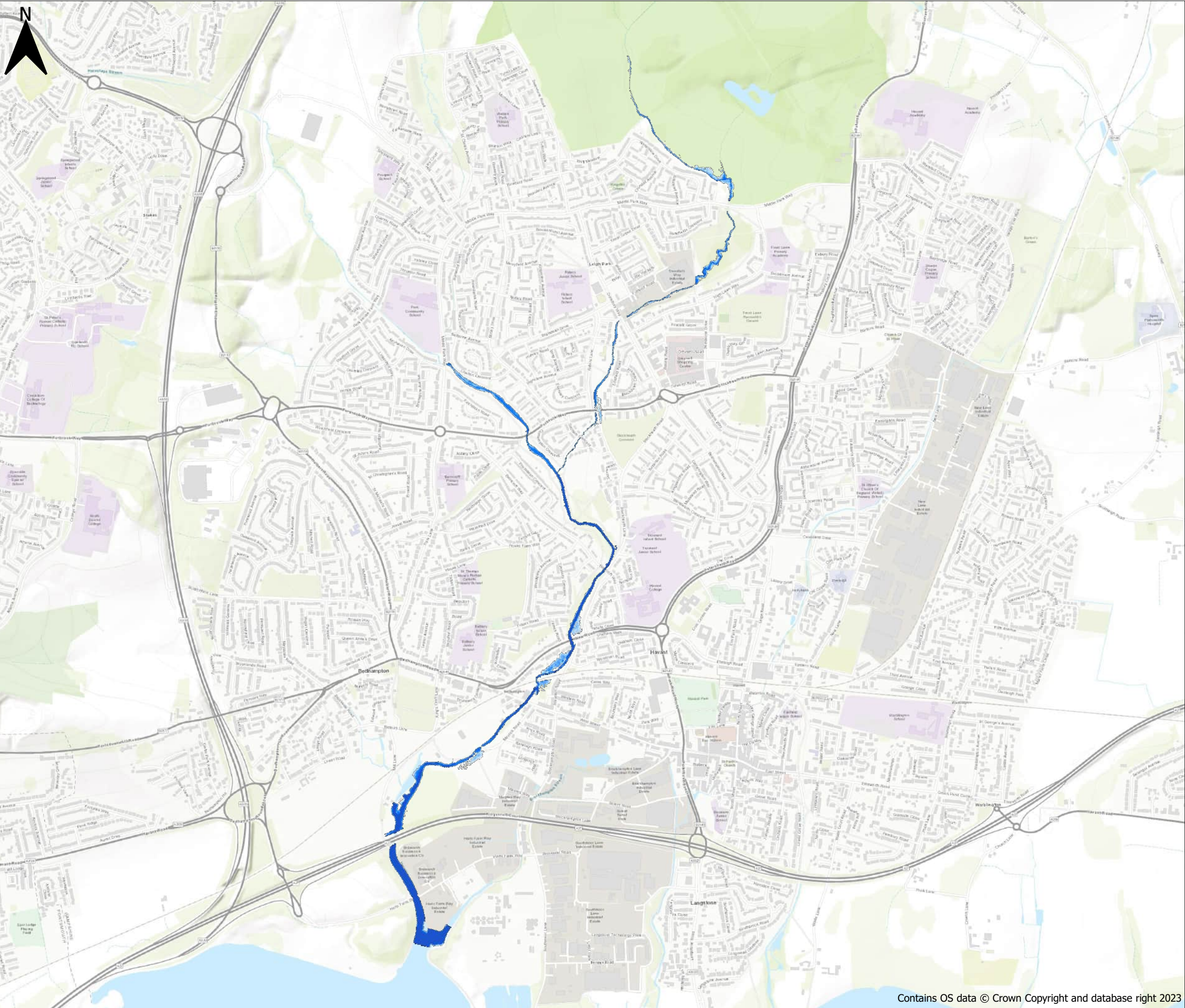
DRAWING NUMBER

APPENDIX A - FIGURE A4

SHEET SIZE A3	SCALE 1:16000 @ A3	REVISION P03
------------------	--------------------------	-----------------



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Baseline - 3.33 AEP
Flood Depth (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO



CONTRACTOR



CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

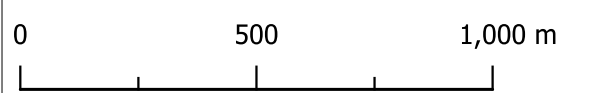
PURPOSE OF ISSUE

ISSUE TO CLIENT

DRAWING NUMBER

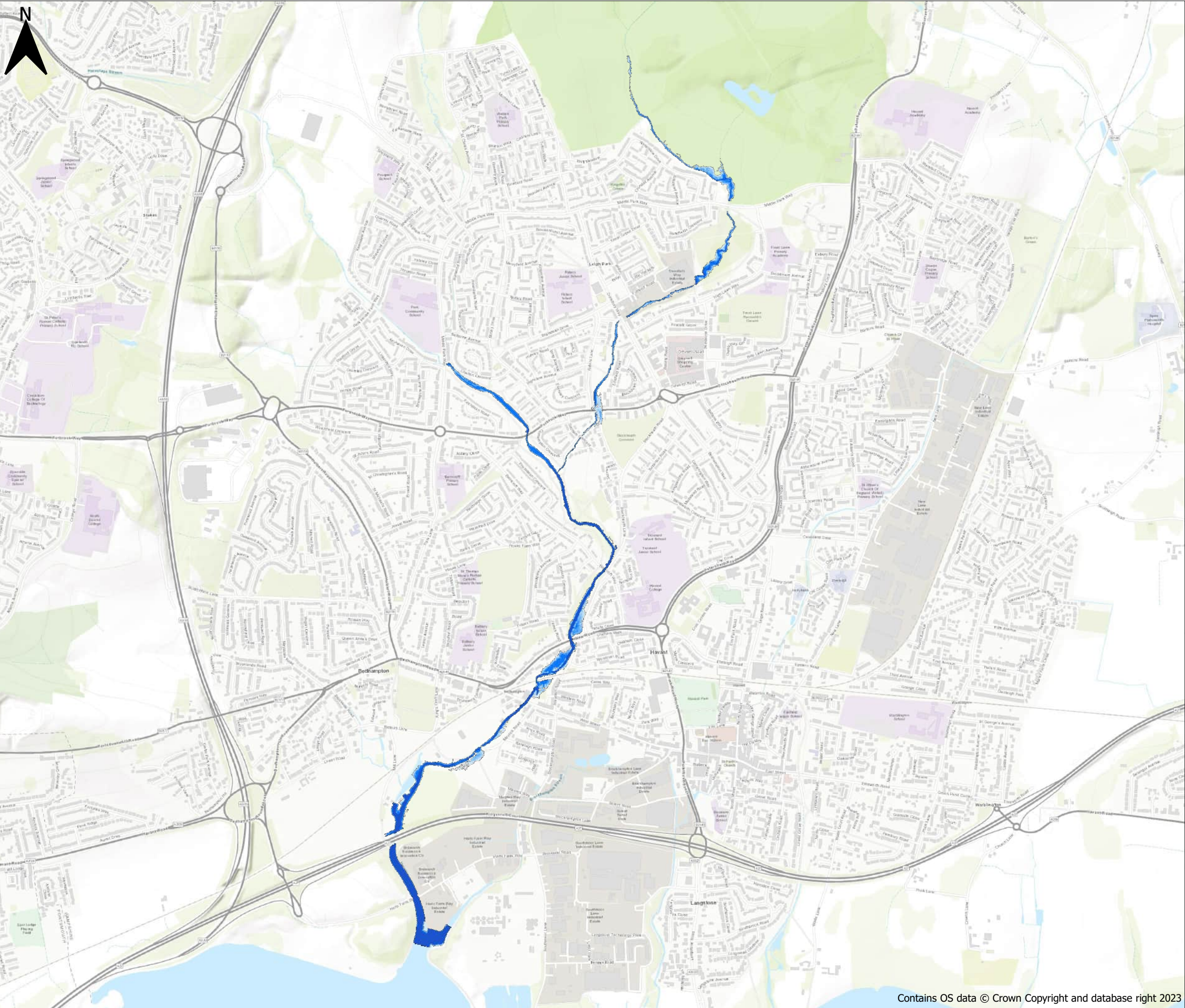
APPENDIX A - FIGURE A5

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



Contains OS data © Crown Copyright and database right 2023

This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Baseline - 1% AEP
Flood Depth (m)

- ≤ 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

PURPOSE OF ISSUE

ISSUE TO CLIENT

DRAWING NUMBER

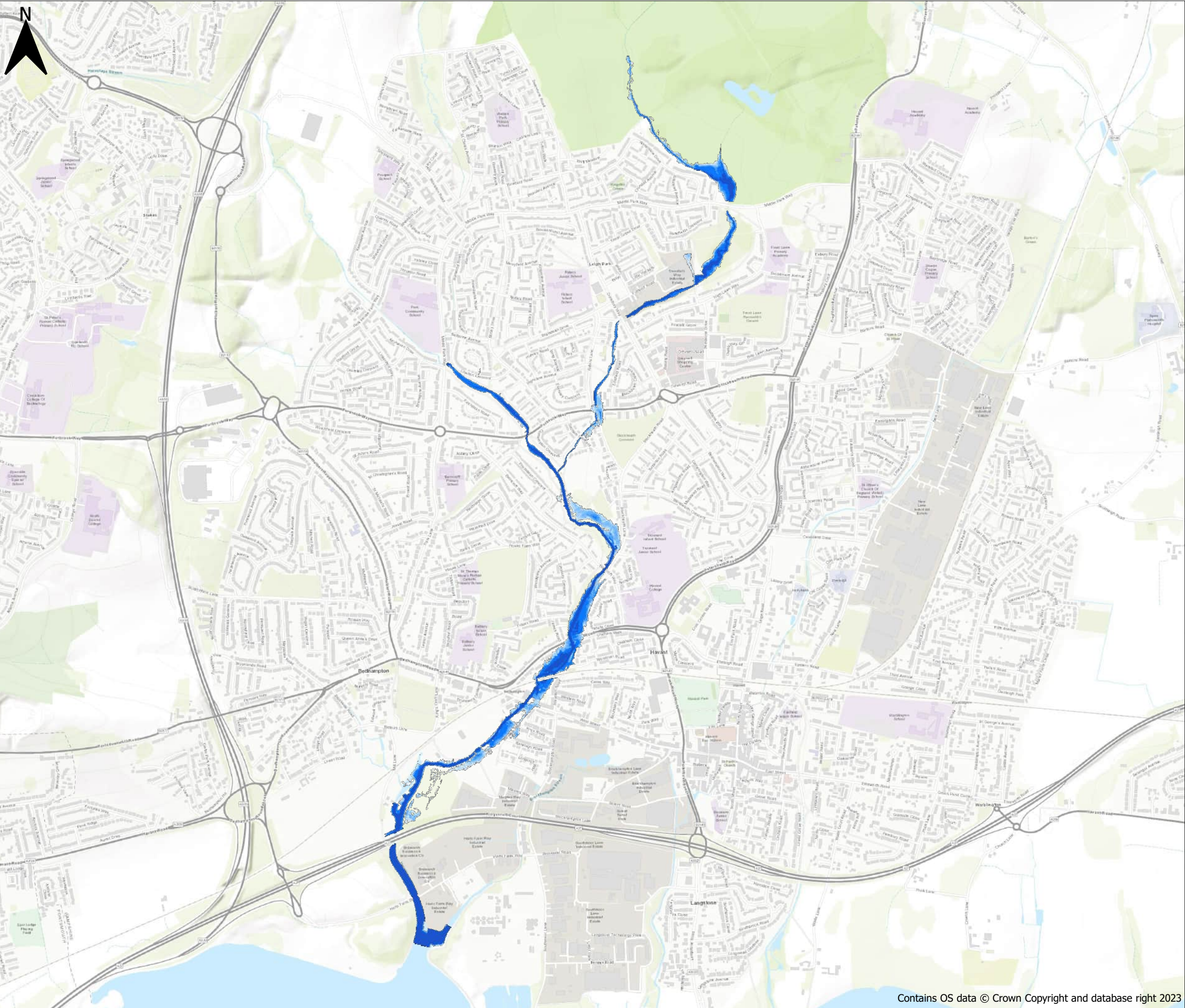
APPENDIX A - FIGURE A6

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



Contains OS data © Crown Copyright and database right 2023

This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Baseline - 0.1% AEP
Flood Depth (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN RV	CHECKED JP	AUTHORISED 22/05/23
-------------	---------------	------------------------

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

PURPOSE OF ISSUE

ISSUE TO CLIENT

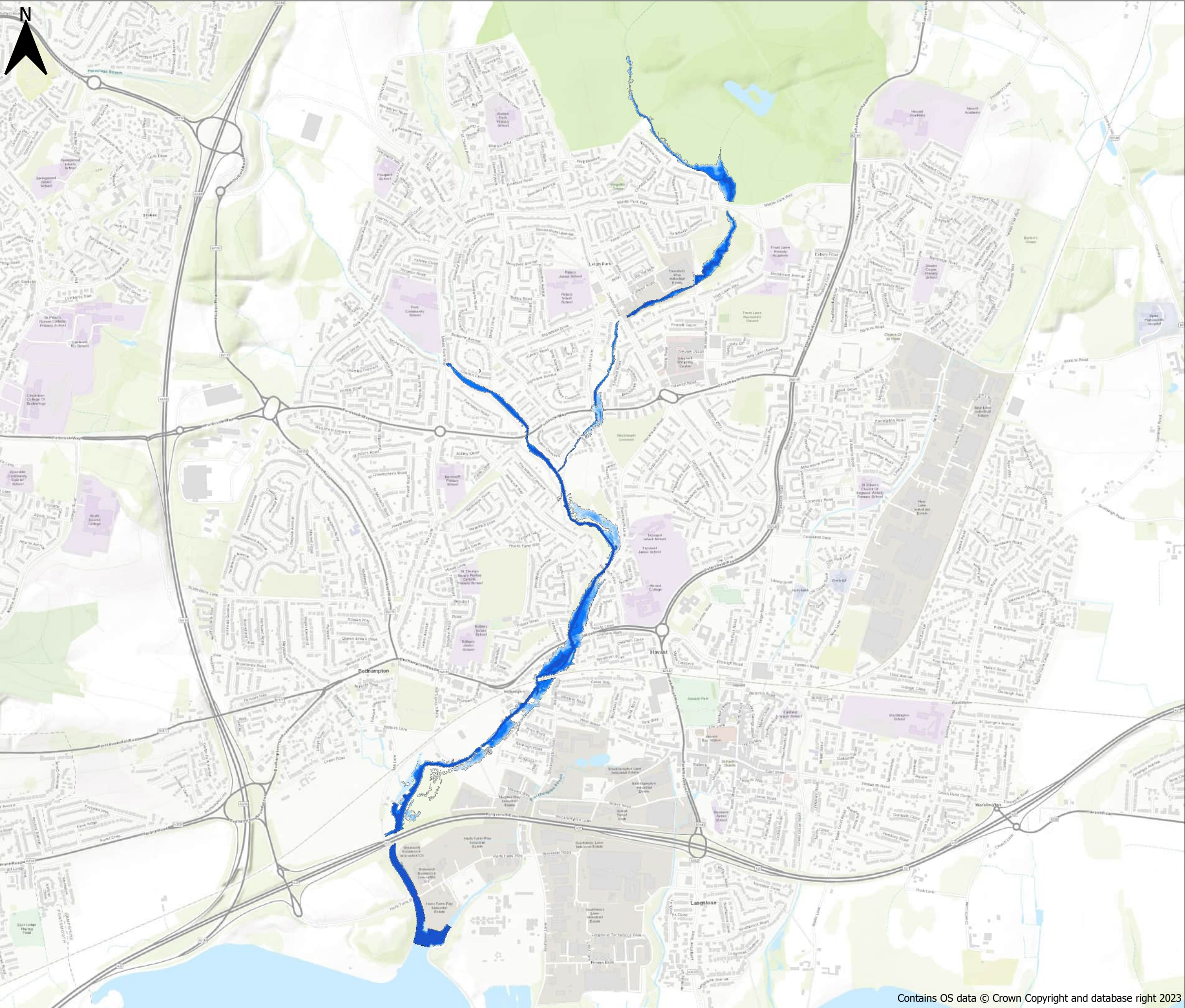
DRAWING NUMBER

APPENDIX A - FIGURE A7

SHEET SIZE A3	SCALE 1:16000 @ A3	REVISION P03
------------------	--------------------------	-----------------



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Baseline - 1% AEP + 51% CC
Flood Depth (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

PURPOSE OF ISSUE

ISSUE TO CLIENT

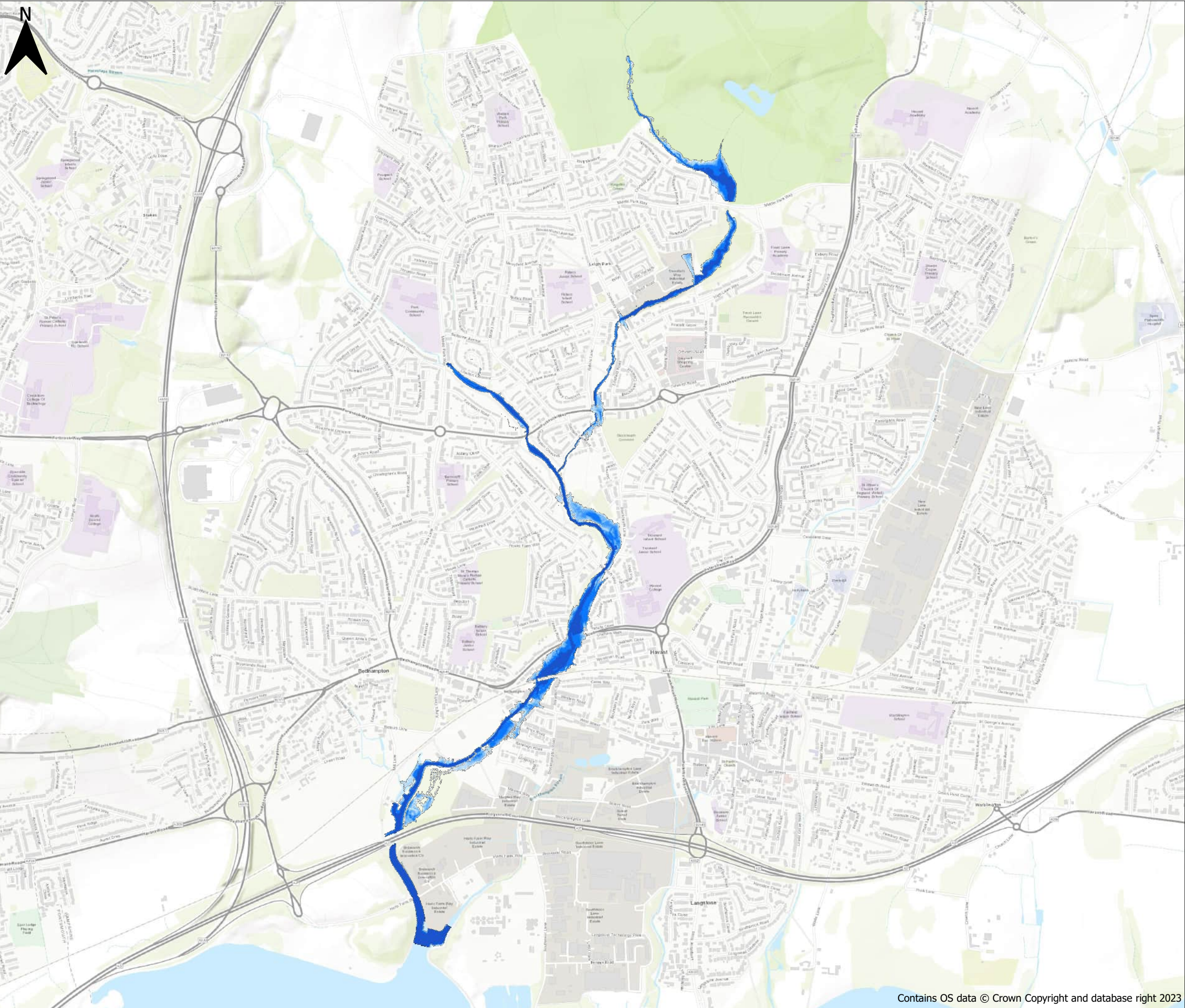
DRAWING NUMBER

APPENDIX A - FIGURE A8

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Baseline - 1% AEP + 88% CC
Flood Depth (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN RV	CHECKED JP	AUTHORISED 22/05/23
-------------	---------------	------------------------

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE
HAVANT PIPELINE

PROJECT STAGE
DETAILED DESIGN

PURPOSE OF ISSUE
ISSUE TO CLIENT

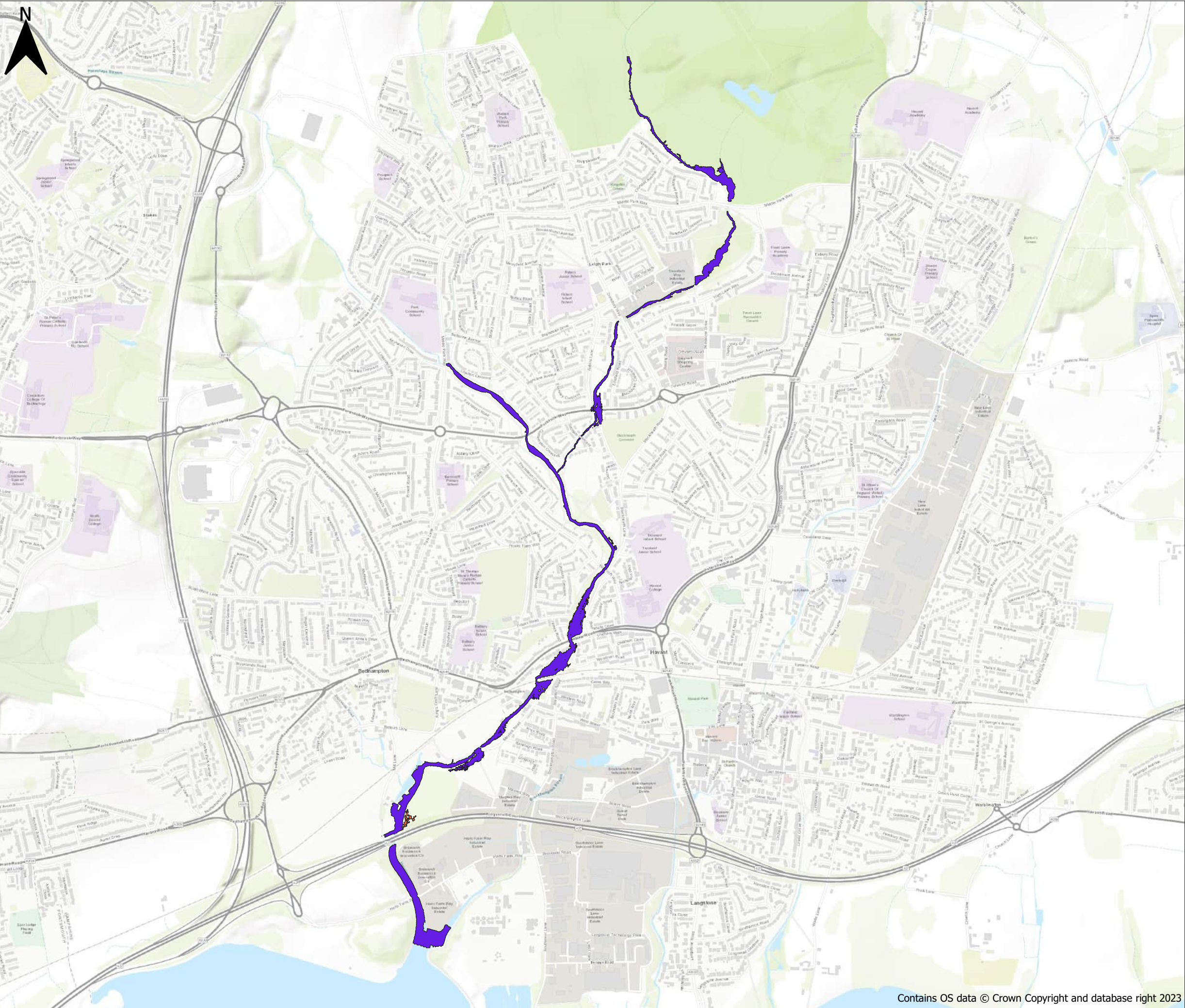
DRAWING NUMBER
APPENDIX A - FIGURE A9

SHEET SIZE A3	SCALE 1:16000 @ A3	REVISION P03
-------------------------	---------------------------------	------------------------



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.

Contains OS data © Crown Copyright and database right 2023



Havant Pipeline

Baseline Flood Extent 1%
AEP Comparison

- 2024 FRA
- 2020 FRA



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

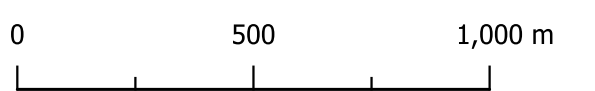
PURPOSE OF ISSUE

ISSUE TO CLIENT

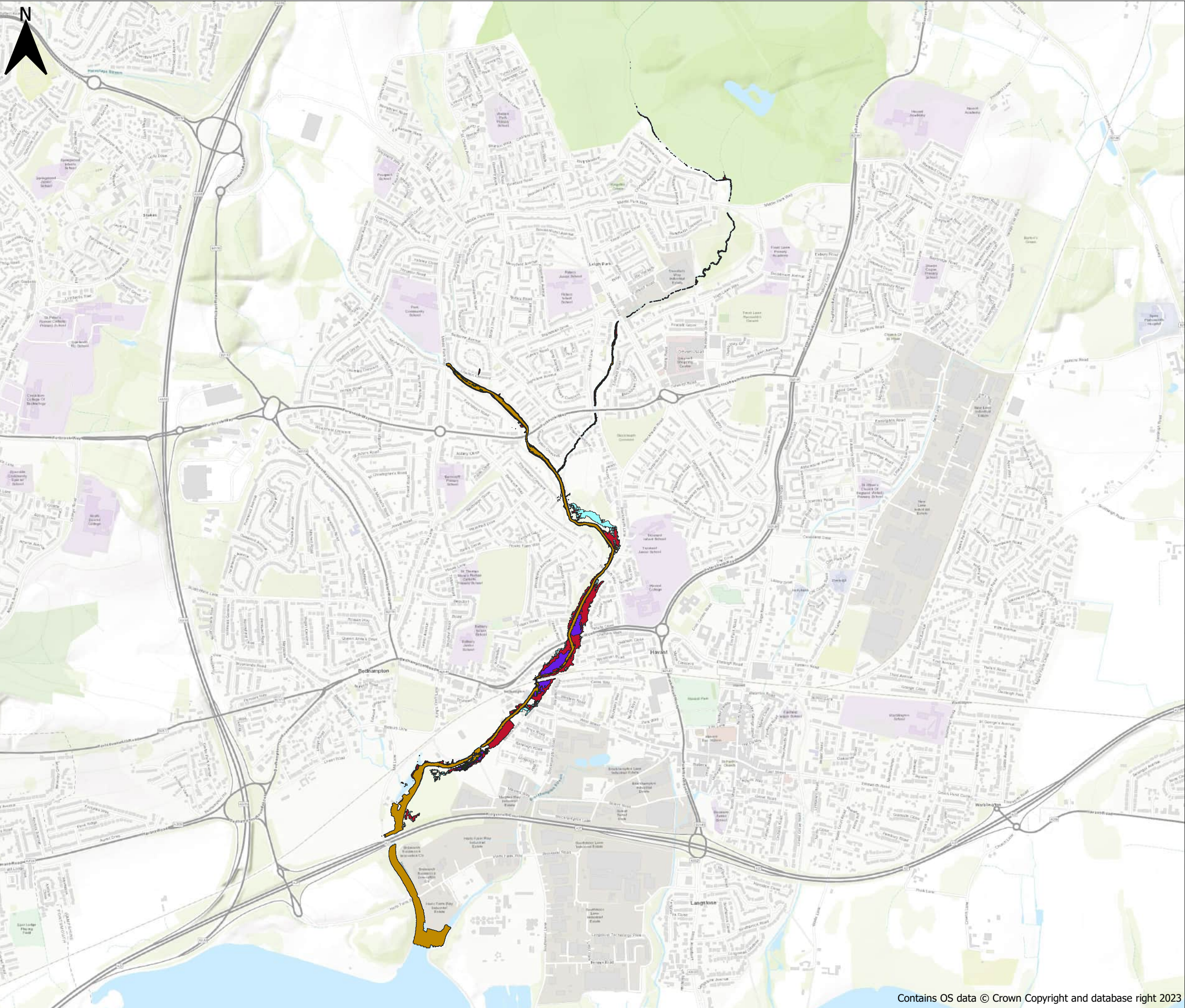
DRAWING NUMBER

APPENDIX A - FIGURE A10

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Operational Flood Extents

- 50% AEP
- 10% AEP
- 1% AEP
- 1% AEP + 51% CC
- 0.1% AEP



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

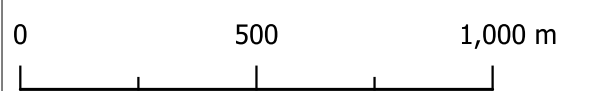
PURPOSE OF ISSUE

ISSUE TO CLIENT

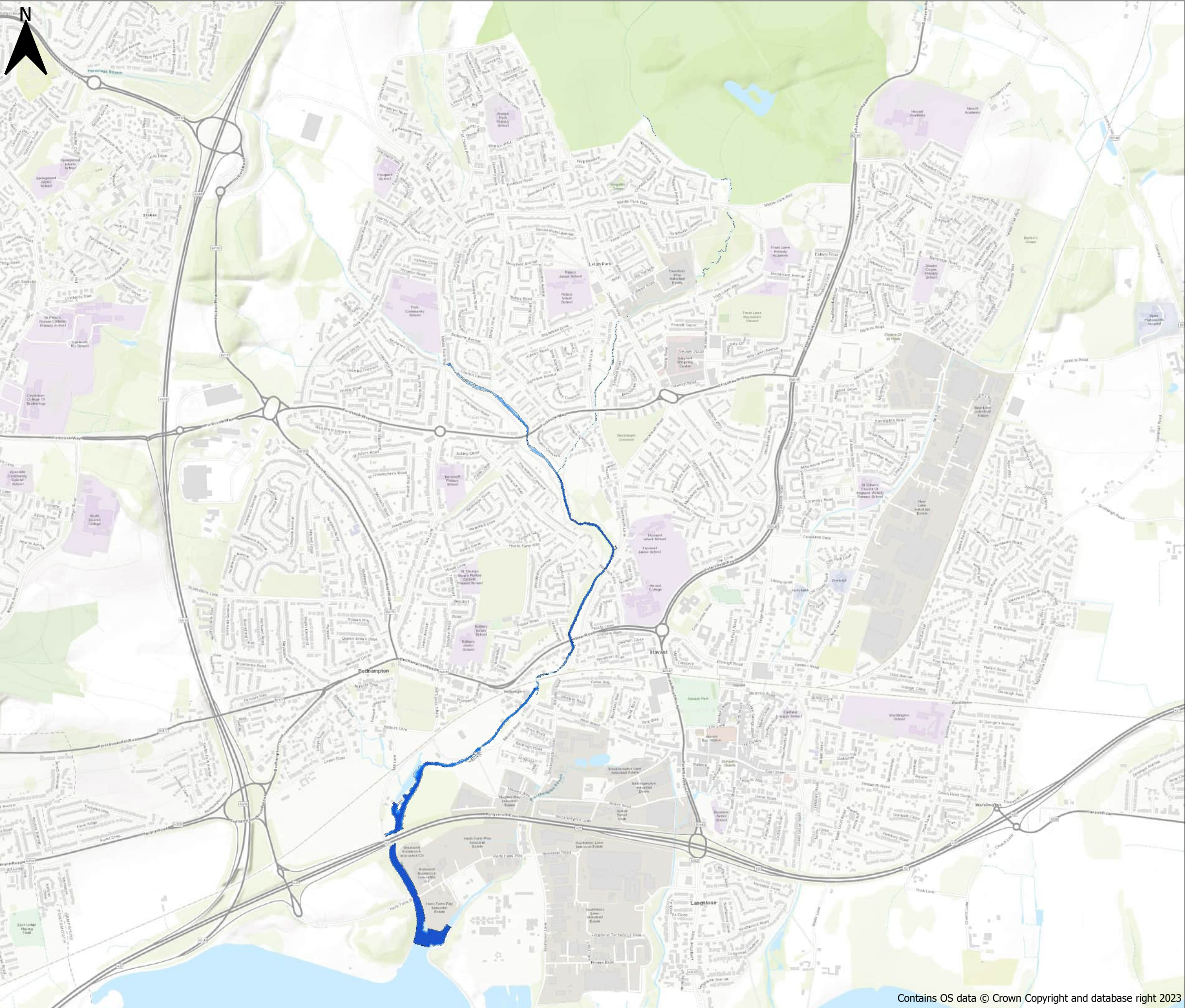
DRAWING NUMBER

APPENDIX A - FIGURE A11

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Operational - 50% AEP
Flood Depths (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

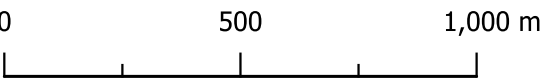
PURPOSE OF ISSUE

ISSUE TO CLIENT

DRAWING NUMBER

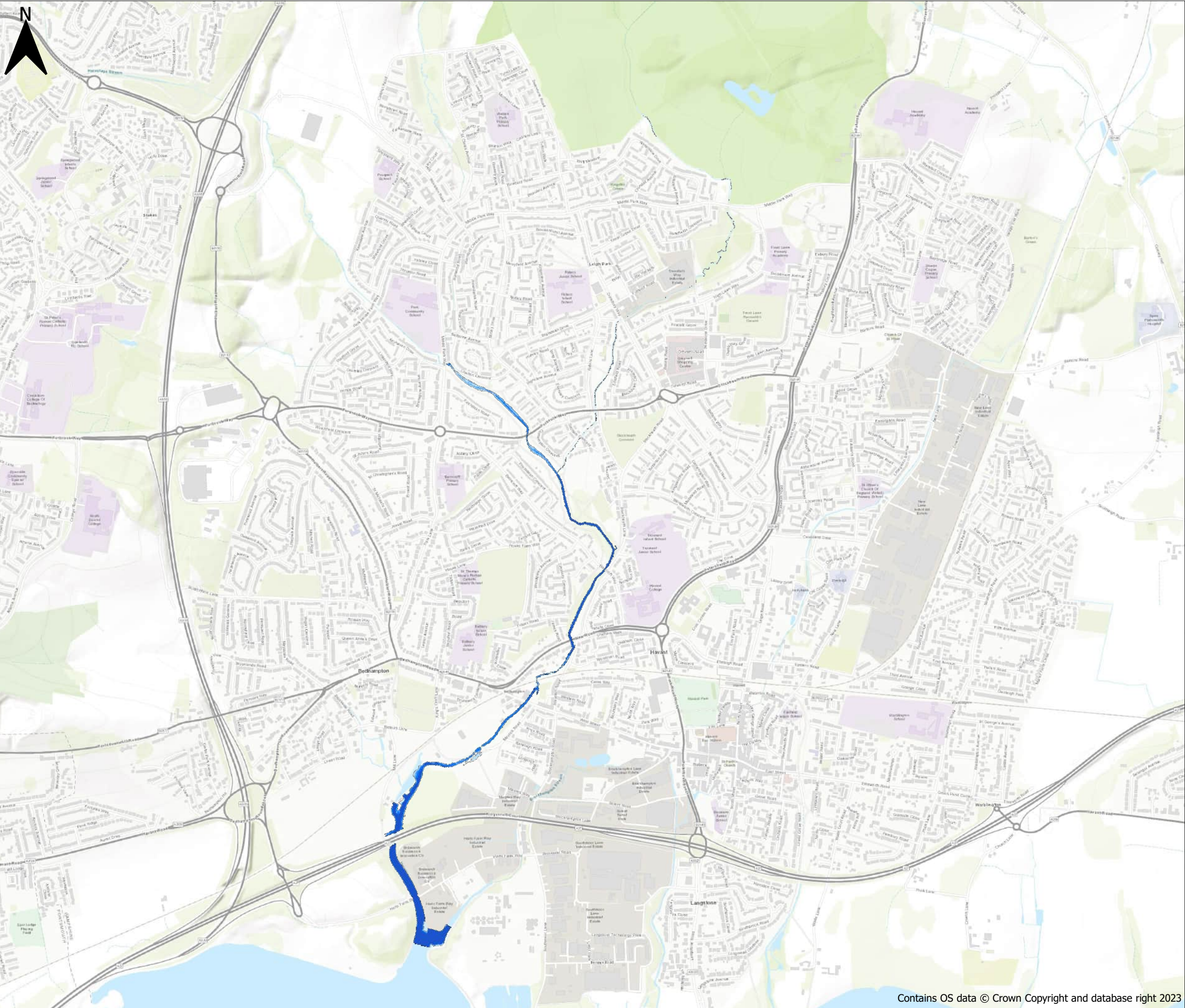
APPENDIX A - FIGURE A12

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



Contains OS data © Crown Copyright and database right 2023

This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Operational - 20% AEP
Flood Depths (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

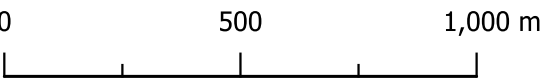
PURPOSE OF ISSUE

ISSUE TO CLIENT

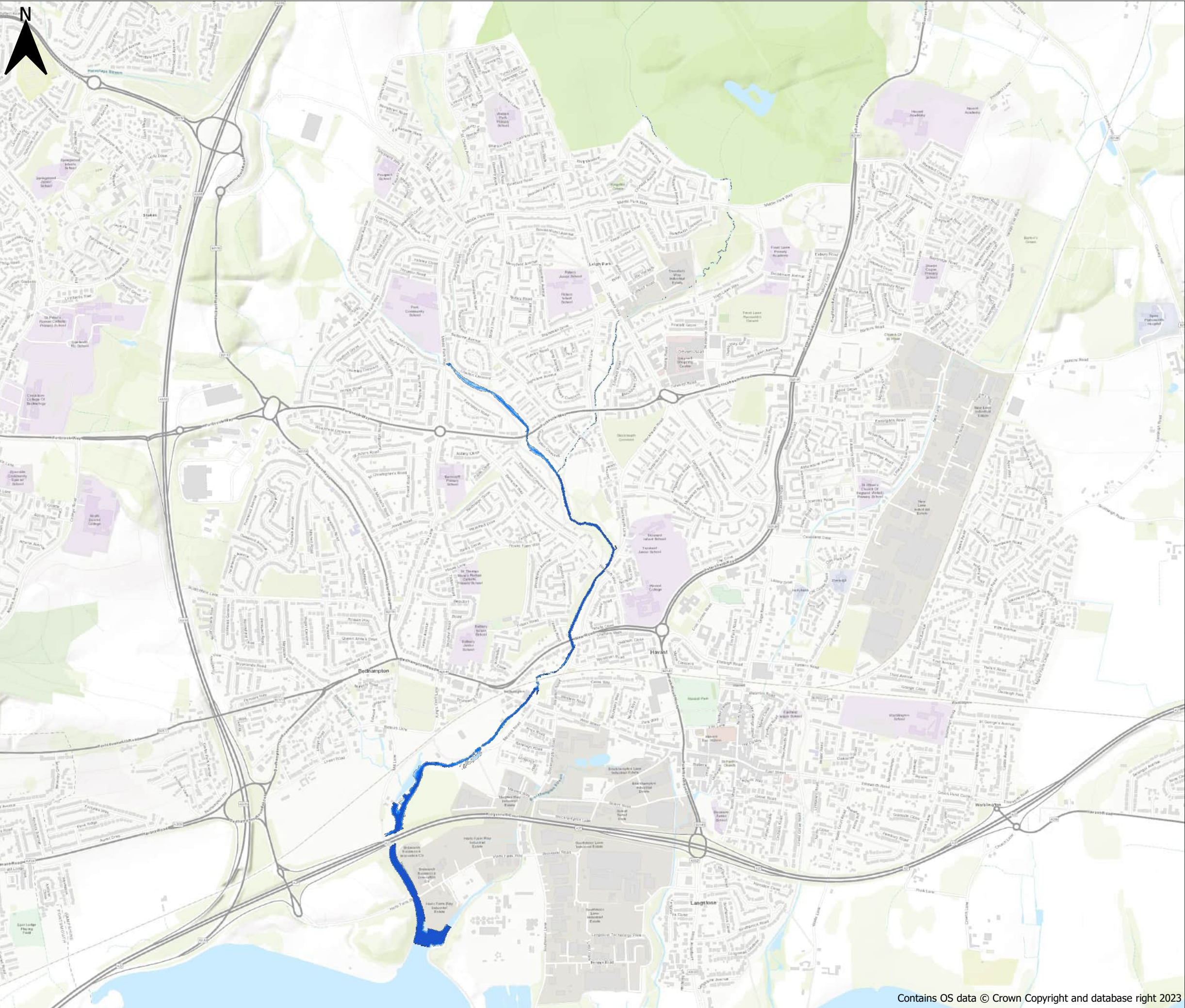
DRAWING NUMBER

APPENDIX A - FIGURE A13

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Operational - 10% AEP
Flood Depth (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN RV	CHECKED JP	AUTHORISED 22/05/23
-------------	---------------	------------------------

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

PURPOSE OF ISSUE

ISSUE TO CLIENT

DRAWING NUMBER

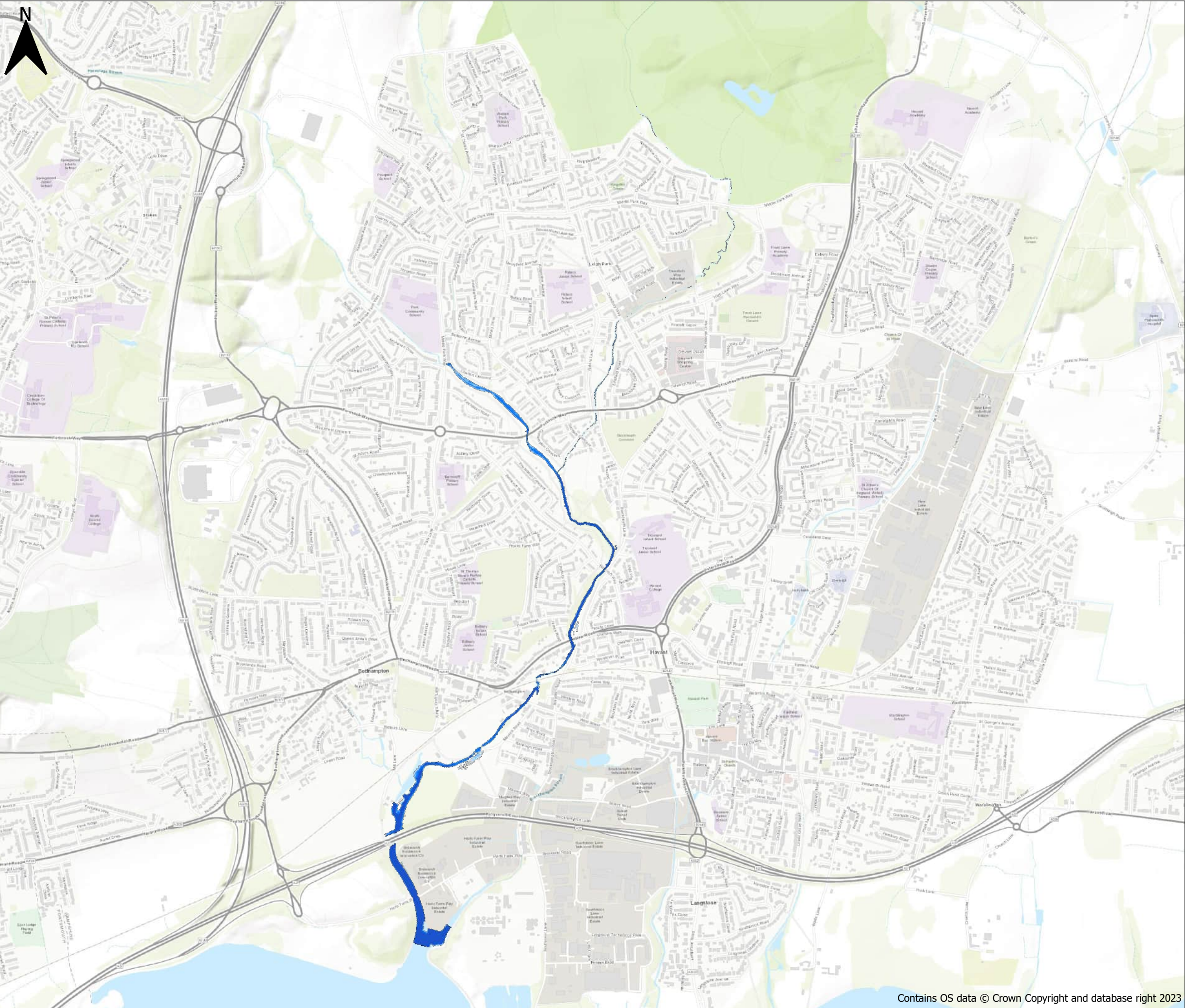
APPENDIX A - FIGURE A14

SHEET SIZE A3	SCALE 1:16000 @ A3	REVISION P03
------------------	--------------------------	-----------------



Contains OS data © Crown Copyright and database right 2023

This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Operational - 3.33 AEP
Flood Depth (m)

<= 0.05
0.1
0.2
0.3
0.4
0.5
1.0
1.0+



DRAWN RV	CHECKED JP	AUTHORISED 22/05/23
-------------	---------------	------------------------

DESIGNER

SWECO

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

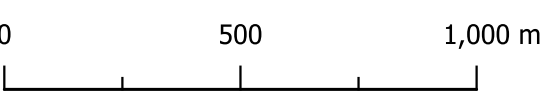
PURPOSE OF ISSUE

ISSUE TO CLIENT

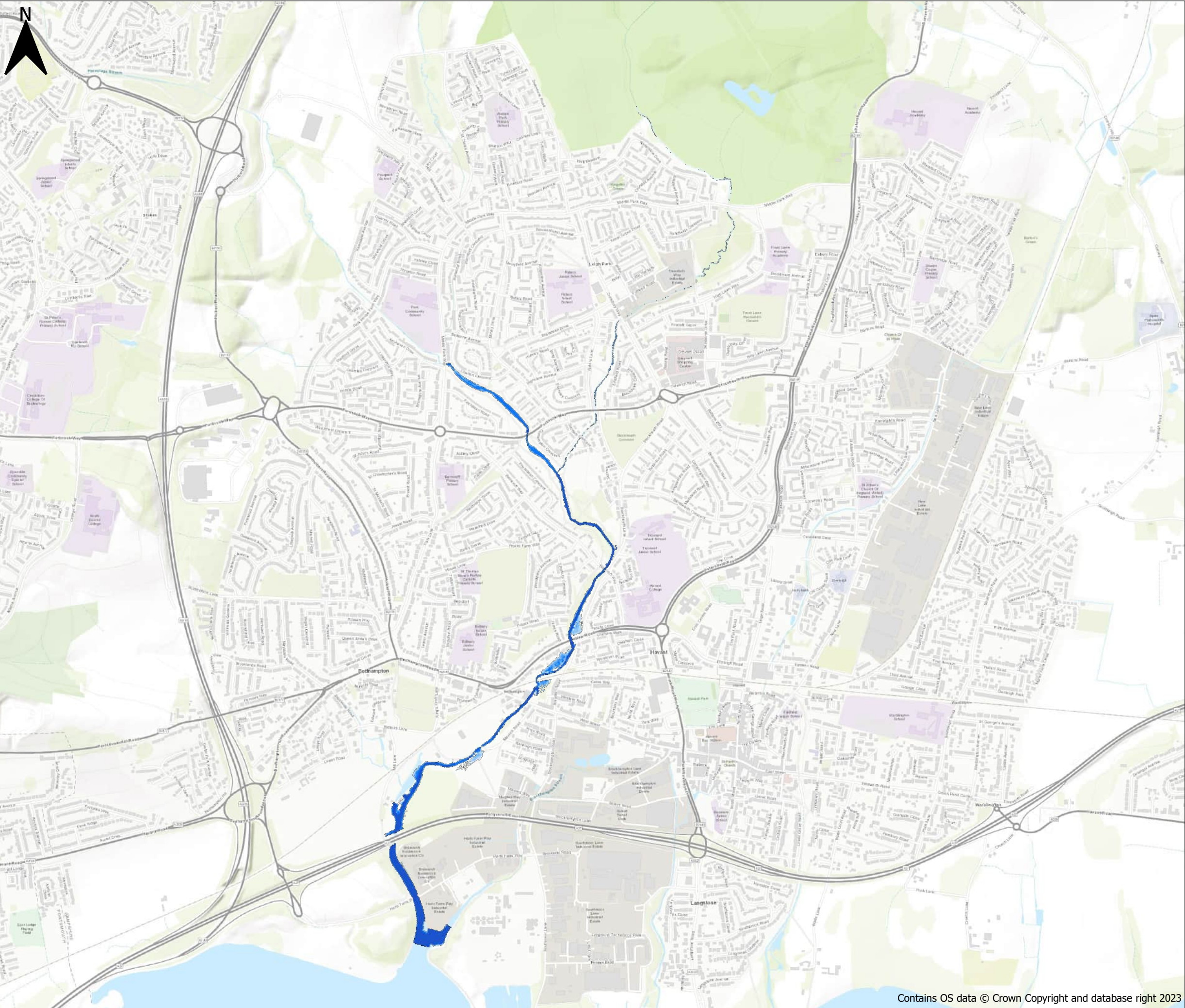
DRAWING NUMBER

APPENDIX A - FIGURE A15

SHEET SIZE A3	SCALE 1:16000 @ A3	REVISION P03
------------------	--------------------------	-----------------



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Operational - 1% AEP
Flood Depth (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN RV	CHECKED JP	AUTHORISED 22/05/23
-------------	---------------	------------------------

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



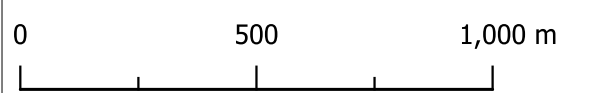
PROJECT TITLE
HAVANT PIPELINE

PROJECT STAGE
DETAILED DESIGN

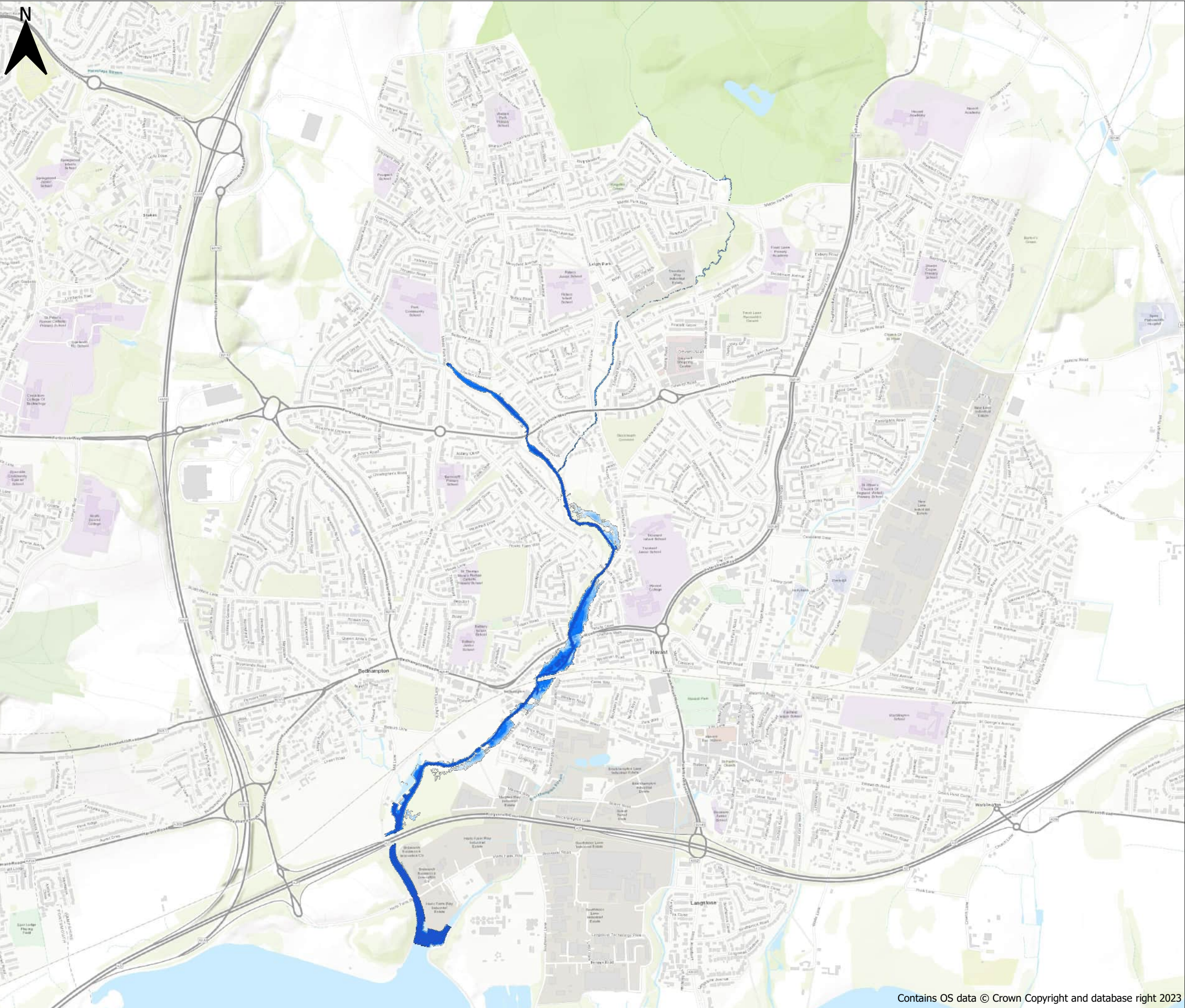
PURPOSE OF ISSUE
ISSUE TO CLIENT

DRAWING NUMBER
APPENDIX A - FIGURE A16

SHEET SIZE A3	SCALE 1:16000 @ A3	REVISION P03
------------------	--------------------------	-----------------



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Operational - 0.1% AEP
Flood Depth (m)

- ≤ 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN RV	CHECKED JP	AUTHORISED 22/05/23
-------------	---------------	------------------------

DESIGNER

SWECO

CONTRACTOR

WARD & BURKE

CLIENT



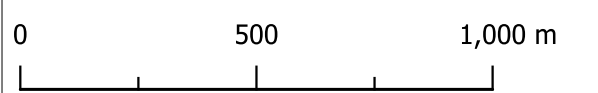
PROJECT TITLE
HAVANT PIPELINE

PROJECT STAGE
DETAILED DESIGN

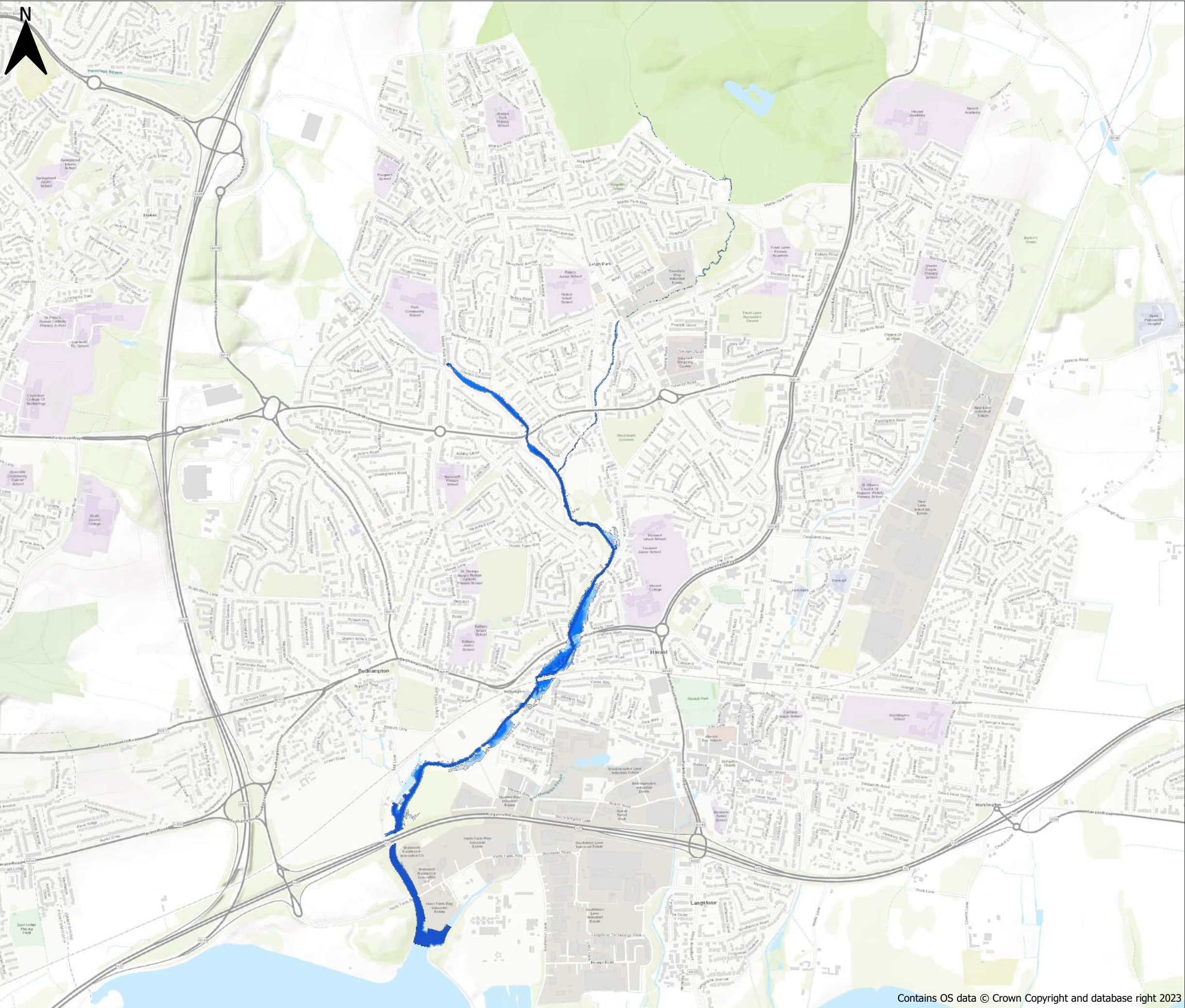
PURPOSE OF ISSUE
ISSUE TO CLIENT

DRAWING NUMBER
APPENDIX A - FIGURE A17

SHEET SIZE A3	SCALE 1:16000 @ A3	REVISION P03
------------------	--------------------------	-----------------



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Operational - 1% AEP + 51% CC
Flood Depth (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



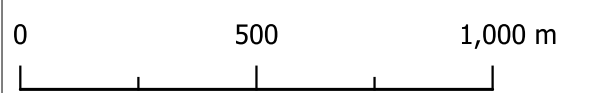
PROJECT TITLE
HAVANT PIPELINE

PROJECT STAGE
DETAILED DESIGN

PURPOSE OF ISSUE
ISSUE TO CLIENT

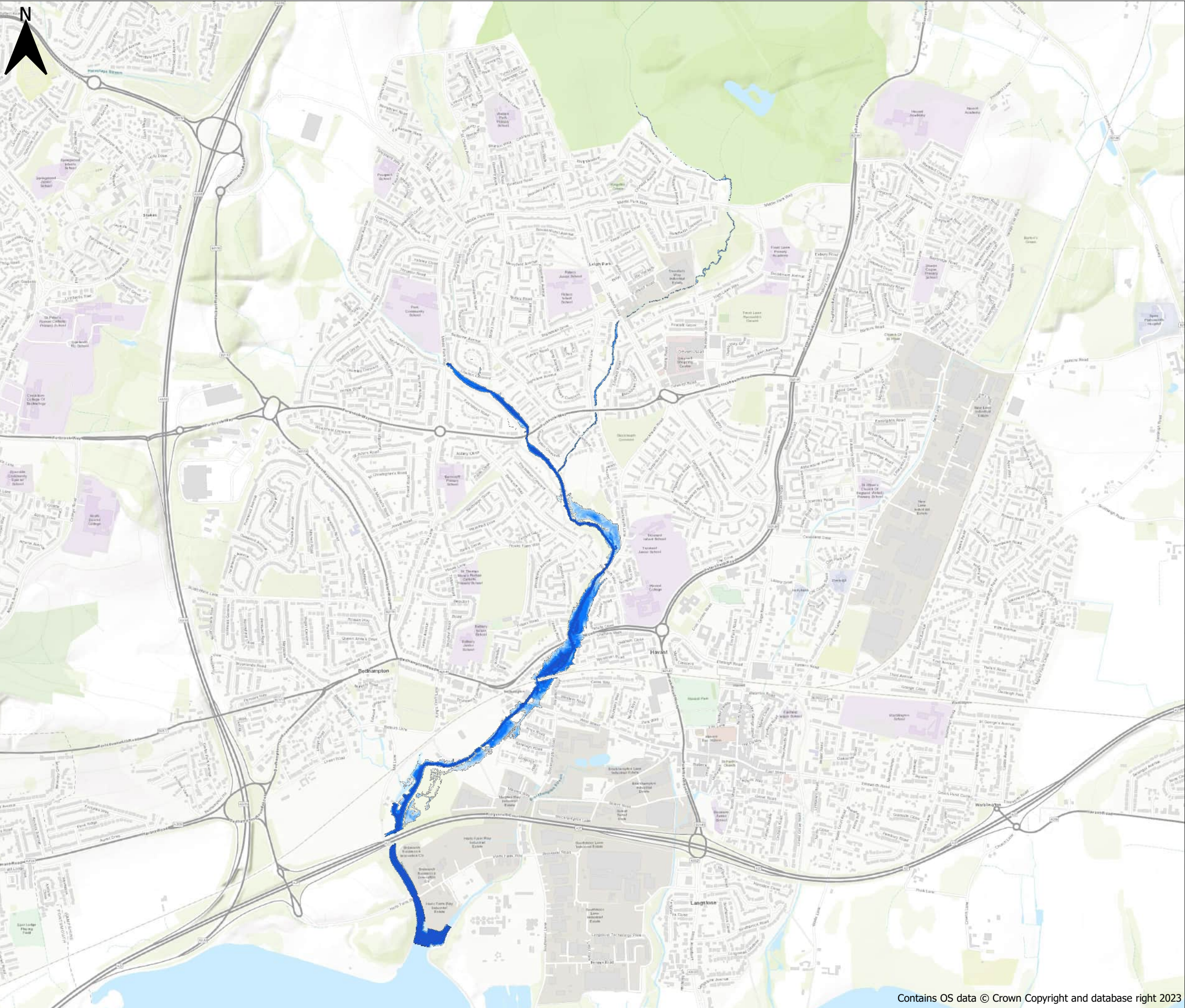
DRAWING NUMBER
APPENDIX A - FIGURE A18

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



Contains OS data © Crown Copyright and database right 2023

This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Operational - 1% AEP + 88% CC
Flood Depth (m)

- <= 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1.0
- 1.0+



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO 

CONTRACTOR

WARD & BURKE

CLIENT



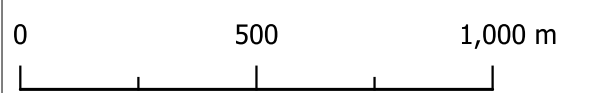
PROJECT TITLE
HAVANT PIPELINE

PROJECT STAGE
DETAILED DESIGN

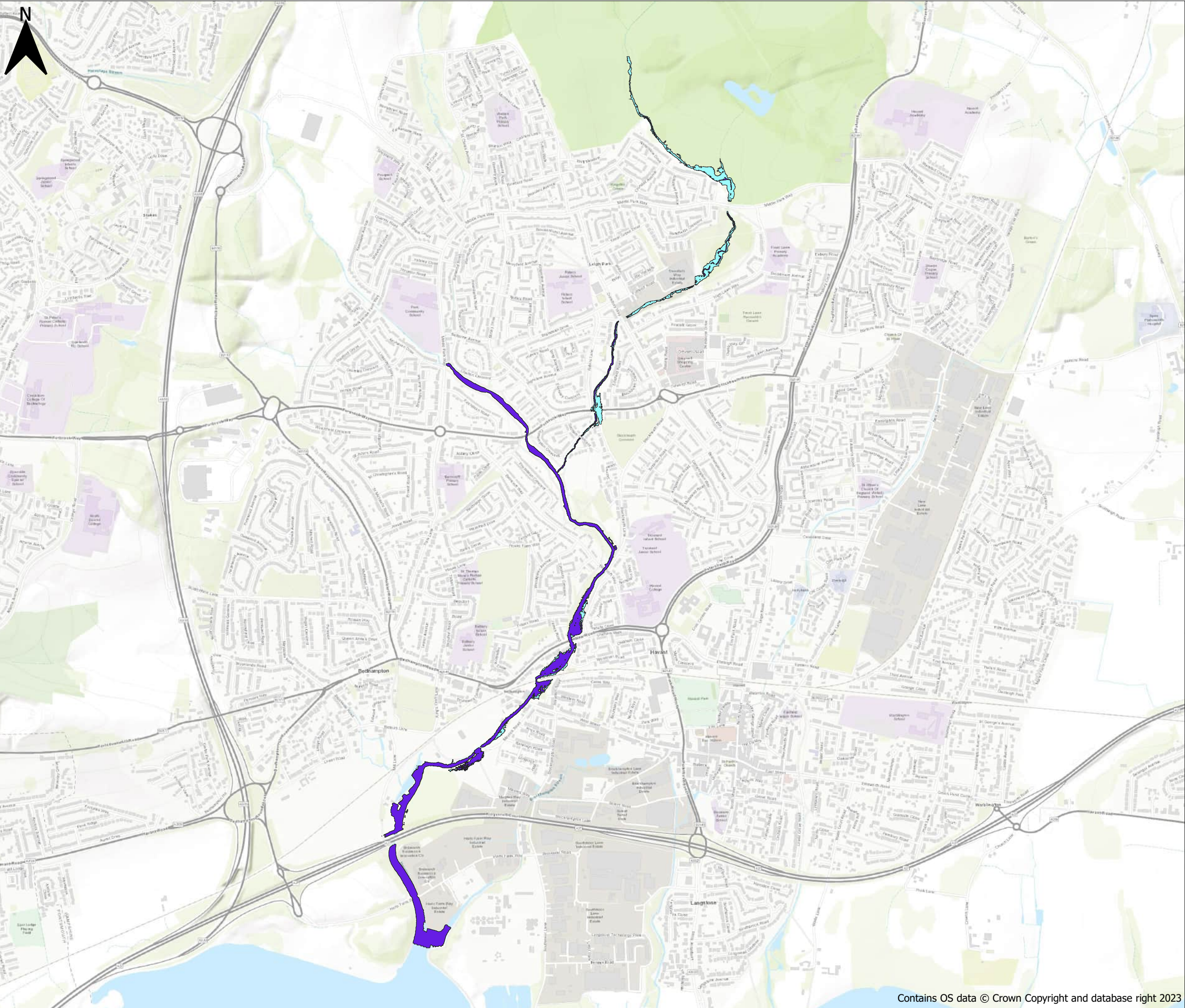
PURPOSE OF ISSUE
ISSUE TO CLIENT

DRAWING NUMBER
APPENDIX A - FIGURE A19

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.

Havant Pipeline

1% AEP Flood Extent Comparison

- Baseline
- Operational



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO

CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

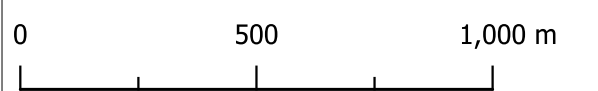
PURPOSE OF ISSUE

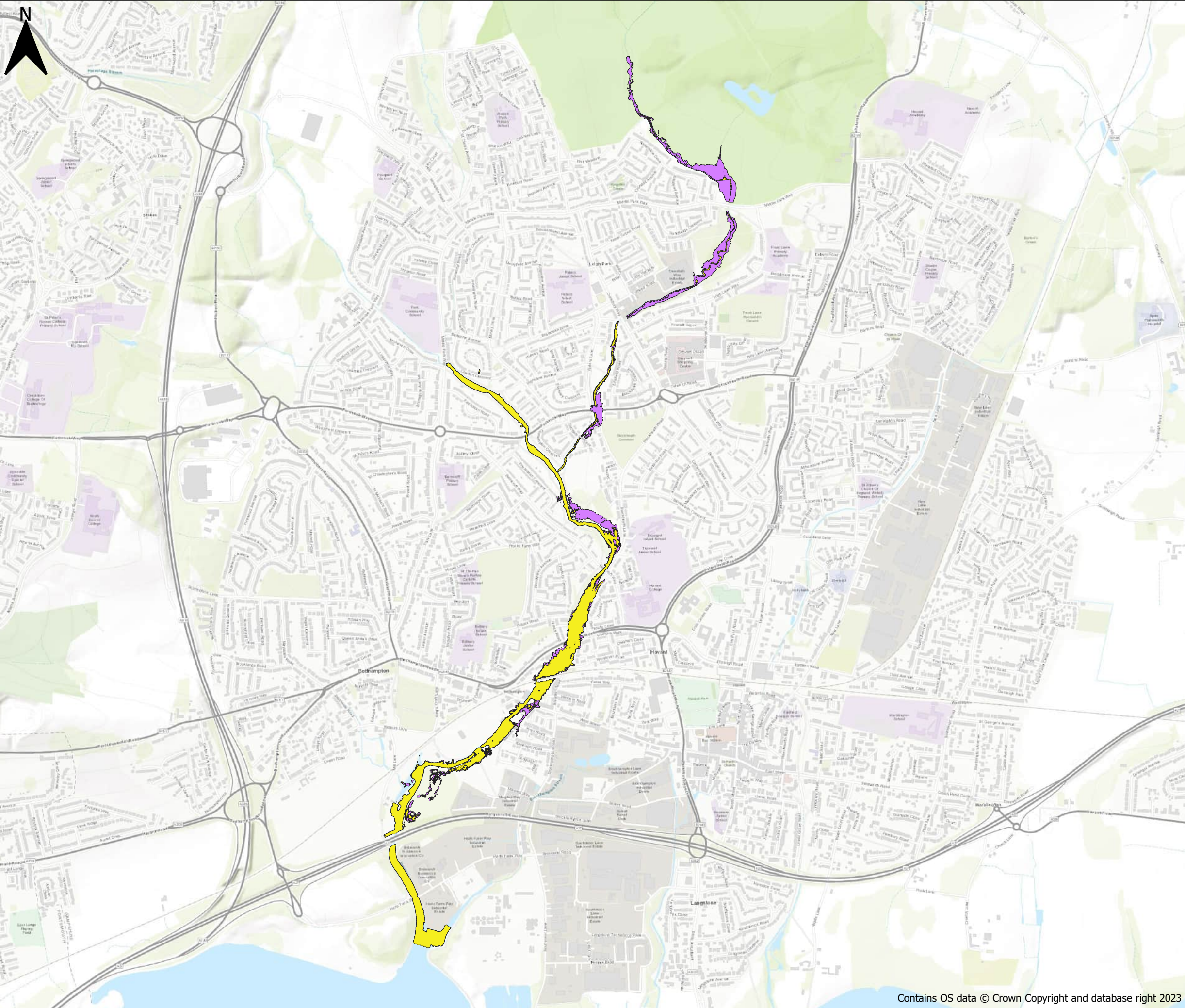
ISSUE TO CLIENT

DRAWING NUMBER

APPENDIX A - FIGURE A20

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03





Havant Pipeline

1% AEP + 51% CC
Flood Extent Comparison

Baseline

Operational

DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO

CONTRACTOR

WARD & BURKE

CLIENT

PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

PURPOSE OF ISSUE

ISSUE TO CLIENT

DRAWING NUMBER

APPENDIX A - FIGURE A21

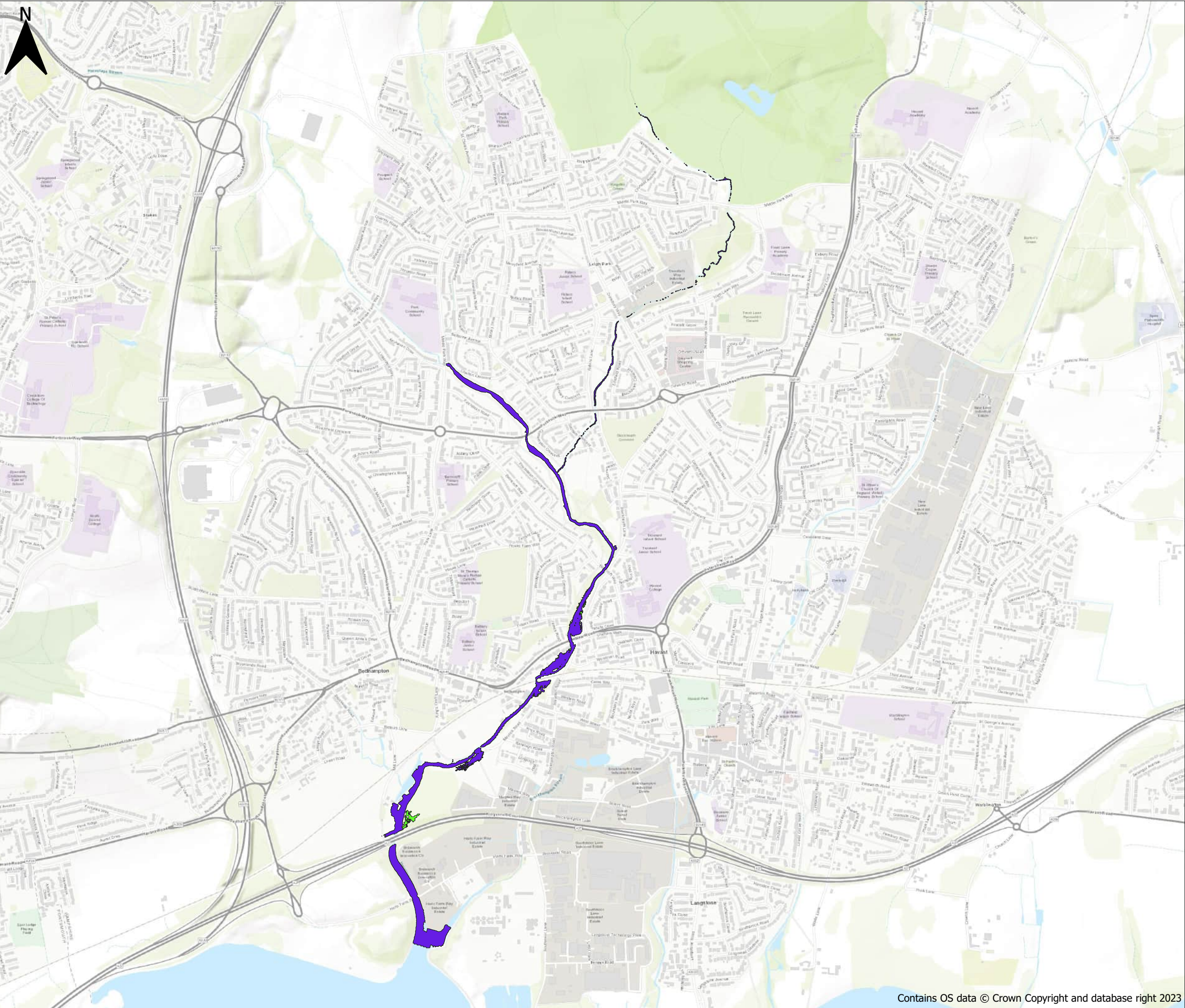
SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03

0

500

1,000 m

This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Operational 1% AEP
Flood Extent Comparison

2024 FRA

2020 FRA

DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO

CONTRACTOR

WARD & BURKE

CLIENT

PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

PURPOSE OF ISSUE

ISSUE TO CLIENT

DRAWING NUMBER

APPENDIX A - FIGURE A22

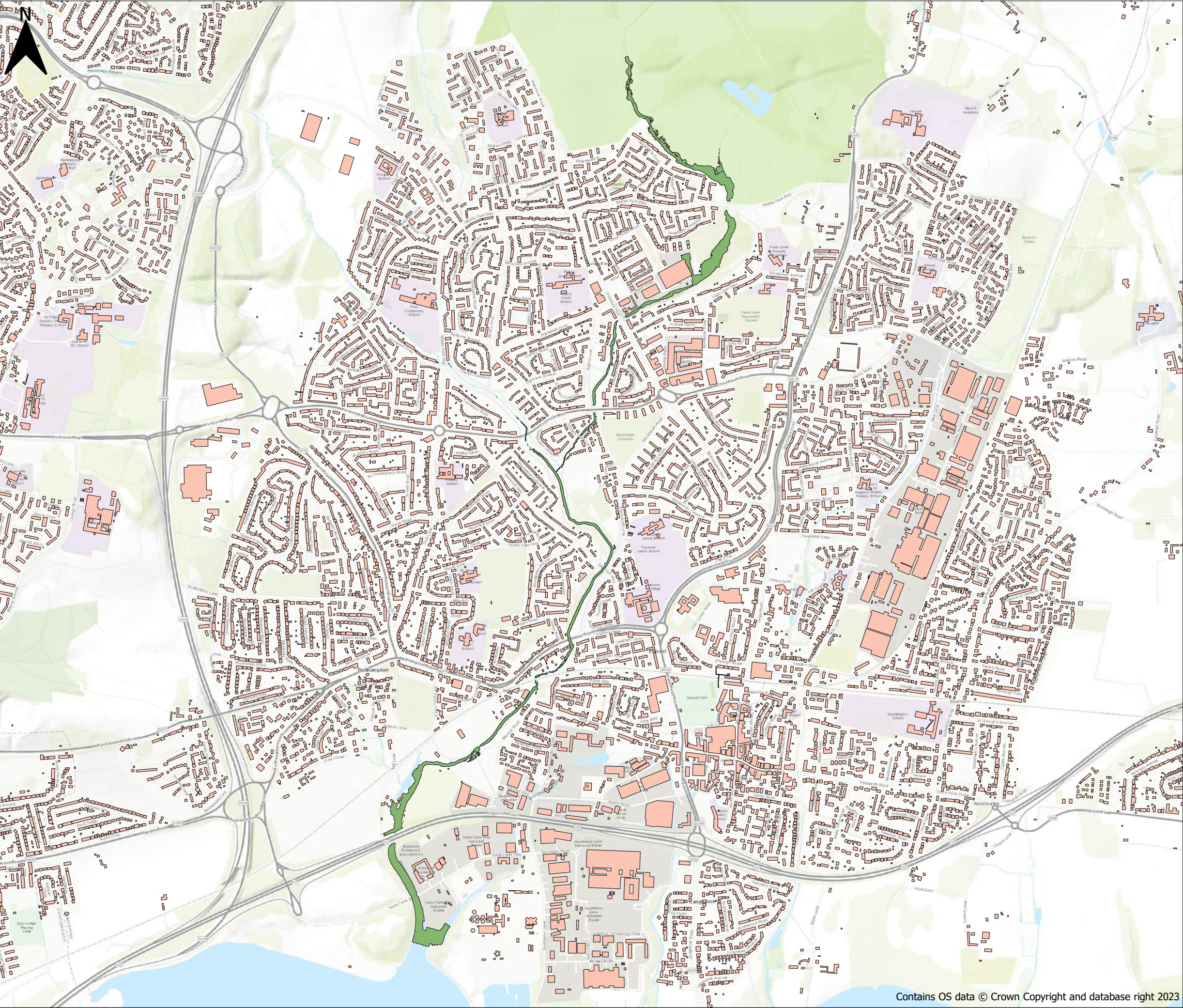
SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03

0

500

1,000 m

This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.

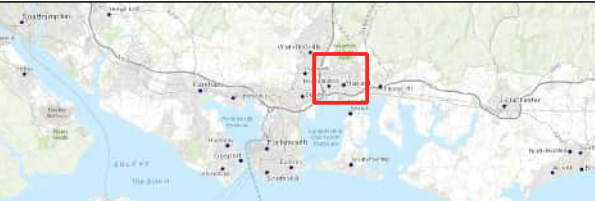


Havant Pipeline

Emergency Discharge

Buildings

Operational Flood Extent



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO

CONTRACTOR

WARD & BURKE

CLIENT

PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

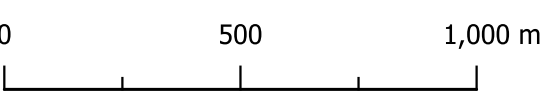
PURPOSE OF ISSUE

ISSUE TO CLIENT

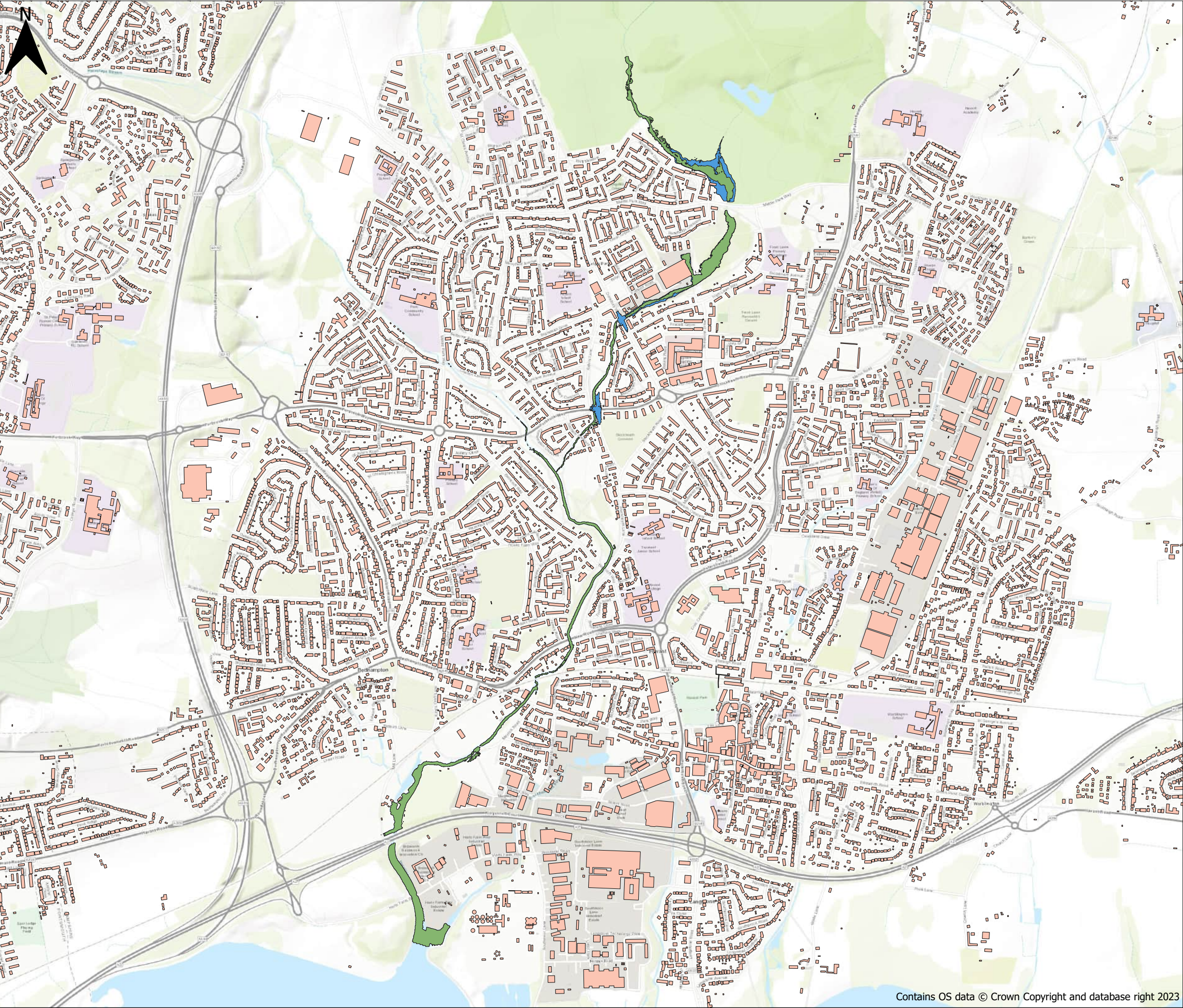
DRAWING NUMBER

APPENDIX A - FIGURE A23

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



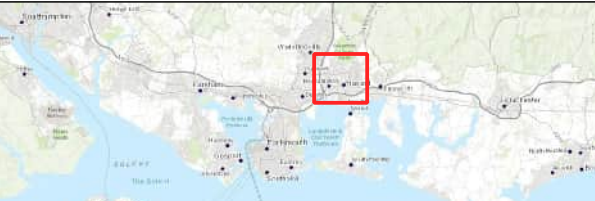
This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Emergency Discharge

- Buildings
- Baseline Flood Extent
- Operational Flood Extent



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO



CONTRACTOR

WARD & BURKE

CLIENT



PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

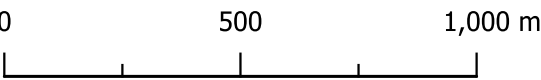
PURPOSE OF ISSUE

ISSUE TO CLIENT

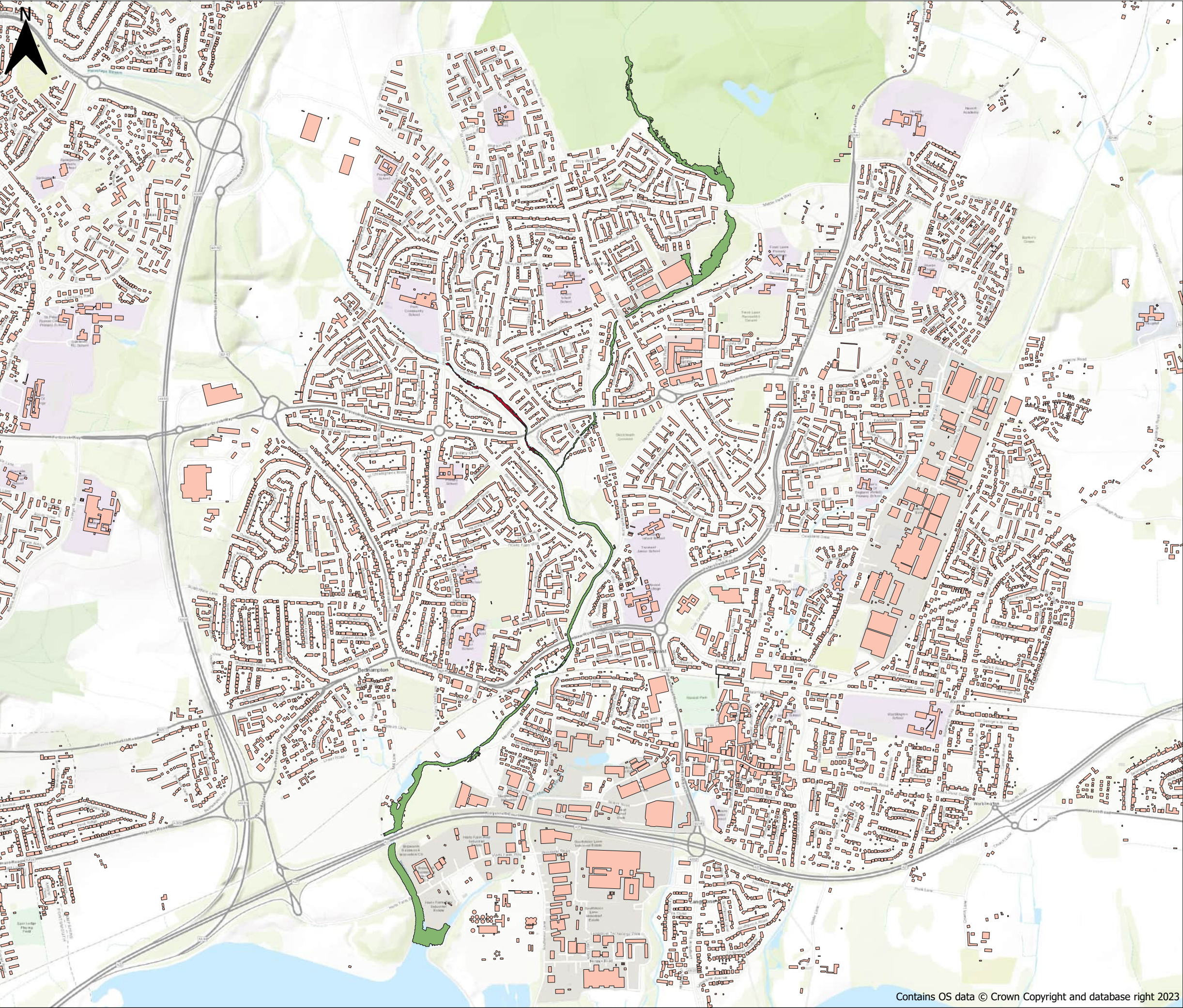
DRAWING NUMBER

APPENDIX A - FIGURE A24

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



Havant Pipeline

Emergency Discharge Comparison

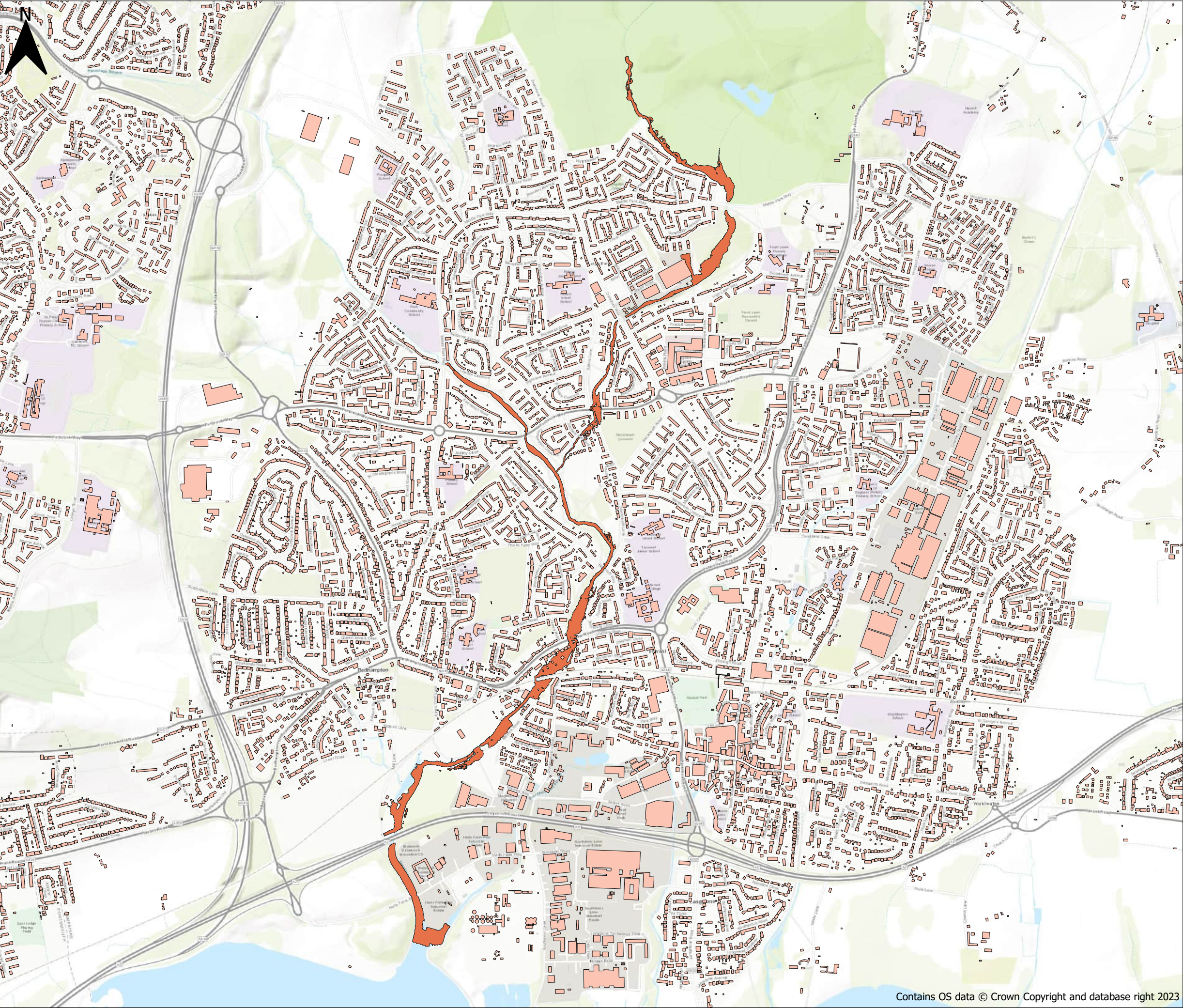
Buildings

2024 Flood Extent

2020 Flood Extent

DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23
DESIGNER		
SWECO		
CONTRACTOR		
WARD & BURKE		
CLIENT		
Portsmouth Water		
PROJECT TITLE		
HAVANT PIPELINE		
PROJECT STAGE		
DETAILED DESIGN		
PURPOSE OF ISSUE		
ISSUE TO CLIENT		
DRAWING NUMBER		
APPENDIX A - FIGURE A25		
SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03
05001,000 m		

This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.

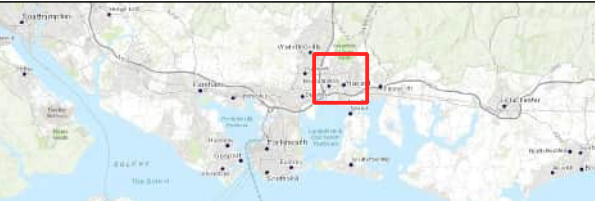


Havant Pipeline

Emergency Discharge

Buildings

Operational + 3.33% AEP
Fluvial Flood Extent



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO

CONTRACTOR

WARD & BURKE

CLIENT

PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

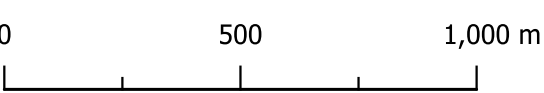
PURPOSE OF ISSUE

ISSUE TO CLIENT

DRAWING NUMBER

APPENDIX A - FIGURE A26

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.

Appendix B – Hydraulic Modelling Report

Hydraulic Modelling Report

Havant Pipeline

Rev.	Date	Reason for issue	Prepared	Reviewed	Approved
[1]	12/05/23	Draft	RV	JP	JB
[2]	15/05/23	Draft	RV	JP	JB
[3]	24/05/23	Issued to EA 1 st Review	RV	JP	JB
[4]	17/08/23	Draft	RV	JB	JP
[5]	13/11/23	Issued to client	RV	JP	JP
[6]	18/01/24	Issued to EA 2 nd Review	RV	JP	JP
[7]	08/05/24	FOR PLANNING	RV	ASi	ASm

Project Name: Havant Pipeline
Project Number: 65209354-001
Client: Ward & Burke
Date: 29/05/2024
Author: Richard Vivian
Document Reference: HTR-SWE-PI-XX-RP-C-0001

Table of contents

1	Introduction	4
1.1	General	4
1.2	Objectives and Recommendations	4
2	Climate change allowances	6
3	Model inflow updates	7
3.1	Fluvial	7
3.1.1	Catchment Inflows	7
3.1.2	Lavant Link Pipe contribution	7
3.2	Emergency Discharge Flow	8
3.2.1	Base Flow Condition	8
3.2.2	Emergency Discharge Condition	8
3.3	Tidal	10
3.4	Modelled events and scenarios	10
3.5	Model parameters	11
4	Baseline Hydraulic Model Build	12
5	Baseline model results	13
5.1	Study sections and reporting locations	13
5.2	Fluvial events	15
5.3	Emergency Discharge Flow	16
6	Proposed Development model build	18
7	Proposed Development results	20
7.1	Fluvial	20
7.2	Emergency Discharge Flow	22
7.3	Construction flood risk	22
7.4	Sensitivity	23
7.4.1	Estimated onset of flooding	23
7.4.2	Tidal boundary interaction	23
7.4.3	Model roughness	24
8	Conclusions	25

1 Introduction

1.1 General

As part of the Flood Risk Assessment (FRA) addendum for the proposed Havant Pipeline project, a hydraulic model has been developed in order to inform the FRA addendum and the design of the Proposed Development.

The Havant Thicket Reservoir FRA and accompanying hydraulic model were developed by Atkins in 2020 as part of the Havant Thicket Reservoir Project¹. The project has since progressed through detailed design and proposes the following major design changes:

- The single bi-directional pipeline has been replaced by a twin pipeline, one inlet pipe for filling the reservoir and one outlet pipe for emergency drawdown.
- The inlet pipeline extends north of the reservoir embankment beyond the contractual boundary of the main pipeline.
- The development boundary has changed, and the pipelines now closely follows the course of the Riders Lane and Hermitage Streams.
- The pipeline construction methodology has changed from open cut trench to a combination of open cut trench and tunnelling.
- The number of construction areas has increased from five to eight to accommodate the change in construction methodology.
- The position of the emergency discharge into the Hermitage Stream has moved from downstream of Middle Park Way to the Hermitage Stream and Riders Lane Stream confluence adjacent to Corhampton Crescent.

For the purposes of this report, the twin pipeline is referred to as 'the pipeline'.

This technical note provides a summary of the hydraulic modelling methodology, an overview of the modelling results and draws comparison to the flood impacts presented in the 2020 FRA.

The hydrological assessment and hydraulic model were accepted by the Environment Agency on 18th July 2023.

1.2 Objectives and Recommendations

This modelling report has considered the following:

- Review of updated climate change allowances and hydraulic model inflows;
- Updates to the baseline 2020 hydraulic model;
- Modelling of proposed changes to the development including a relocated pipeline and emergency discharge location;
- Analysis of results.

An external audit of the 2020 FRA hydraulic model was carried out by JBA Consulting in 2023² on behalf of Future water. A number of recommendations were made and considered for this assessment:

¹ Atkins, *Havant Thicket Reservoir Project*, Environmental Statement Volume 4 -Appendices, Appendix A15 Water, A15.2 Flood Risk Assessment Report, 2020

² JBA Consulting, *Independent review of flood study and emergency discharge modelling for Havant Springs Reservoir*, P02, 2023

Essential

- *Extend the Hermitage Stream model upstream of the inflow point, so that back water can be represented.*
- *Run the Baseline scenario for the Q_{10} event, so the results are available to contrast with the Emergency Discharge scenario.*
- *Map the predicted flooding resulting from the Baseline and Emergency Discharge scenarios, for comparison.*

Recommended

- *Take a 1D-2D approach to representing fluvial flooding across the model.*
- *Update the model to the latest InfoWorks ICM software release.*

It should be noted that although regarded as an essential change following the audit, the relocation of the emergency discharge further downstream caused back water effects to be diminished within the Hermitage Stream. The Hermitage Stream was therefore not extended upstream to capture these effects.

The suitability of a 1D-2D approach was assessed by converting the 1D areas that represented floodplain into 2D. It was found that areas of the model containing receptors were represented in 2D. Any further conversion of 1D areas to 2D would not provide additional detail to flood impacts to receptors. Therefore, no additional 2D areas were built within the model.

2 Climate change allowances

Current climate change estimates for peak river flow allowances are based on the UK Climate Projections 2018, in accordance with the latest Environment Agency's allowances for Flood Risk Assessment. Climate change is expected to increase flood risk and experiences in recent years suggest that the incidence of flooding in England is increasing.

The development at the site, comprising the pipeline and shaft chambers, are classified as 'essential infrastructure' under Annex 3 of the flood risk vulnerability classification within the National Planning Policy Framework³. The catchments of the site are located within the East Hampshire Management Catchment and the time horizon of the project is 2080s. The following climate change allowances for the East Hampshire Management Catchment and for a time horizon of 2080s are given below:

- Central – 37%
- Higher – 51%
- Upper – 88%

As the site is essential infrastructure within Flood Zone 3a, the peak flow 'higher' climate change allowance of 51% has been used to uplift the inflow hydrographs⁴.

The upper allowance of 88% has been used as a sensitivity check as confirmed by the Environment Agency on 2nd May 2023.

³ Environment Agency, 2021. Available online at: <https://www.gov.uk/guidance/national-planning-policy-framework/annex-3-flood-risk-vulnerability-classification>

⁴ Environment Agency, 2022. Available online at: <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>

3 Model inflow updates

The below sections detail the updates made, if any, to the inflow files in the hydraulic model.

3.1 Fluvial

3.1.1 Catchment Inflows

A full hydrological assessment was carried out for the Proposed Development and compiled into the FEH Proforma, found in Appendix A. The findings of the assessment largely resembled those found in the 2020 FRA hydrological assessment and as such, stated there would be no update to the catchment hydrology for this assessment. The 2020 hydrology was used for this assessment, this has been agreed with the Environment Agency.

The following events given as both the return period and the AEP (Annual Exceedance Probability), have been modelled for reporting purposes in line with the 2020 FRA:

- 30-year event - 3.33% AEP
- 100-year event - 1% AEP
- 100-year event plus 51% climate change - 1% AEP + 51% climate change
- 1000-year event - 0.1% AEP

The following events have been modelled for flood mapping purposes:

- 2-year event - 50% AEP
- 5-year event - 20% AEP
- 10-year event - 10% AEP
- 100-year event plus 88% climate change - 1% AEP + 88% climate change

3.1.2 Lavant Link Pipe contribution

Flow is transferred from the Lavant Link Stream to the Hermitage Stream via the Lavant Link Pipe (LLP) when above a threshold thought to be approximately $0.28\text{m}^3/\text{s}$. The Havant Flood Mapping Study⁵ identified that a peak flow of $2.17\text{m}^3/\text{s}$ was transferred in the 0.1% AEP event in response to a peak flow in the Lavant Stream of $6\text{m}^3/\text{s}$. The design capacity of the LLP is $3\text{m}^3/\text{s}$.

No additional information was available to inform this assessment regarding flow contributions from the LLP. Flow contributions from the LLP therefore remain unchanged from the 2020 FRA and are given below:

- LLP100 – Coupled with a 1% AEP event ($2.02\text{m}^3/\text{s}$ peak)
- LLP1000 – Coupled with a 0.1% AEP event ($2.17\text{m}^3/\text{s}$ peak)
- LLPMAX – Coupled with the climate change events – ($3.00\text{m}^3/\text{s}$ constant flow)

⁵ Atkins, Havant Flood Mapping Study, Environment Agency, 2008

3.2 Emergency Discharge Flow

The 2020 FRA proposed Emergency Discharge Condition was modelled in combination with a base flow condition (Q_{10}), as agreed in email with the Environment Agency within the 2020 FRA (8th March 2019). The same approach was agreed for this assessment in consultation between the EA and Sweco (12th January 2023).

The Emergency Discharge Flow is termed 'ED + Q_{10} '.

3.2.1 Base Flow Condition

The Q_{10} flow at the Havant gauging station was $0.57\text{m}^3/\text{s}$ for the year 2019 when used within the 2020 FRA modelling. The Q_{10} flow at the Havant gauging station as of 2023 was $0.56\text{m}^3/\text{s}$ ⁶. For the sake of simplicity and conservatism, the 2020 FRA base flow condition was carried forward into this assessment.

The exceedance flows were apportioned on the basis of catchment area, as in the 2020 FRA, as follows:

- $0.14\text{m}^3/\text{s}$ applied at the upstream extent of Riders Lane Stream
- $0.43\text{m}^3/\text{s}$ applied at the upstream extent of Hermitage Stream

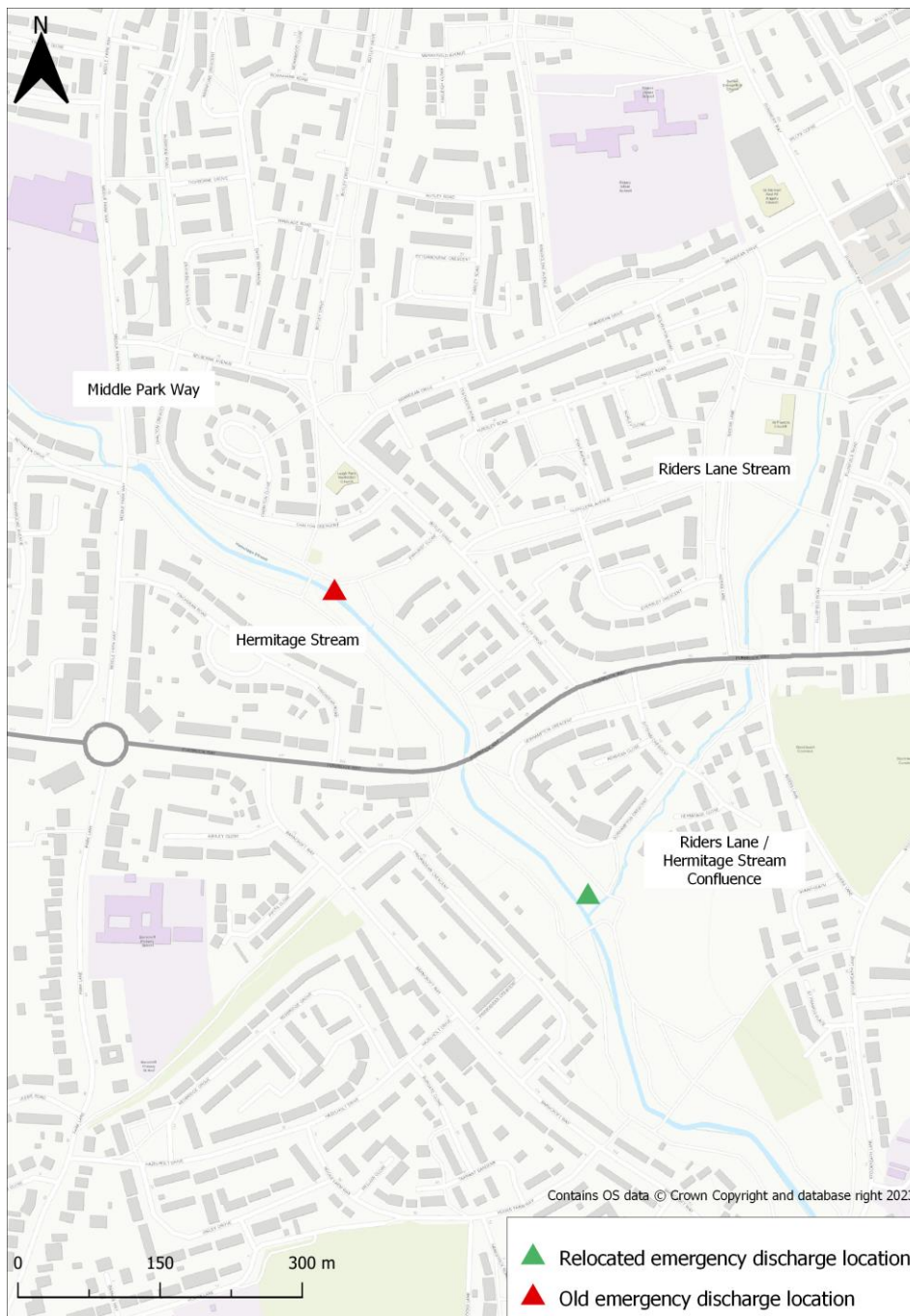
3.2.2 Emergency Discharge Condition

No changes to the reservoir extents or levels have been made since the 2020 FRA. As such, the total emergency discharge rate of $10.9\text{m}^3/\text{s}$ remains unchanged for this assessment. The 2020 FRA modelling split the discharge to allow $7.05\text{m}^3/\text{s}$ to the Riders Lane Stream directly downstream of the reservoir embankment and $3.85\text{m}^3/\text{s}$ to the Hermitage Stream.

Part of this assessment determined the effects of moving the proposed discharge at the Hermitage Stream to the Hermitage Stream and Riders Lane Stream confluence (Figure 3-1).

⁶ Centre for Ecology and Hydrology, 2023. Available online at: <https://nrfa.ceh.ac.uk/data/station/info/42017>

Figure 3-1: Moved emergency discharge location



The total discharge from the reservoir in this assessment has been split to allow:

- 7.05m³/s into the Riders Lane Stream directly downstream of the reservoir embankment.
- 3.85m³/s to Hermitage Stream and Riders Lane Stream confluence.

3.3 Tidal

The design tidal curves for the 2020 FRA have been generated in accordance with guidance provided in the Coastal flood boundary conditions for the UK: update 2018 (CFB18)⁷. The three components of extreme sea level, base astronomical tide curve and surge shape were combined to produce the design tide curves.

The extreme sea level (recorded at the closest point to Langstone Harbour) was taken from the CFB18 dataset for a base year of 2017. The CFB18 dataset was revisited as part of this assessment and found no update to the sea level within the dataset. The CFB18 guidance states the extreme sea level should be combined with a harmonic astronomical tidal curve and uplifted using a surge shape from the CFB18 dataset.

The changes in harmonic astronomical tidal curve between the years 2018 and 2023 is considered negligible. The surge shape used in the 2020 FRA, taken from the CFB18 dataset remains the same. The 2020 FRA noted the tidal influence at Hermitage Stream had negligible impacts to flood extents within the site boundary.

Taking the above into consideration, no changes from the 2020 FRA to tidal levels were made for this assessment. The following tidal boundaries were carried forward to this assessment from the 2020 FRA:

- T2 - 1 in 2-year tidal event
- T1000 + CC - 1 in 1000-year tidal event plus climate change allowance

The 2020 FRA Upper climate change allowance was used in this assessment to compare the tidal flood impacts on the moved discharge.

The T2 was used as the tidal boundary for all fluvial events and the Emergency Discharge Flow.

3.4 Modelled events and scenarios

The baseline scenario was modelled to assess fluvial flood risk and the potential impacts of the Emergency Discharge Flow. The 'Proposed Development' scenario was modelled to compare the fluvial impacts to the baseline scenario to show no increase in flood risk as a result of the development. Any emergency discharge modelling including sensitivity testing was carried out within the Proposed Development scenario. A summary of the modelled events is shown in Table 3-1.

Table 3-1: Modelled events

		Baseline	Proposed Development
Reporting	Fluvial	F30 + T2 + LLP100	F30 + T2 + LLP100
		F100 + T2 + LLP100	F100 + T2 + LLP100
		F100CC (Higher) + T2 + LLPMAX	F100CC (Higher) + T2 + LLPMAX
		F1000 + T2 + LLP1000	F1000 + T2 + LLP1000

⁷ Environment Agency, 2018. Available online at: <https://www.gov.uk/government/publications/coastal-flood-boundary-conditions-for-uk-mainland-and-islands-design-sea-levels>

		Baseline	Proposed Development
	Emergency Discharge	ED + Q10 + T2	ED + Q10 + T2
Sensitivity / Flood Maps	Fluvial		F2 + T2 + LLP100
			F5 + T2 + LLP100
			F10 + T2 + LLP100
			F100CC (Upper) + T2 + LLPMAX
	Emergency Discharge + Fluvial		ED + F2 + T2
			ED + F5 + T2
			ED + F10 + T2
			ED + F30 + T2
			ED + F100 + T2
	Tidal		ED + Q10 + T1000CC
	Roughness		ED + Q10 + T2 + 20% roughness

3.5 Model parameters

A summary of the model simulation parameters is given in Table 3-2. Note, the maximum number of timestep halvings, iterations and iterations after doubling were increased for the Proposed Development scenario to increase stability.

Table 3-2: Model parameters

Simulation Parameters	
Timestep:	1s
Output timestep:	900s
1D/2D calculations:	Link 1D/2D calculations at minor timestep
Max number of timestep halvings:	Baseline- 10 Proposed- 25
Max number of iterations:	Baseline- 10 Proposed- 25
Max number of iterations after doubling:	Baseline- 7 Proposed- 15

4 Baseline Hydraulic Model Build

The 2020 FRA hydraulic model was updated using the most up to date InfoWorks ICM software release (2023.2.0), as per the audit recommendation. The latest release flagged a number of errors that were not flagged in older versions of the software. A total of eight bridge links flagged the following errors:

- *u/s bed is at or above soffit of opening*
- *u/s bed is at or above soffit of opening near left/right ends. Try inserting opening into bridge sections*
- *d/s bed is at or above soffit of opening*
- *d/s bed is at or above soffit of opening near left/right ends. Try inserting opening into bridge sections*

The bridges had been originally built such that the soffit of the opening matched the soffit in the corresponding bridge cross-section. The coordinates of the bridge openings in question were manually reduced by 1mm so no bridge cross-section levels between panels were above the bridge openings. The changes removed the errors.

No further changes were made to the baseline model.

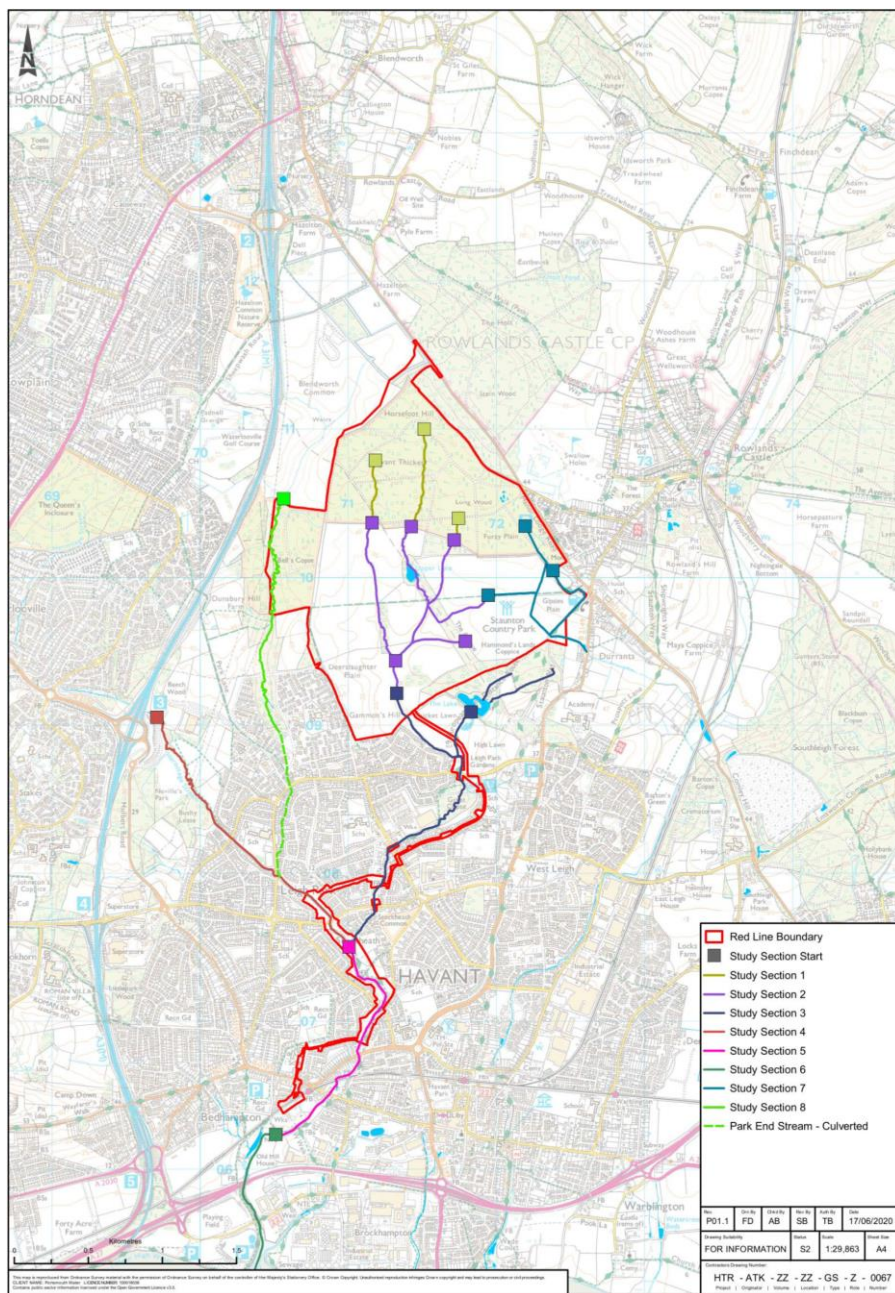
5 Baseline model results

Baseline flood maps are provided for the modelled events (Table 3-1) in Appendix A of the FRA addendum.

5.1 Study sections and reporting locations

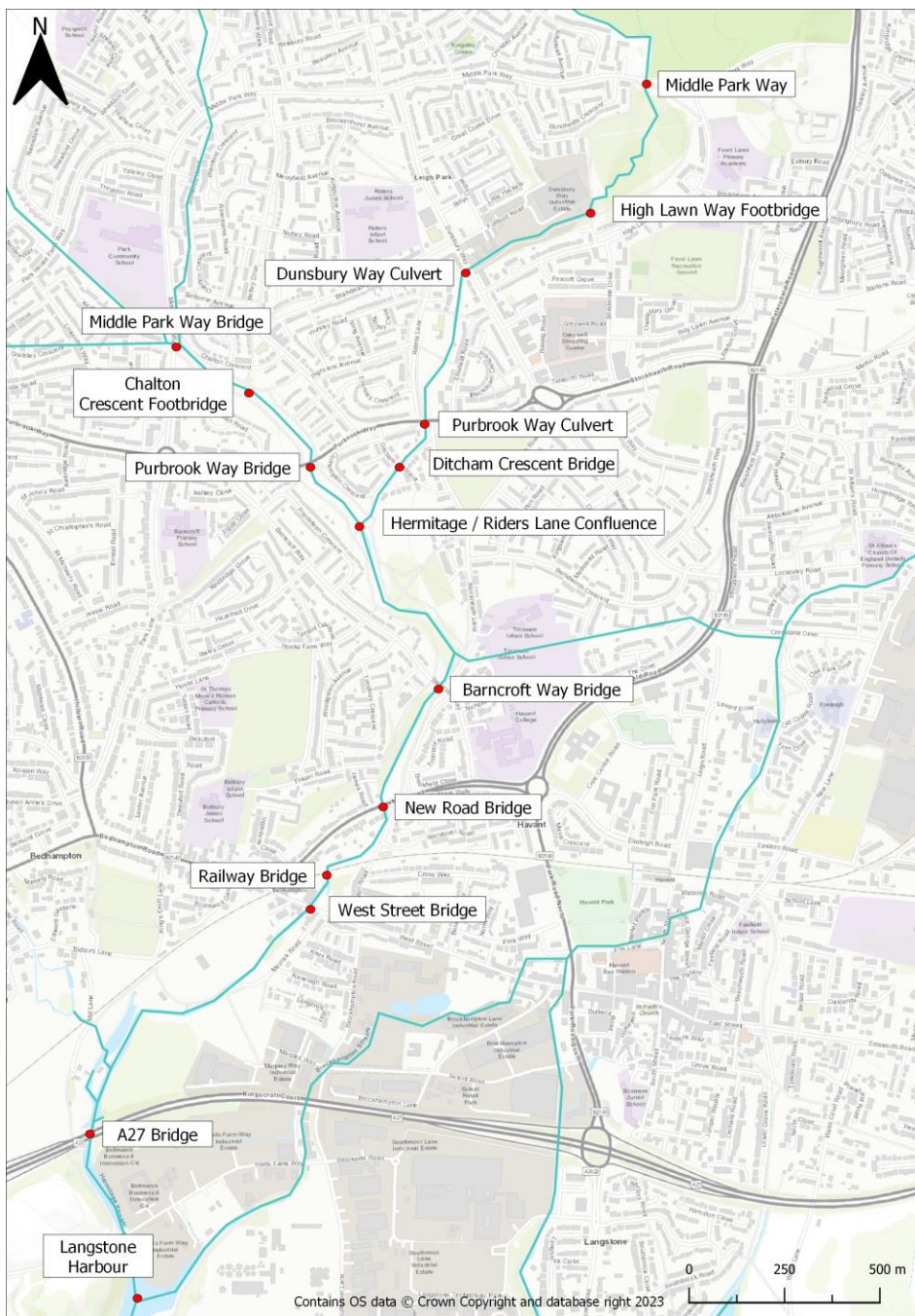
The hydraulic model has been divided up into study sections for analysis of results. The study sections are the same as used in the 2020 FRA for consistency. Only study sections three through to six are used in this assessment. The red line boundary in Figure 5-1 should be ignored, the figure has been taken from the 2020 FRA.

Figure 5-1: Map showing study sections used for analysis



Results reporting locations for the proposed development are provided in Figure 5-2. The figure is taken from the 2020 FRA.

Figure 5-2: Reporting locations for the Proposed Development



5.2 Fluvial events

Study section 3 through to 6 were used to compare the impact on the 1% AEP event when updating the bridge links. Table 5-1 shows a comparison of the 2020 FRA results and results from this assessment.

Table 5-1: Impact of updating bridge links on results for the 1% AEP event

Study section	Assessment	u/s peak level (mAOD)	d/s peak level (mAOD)	u/s peak flow (m ³ /s)	d/s peak flow (m ³ /s)
Study section 3	2020 FRA	20.86	8.06	3.84	6.62
	2024 Assessment	20.86	8.07	3.84	6.62
Study section 4	2020 FRA	10.10	8.06	14.53	16.68
	2024 Assessment	10.10	8.07	14.53	16.68
Study section 5	2020 FRA	8.06	3.04	23.26	22.70
	2024 Assessment	8.07	3.04	23.28	22.53
Study section 6	2020 FRA	3.04	2.72	22.70	29.91
	2024 Assessment	3.04	2.72	22.54	29.79

The results in the baseline scenario produced negligible differences compared to the 2020 FRA baseline results. Any observed changes are attributed to a combination of updating the model to the latest software release, the changes described in Section 1 and rounding to two decimal places when reporting.

Considering the above, the baseline 2020 FRA results are considered comparable to the baseline results produced in this assessment. Flood maps for the modelled events can be found in Appendix A of the FRA addendum.

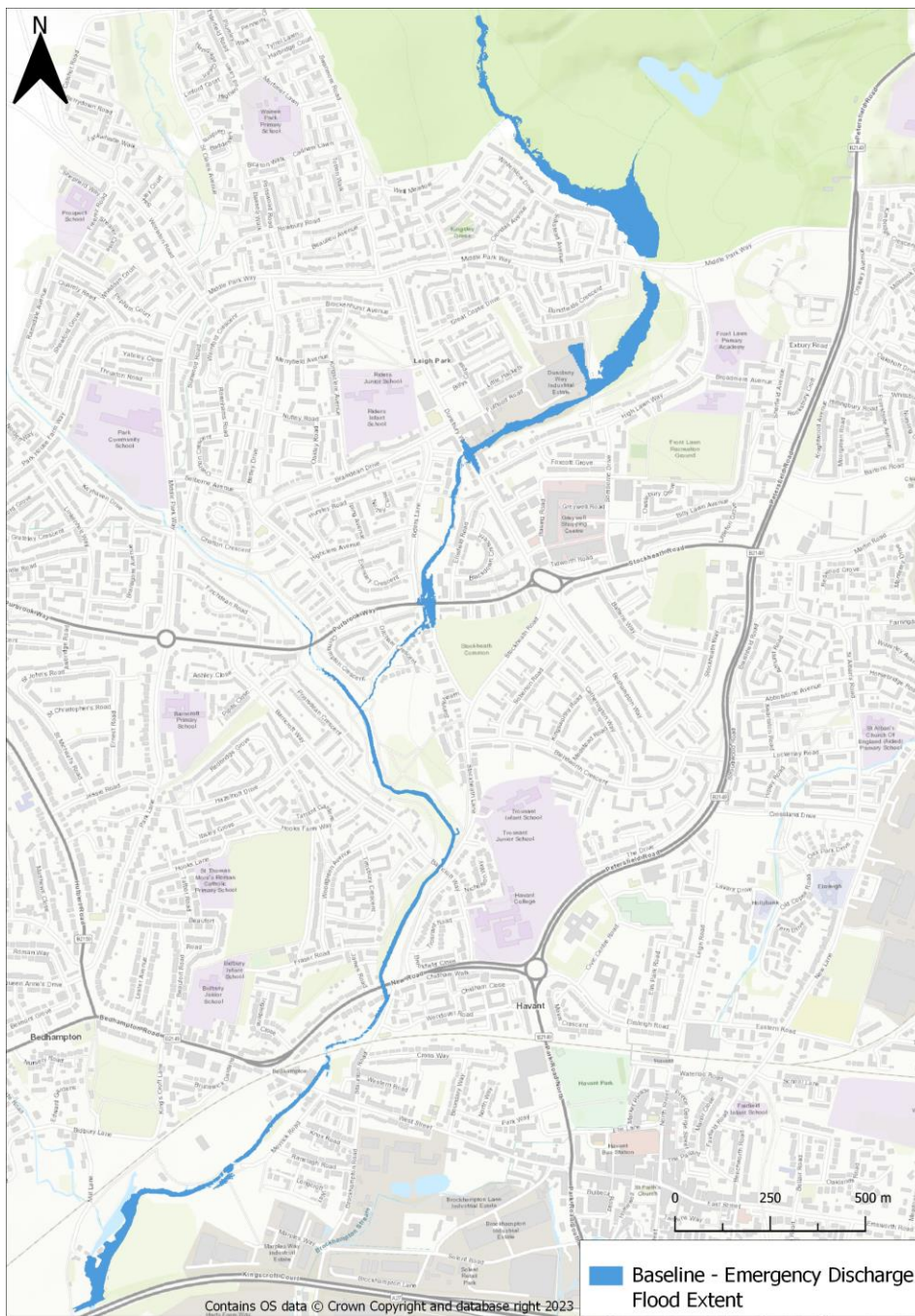
5.3 Emergency Discharge Flow

The hydraulic model indicated that the Emergency Discharge Flow under baseline conditions resulted in:

- one property upstream of Middle Park Way culvert being at risk of flooding,
- minor flooding to one industrial unit
- minor flooding to 2-3 gardens / outbuildings
- inundation of Dunsbury Way road / bridge and
- inundation of Purbrook Way road / bridge.

The baseline Emergency Discharge Flow extent is shown in Figure 5-3.

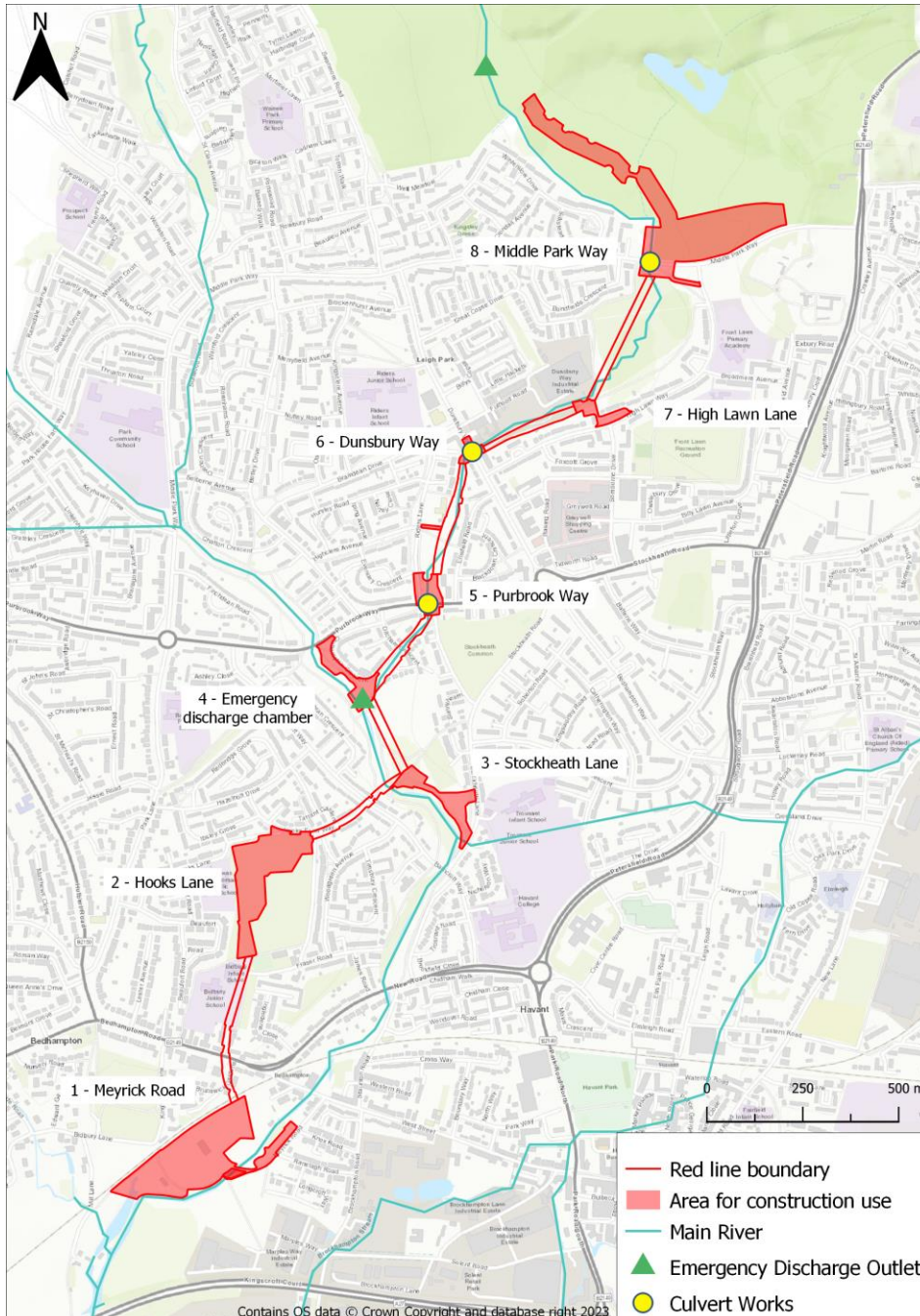
Figure 5-3: Baseline Emergency Discharge Flow extent



6 Proposed Development model build

The Proposed Development extents, including designated construction areas for the emergency discharge and pipeline shafts, are shown in Figure 6-1.

Figure 6-1: Proposed Development



The Proposed Development scenario assessed the flood impacts of the reservoir and pipeline infrastructure. This assessment assumed that no changes to the reservoir levels or extents have been made since the 2020 FRA. Furthermore, detailed design of the Havant Thicket Reservoir falls under a

separate contract of works and any matters pertaining to the reservoir do not form part of this assessment.

The Emergency Discharge Flow caused out of bank flooding at a number of locations, as reported in Section 5.3. The 2020 FRA made alterations to three culverts as to not increase flood risk to the Riders Lane and Hermitage Streams. This assessment modelled the same culvert upgrades to assess their suitability with respect to the relocated discharge (Table 6-1).

Table 6-1: Alterations to existing culverts

Location	Existing configuration	Proposed configuration
Middle Way Park	1 x 1540 mm circular concrete culvert	1 x 1540mm + 1 x 1200 mm circular culverts
Dunsbury Way	1 x 1450mm circular culvert	1 x 1450mm + 1 x 1200 mm circular culverts
Purbrook Way	3 x 900mm circular culvert	5 x 900mm circular culvert

Flood risk implications due to the construction of Shaft 6 were modelled within the hydraulic model. The installation of sheet piling to protect the shaft will result in a reduction in channel width by up to 50%. The width of the 1D cross-sections in the area of the sheet piles were reduced by 50% within the model. The impingement was modelled for the full width of the circular sheet piling array that resulted in a channel reduction for a reach length of 9m.

A conservative approach was taken to capture the construction flood risk implications. Construction flood risk impacts were modelled for the 1% AEP plus 51% climate change event within the baseline scenario. This assumed construction of the shafts would take place before any culvert upgrade works and reservoir construction, resulting in a worst case.

Sensitivity tests were carried out to assess how the emergency discharge condition interacts with:

- high flow fluvial events,
- the tidal boundary,
- a 20% uplift in model roughness.

These sensitivity tests reflected those used in the 2020 FRA.

Changes were made to the model inflows to represent the fluvial and ED interaction. The same tidal inflow of 0.1% AEP plus the upper allowance of climate change used in the 2020 FRA was used to draw comparison to results. Roughness values were uplifted by 20% in the hydraulic model for channels, floodplain, bridges and culverts. An uplift to head loss coefficients were made in the 2020 FRA modelling, however the results indicated no significant increase in water level from the baseline. As such no head loss sensitivity modelling was carried out in this report.

7 Proposed Development results

Proposed Development flood maps are provided for the modelled events in Appendix A of the FRA addendum.

7.1 Fluvial

Construction of the reservoir and alterations to the existing culverts reduced the fluvial flood risk to the development area. Increasing the culvert capacities passed flow downstream and reduced out of bank flooding compared to the baseline scenario. Table 7-1 compares the flood extents for the 1% AEP event between the baseline and Proposed Development scenarios.

Figure 7-1: Comparison of baseline and Proposed Development flood extents for the 1% AEP event

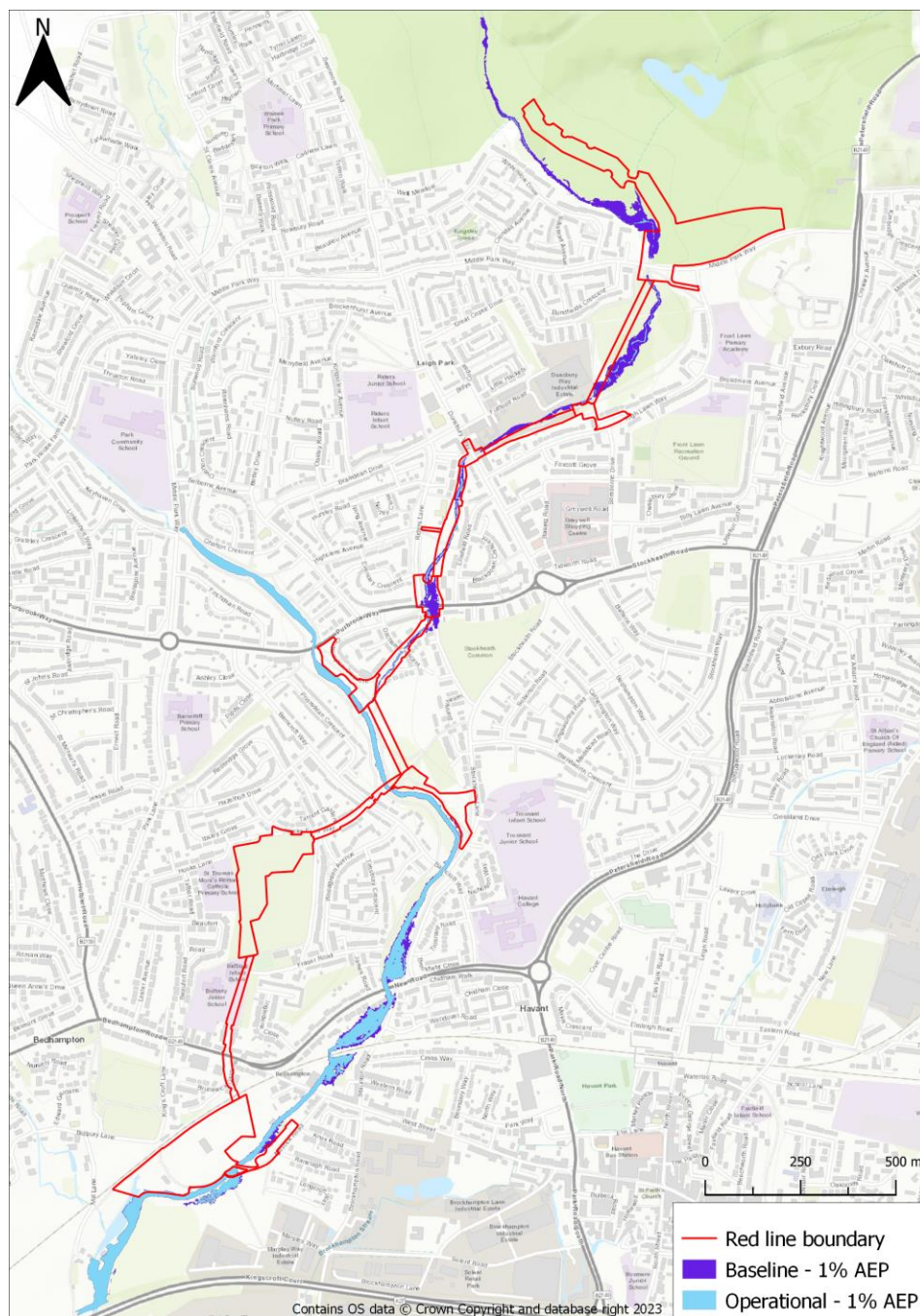


Table 7-1 compares the ‘with Scheme’ results of the 2020 FRA with the Proposed Development results in this assessment. The Study Sections are taken from Figure 5-1.

Table 7-1: Comparison of ‘with Scheme’ and Proposed Development results

Study section	Assessment	u/s peak level (mAOD)	d/s peak level (mAOD)	u/s peak flow (m ³ /s)	d/s peak flow (m ³ /s)
Study section 3	2020 FRA	20.22	7.91	0.20	3.25

Study section	Assessment	u/s peak level (mAOD)	d/s peak level (mAOD)	u/s peak flow (m³/s)	d/s peak flow (m³/s)
	2024 Assessment	20.23	7.90	0.20	3.25
Study section 4	2020 FRA	10.10	7.90	14.53	16.68
	2024 Assessment	10.10	7.90	14.53	16.68
Study section 5	2020 FRA	7.90	2.97	19.76	19.50
	2024 Assessment	7.90	2.97	19.76	19.11
Study section 6	2020 FRA	2.97	2.72	19.50	27.13
	2024 Assessment	2.97	2.72	19.11	26.29

The results in the Proposed Development scenario produced negligible differences compared to the 2020 FRA 'With Scheme' results. These are attributed to a combination of updating the model to the latest software release, the changes made in Section 1 and rounding to two decimal places when reporting. The results in this assessment showed changes in peak level of no more than 10mm compared to the 2020 FRA results. The largest difference in peak level occurred at the downstream extent of the model.

7.2 Emergency Discharge Flow

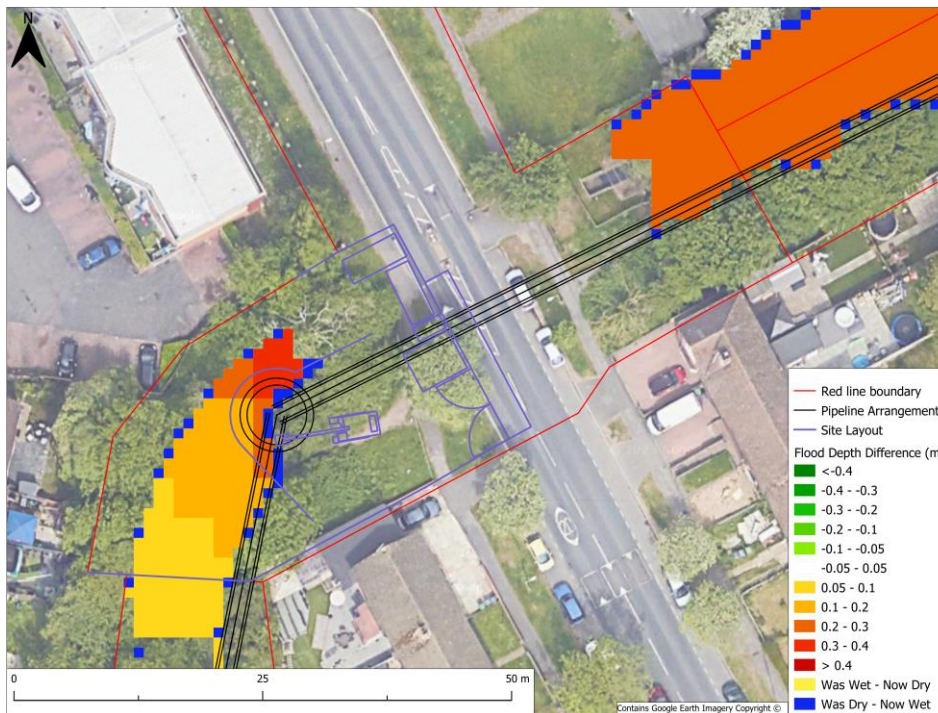
The Emergency Discharge Flow results showed no residential properties / dwellings being at risk of flooding, however, a small number of gardens / outbuildings (2-3) and one industrial unit are within the modelled extent, showing depths between 0.1m-0.2m. The current strategy meets the requirement set by the Local Planning Authority (LPA) of causing no flooding to residential properties.

7.3 Construction flood risk

Construction of Shaft 6 is predicted to cause localised increases in flood depths. The greatest increase in depths are predicted to occur immediately downstream of Dunsbury Way culvert by up to 300mm (Figure 7-2). Critically, construction of Shaft 6 is predicted to result in no increase in flood risk to receptors.

The location of depth changes in Figure 7-2 relative to the location of the sheet piling are indicative. In reality no flooding is predicted within the extents of the sheet piles. The reasons for flood depths shown within the sheet piles are due to differences in the representation of the 1D/2D channel boundary within the model and the proposed pipeline drawing.

Figure 7-2: Construction flood risk



7.4 Sensitivity

7.4.1 Estimated onset of flooding

As advised by the Environment Agency, the Emergency Discharge Condition should be paired with a Q_{10} flow and 50% AP downstream tidal condition. With these conditions, the FRA demonstrates that emergency drawdown can be safely achieved, causing no inundation to residential property.

It is important to understand, however, the fluvial events which, when paired with the Emergency Discharge Condition, causes inundation to residential property.

The model results show that for the Riders Lane Stream, the 50% AEP event would cause minor inundation of one residential property, and for the Hermitage Stream, the onset of flooding is the 20% AEP, with up to three residential properties also potentially affected. The flood extents of the emergency discharge paired with fluvial events are shown in Appendix B.

7.4.2 Tidal boundary interaction

The Emergency Discharge Flow was paired with the 0.1% AEP tidal condition plus an allowance for climate change. The same extreme event was modelled in the 2020 FRA. In this scenario, there is no additional flood risk compared to the extreme tidal event modelled in the 2020 FRA.

Moving the discharge to the confluence of the Hermitage and Riders Lane Streams has not increased flood risk when paired with an extreme tidal boundary.

7.4.3 Model roughness

Table 7-2 gives the predicted levels for the 1% AEP event at various key locations with the outputs of the roughness sensitivity testing also included.

Table 7-2: Emergency Discharge Flow and roughness sensitivity testing

Location	Water Level (mOD)	
	Emergency Discharge Flow	
	Base	Sensitivity Manning's Roughness + 20%
Riders Lane Stream		
Middle Park Way (u/s)	16.21	17.41
High Lawn Way Footbridge (u/s)	15.46	15.57
Dunsbury Way (u/s)	13.17	14.72
Riders Lane Footbridge (u/s)	12.25	12.28
Purbrook Way (u/s)	10.25	10.56
Ditcham Crescent (u/s)	9.10	9.23
Hermitage Stream		
Chalton Crescent Footbridge (u/s)	8.48	8.50
Purbrook Way (u/s)	7.70	7.72
Barncroft Way (u/s)	6.48	6.60
New Road Bridge (u/s)	6.23	6.32
Railway Bridge (u/s)	6.01	6.10
West Street Bridge (u/s)	5.67	5.76
Meyrick Road Bridge (u/s)	5.11	5.13
Langstone Harbour	2.72	2.72

With increased roughness there is the potential for:

- Shallow flooding up to 0.2m of one property upstream of Middle Park Way;
- Inundation of Dunsbury Way up to 0.4m;
- Increased inundation depths of Purbrook Way and Riders Lane up to 0.5m;
- Flooding of an additional three properties downstream of Purbrook Way culvert up to 0.2m.

The flood extent of the plus 20% roughness sensitivity scenario is shown in Appendix B. Minor changes are predicted in the flood extents of the 20% roughness uplift scenario compared to the same scenario in the 2020 FRA.

8 Conclusions

The following conclusions have been made:

- The 2020 FRA hydraulic model has been updated to the latest InfoWorks ICM software (v2023.2.0) release and minor changes made to structures.
- The 2020 FRA baseline model results were compared to the baseline results in this assessment and shown to have comparable flood extents and in channel levels and flows.
- The Emergency Discharge Flow was tested under the baseline condition. The results predicted flooding to one residential property, one industrial unit, up to three gardens or outbuildings and the inundation of two roads.
- The same culvert upgrades were used as in the 2020 FRA which formed the Proposed Development scenario.
- The impact of shaft construction was assessed and is predicted to cause a slight increase in localised flood risk. Critically, construction works are predicted to result in no increase in flood risk to receptors.
- The 2020 FRA 'With Scheme' model results were compared to the Proposed Development results from this assessment and shown to have comparable in channel levels and flows.
- The Emergency Discharge Flow showed no residential properties/dwellings to be at risk of flooding. Minor external inundation is indicated for the industrial unit near High Lawn Way. The current emergency drawdown strategy meets the requirements set by the LPA of causing no flooding to residential properties.
- The hydrological assessment and hydraulic model were accepted by the Environment Agency on 18th July 2023.

Annex A – FEH Hydrology Proforma

Flood Estimation Report Template

Template: LIT 65087

Published: 29/12/2022

Audience: Environment Agency

Description: This report template is a supporting document to the Environment Agency's Flood Estimation Guidelines (LIT 11832). It provides a record of the hydrological context, the method statement, the calculations, the decisions made, and the results of flood estimation. This document can be used for one site or multiple sites.

Guidance notes to help you complete this template are available separately.

Contents

Contents	1
Approval	3
Abbreviations.....	4
1. Summary of assessment.....	5
1.1 Summary.....	5
1.2 Flood frequencies.....	6
2. Method Statement	7
2.1 Requirements for flood estimates.....	7
2.2 The Catchment.....	7
2.3 Hydrometric Data.....	8
2.4 Hydrological understanding of the catchment.....	11
2.5 Initial choice of approach.....	13
3. Locations where flood estimates are required	14
3.1 Summary of subject sites	14
3.2 Catchment Descriptors	14
4. Stationary statistical methods.....	16
4.1 Method overview	16
4.2 Estimating QMED	16
4.3 Estimating growth curves	18
4.4 Final choice of QMED and growth curves	21
5. Revitalised flood hydrograph 2 (ReFH2.3) method	23

5.1 Method Overview.....	23
5.2 Model Parameters	23
5.3 Model inputs for design events	24
5.4 Final choice of ReFH2.3 flow estimates	24
6. Discussion and summary of results.....	25
6.1 Comparison of results from different methods	25
6.2 Final choice of method	25
6.3 Final results	26
6.4 Checks	27
Return period estimates:	27
6.5 Assumptions, limitations, and uncertainty.....	28

Approval

Revision stage	Analyst:	Approved by:	Amendments	Date
Method statement	J Pickering	R.Vivian	DRAFT	07/03/2023
Calculations - Revision 1	J Pickering	R.Vivian	1st EA Review	08/03/2023
Calculations - Revision 2	R Vivian	J.Pickering	2nd EA Review	22/05/2023
Calculations - Revision 3	R Vivian	J.Pickering	FINAL	17/08/2023

Abbreviations

Abbreviation	Short for
AEP	annual exceedance probability
AMAX	Annual Maximum
AREA	Catchment area (km ²)
BFI	Base Flow Index
BFIHOST19	Base Flow Index derived using the HOST soil classification, revised in 2019
FARL	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
GEV	Generalised Extreme Value
GLO	Generalised Logistic
HOST	Hydrology of Soil Types
IF	Impervious Fraction
IRF	Impervious Runoff Factor
LF	Low flow statistics (flow duration curve)
NRFA	National River Flow Archive
POT	Peaks Over a Threshold
QMED	Median Annual Flood (with return period 2 years)
ReFH	Revitalised Flood Hydrograph method
ReFH2	Revitalised Flood Hydrograph 2 method
SAAR	Standard Average Annual Rainfall (mm)
Tp	Time to peak of the instantaneous unit hydrograph
URBAN	Flood Studies Report index of fractional urban extent
URBEXT1990	FEH index of fractional urban extent
URBEXT2000	Revised index of urban extent, measured differently from URBEXT1990
WINFAP	Windows Frequency Analysis Package (software that can be used for FEH statistical method)

1. Summary of assessment

1.1 Summary

Catchment location:

Hemitage Stream at Havant (NRFA Gauge 42017) full catchment upstream of the gauge.

Purpose of study and complexity:

An original hydrology assessment was completed to inform the Havant Reservoir Project. This included Enhanced Single Site Analysis at gauge 42017, as well as pooled and ReFH2.3 analysis. As agreed with the EA as part of the update to the hydraulic modelling of the Emergency Discharge, a high level assessment of hydrology at the gauge should be completed to ensure no significant changes in gauged data which might impact the hydrological assessment.

This study follows the methodology outlined in the 2020 study by comparing the FEH Statistical peaks to the hydraulic model routed ReFH2.3 flows. ReFH2.3 will be used for deriving inflow hydrographs for the model.

Key catchment features:

Impermeable, urban, no storage, small area.

Flooding mechanisms:

Likely to be both fluvial and surface water considering the low permeability.

Gauged / ungauged:

Catchment is gauged to QMED only. There is uncertainty in using the gauge to extrapolate to high flows.

Final choice of method:

Propose REFH2.3 flows remain unchanged following a pooled assessment which confirms urbanised FEH Statistical and ReFH2.3 estimates are in agreement with similar peak flows.

Key limitations / uncertainties in results:

There is uncertainty in using the gauge to extrapolate to high flows. The gauged data includes contributions from the neighbouring Lavant catchment during high

flow events. The ReFH2.3 method does not account for the inflow from the Lavant and this will be applied within the model.

1.2 Flood frequencies

- The frequency of a flood can be quoted in terms of a return period, which is defined as the average time between years with at least one larger flood, or as an annual exceedance probability (AEP), which is the inverse of the return period.
- Return periods are output by the Flood Estimation Handbook (FEH) software and can be expressed more succinctly than AEP. However, AEP can be helpful when presenting results to members of the public who may associate the concept of return period with a regular occurrence rather than an average recurrence interval.
- Results tables in this document contain both return period and AEP titles; both rows can be retained, or the relevant row can be retained and the other removed, depending on the requirement of the study.
- The table below is provided to enable quick conversion between return periods and annual exceedance probabilities.

AEP (%)	50	20	10	5	3.33	2	1.33	1	0.5	0.1
AEP	0.5	0.2	0.1	0.05	0.033	0.02	0.013	0.01	0.005	0.001
Return period (yrs)	2	5	10	20	30	50	75	100	200	1,000

2. Method Statement

2.1 Requirements for flood estimates

Overview and Project Scope:

The purpose of this exercise is to repeat an enhanced single site analysis of flood peaks at the 42017 gauge so that any change in peak flow could be considered against the ReFH2.3 peak flows used in the previous EA approved assessment.

2.2 The Catchment

Maps:

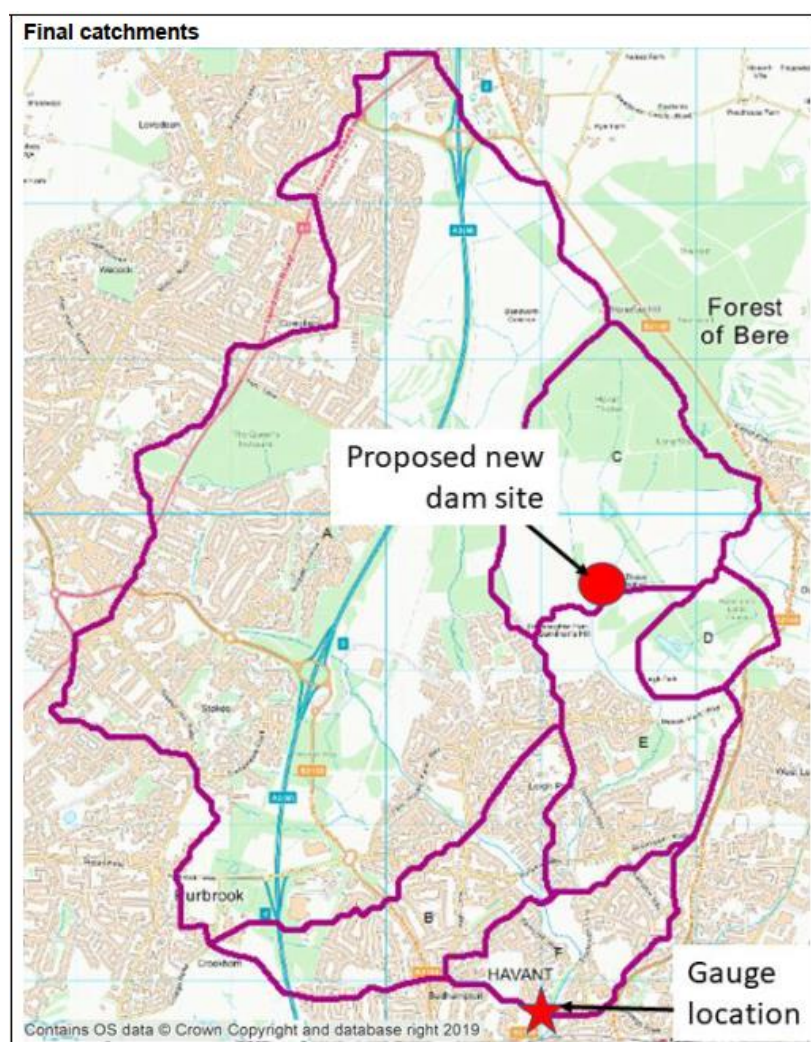


Figure 1 - Hydrological catchment. Figure taken from 2020 FRA. Note gauge location (42017)

Catchment Description:

The Hermitage Stream drains a total catchment of just over 17 km² (Figure 1). The catchment is mainly impervious and is underlain by Reading Beds and London Clay. Intensive suburban development has occurred since the early 1960s, and the lower catchment is now heavily urbanised.

The catchment has a flashy and responsive regime. There is a flood relief culvert which transfers flow from the River Lavant catchment, which is to the east; flow is diverted via a pipe into the Hermitage Stream when the flow in the River Lavant exceeds 0.28 m³/s.

2.3 Hydrometric Data

Source of flood peak data:

NRFA peak flows dataset version 11.1

Gauging stations (flow and level):

Watercourse	Station name	Gauging authority number	NRFA number	Catchment area (km ²)	Type (rated / ultrasonic / level...)	Start of record and end if station closed
Hermtiage Stream	Havant	42017	42017	17.33	Velocity-Area	1953 - present

Data available at each flow gauging station:

Station name	Data source	Data type	Start and end of flood peak record	Update for this study?	OK for QMED ?	OK for pooling?	Data quality check needed ?	Station and flow data quality summary
Hermtiage Stream	NRFA	Peak Flows	1953 - present	No	Yes	No	Yes	Gauged above QMED. Some scatter in gaugings evident.

Updates or revisions to flood peak data:

2020 assessment used NRFA peak flow dataset Version 8. This has been updated to version NRFA Version 11.1 for this assessment. A key change between the 2020 study and this assessment is the change in available years of data for the Hermitage Stream @ Havant catchment. The Available years of data has reduced from 52 to 37 between the two NRFA datasets.

Data quality checks carried out:

A detailed rating review was beyond the scope of this study given the review carried out for the 2020 assessment. The data from the gauge has been considered suitable for use in this study.

Rating Equations:

Station name	Type of rating e.g., theoretical, empirical; degree of extrapolation	Rating review needed?	Comments and link to any rating reviews
42017	Extrapolation	No	No rating review undertaken

A plot of the rating from the NRFA is below.

Rating reviews:

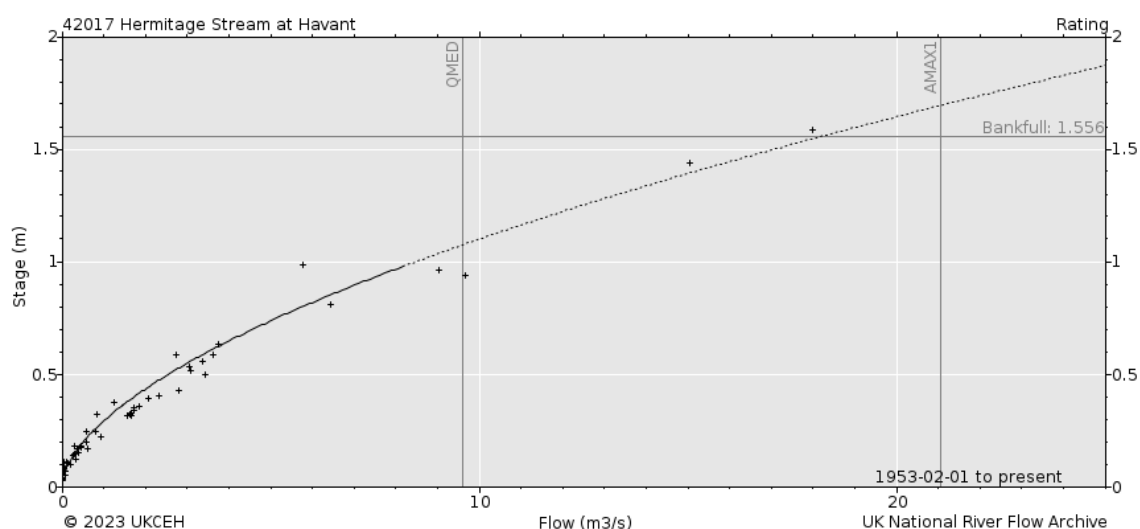


Figure 2 - Ratings Curve 42017

Other data available and how it has been obtained:

Type of data	Data relevant to this study?	Data available?	Source of data	Details
Check flow gaugings	No			
Historical flood data	No			
Flow or river level data for events	No			
Rainfall data for events	No			
Potential evaporation data	No			
Results from previous studies	Yes	Yes	2020 original study and hydrology report	A hydrological assessment was completed for the Havant Thicket Reservoir project in 2020 by Atkins
Other data or information	N/A			

Conclusions of hydrometric data review:

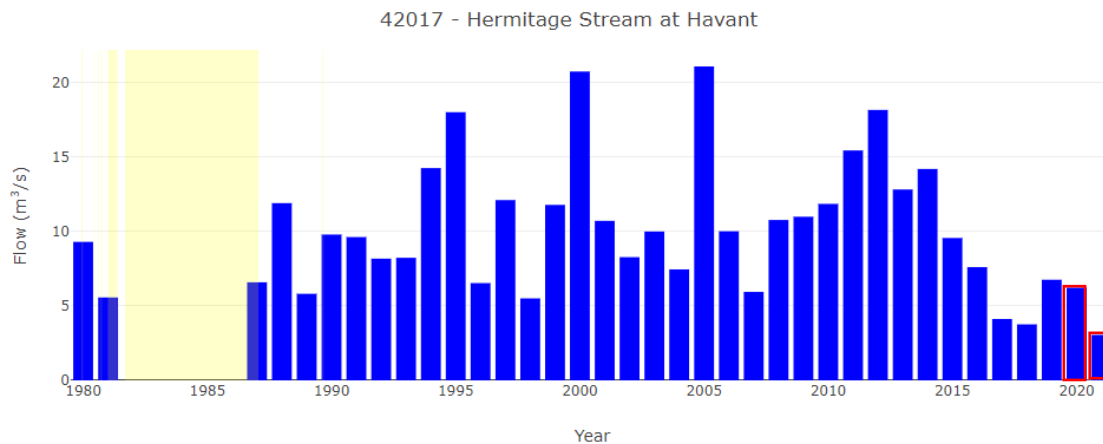
Station name	Rating suitability	Suitability for flood estimation calculations	Non-stationary analysis requirements
42017	Unsuitable	Unsuitable	Unsuitable

2.4 Hydrological understanding of the catchment

Plots of flood peak data and interpretation:

Table 1 - 42017 AMAX Data - note the majority of ratings are extrapolation.

Rank	Water Year	Date	Time	Stage (m)	Flow (m ³ /s)	Rating	Source	Ref
21	1979-1980	27/12/1979	23:00	1.054	9.291	Extrap.	Digital Archive	20462
33	1980-1981	25/05/1981	09:15	0.783	5.561	In Range	Digital Archive	20462
	1981-1982							
	1982-1983							
	1983-1984							
	1984-1985							
	1985-1986							
28	1986-1987	22/08/1987	03:45	0.863	6.579	In Range	Digital Archive	20462
10	1987-1988	09/10/1987	17:15	1.216	11.891	Extrap.	Digital Archive	20462
32	1988-1989	09/10/1988	06:30	0.803	5.808	In Range	Digital Archive	20462
18	1989-1990	03/02/1990	12:15	1.086	9.783	Extrap.	Digital Archive	20462
19	1990-1991	23/06/1991	16:30	1.075	9.613	Extrap.	Digital Archive	20462
24	1991-1992	20/07/1992	18:45	0.978	8.165	In Range	Digital Archive	20462
23	1992-1993	01/04/1993	11:15	0.982	8.223	Extrap.	Digital Archive	20462
6	1993-1994	12/10/1993	21:30	1.35	14.241	Extrap.	Digital Archive	20462
4	1994-1995	14/09/1995	22:15	1.546	17.991	Extrap.	Digital Archive	20462
29	1995-1996	12/02/1996	04:45	0.859	6.526	In Range	Digital Archive	20462
9	1996-1997	04/07/1997	12:30	1.228	12.094	Extrap.	Digital Archive	20462
34	1997-1998	18/01/1998	09:15	0.778	5.499	In Range	Digital Archive	20462
12	1998-1999	22/09/1999	14:45	1.209	11.773	Extrap.	Digital Archive	20462
2	1999-2000	15/09/2000	12:45	1.678	20.72	Extrap.	Digital Archive	20462
15	2000-2001	31/12/2000	22:45	1.144	10.702	Extrap.	Digital Archive	20462
22	2001-2002	09/09/2002	16:15	0.985	8.266	Extrap.	Digital Archive	20462
17	2002-2003	21/01/2003	21:15	1.099	9.986	Extrap.	Digital Archive	20462
26	2003-2004	24/08/2004	14:00	0.927	7.444	In Range	Digital Archive	20462
1	2004-2005	19/08/2005	05:30	1.694	21.061	Extrap.	Digital Archive	20462
16	2005-2006	30/09/2006	04:30	1.1	10.002	Extrap.	Digital Archive	20462
31	2006-2007	06/10/2006	12:15	0.813	5.934	In Range	Digital Archive	20462
14	2007-2008	26/05/2008	06:30	1.147	10.759	Extrap.	Digital Archive	20462
13	2008-2009	09/02/2009	19:15	1.161	10.978	Extrap.	Digital Archive	20462
11	2009-2010	23/08/2010	00:15	1.213	11.84	Extrap.	Digital Archive	20462
5	2010-2011	02/10/2010	22:30	1.414	15.425	Extrap.	Digital Archive	20462
3	2011-2012	11/06/2012	12:15	1.554	18.143	Extrap.	Digital Archive	20462
8	2012-2013	20/12/2012	03:30	1.269	12.807	Extrap.	Digital Archive	20462
7	2013-2014	24/12/2013	03:00	1.347	14.183	Extrap.	Digital Archive	20462
20	2014-2015	08/01/2015	08:45	1.071	9.551	Extrap.	Digital Archive	20462
25	2015-2016	22/06/2016	22:00	0.938	7.597	In Range	Digital Archive	20462
35	2016-2017	12/01/2017	17:30	0.658	4.117	In Range	Digital Archive	20462
36	2017-2018	15/01/2018	11:15	0.624	3.755	In Range	Digital Archive	20462
27	2018-2019	15/12/2018	18:45	0.876	6.751	In Range	Digital Archive	20462
30	2019-2020	05/03/2020	16:15	0.836	6.227	In Range	Digital Archive	20462
37	2020-2021	15/11/2020	10:30	0.554	3.056	In Range	Digital Archive	20462



Yellow shading indicates periods of missing data. Pink shading represents periods of unrepresentative data.

Figure 3: Amax data from the gauge.

Note the additional two years of data since the 2020 study highlighted in red. The additional two years since the 2020 study are given below:

2019-2020: 6.227m³/s

2020-2021: 3.056 m³/s

The additional two years of data have largely insignificant flows compared to the complete AMAX series.

There is some augmentation of high flows by runoff from the adjacent catchment of the Lavant Stream. Flow is diverted via the Lavant Link Pipe (LLP) into the Hermitage Stream, whenever the flow in the Lavant exceeds 0.28 m³/s. The gauged AMAX series is therefore not a natural reflection of the catchment AMAX series and are likely over-estimated. Contributions from the LLP were investigated as part of the 2020 assessment. These contributions are fixed for this analysis. Contributions from the LLP are applied separately within the hydraulic model.

Conceptual model:

The main site of interest is around the confluence of the Hermitage Stream and the Rider's Lane Stream. Close to this point will be a proposed emergency discharge from the proposed reservoir. The flow estimate at the gauge site is of importance as the flow within the hydraulic model has been compared with that of the gauged Qmed and growth factors for the gauge itself. Therefore, the estimates at the gauge are of paramount importance if using them to base the accuracy of the hydraulic model from.

Unusual catchment features:

Flows thought to be above 0.28 m³/s in the Lavant Stream are transferred into the Hermitage Stream via the Lavant Link Pipe. The maximum flow transfer (design capacity) of the Lavant Link Pipe is 3 m³/s. Contributing flows from the LLP are accounted for within the model.

2.5 Initial choice of approach**Are FEH methods appropriate?**

Yes

Initial choice of method(s) and reasons:

Initial choice was to replicate the enhance single site (ESS) analysis to ensure the most recent two AMAX flows included within the NRFA dataset are used in the statistical analysis. To then compare the Qmed and growth curve fittings to the updated ESS and consider if any scaling of the original hydrographs is necessary.

How will hydrograph shapes be derived if needed?

Hydrograph shapes will be derived using ReFH2.3

Will the catchment be split into sub-catchments? If so, how?

This assessment focuses solely on the estimation point at the gauge. The results of which will determine if further hydrological assessment is required to re-establish estimates for each of the smaller subcatchments represented in the original assessment.

Software to be used:

WINFAP v5 and ReFH2.3

3. Locations where flood estimates are required

3.1 Summary of subject sites

Site code	Type of estimate: lumped (L) or sub-catchment (S)	Water-course	Site name / description	Easting	Northing	AREA on FEH Web Service (km ²)	Revised AREA (if altered) (km ²)
42017	Lumped	Hermitage Stream	Havant gauge	471050	106800	17.33	17.14

3.2 Catchment Descriptors

Final catchment descriptors at each subject site:

Site code	FARL	PROPWET	BFIHOST19	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	URBEXT 1990	URBEXT 2000	FPEXT
42017	0.991	0.34	0.273	4.04	32.7	785	0.1675	0.2376	0.0749

Catchment boundary checks and revisions:

Area has been updated from 17.33 km² to 17.14 km² to match the original assessment for the purposes of comparison of peak estimates.

URBEXT source and method for updating:

Urbext2000 has been updated using the OS Mastermap estimate noted in the 2020 original report. A check on land use change within the catchment was made between the 2020 assessment and present day. No significant changes and therefore no need to update.

BFIHOST source, checks and updates:

BFIHOST19 used. No change from 2020 hydrological assessment to ensure comparison is accurate.

Checks and revisions to other catchment descriptors:

No other changes made to catchment descriptors. The estimate is at the gauged site. The 2020 assessment used Qmed from the gauge and therefore did not update catchment descriptors. Given small change in area, there would be very little impact to DPLbar. BFIHOST19 and SAAR are considered accurate, with very limited storage in the catchment FARL is not required to be updated.

4. Stationary statistical methods

4.1 Method overview

What is the purpose of applying these methods?

A lumped estimate is required at the flow gauge location to compare the peak flow estimates from FEH Statistical Methods against the gauged Qmed, and to check for any changes since the 2020 assessment was completed.

What methods will be used to estimate QMED and growth curves?

FEH Statistical, Single Site, Enhanced Single Site and Pooled analysis will be completed where appropriate to allow direct comparisons with the 2020 assessment.

Site code	Methods used for QMED	Methods used for growth curves
42017	QMED estimated from gauge.	Pooled analysis

4.2 Estimating QMED

QMED at gauged subject sites:

Site code	Method (AM/POT/LF)	Initial QMED (m ³ /s)	Number of water years of data used	Adjustment for climatic variation?	Final QMED (m ³ /s)
42017	AM	9.61	37		9.61

The gauge is considered suitable for estimation of QMED.

Methods: AM – Annual maxima; POT – Peaks over threshold; LF – Low flow (flow duration curve) statistics.

Urban adjustment of QMED:

No adjustment for urban as the observed QMED at the gauge is used.

Search for donor sites:

No donor adjustment used as the QMED from the gauge is used.

Donor sites chosen and QMED adjustment factors:

Not applicable.

4.3 Estimating growth curves

Derivation of growth curves at subject sites:

Site code	Method (SS, P, ESS, H.)	If P or ESS, name of pooling group	Distribution used and reason for choice	Any urban or non-flood years adjustments	Parameters of distribution (location, scale and shape after adjustments)	Growth factor for 100-year return period
42017	SS	NA	GEV, best fit	None		2.777
42017	ESS	Pooled Group A ESS	GEV, best fit	UAF = 1.23	Location: 1.000 Scale: 0.248 Shape: -0.223	2.982
42017	P	Pooled Group A	GEV, best fit	UAF = 1.23	Location: 1.000 Scale: 0.238 Shape: -0.237	2.979

Methods: SS - Single Site; P - Pooled; ESS - Enhanced Single Site; H - Historical. Pooled and ESS growth curves were derived using the procedures from Science Report SC050050 (2008). Urban adjustments are carried out using the WINFAP V4 urban adjustment method.

Flood frequency curve plots:

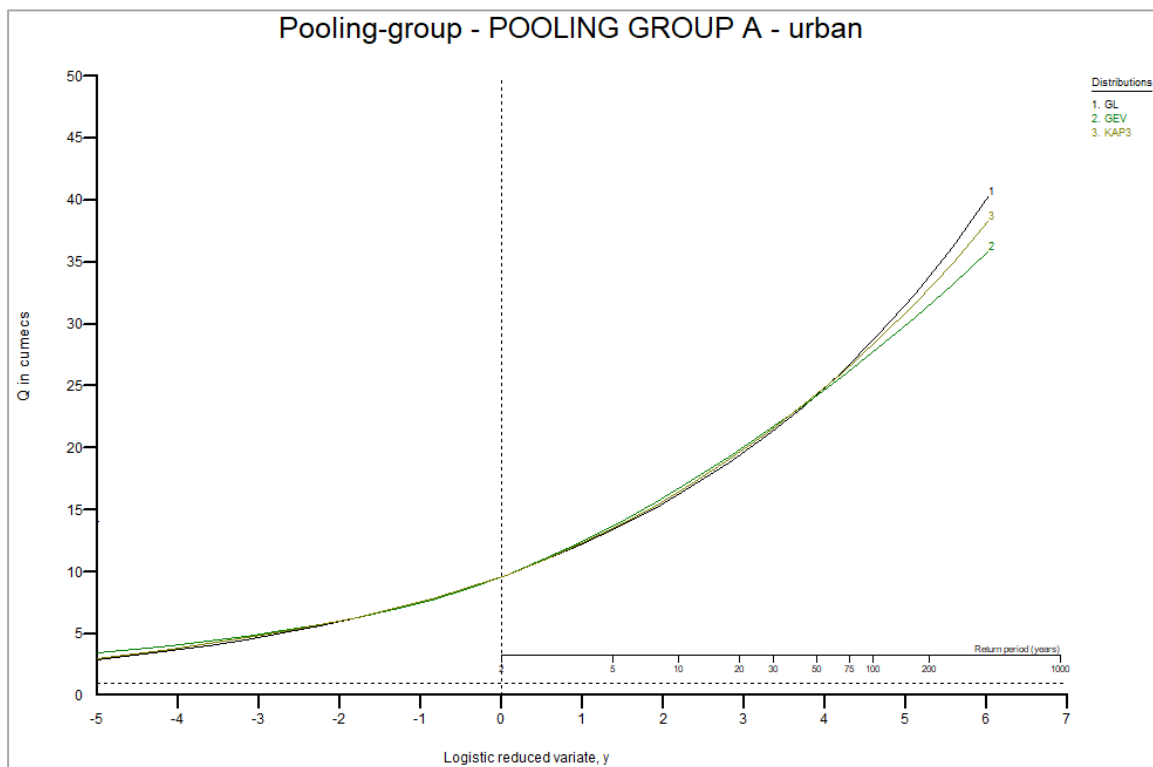


Figure 4: Pooling group A growth curves

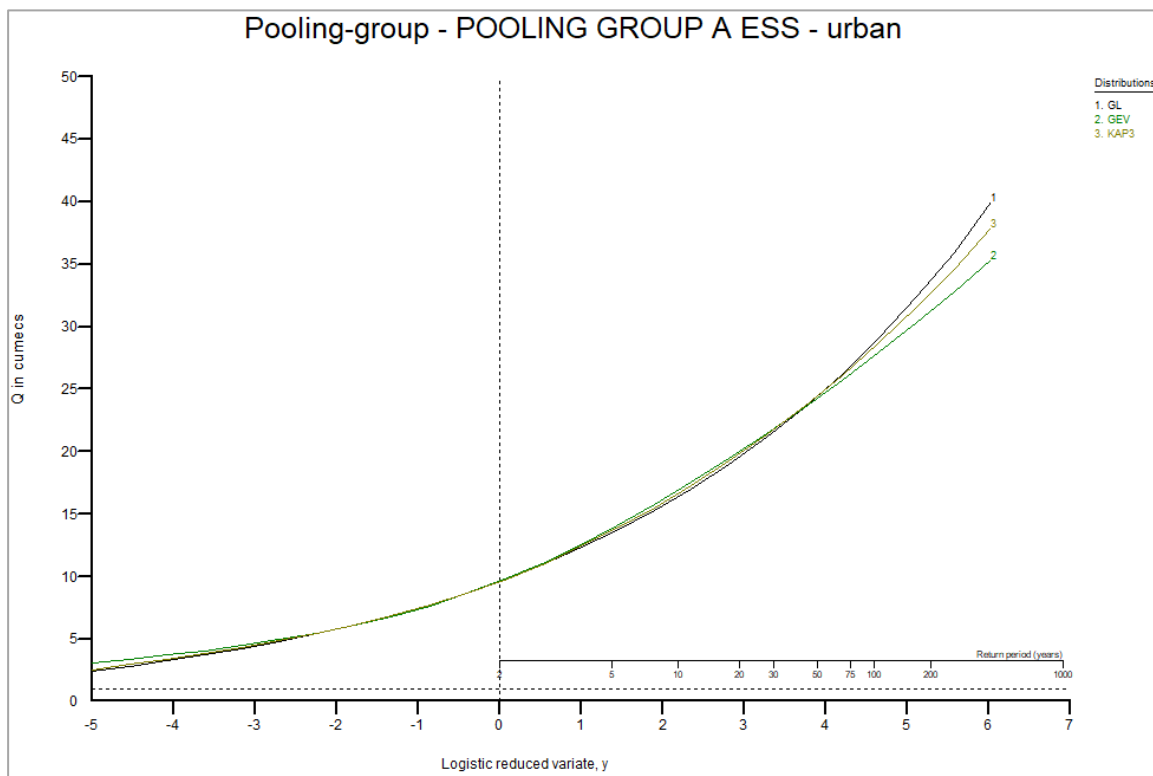


Figure 5: Pooling group A ESS growth curves

Derivation of pooling groups:

Name of group	Site code from whose descriptors group was derived	Subject site treated as gauged? (ESS)	URBEXT2000 threshold applied to pooling group selection?	L-moments deurbanised (including subject site for ESS)?	Small catchment pooling procedure applied?
SS	42017	Yes	N/A		
Pooling Group A ESS	42017	Yes	0.03	L-CV 0.245 L-Skew 0.223	Yes
Pooling Group A	42017	No	0.03	L-CV 0.238 L-Skew 0.237	Yes

Methods: Unless otherwise stated, pooling groups were derived using the procedures from Science Report SC050050 (2008). The small catchment pooling procedure is given in the report on Phase 2 of project SC090031 (2021) and implemented in WINFAP v5.

Pooling group composition:

Name of group	Changes made to default pooling group, with reasons	Weighted average L-moments
Pooling Group A ESS	Rejected Sites: 26016 (Gypsy Race @ Kirby Grindalythe) - Highly Permeable 26017 (Ings Beck @ South Newbald) - Highly Permeable 26014 (Water Forlornes @ Driffield) - Highly Permeable 7011 (Black Burn @ Pluscarden Abbey) - Highly Permeable 27073 (Brompton Beck @ Snainton Ings) - Highly Permeable 44008 (South Winterbourne @ Winterbourne - Highly Permeable 28058 (Henmore Brook @ Ashbourne) - Data since 1994 listed as unrepresentative 9006 (Deskford Burn @ Cullen) - Short Gauge History 39033 (Winterbourne Stream @ Bagnor) - Highly Permeable 49005 (Bolingey Stream @ Bolingey Cocks Bridge) - Short Gauge History 44013 (Piddle @ Little Puddle) - Highly Permeable	L-CV 0.304 L-Skew 0.240 L-CV 0.216 L-Skew 0.059 L-CV 0.316 L-Skew 0.163 L-CV 0.491 L-Skew 0.521 L-CV 0.213 L-Skew 0.005 L-CV 0.422 L-Skew 0.289 L-CV 0.147 L-Skew -0.049 L-CV 0.290 L-Skew 0.139 L-CV 0.338 L-Skew 0.375 L-CV 0.263 L-Skew 0.206 L-CV 0.463 L-Skew 0.258

Name of group	Changes made to default pooling group, with reasons	Weighted average L-moments
	Added Sites 41022 (Lod @ Halfway Bridge) 20006 (Biel Water @ Belton House) 76019 (Roe Beck @ Stockdalewath) 37016 (Pant @ Copford Hall) 36003 (Box @ Polstead) 20005 (Birns Water @ Saltoun Hall) 21027 (Blackadder Water @ Mouth Bridge)	L-CV 0.297 L-Skew 0.181 L-CV 0.375 L-Skew 0.128 L-CV 0.218 L-Skew 0.311 L-CV 0.285 L-Skew 0.099 L-CV 0.313 L-Skew 0.080 L-CV 0.303 L-Skew 0.222 L-CV 0.321 L-Skew 0.211
Pooling Group A	Pooling Group A ESS shares the same pooling group as Pooling Group A with the inclusion of the gauged catchment.	

4.4 Final choice of QMED and growth curves

Method choice and reasons:

Flow estimates from the three methods are all very similar

Site code	Final choice of QMED and reasons	Final choice of flood growth curve method and reasons
42017	QMED to be estimated from the gauge.	GEV, best fit according to WINFAP5

Final flood estimates from stationary statistical methods:

A comparison of results between the 2020 assessment for all three methods and the three methods used in this assessment are shown below. Flood peak in m³/s for the return periods in years or AEP (%) events.

Study	Site code	2 50%	5 20%	10 10%	20 5%	30 3.3%	50 2%	75 1.3%	100 1%	200 0.5%	1000 0.1%
2020	SS	8.90	12.40	15.50		19.40	21.70	23.70	25.20	29.20	
	ESS	8.90	12.30	14.90		19.70	22.10	24.40	26.10	30.80	
	P	8.90	11.70	13.90		18.30	20.10	22.10	23.60	27.80	
2023	SS	9.61	13.43	16.14	18.97	20.75	23.13	25.16	26.69	30.66	
	ESS	9.61	15.48	16.36	19.52	21.55	24.36	26.78	28.67	33.67	
	P	9.61	13.37	16.21	19.36	21.40	24.24	26.73	28.64	33.79	

Reasons for an increase in the 1% AEP flow between the 2020 assessment and this assessment are given below:

- The QMED value has increased from 8.90 to 9.61 m³/s due to the additional AMAX readings.
- The small catchment pooling method has been used in this assessment which was not available for the 2020 assessment.
- Additional years of data within the NRFA dataset between the two methods.

Since the 2020 assessment, the number of available years of data at the Havant gauge has dropped from 52 years to 37 years of data. This is likely the driving factor of increasing the value of QMED between the assessments. ESS was used in the 2020 assessment to compare to the ReFH2.3 flows. The ESS will again be used for comparison in this assessment.

5. Revitalised flood hydrograph 2 (ReFH2.3) method

5.1 Method Overview

What is the purpose of applying this method?

Lumped estimate required at the gauging site to compare to the FEH Statistical method and gauged Q_{med}, as well as the original 2020 assessment.

Rural and urban catchment sub-divisions:

URBEXT < 0.3

Version of ReFH2 applied:

ReFH2.3 (FEH13 rainfall)

5.2 Model Parameters

Summary of model parameters:

Site code	Method	Tp (hours) rural	Cmax (mm)	BL (hours)	Area modelled as urban (km ²)	TP urban scaling factor	IF	IRF	DS
42017	CD	4.81	226.50	31.34	7.57	0.75	0.40	0.70	0.50

Methods: OPT: Optimisation from event analysis, BR: Baseflow recession fitting, LAG: TP from lag analysis, CD: Catchment descriptors, DT: Data transfer, CAL: model calibration.

Analysis undertaken to derive model parameters:

The 2020 assessment completed a calibration to adjust model parameters. It concluded that calibration from the dataset suggested a much shorter Time to Peak (TP) would be more appropriate. However, the assessment found the unadjusted ReFH2.3 peaks to be a closer match to the gauge and that the defaults should be used. This reasoning has been carried through to this assessment.

No adjustments were made for this assessment.

5.3 Model inputs for design events

Design events for lumped catchments:

Site code	Rainfall DDF model	Urban or rural	Highly permeable?	Season of design event	Storm duration (hrs)	Initial soil moisture Cini	Initial baseflow BFO
42017	FEH13	Urban	No	Winter	8.5	137.629	0.93

Design events for subcatchments and intervening areas:

Not applicable.

Storm duration testing:

Not applicable for this assessment

5.4 Final choice of ReFH2.3 flow estimates

Method choice and reasons:

Site code	Final choice of design inputs and model parameters
CD	Based on the 2020 hydrological assessment conclusions regarding the use of default parameters and to be consistent in methods to compare vs WINFAP5 assessment

Final flood estimates from ReFH2.3 method:

Urbanised provided. There are no changes to the ReFH2.3 flows between the 2020 assessment and those in this assessment. Flood peak in m³/s for the return periods in years or AEP (%) events.

Site code	2 50%	5 20%	10 10%	20 5%	30 3.3%	50 2%	75 1.3%	100 1%	200 0.5%	1000 0.1%
42017	8.74	11.39	13.26	15.13	16.28	17.80	19.10	20.08	22.76	32.91

6. Discussion and summary of results

6.1 Comparison of results from different methods

Site code	<i>e.g., Ratio of ReFH2.3 to stationary statistical peak, 50% AEP</i>	<i>e.g., Ratio of ReFH2.3 to stationary statistical peak, 1% AEP</i>
42017- 2023 assessment	0.91	0.70
42017- 2020 assessment	0.98	0.77

6.2 Final choice of method

The 2020 assessment routed the ReFH2.3 flows using default parameters through the hydraulic model to compare the modelled peaks at the flow gauge location (42017). The ESS was used to compare to the ReFH2.3 routed flows. There was a difference of 7.4% between the 100-year flows of the two methods.

The model was approved by the Environment Agency in 2020. The hydraulic model was updated as part of the 2023 assessment. The ReFH2.3 flows from the 2020 assessment (same as those in this assessment) were routed through the 2023 hydraulic model, with the addition of the LLP contribution. The routed 100-year flow recorded at the location of the gauge was 26.37 m³/s. This closely matched the SS flow and is 8.7% lower than the ESS and Pooled 100-year flow.

Study	Site code	2 50%	5 20%	10 10%	20 5%	30 3.3%	50 2%	75 1.3%	100 1%	200 0.5%	1000 0.1%
2020	SS	8.90	12.40	15.50		19.40	21.70	23.70	25.20	29.20	
	ESS	8.90	12.30	14.90		19.70	22.10	24.40	26.10	30.80	
	P	8.90	11.70	13.90		18.30	20.10	22.10	23.60	27.80	
	Routed ReFH	10.60	14.00	16.30		20.30			24.30		32.90
2023	SS	9.61	13.43	16.14	18.97	20.75	23.13	25.16	26.69	30.66	
	ESS	9.61	15.48	16.36	19.52	21.55	24.36	26.78	28.67	33.67	
	P	9.61	13.37	16.21	19.36	21.40	24.24	26.73	28.64	33.79	
	Routed Refh	12.64	15.91	18.20		21.90			26.37		34.18

Choice of method and reasons:

The FEH Statistical Method is generally preferred since it makes use of a much wider dataset. However, there is a lack of confidence in the FEH Statistical Method for longer return periods, given the low confidence in the accuracy of the local AMAX for large flow events.

The 2020 assessment proposed that when the ReFH2.3 flows (with default parameters) from the sub-catchments were routed through the 2020 hydraulic model, and the estimated inflow from the LLP is included, then the peaks at the gauge location were very similar to the FEH Statistical peak flow. The ReFH2.3 flows were therefore adopted to be used to calculate the sub-catchment flow hydrographs with no adjustment to T_p and CMAX.

The 2023 assessment found that the FEH Statistical peak flow increased with additional years of AMAX data and use of new guidance. The ReFH2.3 flows were routed through the model and the LLP contribution included. The routed ReFH2.3 flows closely matched the FEH Statistical peak flow, as in the 2020 assessment.

The ReFH2.3 flows are therefore to be used as the sub-catchment inflows to the model. There is to be no update to the original hydrology ReFH2.3 inflow hydrographs.

How will the 0.1% AEP flows be estimated?

ReFH2.3 0.1% estimations are considered reasonable according to the latest 2023 software guidance.

How will the flows be applied to a hydraulic model?

The same model is to be used which applies 6 model inflows distributed throughout the model to represent intervening catchments.

6.3 Final results

The final results given below are from the ReFh2.3 method for this assessment, however the 2020 FRA ReFh2.3 inflows will be used in the hydraulic model.

Site code	2 50%	5 20%	10 10%	20 5%	30 3.3%	50 2%	75 1.3%	100 1%	200 0.5%	1000 0.1%
42017	8.74	11.39	13.26	15.13	16.28	17.8	19.1	20.08	22.76	32.91

Flood peak in m^3/s for the return periods in years or AEP (%) events.

Design storms applied in the hydraulic model:

Not applicable for this assessment.

Climate change allowances:

Horizon	Central	Higher	Upper
2020s	19%	24%	37%
2050s	22%	30%	51%
2080s	37%	51%	88%

The reservoir infrastructure is considered Essential Infrastructure and therefore the Higher allowance is appropriate (51%). Flows have also been uplifted by 88% as a sensitivity check within the model.

Climate change uplift factors have been applied to the flow hydrographs.

6.4 Checks

Growth factor checks:

Growth factor checks for the ESS method are given below.

Site code	1% AEP growth factor	0.1% AEP / 1% AEP ratio
42017	GL 2.982	1.70
42017	GEV 2.877	1.46
42017	KAP3 2.946	1.58

The 1% growth factors for the ESS method are within the typical range.

Comparisons with previous studies:

Comparisons to the 2020 assesment have been provided throughout this report.

Checks on hydraulic model results:

Not applicable.

Return period estimates:

The AMAX-1, AMAX-2 and AMAX-3 events have been checked against the FEH Statistical SS peaks and the peaks within the model using routed ReFH2.3 flow. The routed ReFH2.3 flow includes the contribution from the LLP of 2 m³/s up to the 1% AEP. The SS method has been used here for comparison as the calculations are easily undertaken using WINFAP, however, the SS flows and ESS flows are similar. It should be noted, there is uncertainty in the data above QMED at the gauge. The AMAX 1,2 and 3 flows equate to much higher FEH Statistical and ReFH2.3 peak flows. Given the reduced record length of 37 years from 52 these results seem sensible.

Date of peak	Peak flow (m3/s)	FEH Statistical (single site) (m3/s)	ReFH2.3 default parameters (m3/s)
19-Aug-05	21.1	32.4	30
15-Sep-00	20.7	29.7	10 to 30
11-Jun-12	18.1	16.2	10

6.5 Assumptions, limitations, and uncertainty

Assumptions (specific to this study):

This assessment assumes the 2020 assessment was accurate at the time of writing as approved by the EA. It assumes that the catchment boundaries are representative and assumes the flow recorded at the gauge (42017) are representative of the catchment response and suitable for QMED estimation.

Limitations:

FEH Statistical Methods are more limited at smaller catchment sizes of which this is a small catchment. However, the catchment in question is entirely suitable to both FEH Statistical Methods used for this assessment. The inflow from the Lavant along the LLP is not gauged. The 2020 assessment reported that the model is generally insensitive to the impact of the Lavant inflow due to the very high conveyance capacity of the Hermitage Stream.

Suitability of results for future studies:

The ReFH2.3 and or Hybrid method using FEH Statistical peak flows are both considered suitable for inflow hydrology to the hydraulic model. The gauged Qmed is higher than the FEH Statistical method.

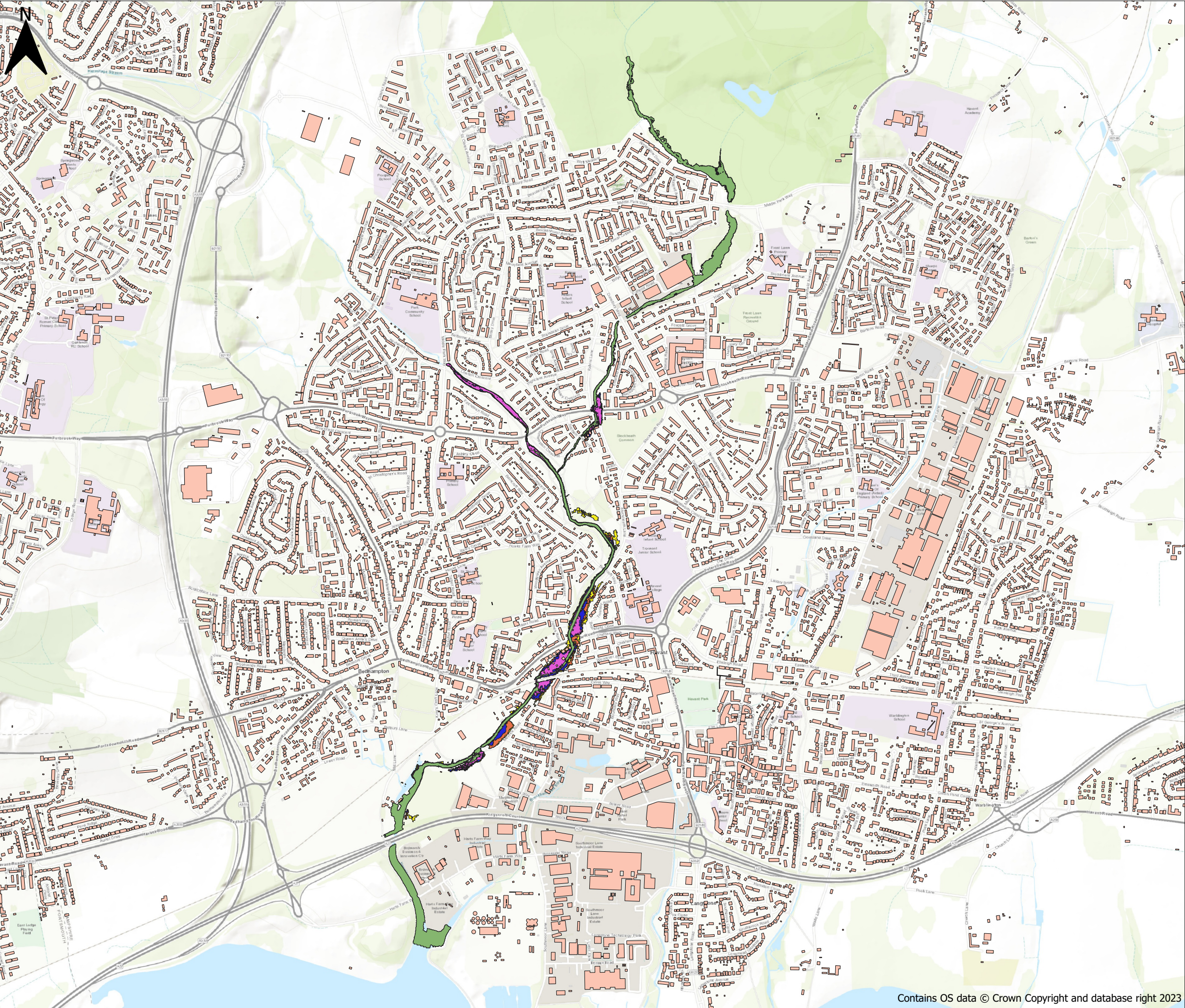
Submission and final EA review of this hydrological assessment fell either side of the release of the updated FEH22 rainfall statistics. Allowances for potential increases in flows due to the recalibration of rainfall data have not been made within this assessment.

Given that the project is a reservoir design, it would be worth testing the 0.01% event using the FEH22 data for future analyses. However, testing using the FEH22 rainfall is beyond the scope for this hydrological analysis.

Annex B – Emergency Discharge Sensitivity Modelling Flood Maps

Figure B1 - Emergency Discharge + Fluvial Events

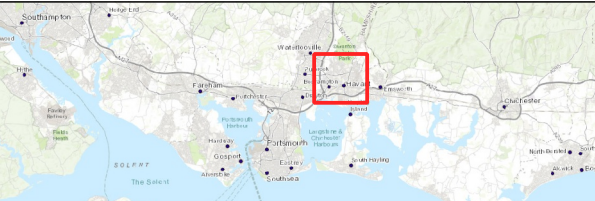
Figure B2 - Emergency Discharge + 20% Roughness



Havant Pipeline

Emergency Discharge Flood Extents
Plus Fluvial Events

- Buildings
- Emergency Discharge + Q10
- Emergency Discharge + 50% AEP
- Emergency Discharge + 10% AEP
- Emergency Discharge + 3.33% AEP
- Emergency Discharge + 1% AEP



DRAWN RV	CHECKED JP	AUTHORISED 22/05/23
-------------	---------------	------------------------

DESIGNER

SWECO

CONTRACTOR

WARD & BURKE

CLIENT

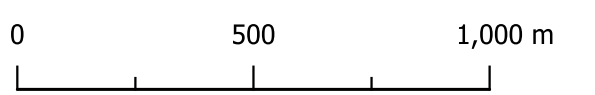
PROJECT TITLE
HAVANT PIPELINE

PROJECT STAGE
DETAILED DESIGN

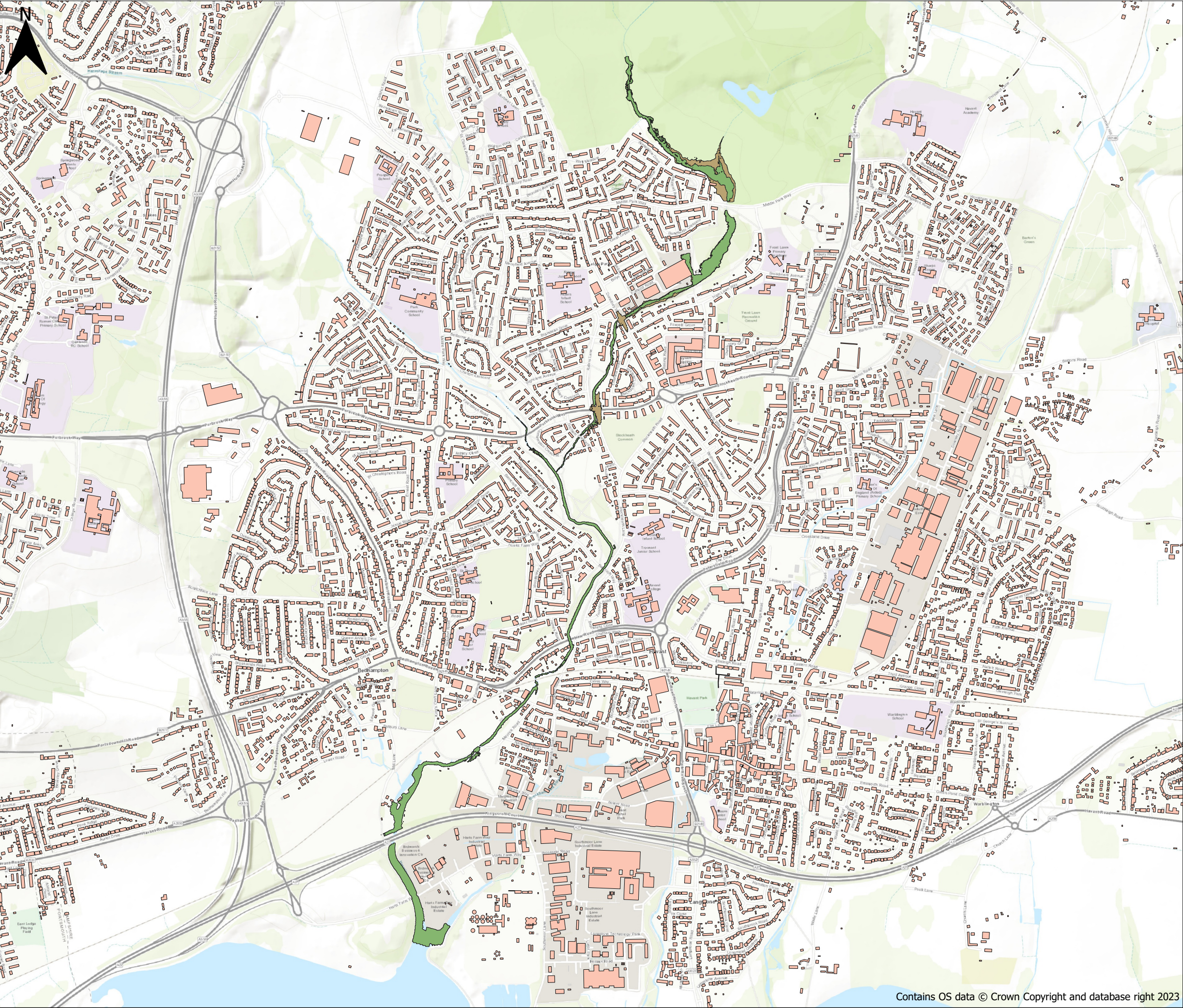
PURPOSE OF ISSUE
ISSUE TO CLIENT

DRAWING NUMBER
APPENDIX B - FIGURE B1

SHEET SIZE A3	SCALE 1:16000 @ A3	REVISION P03
------------------	--------------------------	-----------------



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.



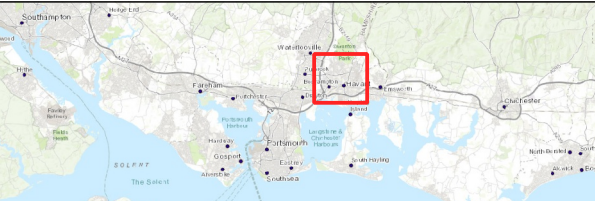
Havant Pipeline

Emergency Discharge Flood Extents

Buildings

Emergency Discharge + Q10

Sensitivity- n+20%



DRAWN	CHECKED	AUTHORISED
RV	JP	22/05/23

DESIGNER

SWECO

CONTRACTOR

WARD & BURKE

CLIENT

PROJECT TITLE

HAVANT PIPELINE

PROJECT STAGE

DETAILED DESIGN

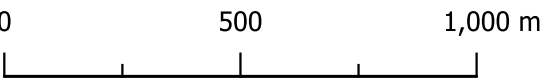
PURPOSE OF ISSUE

ISSUE TO CLIENT

DRAWING NUMBER

APPENDIX B - FIGURE B2

SHEET SIZE	SCALE	REVISION
A3	1:16000 @ A3	P03



This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Sweco UK Ltd was commissioned. Sweco UK Ltd accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared on behalf of Ward & Burke by Sweco UK Ltd for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Ward & Burke being obtained. Sweco UK Ltd accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his/her agreement, to indemnify Sweco UK Ltd for all loss or damage resulting therefrom.