Croudace Homes Limited

Stoneyfields, Oxted

Hydraulic Modelling Report

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December 2024

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Contents

Page

Appendices

Figures

Tables

Document Control Sheet

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Distribution

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1. Introduction

1.1. Ardent Consulting Engineers (hereafter referred to as Ardent) has been instructed by Croudace Homes Limited to undertake surface water hydraulic modelling to support a proposed development at Stoneyfields, Oxted.

1.2. The Site location is shown in **Figure 1-1**. The proposed development consists of residential dwellings and a care home with associated parking and landscaping, with vehicular access via Wheeler Avenue from the south and Barrow Green Road to the north.

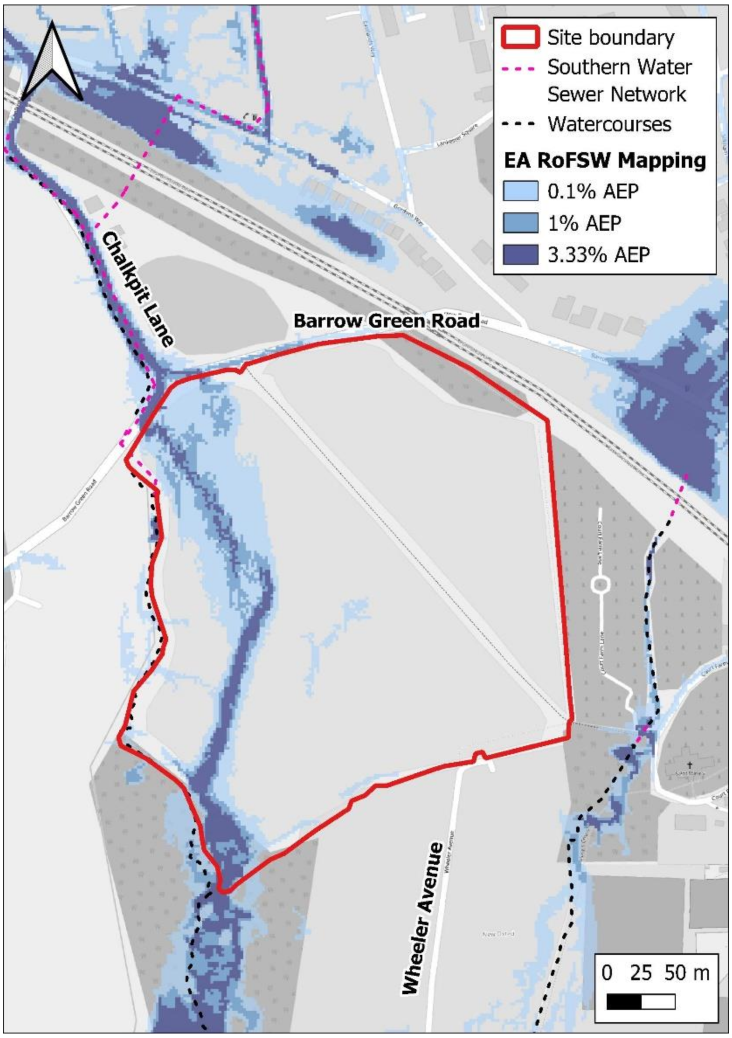


Figure 1-1: Site location plan and EA surface water flood mapping

1.3. An ordinary watercourse runs along the western boundary from north to south. The watercourse is primarily fed by a Southern Water surface water sewer that discharges into the watercourse in the northwest of the Site, along with a ditch that runs adjacent to Chalkpit Lane from the north. An ordinary watercourse is also located east of the Site through the adjacent cemetery.

1.4. The Environment Agency (EA) Risk of Flooding from Surface Water (RoFSW) shows parts of the Site are predicted to be at a low to high risk of surface water flooding (see **Figure 1-1**). However, the EA mapping is carried out at national scale and does not explicitly represent local drainage features such as the sewer network.

1.5. Therefore, a detailed 1D-2D linked direct rainfall-runoff model has been developed using TUFLOW software to refine the understanding of surface water flood risk to the Site and inform potential flood risk mitigation measures.

2. Site Visit

2.1. To support the hydraulic model build, a Site visit was undertaken on 24 May 2024 to identify any structures/drainage features that may influence the surface water flood risk to the Site and assess the condition of the watercourse. Features identified during the Site visit are shown in **Figure 2-1**, with photographs shown in **Appendix A**. The Site visit was supported by topographic survey (see **Appendix B**) and Southern Water sewer mapping (see **Appendix C**).

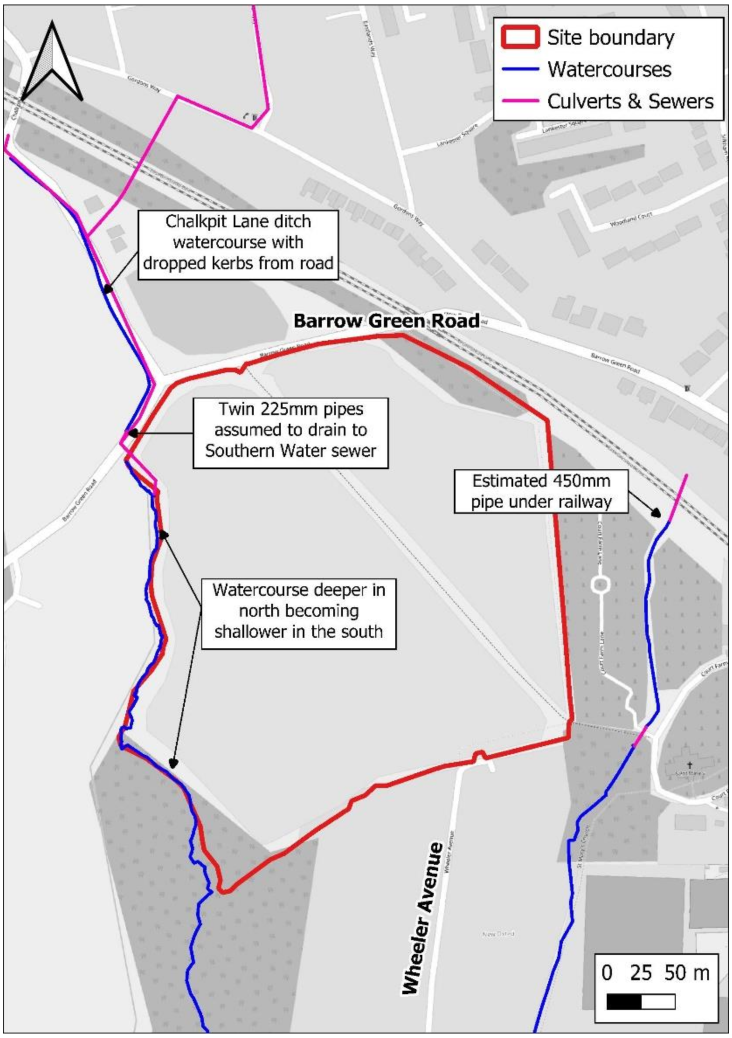


Figure 2-1: Culverts identified during Site visit

2.2. A ditch running north to south adjacent to Chalkpit Lane was identified during the Site visit, which then turns west for a short length along Barrow Green Road (see **Photo A.1**). A series of dropped kerbs along Chalkpit Lane leading into the ditch were also identified. The ditch was approximately 0.75m - 1m deep and 1m – 1.5m wide at bankfull. At the time of the visit the ditch contained a large amount of summer vegetation.

2.3. Several road gullies and manholes were identified along Chalkpit Lane and Barrow Green Road. It is assumed that these drain into a surface water sewer shown on Southern Water sewer mapping to run along Chalkpit Lane before entering the northwest corner of the site and discharging into the watercourse adjacent to the Site (see **Appendix C**).

2.4. At the downstream end of the ditch two 225mm culverts were observed, one concrete and one PVC (see **Photo A.2**). No culvert was identified immediately south of Barrow Green Road along the watercourse adjacent to the Site. The 225mm culverts are therefore assumed to drain into the Southern Water surface water network.

2.5. Due to vegetation growth it was not possible to view the outfall of the Southern Water network to the watercourse to the west of the Site. However, the location shown of the outfall on sewer mapping correlates with the Site topographic survey. Additionally, flow within the watercourse was only observed downstream of the mapped outfall location.

2.6. The watercourse is relatively deeply incised along boundary in the northwest of the Site (see **Photo A.3**), with a defined channel shown to be approximately 0.75 – 1.25m deep in the topographic survey. At the time of the Site visit the channel was largely clear, though with occasional debris and densely vegetated banks.

2.7. In the southwest of the Site the watercourse becomes shallower and spreads over a wider area with waterlogged ground (see **Photo A.4**). The channel becomes more overgrown within this area.

2.8. The watercourse to the east of the Site was also visited and is largely a clear channel approximately 1m deep with grass lined banks. The culvert under the railway into the cemetery from the north was estimated to be 450mm in diameter based on observations taken during the Site visit (see **Photo A.5**).

3. Hydrological Assessment

3.1. To inform the hydraulic modelling and assess surface water flood risk to the Site, rainfall hyetographs were derived to input to the hydraulic model.

3.2. FEH22 catchment descriptor data was obtained from the Flood Estimation Handbook (FEH) Web Service for the catchment covering the Site (see **Figure 3-1**). The catchments consist of rural areas to the north and west of Oxted, and a residential area in the north of Oxted.

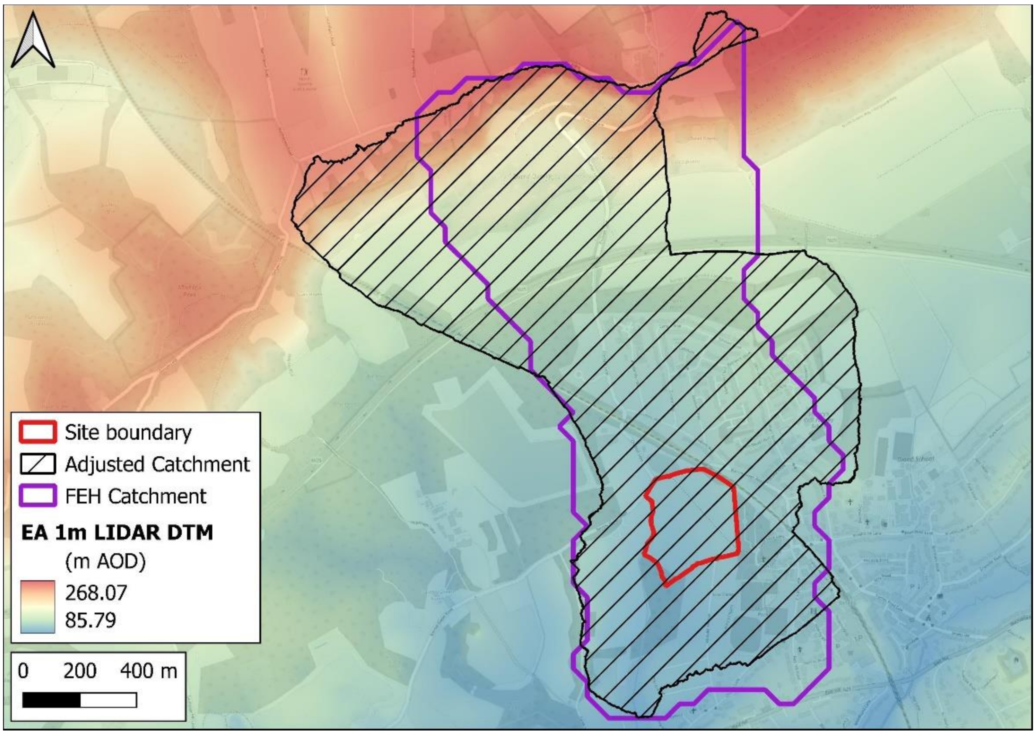


Figure 3-1: Estimated catchment boundary

3.3. A catchment analysis was undertaken using catchment delineation tools within QGIS to determine the catchment area draining to the Site based on the latest 1m EA LIDAR Composite DTM, with the LIDAR data last collected in 2018. The updated catchment area is shown in **Figure 3-1**. The adjusted catchment has an area of 2.28km^2, compared to the value of 2.12km^2 for the FEH catchment, with the adjusted area used to derive rainfall.

3.4. Analysis of satellite imagery indicated no major development had occurred within the catchment and as such URBEXT values were only updated to 2024 in line with available guidance.

3.5. The other catchment descriptors used to derive design rainfall and net rainfall for rural areas (SPRHOST, BFIHOST, SAAR, DPLBAR etc.) were assessed against available data, such as British Geological Society geology mapping and LANDIS SoilScapes mapping. The key FEH catchment descriptors were considered appropriate and as a result only the catchment area and URBEXT values were updated.

3.6. The FEH22 data was inputted to the Revitalised Flood Hydrograph 2 (ReFH2) software, which was used to derive rainfall hyetographs for the 3.3%, 1%, and 0.1% Annual Exceedance Probability (AEP) events.

3.7. Rainfall hyetographs were also derived for the 3.3% AEP event uplifted by 35% and the 1% AEP event uplifted by 45% to account for the potential impacts of climate change, in line with the latest EA guidance for the 2070s epoch upper end allowance in the Medway Management Catchment[1].

3.8. A winter storm profile was used to derive the hyetographs in line with available ReFH2 guidance on critical seasonality for rural areas based on the BFIHOST value and updated URBEXT2000 value.

3.9. The default storm duration for the catchment is 3.25 hours. Hyetographs were also derived for a 1.25-hour, 2.25-hour, and 4.25-hour storm duration, with all four durations tested within the model for the 1% AEP plus 45% climate change event in the baseline model. The duration testing found the 2.25-hour storm event resulted in the highest peak flood depths at key locations in the Site, with this therefore used as the final design storm duration.

3.10. The design and net rainfall hyetographs were exported from ReFH2, with details of how rainfall losses from rural and urban areas were represented in the hydraulic model outlined in **Section 4**. An example ReFH2 report for the 1% AEP plus 45% climate change event is provided in **Appendix D**, including details of the descriptor data.

[1] Medway Management Catchment peak rainfall allowances, Environment Agency. Available: https://environment.data.gov.uk/hydrology/climate-change-allowances/rainfall?mgmtcatid=3055

4. Baseline model build

4.1. The baseline model has been built using the hydraulic modelling software TUFLOW. All scenarios have been run using Tuflow build version 2023-03-AC-iSP-w64.

2D build

4.2. A 2D model schematic is shown in **Figure 4-1**.

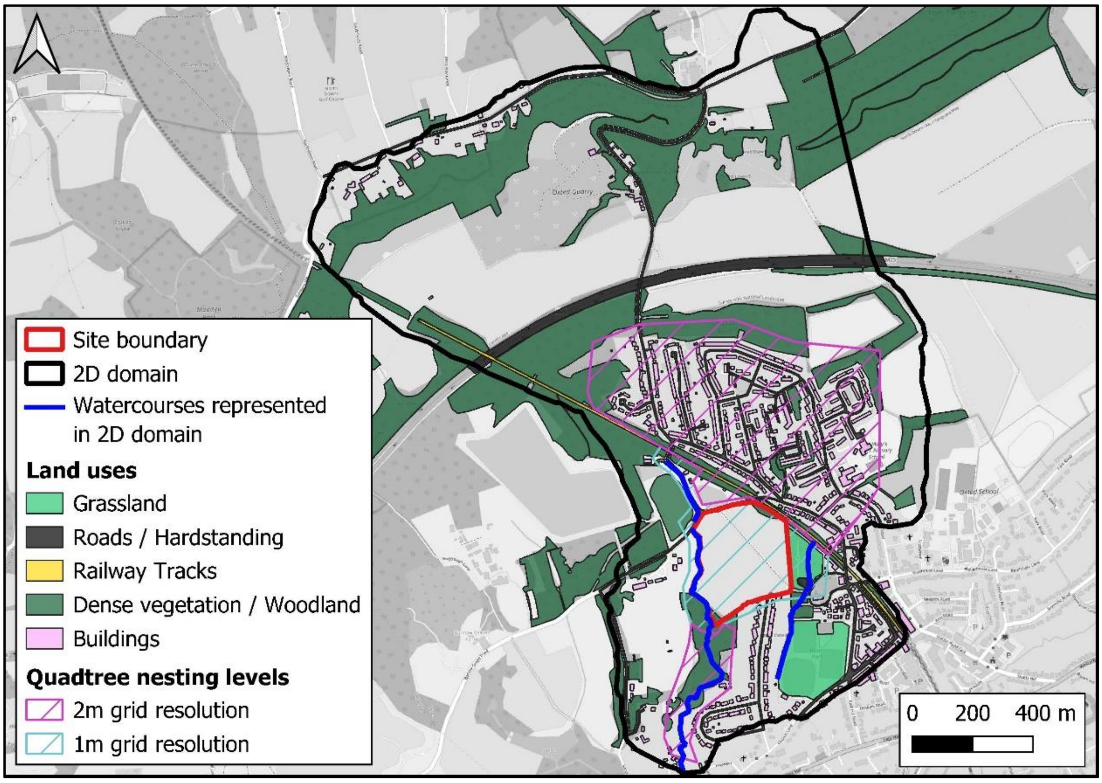


Figure 4-1: 2D Model schematic

4.3. Watercourses and the wider catchment are represented in the 2D domain, which covers an area of 2.78km^2, including the entire catchment derived in **Section 3**.

4.4. Ground levels at the Site have been informed by a topographic survey collected in March 2023 by Encompass Surveys (see **Appendix B**). Elevations across the wider catchment were derived from the 2018 EA 1m LIDAR DTM.

4.5. A 4m cell size has been applied across the model with Quadtree used to refine this to a 2m grid size within the urban area north of the Site and the watercourse downstream of the Site. A 1m grid size is applied at the Site, adjacent watercourse and along Chalkpit Lane. Sub-grid sampling has been enabled within TUFLOW, ensuring surface water flow paths were adequately represented.

4.6. Different land uses derived from topographic survey and OS VectorMapping have been assigned roughness values within the 2D domain. A general roughness value of 0.055 was applied to the model domain representing light vegetation/pasture and fenced gardens. '2D_mat' files were then used to specify roughnesses for different land uses (see **Figure 4-1**). The values applied are shown in **Table 4-1**.

Table 4-1: 2D Manning's 'n' roughness values

Land use	Manning's 'n' roughness value
Light vegetation / pasture / fenced gardens	0.055
Open areas / Grassland	0.045
Railway tracks	0.035
Roads / Hardstanding	0.02
Buildings	0.3
Woodland / Dense vegetation	0.1
2D Watercourses	0.048

4.7. The ordinary watercourse was represented in the 2D domain. Adjacent to the Site boundary a 'Z-line' was used to stamp in channel levels taken from the topographic survey (see **Figure 4-1**). Where survey data was not available the watercourse levels were taken from the LIDAR DTM. This approach is considered conservative as LIDAR data only captures the water surface and not the channel bed levels, therefore underestimating the channel capacity.

4.8. The ditch along Chalkpit Lane was poorly represented within the LIDAR DTM. As a result, a 'Z-line' was used to lower the ground model by 0.5m to conservatively represent the capacity of the ditch.

1D build

4.9. The culverts identified during the Site visit (see **Section 3**) and from topographic survey were represented in the 1D domain (see **Figure 4-2**). A culvert to southeast of the Site was represented as a 580mm circular pipe, with the dimensions and inverts taken from topographic survey.

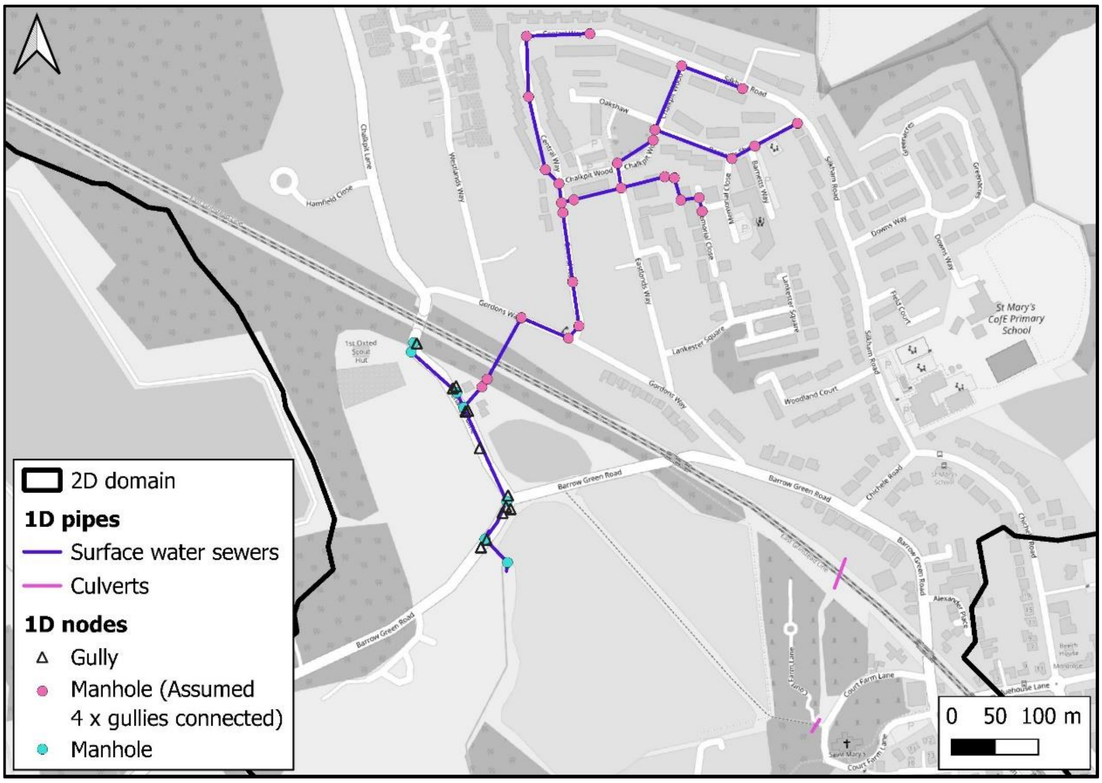


Figure 4-2: 1D model schematic

4.10. The two 225mm culverts at the downstream end of the ditch north the of Site were represented in the 1D domain, connecting into the adjacent sewer network, while the 450mm culvert under the railway line to the east of the Site was connected to the 2D domain at the upstream and downstream ends. In the absence of topographic survey, the culvert invert levels were inferred from the EA LIDAR data used to define the ground model. The culvert dimensions were informed by measurements and observations taken during the Site visit.

4.11. The sewers were represented using information obtained from Southern Water sewer mapping (see **Appendix C**). Pipe inverts and dimensions were taken from the mapping, with details inferred or interpolated where values were missing. A pipe roughness of 0.013 was applied in line with available guidance (i.e. Chow, 1959) assuming a good condition.

4.12. Road gullies along Chalkpit Lane identified during the Site visit were represented within the model (see **Figure 4-2**), with cover levels taken from the EA LIDAR DTM and invert levels set 0.5m below this. Manholes were represented with cover levels taken from the EA LIDAR DTM to ensure a linkage between the 1D and 2D domains using SXL connections (see **Figure 4-2**).

4.13. The flow in and out of road gullies was represented using standard head discharge curves, in line with industry guidance assuming 150mm pipe connections. The road gullies were set to connect to the nearest manhole in the 1D domain. Where road gullies were represented in the model, manholes were represented using standard head discharge curves that assume minimal inflows but allow surcharging to occur. Where no gullies were represented in the model upstream of the railway line the manholes were set to have a head discharge curve that assumed four gullies were connected to each manhole in the absence of gully mapping.

4.14. A blockage analysis of the twin 225mm culvert at the downstream end of the ditch north of the Site was undertaken to assess the residual flood risk to the Site and demonstrate the sensitivity of the model outputs to the assumptions made regarding their representation. The blockage analysis found only a minor impact on flood depths within the Site boundary meaning the representation of the culverts was considered appropriate (see **Appendix E** for further details).

4.15. Pipe roughness was applied in line with available guidance (i.e. Chow, 1959) based on observations and assumptions about the pipe material and condition. All sewers had a Manning's 'n' value of 0.013 applied, while the three culverts had values of 0.015 applied. Standard entry and exit losses were applied in line with TUFLOW guidance.

Boundary conditions

4.16. A '2d_rf' layer was used to apply rainfall directly to the 2D model domain. Rainfall losses associated with infiltration for the rural areas of the catchment were estimated within ReFH2, with the rural net rainfall hyetograph applied to the area shown in **Figure 4-3**.

4.17. The urban eastern half of the catchment is heavily urbanised, with indicative measurements indicating approximately 60-70% of the area is hardstanding. As a result, a conservative approach to apply rainfall to the urban catchment was undertaken, with the design rainfall hyetograph applied to the entire urban area shown in **Figure 4-3**. To account for infiltration losses and storage within urban areas (i.e. gutters, drains) 80% of the total design rainfall hyetograph was applied to the urban areas.

4.18. No losses were applied to account for the presence of surface water sewers within the catchment where these were not represented explicitly as it is assumed these would drain to the study watercourse and not be lost from the catchment.

4.19. Sensitivity testing of the application of rainfall to the model was undertaken and demonstrates the model has a low sensitivity to the approach used (see **Appendix E**).

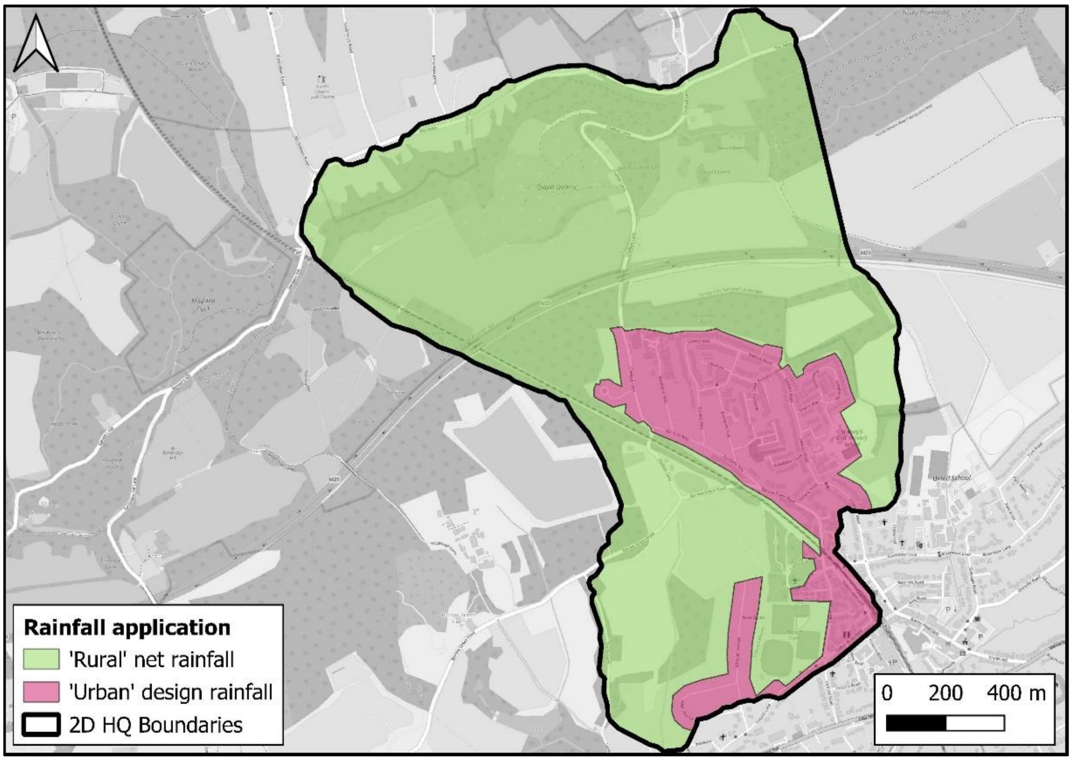


Figure 4-3: Model boundaries

4.20. To allow runoff to pass out of the 2D domain an HQ boundary was applied at the downstream extent of the watercourse and other flow paths in the model domain, with a gradient derived from the EA LIDAR DTM. The downstream boundary was located sufficiently downstream that it does not impact the model outputs at the Site. HQ boundaries with general slope values were applied to the rest of 2D domain to prevent glass-walling (see **Figure 4-3**).

4.21. 2D_bc 'SX' links have been used to link the 1D culverts to the 2D domain, with inverts taken from the EA LIDAR DTM. The 1D manholes and gullies were also connected to the 2D domain using 'SX' links.

Assumptions / limitations

4.22. The representation of any complex system by a model requires a number of assumptions to be made. In the case of the 1D and 2D elements of the model, the following assumptions have been made:

- Model parameters, such as roughness and structure coefficients, are representative of the general conditions;
- The units used to represent hydraulic structures within the model represent the situation accurately using the available information, including assumptions made to simplify representations where necessary;
- Culvert dimensions and inverts have been estimated where data is not available;
- The model hydrology accurately represents flows in the models given there was no flow / level data available for the catchment to calibrate flows in the model;
- Watercourses are modelled to be dry at the beginning of the simulation, with inflows solely from rainfall;
- The LIDAR and OS mapping are representative of the land surface and are an up to date reflection of current ground levels and land uses.

5. Baseline modelling results

5.1. The model has been run using the TUFLOW HPC solver with adaptive timestepping. The model is run for a total duration of 6 hours to allow the full storm event to pass through the Site. Model results have been filtered to remove depths below 0.05m.

5.2. Peak flood extents for the modelled storm events are shown in **Figure 5-1**.

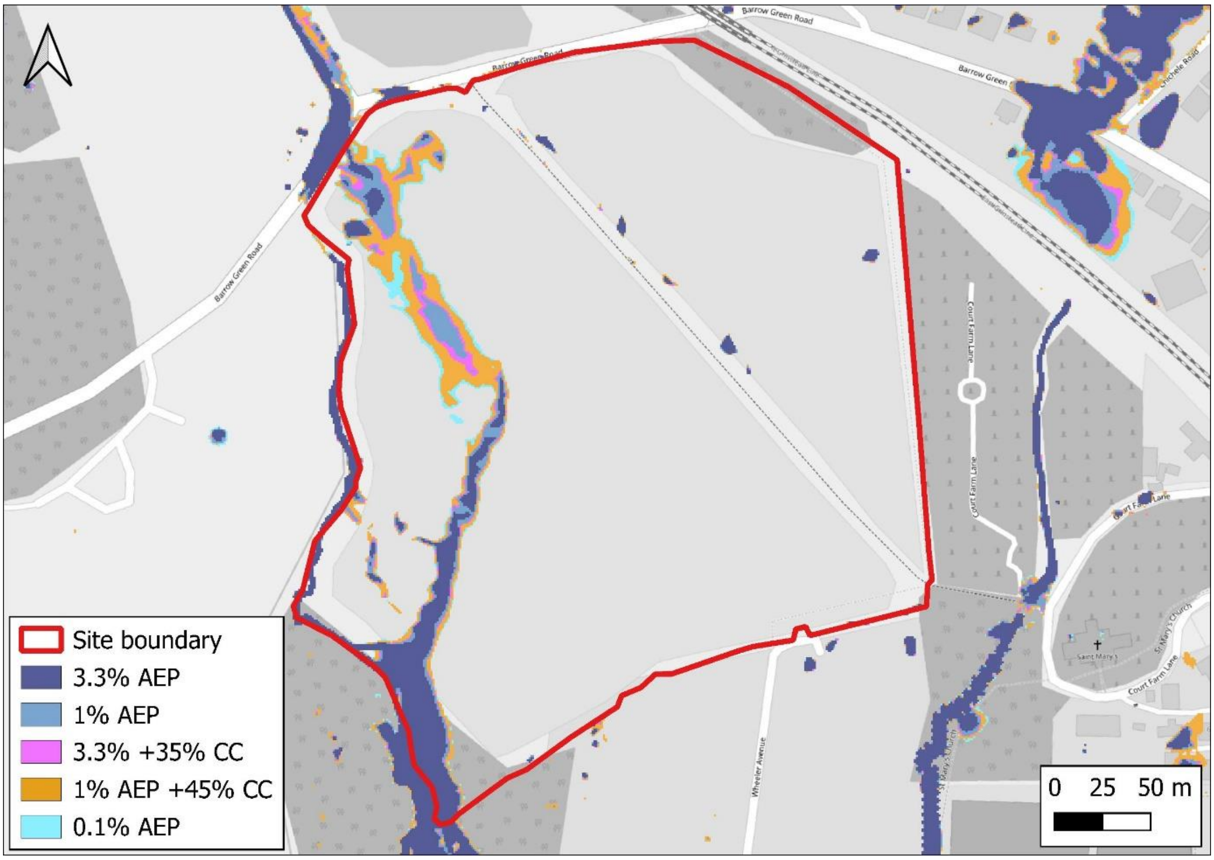


Figure 5-1: Baseline model flood extents

5.3. During all modelled events overland flows are predicted to enter the northwest corner of the Site, forming a shallow overland flow path that runs north to south through the Site separated from the adjacent watercourse by a slight ridge of higher land along the field boundary.

5.4. The capacity of the drainage ditch and surface water sewer network along Chalkpit Lane are modelled to be exceeded during all events, resulting in ponding on Barrow Green Road before flows spill into the Site. During the smaller magnitude events the flow path through the Site is very shallow (i.e. <0.05m).

5.5. The remainder of the Site is not predicted to be at risk of surface water flooding, with only isolated areas of surface water ponding shown in topographic depressions.

Additionally, the location of the proposed vehicular accesses are outside of the areas of flood risk.

5.6. The flow path is predicted to be very flashy with flows only conveyed through the Site for approximately 1.5-2 hours during the design storm for a 1% AEP plus 45% climate change event.

5.7. Peak modelled flood depths during the 1% AEP plus 45% climate change event are presented in **Figure 5-2**.

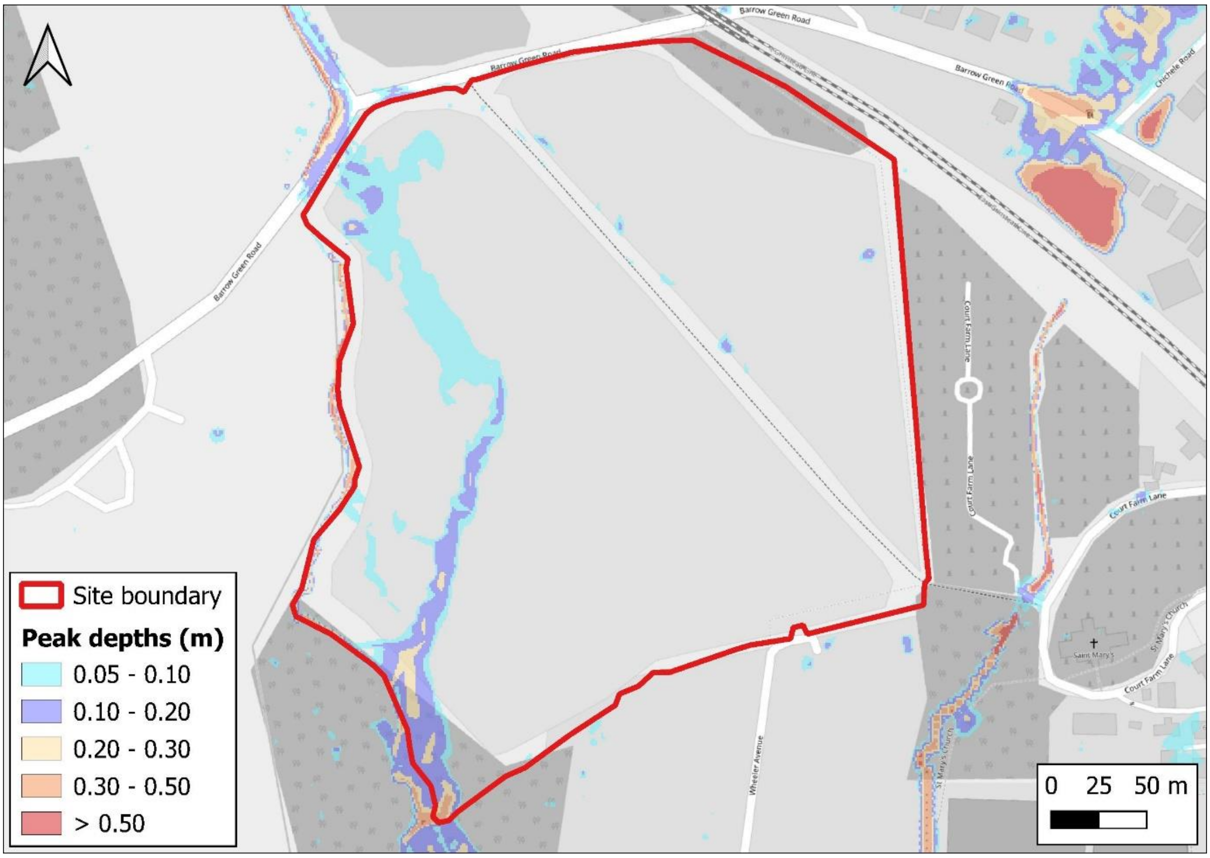


Figure 5-2: Peak modelled depths – 1% AEP +45% climate change

5.8. Through the northwest of the Site the flow path is modelled to be shallow, typically less than 0.10m, ranging in width from approximately 5-20m.

5.9. In the centre of the Site the flow path becomes more concentrated within a slight valley in the local topography that directs the flow path southwest towards the ordinary watercourse, with peak depths in this area typically around 0.15m.

5.10. In the southwest corner where the flow path joins the ordinary watercourse depths of approximately 0.25m are predicted.

Model Validation

5.11. No gauging data of flows or levels was available to inform the model validation. However, the modelling shows a good comparison with the existing EA RoFSW flood mapping (see **Figure 1-1**). The modelled flood extent is predicted to be slightly less extensive in the northwest of the Site due to the inclusion of the site specific topographic survey and local drainage features.

5.12. The similarities between the model outputs and the EA RoFSW mapping indicate the model is appropriately representing the flood risk to the Site.

5.13. The maximum uncertainty associated with the model outputs is approximately +/-50mm (see **Appendix E**).

Model stability

5.14. A review of the model outputs indicates the model is stable for the duration of the event, with total mass errors of 0% and timestep efficiency above 99% after the model initialisation. The model runs have no negative depths or repeated timesteps.

6. Post-development Modelling

Model updates

6.1. The proposed Site masterplan is provided in **Appendix F**. To increase the developable area of the Site post-development modelling was undertaken to assess the potential impacts of reprofiling ground levels so the overland flow path is diverted along the western boundary, away from the proposed residential development in the centre of the Site (see **Figure 6-1**).

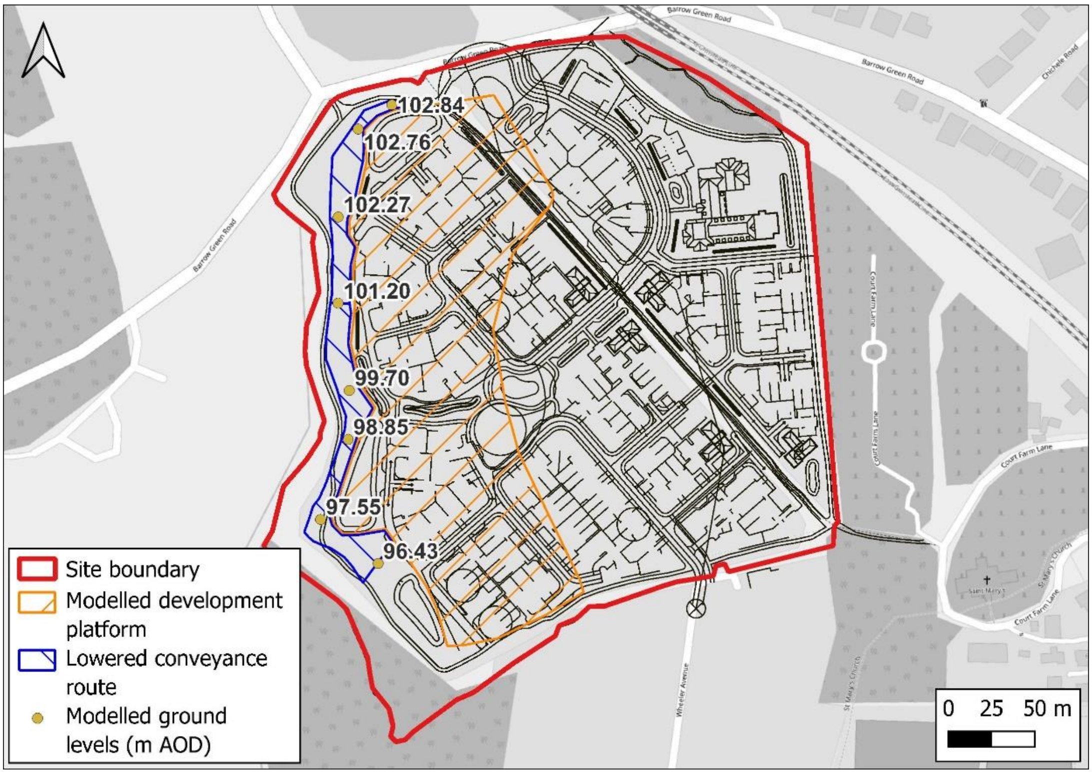


Figure 6-1: Proposed mitigation measures and Site layout

6.2. A conveyance route was formed along the western Site boundary, running from where the flow path enters the Site down to the southwest corner where the existing flow path joins the watercourse. The conveyance route was formed by slight ground lowering typically 100-300mm, with the modelled levels shown in **Figure 6-1**.

6.3. The conveyance route was represented within the post-development scenario using a Z-shape. Additionally, a development platform was represented adjacent to this, raising ground levels above the peak modelled flood levels for the purposes of the modelling so the platform remains dry.

6.4. The only other change to the post-development model was that rainfall was excluded from the developed area of the Site as this will be managed by the on-site drainage network. A '2D_bc' layer was used to apply the discharge from the drainage network to the watercourse at the proposed connection point, in line with the maximum discharge rate specified in the drainage strategy. This maximum discharge rate was applied for the duration of the model simulation, providing a conservative estimate of the outflow.

Post-Development Model Results

6.5. Peak flood depths and levels for the 1% AEP plus 45% climate change event during the post-development scenario are shown in **Figure 6-2**.

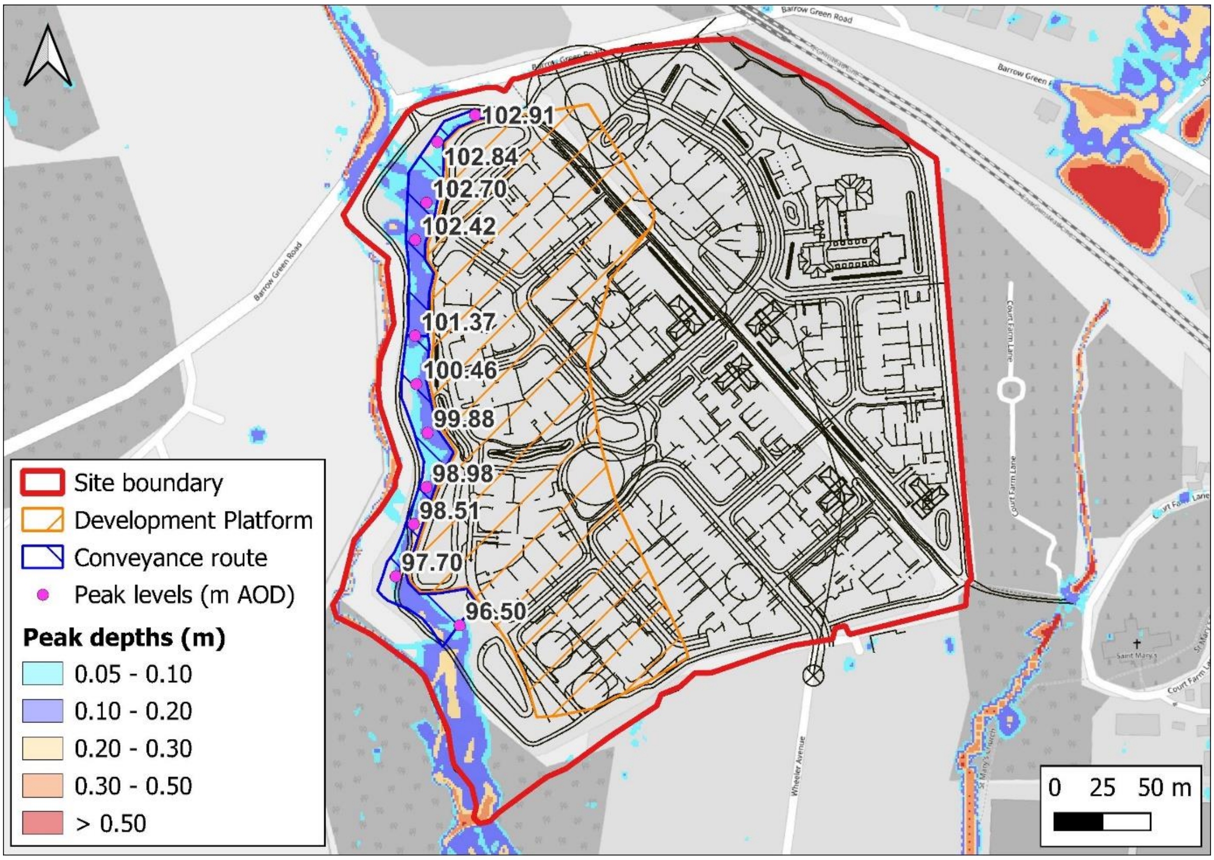


Figure 6-2: Peak modelled depths and levels – 1% AEP plus 45% climate change – Post-development scenario

6.6. The ground level reprofiling is modelled to divert the overland flows along the Site western boundary between the watercourse and the modelled development platform. All residential development and SuDS features are located outside of the western flow path.

6.7. The peak flood depths along the flow path are typically shallow, modelled to be approximately 150-170mm along much of the western boundary during the 1% AEP plus climate change event. Depths of up to approximately 250mm are predicted within the deepest areas.

6.8. The peak levels along the flow path range from 102.91m AOD in the north of the Site to 96.5m AOD in the southwest during the 1% AEP plus climate change event. It is recommended that the ground levels and SuDS features within the development platform, as well as residential finished floor levels, are set above the peak modelled flood levels during the 1% AEP plus climate change event with an appropriate freeboard.

6.9. A comparison of the peak flood depths between the baseline and post-development scenarios is shown in **Figure 6-3**. The model results demonstrate the proposals are not predicted to have a detrimental impact on flood risk to third party land, with all increases in peak depths contained within the Site boundary.

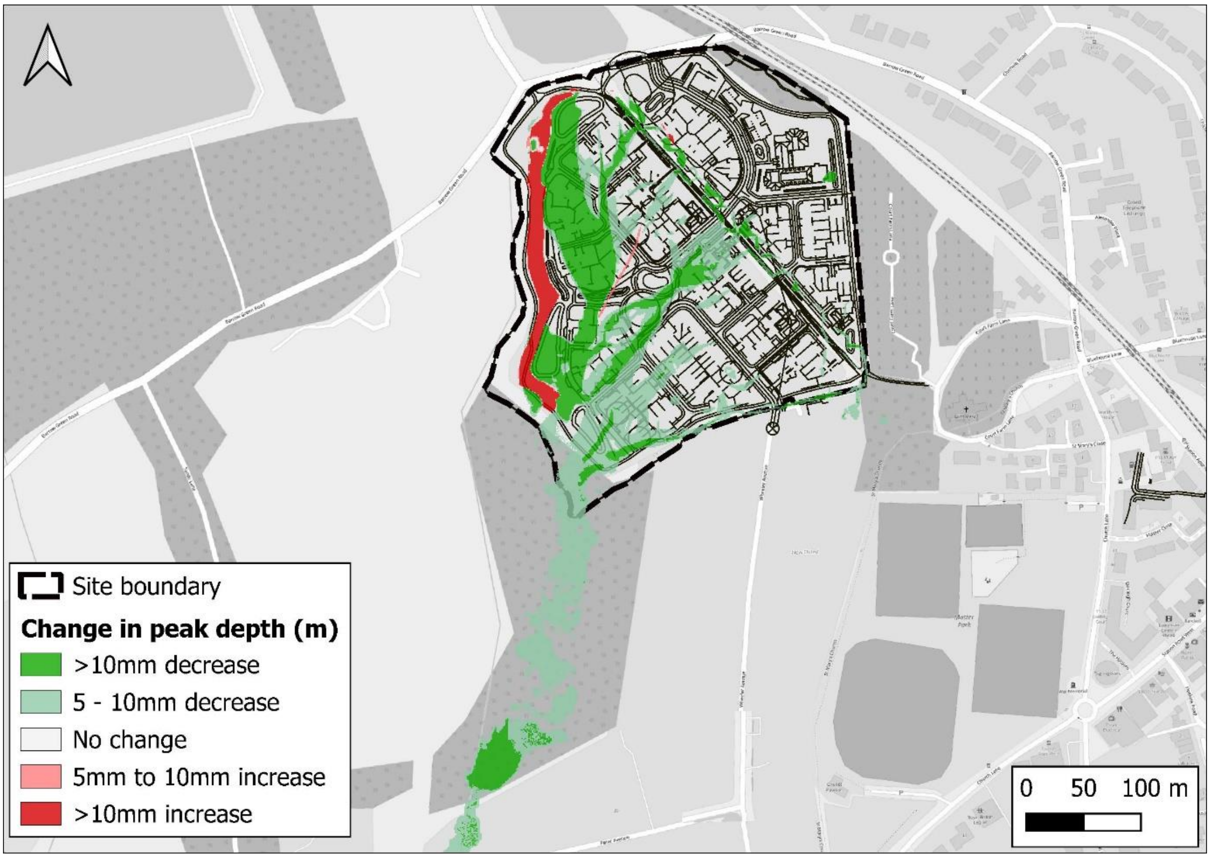


Figure 6-3: Change in peak modelled depths – 1% AEP +45% climate change

6.10. The area to the south of the Site is predicted to show slight benefits due to a reduction in the overall flows leaving the Site associated with the on-site drainage network. The decreases in peak depths are typically around 6-7mm, with an area where decreases of up to 11-12mm are predicted.

6.11. The peak modelled flood hazard during the 1% AEP plus 45% climate change event is shown in **Figure 6-4**.

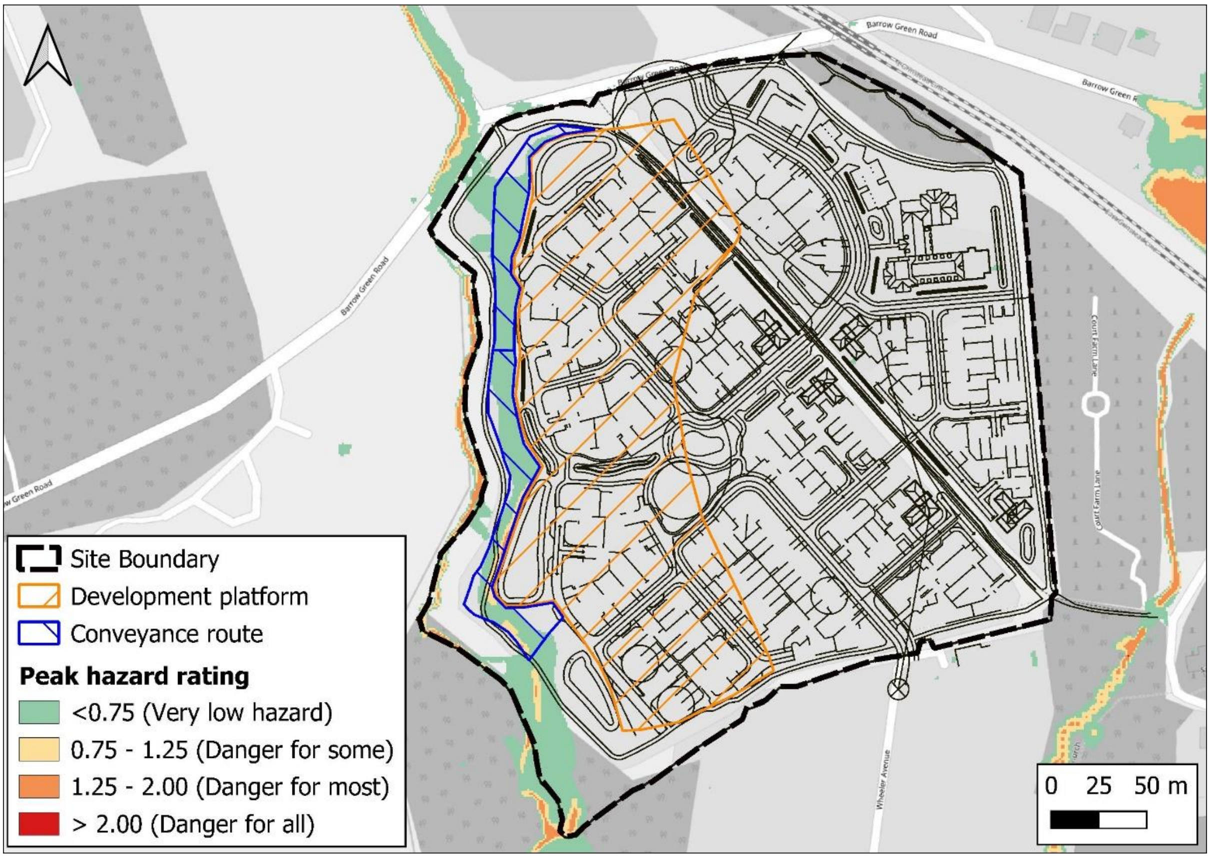


Figure 6-4: Peak modelled hazard rating – 1% AEP +45% climate change

6.12. The hazard rating is modelled to be very low during the 1% AEP plus climate change event along most of the flow path, with small areas at a 'danger for some'. As the development platform and associated accesses are shown to be outside the modelled flood extents the entire Site is provided safe dry access and egress.

7. Summary

7.1. Ardent Consulting Engineers has been instructed by Croudace Homes Limited to undertake surface water hydraulic modelling to support a proposed development at Stoneyfields, Oxted.

7.2. A detailed 1D-2D linked direct rainfall-runoff model has been developed using TUFLOW software to refine the understanding of surface water flood risk to the Site. The model outputs have also been used to inform the Site design and associated flood risk mitigation measures.

7.3. A hydrological analysis has been undertaken to derive rainfall hyetographs for the study area for the 3.3%, 3.3% plus 35% climate change, 1%, 1% plus 45% climate change uplift and 0.1% Annual Exceedance Probability Events.

7.4. A baseline hydraulic model has been built using a combination of LIDAR data, topographical survey data, Ordnance Survey land use data, sewer mapping, and information on the local drainage network obtained during a Site visit.

7.5. During all modelled events overland flows are predicted to enter the northwest corner of the Site, forming a shallow overland flow path that runs north to south through the Site separated from the adjacent watercourse by a slight ridge of higher land along the field boundary. Most of the Site is shown to be at a very low risk of surface water flooding.

7.6. The flow path is predicted to be very flashy with flows only conveyed through the Site for approximately 1.5-2 hours during the design storm for a 1% AEP plus 45% climate change event.

7.7. Post-development modelling was undertaken to assess the potential impacts of reprofiling ground levels so the overland flow path is diverted along the western boundary, away from the proposed residential development in the centre of the Site.

7.8. The ground level reprofiling is modelled to divert the overland flows along the Site western boundary between the watercourse and the modelled development platform, with peak depths of up to approximately 150-250mm during the 1% AEP plus 45% climate change event.

7.9. All residential development and SuDS features are located outside of the western flow path. It is recommended that the ground levels and SuDS features within the development platform, as well as residential finished floor levels, are set above the peak modelled flood levels during the 1% AEP plus climate change event with an appropriate freeboard.

7.10. Comparison between the baseline and post-development model outputs during the 1% AEP plus 45% climate change event demonstrate the proposals are not predicted to have a detrimental impact on flood risk to third parties. The post-development scenario is predicted to result in a decrease in peak depths downstream of up to 11mm.

7.11. The entire Site is provided safe, dry access and egress during a 1% AEP plus 45% climate change flood event for vehicles and pedestrians. The modelled flood hazard along the western conveyance route is predicted to be 'very low' along most of its course.

7.12. Sensitivity testing of Manning's 'n' roughness values, critical storm duration, rainfall intensity, and structure blockage has been carried out. The results of the analysis show that the model is not overly sensitive to changes in these parameters and that the proposed development is appropriate.

7.13. The proposed residential development is compliant with national and local policy in terms of surface water flood risk and will not exacerbate flooding off Site. Therefore, there are no surface water flood risk issues to prevent the development from being implemented.

Appendices

Appendix A – Site visit photographs

Figure A.1 – Ditch along Chalkpit Lane (on left hand side of image)

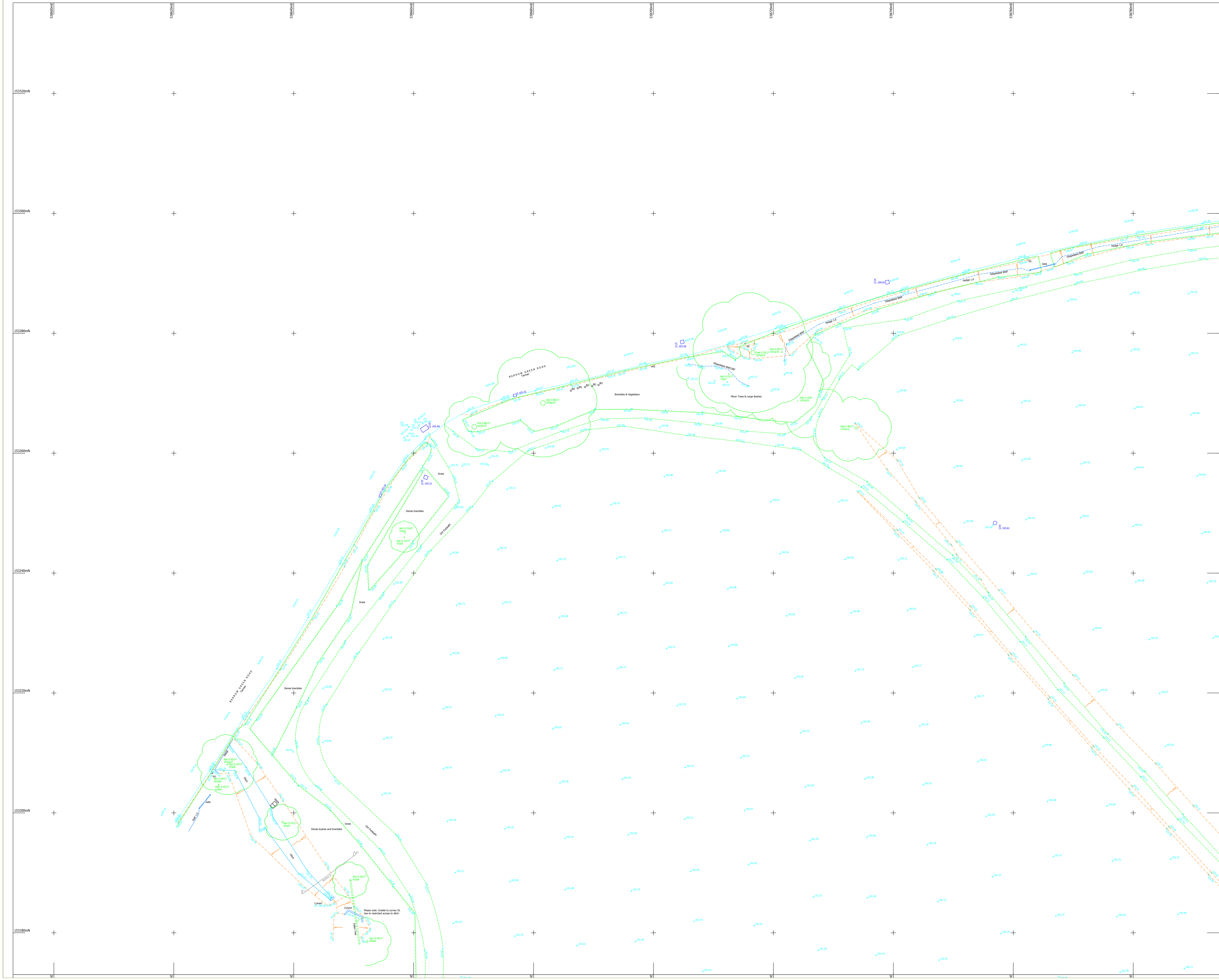
Figure A.2 – Two 225mm culverts identified at downstream end of ditch along Chalkpit Lane / Barrow Green Road

Figure A.3 – Upper reach of watercourse within Site boundary

Figure A.4 – Lower reach of watercourse within Site boundary

Figure A.5 – Culvert under railway line draining to watercourse within adjacent cemetery

Appendix B – Topographic Survey



NOTES:

Drainage:
Inspection Covers are lifted where possible and all drainage invert information has been obtained through visual inspection only, with no entry into manholes. Therefore the complete accuracy cannot be guaranteed. Where drainage is of critical importance we suggest the services of a specialist drainage expert be used.

Trees:
Every effort has been made to identify and detail all trees on site but where trees are of critical importance we suggest the use of a specialist such as an arborist. Tree spread and heights are indicative.

GPS:
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LEGEND

TREE SPECIES INFORMATION

ALDER	ALD	LOCUST	LOC
ASH	ASH	LONDON PLANE	LPN
ASPEN	ASP	MAGNOLIA	MAG
BEECH	BCH	MAPLE	MPL
CEDAR	CED	OAK	OAK
CHERRY	CHY	PINE	PNE
CYPRESS	CYP	POPLAR	POP
ELM	ELM	PRUNUS	PNS
FIR	FIR	RHODODENDRONS	RDN
FRUIT	FRT	ROWAN	RWN
HAWTHORN	HAW	SILVER BIRCH	SIB
HAZEL	HAZ	SORBUS	SOR
HOLLY	HLY	SWEET CHESTNUT	SCH
HORSE CHESTNUT	HCH	SYCAMORE	SYC
HORNBEAM	HRM	WALNUT	WNT
LABURNUM	LRM	WILLOW	WLW
LARCH	LAR	YEW	YEW
LIME	LIM	SPECIES UNKNOWN	SPU
		COPPICED	COP

TREE ANNOTATIONS: Tree Species / Tree Boll Size / No of Bolls
Tree Height / Tree Canopy Spread

FENCE INFORMATION

BARBED WIRE FENCE	BWF
CORRUGATED IRON FENCE	CIF
CLOSE BOARD FENCE	CBF
CHAIN LINK FENCE	CLF
CHESTNUT PALING	CPF
CRASH BARRIER	CBR
HANDRAIL	HDL
IRON RAILINGS	IRF
LARCH LAP FENCE	LLF
MISCELLANEOUS FENCE	MSF
PALISADE FENCE	PSF
PICKET FENCE	PKF
POST AND CHAIN FENCE	PCF
POST AND RAIL FENCE	PRF
POST AND WIRE FENCE	PWF
STOCK WIRE FENCE	SWF
TRELLIS FENCING	TLF

LEVEL INFORMATION

BASEMENT LEVEL	BTL
BED LEVEL	BL
COVER LEVEL	CL
DAMP PROOF COURSE	DPC
FLOOR LEVEL	FL
INVERT LEVEL	IL
OUTFALL LEVEL	OL
THRESHOLD LEVEL	THL
FOUL WATER	FW
SURFACE WATER	SW
UNABLE TO LIFT	UTL
WATER LEVEL	WL

SURFACE INFORMATION

CONCRETE	Conc
BRICK PAVERS	BP
FLOWERBED	FB
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BRITISH TELECOM IC	BTIC	RAIN WATER PIPE	RWP
BUS STOP	BS	RAISED FLOWERBED	RFB
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LITTER BIN	BIN	WATER METER	WM
KERB OUTLET	KO	WATER TAP	Tap
NAME PLATE	NP		

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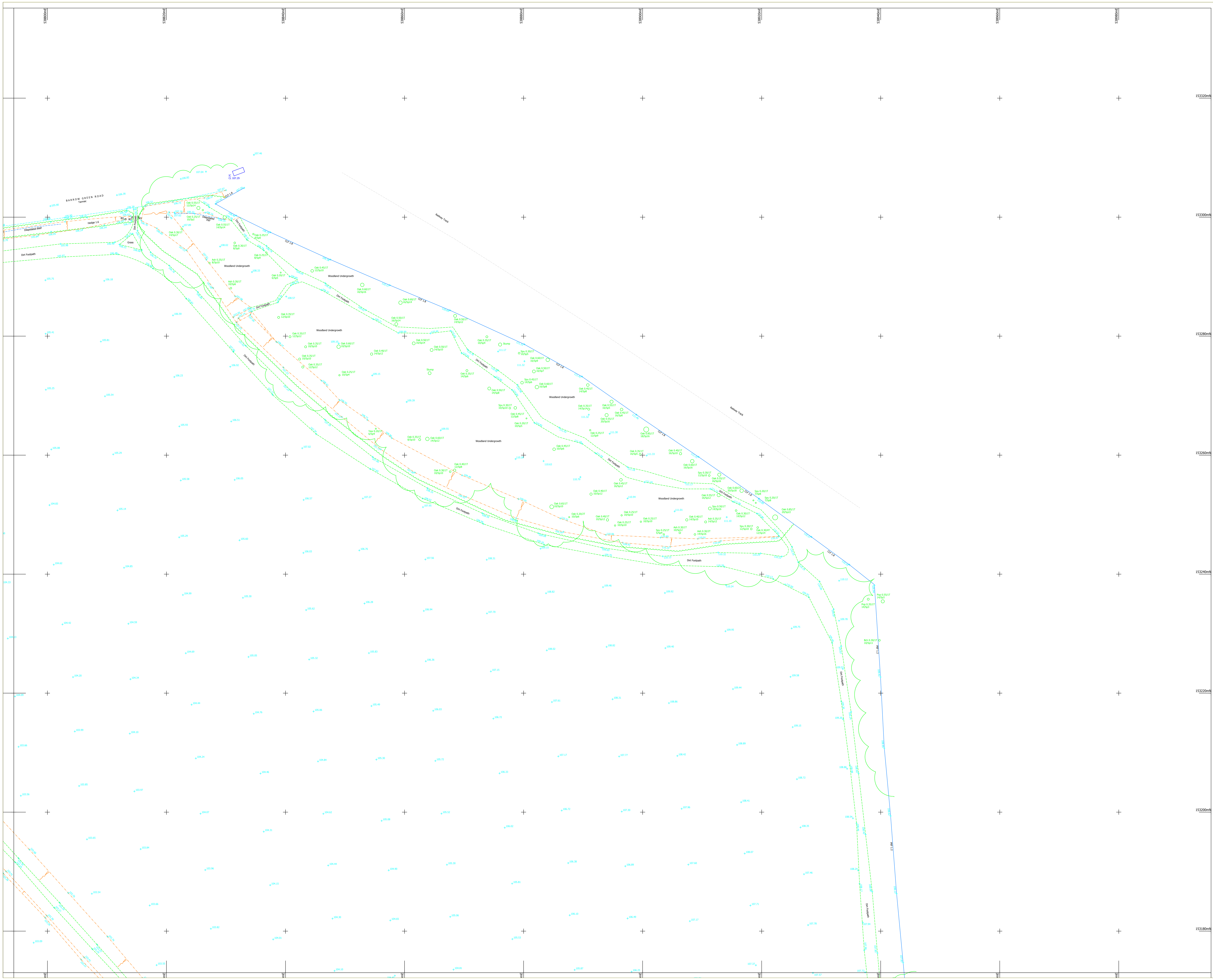
Survey Location:	Stoneyfields Oxted RH8 9LF		
Survey type:	Topographical	Scale:	1:200@A0
Drawing ref:	ENC/220323/2699S1	Date:	March 2023
Drawn/QA:	BF/CH	Plot:	1 of 7



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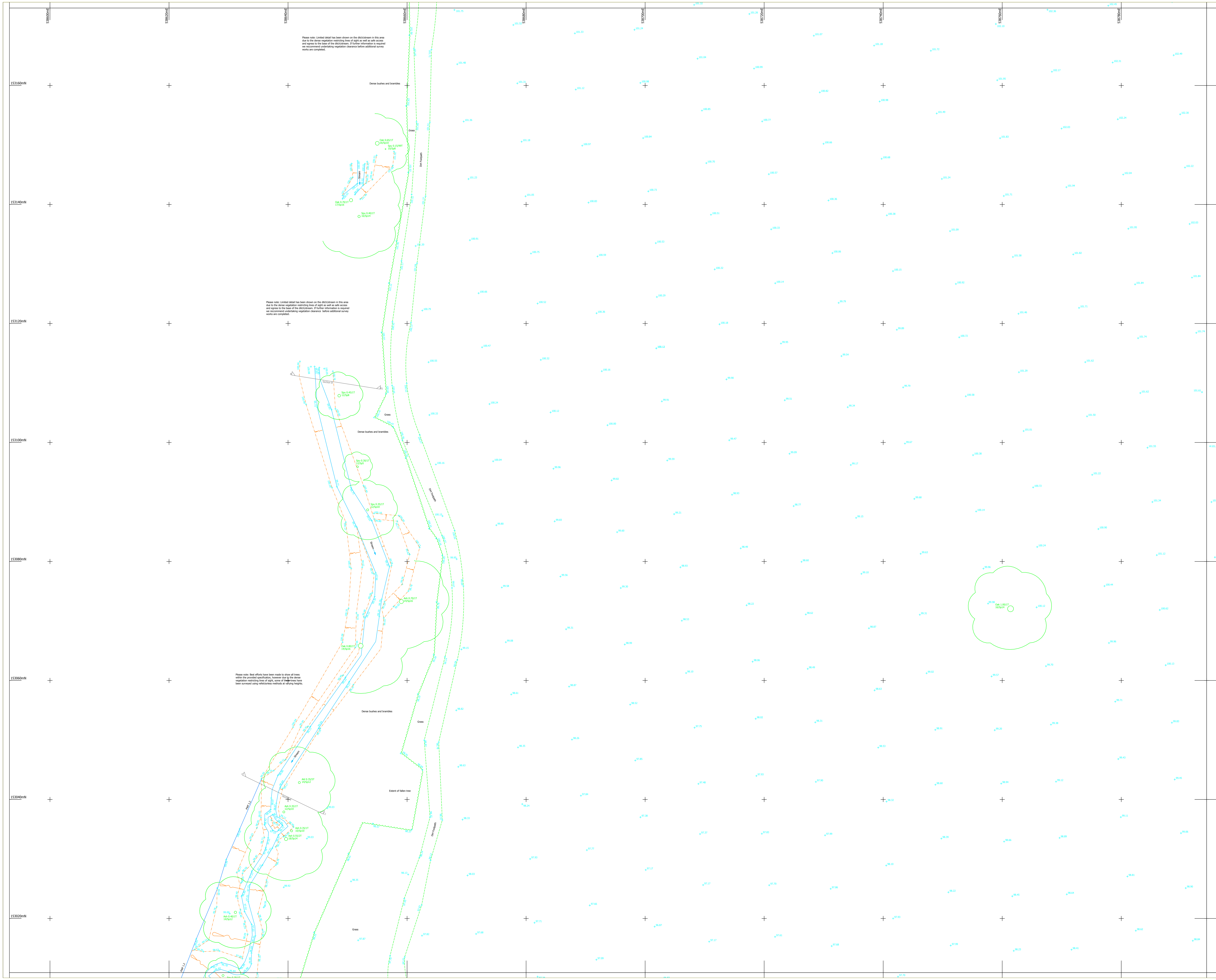

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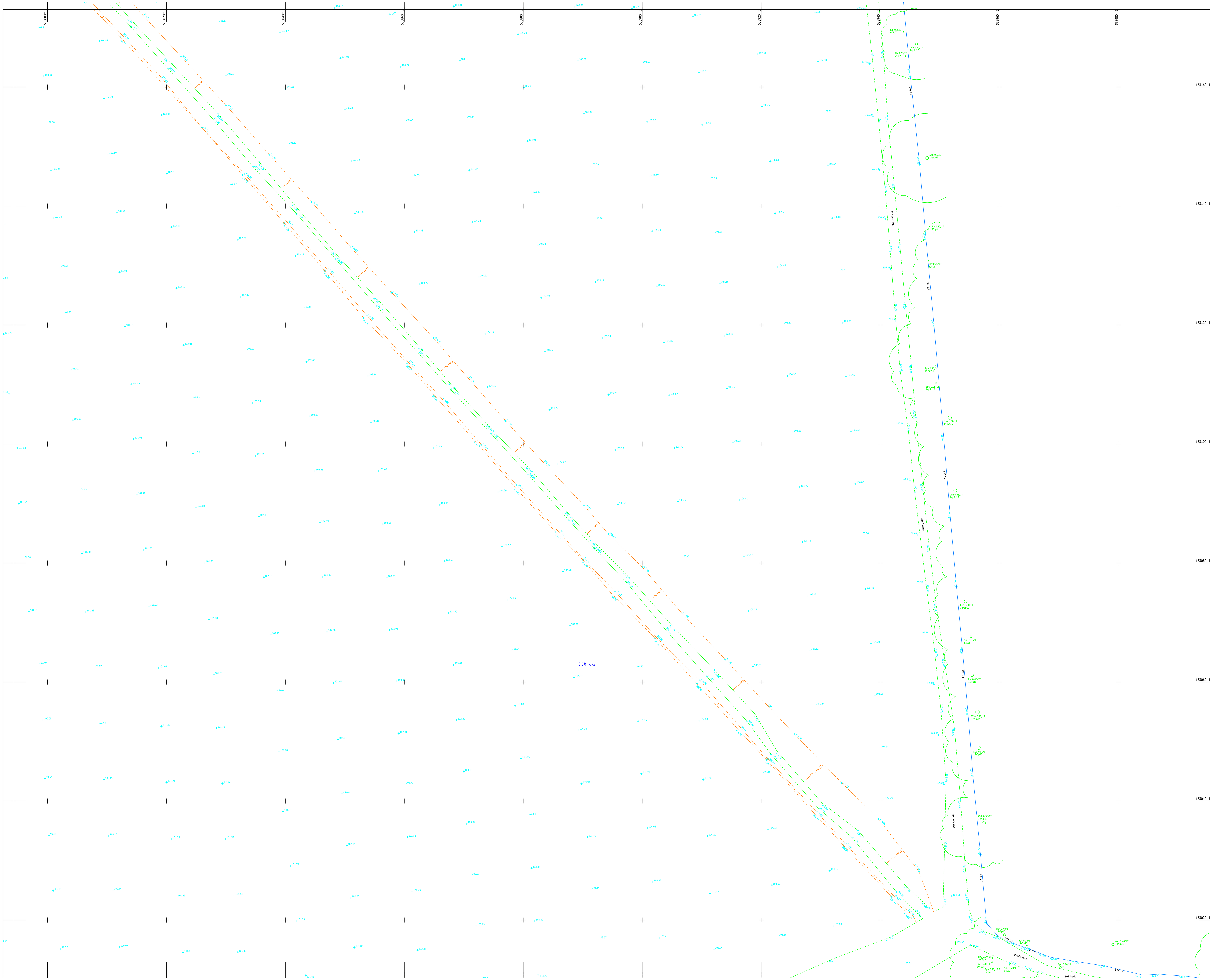

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FLOOR LEVEL	FL
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SURFACE INFORMATION

CONCRETE	Conc
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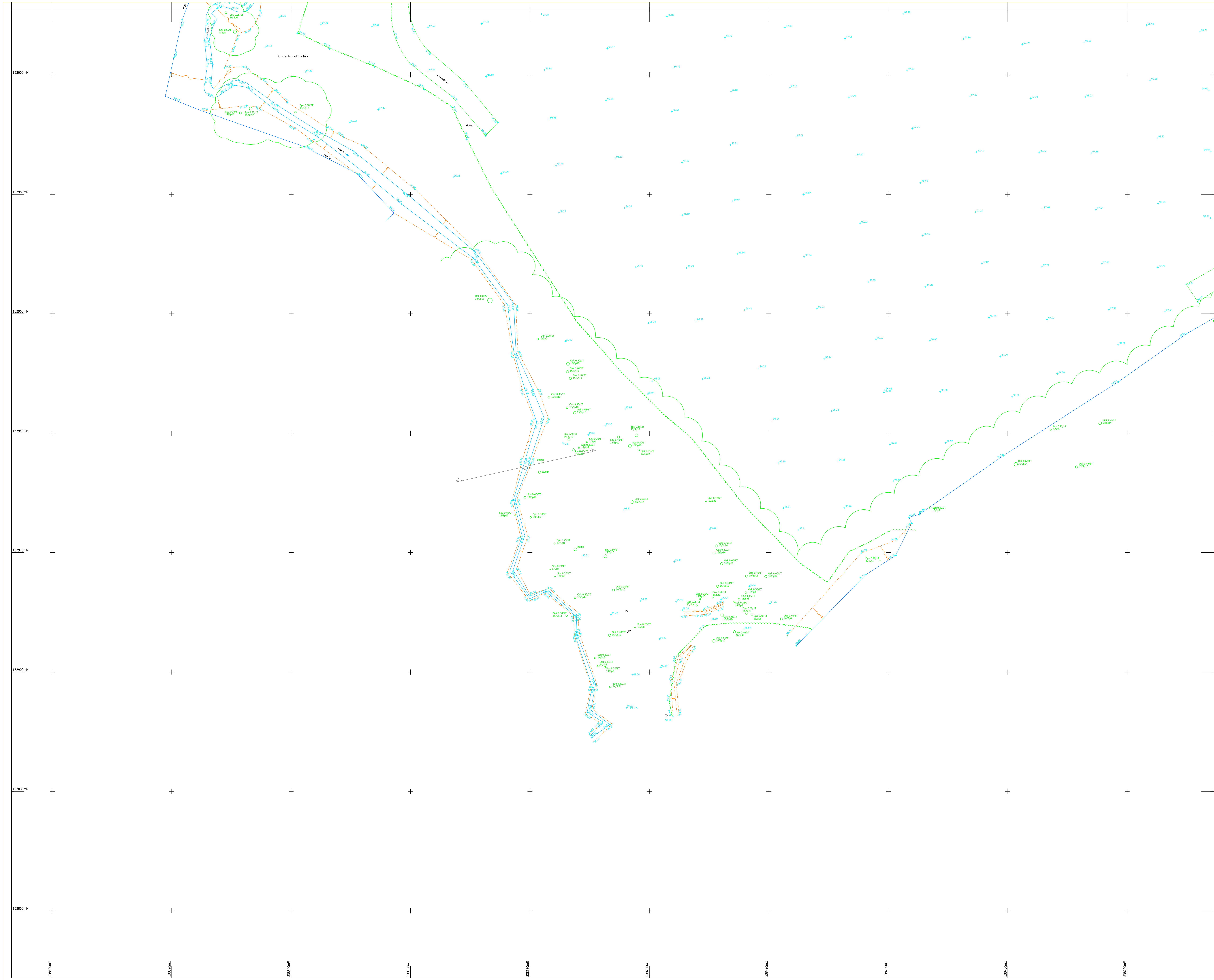

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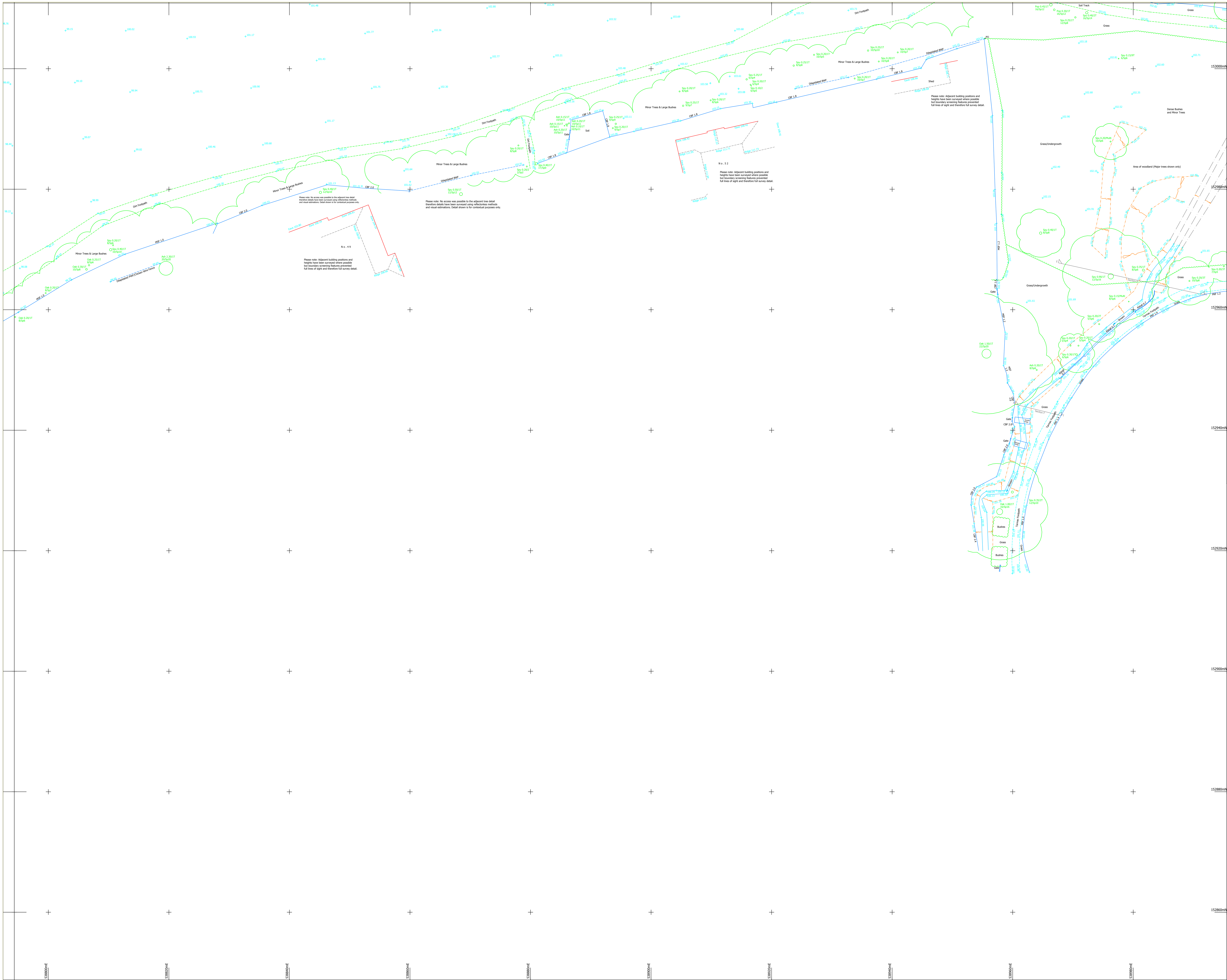

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GPS detail is relative to the time and date of survey. GPS levels and grid are obtained using industry standard guidelines and can vary according to the quality of the GPS network at the time of survey. Unless stated otherwise, surveys are Scale factor 1 and Horizontal and Vertical Datums are established from a central site fix and baseline orientation station utilising GNSS correction data.

Survey notes:
Survey specification is linked to the original purpose of the survey commissioned at source and is to be used for this purpose only. Survey is accurate within limitations of site conditions at the time of survey. In areas difficult to survey due to restricted access, lines of sight or dense vegetation, critical dimensions and positions should be verified following suitable clearance.
Survey detail obtained and shown is relative to the plotting scale.

LEGEND

TREE SPECIES INFORMATION

ALDER	ALD	LOCUST	LOC
ASH	ASH	LONDON PLANE	LPN
ASPEN	ASP	MAGNOLIA	MAG
BEECH	BCH	MAPLE	MPL
CEDAR	CED	OAK	OAK
CHERRY	CHY	PINE	PNE
CYPRESS	CYP	POPLAR	POP
ELM	ELM	PRUNUS	PNS
FIR	FIR	RHODODENDRONS	RDN
FRUIT	FRT	ROWAN	RWN
HAWTHORN	HAW	SILVER BIRCH	SIB
HAZEL	HAZ	SORBUS	SOR
HOLLY	HLY	SWEET CHESTNUT	SCH
HORSE CHESTNUT	HCH	SYCAMORE	SYC
HORNBEAM	HRM	WALNUT	WNT
LABURNUM	LRM	WILLOW	WLW
LARCH	LAR	YEW	YEW
LIME	LIM	SPECIES UNKNOWN	SPU
		COPPICED	COP

TREE ANNOTATIONS: Tree Species / Tree Boll Size / No of Bolls
Tree Height / Tree Canopy Spread

FENCE INFORMATION

BARBED WIRE FENCE	BWF
CORRUGATED IRON FENCE	CIF
CLOSE BOARD FENCE	CBF
CHAIN LINK FENCE	CLF
CHESTNUT PALING	CPF
CRASH BARRIER	CBR
HANDRAIL	HDL
IRON RAILINGS	IRF
LARCH LAP FENCE	LLF
MISCELLANEOUS FENCE	MSF
PALISADE FENCE	PSF
PICKET FENCE	PKF
POST AND CHAIN FENCE	PCF
POST AND RAIL FENCE	PRF
POST AND WIRE FENCE	PWF
STOCK WIRE FENCE	SWF
TRELLIS FENCING	TLF

LEVEL INFORMATION

BASEMENT LEVEL	BTL
BED LEVEL	BL
COVER LEVEL	CL
DAMP PROOF COURSE	DPC
FLOOR LEVEL	FL
INVERT LEVEL	IL
OUTFALL LEVEL	OL
THRESHOLD LEVEL	THL
FOUL WATER	FW
SURFACE WATER	SW
UNABLE TO LIFT	UTL
WATER LEVEL	WL

SURFACE INFORMATION

CONCRETE	Conc
BRICK PAVERS	BP
FLOWERBED	FB
PAVING SLABS	PS
RETAINING WALL	RWall
TACTILE PAVING	Tac

FEATURE INFORMATION

BOLLARD	BO	NOTICE BOARD	NB
BRITISH TELECOM BOX	BTB	POST	P
BRITISH TELECOM IC	BTIC	RAIN WATER PIPE	RWP
BUS STOP	BS	RAISED FLOWERBED	RFB
CABLE TELEVISION BOX	CATB	ROAD SIGN	RS
CABLE TELEVISION IC	CATV	RODDING EYE	RE
EARTHING ROD	ER	SERVICE MARKER POST	SMP
ELECTRICITY CABLE PIT	ELCP	SOIL VENT PIPE	SVP
ELECTRICITY CONTROL BOX	ECB	STOP COCK	SC
ELECTRICITY POLE	EP	STOP VALVE	SV
FIRE HYDRANT	FH	TELEGRAPH POLE	TP
INSPECTION COVER	IC	TELEPHONE CALL BOX	TCB
LAMP POST	LP	TRAFFIC SIGNAL	TS
LETTER BOX	LB	TRAFFIC SIGNALS IC	TSIC
LITTER BIN	BIN	WATER METER	WM
KERB OUTLET	KO	WATER TAP	Tap
NAME PLATE	NP		

Level Datum:
Levels are related to OSGB15 derived from the GPS network

Grid:
Grid is related to OSGB15 derived from the GPS network

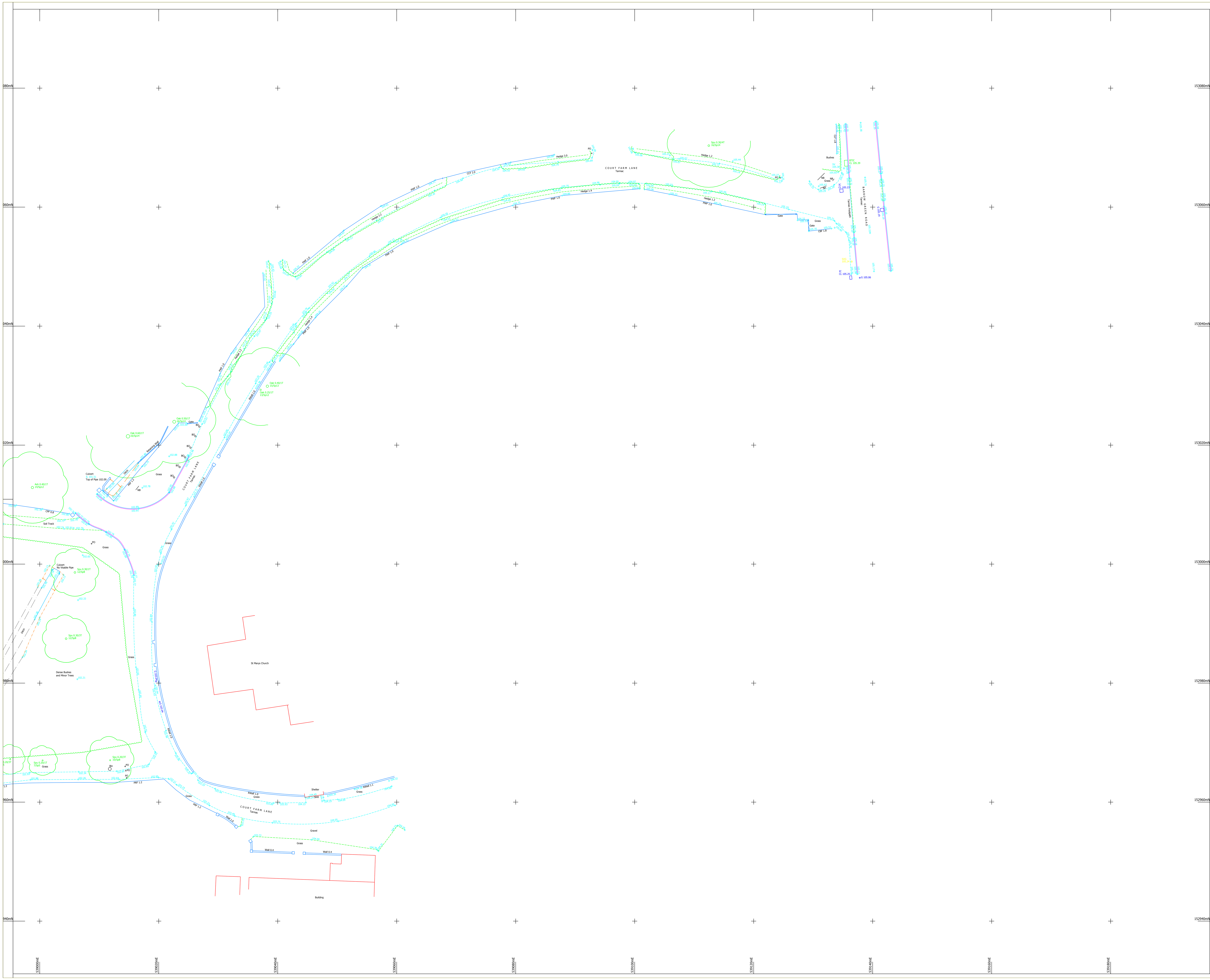
Northpoint:

ENCOMPASS SURVEYS

Encompass Surveys Ltd
Unit 2
Talisman Business Centre
Duncan Road
Park Gate, Southampton
Hampshire SO31 7GA

Tel: 023 80692002 Email: info@encompass-surveys.co.uk
Fax: 023 80697125 Website: encompass-surveys.co.uk

Client:	Croudace Homes		
Survey Location:	Stoneyfields Oxted RH8 9LF		
Survey type:	Topographical	Scale:	1:200@A0
Drawing ref:	ENC/220323/2699S1	Date:	March 2023
Drawn/QA:	BF/CH	Plot:	6 of 7



NOTES:

Drainage:
Inspection Covers are lifted where possible and all drainage invert information has been obtained through visual inspection only, with no entry into manholes. Therefore the complete accuracy cannot be guaranteed. Where drainage is of critical importance we suggest the services of a specialist drainage expert be used.

Trees:
Every effort has been made to identify and detail all trees on site but where trees are of critical importance we suggest the use of a specialist such as an arborist. Tree spread and heights are indicative.

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CYPRESS	CYP	POPLAR	POP
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FRUIT	FRT	ROWAN	RWN
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HAZEL	HAZ	SORBUS	SOR
HOLLY	HLY	SWEET CHESTNUT	SCH
HORSE CHESTNUT	HCH	SYCAMORE	SYC
HORNBEAM	HRM	WALNUT	WNT
LABURNUM	LRM	WILLOW	WLW
LARCH	LAR	YEW	YEW
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		COPPICED	COP

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Tree Height / Tree Canopy Spread

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CHESTNUT PALING	CPF
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HANDRAIL	HDL
IRON RAILINGS	IRF
LARCH LAP FENCE	LLF
MISCELLANEOUS FENCE	MSF
PALISADE FENCE	PSF
PICKET FENCE	PKF
POST AND CHAIN FENCE	PCF
POST AND RAIL FENCE	PRF
POST AND WIRE FENCE	PWF
STOCK WIRE FENCE	SWF
TRELLIS FENCING	TLF

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BED LEVEL	BL
COVER LEVEL	CL
DAMP PROOF COURSE	DPC
FLOOR LEVEL	FL
INVERT LEVEL	IL
OUTFALL LEVEL	OL
THRESHOLD LEVEL	THL
FOUL WATER	FW
SURFACE WATER	SW
UNABLE TO LIFT	UTL
WATER LEVEL	WL

SURFACE INFORMATION

CONCRETE	Conc
BRICK PAVERS	BP
FLOWERBED	FB
PAVING SLABS	PS
RETAINING WALL	RWall
TACTILE PAVING	Tac

FEATURE INFORMATION

BOLLARD	BO	NOTICE BOARD	NB
BRITISH TELECOM BOX	BTB	POST	P
BRITISH TELECOM IC	BTIC	RAIN WATER PIPE	RWP
BUS STOP	BS	RAISED FLOWERBED	RFB
CABLE TELEVISION BOX	CATB	ROAD SIGN	RS
CABLE TELEVISION IC	CATV	RODDING EYE	RE
EARTHING ROD	ER	SERVICE MARKER POST	SMP
ELECTRICITY CABLE PIT	ELCP	SOIL VENT PIPE	SVP
ELECTRICITY CONTROL BOX	ECB	STOP COCK	SC
ELECTRICITY POLE	EP	STOP VALVE	SV
FIRE HYDRANT	FH	TELEGRAPH POLE	TP
INSPECTION COVER	IC	TELEPHONE CALL BOX	TCB
LAMP POST	LP	TRAFFIC SIGNAL	TS
LETTER BOX	LB	TRAFFIC SIGNALS IC	TSIC
LITTER BIN	BIN	WATER METER	WM
KERB OUTLET	KO	WATER TAP	Tap
NAME PLATE	NP		

Level Datum:
Levels are related to OSGB15 derived from the GPS network

Grid:
Grid is related to OSGB15 derived from the GPS network

Northpoint:

Encompass Surveys Ltd
Unit 2
Talisman Business Centre
Duncan Road
Park Gate, Southampton
Hampshire SO31 7GA

Tel: 023 80692002 Email: info@encompass-surveys.co.uk
Fax: 023 80697125 Website: encompass-surveys.co.uk

Client:	Croudace Homes		
Survey Location:	Stoneyfields Oxted RH8 9LF		
Survey type:	Topographical	Scale:	1:200@A0
Drawing ref:	ENC/220323/2699S1	Date:	March 2023
Drawn/QA:	BF/CH	Plot:	7 of 7

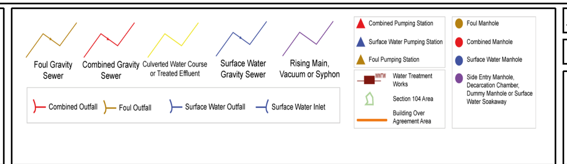
Appendix C – Southern Water Asset Mapping

Date: 29/07/24
Scale: 1:1250
Map Centre: 538698,153568
Data updated: 23/07/24
Our Ref: 1532209 - 1
Wastewater Plan A0
Powered by digdat

The positions of pipes shown on this plan are believed to be correct, but Southern Water Services Ltd accept no responsibility in the event of inaccuracy. The actual positions should be determined on site. This plan is produced by Southern Water Services Ltd (c) Crown copyright and database rights 2024 Ordnance Survey 100031673 .This map is to be used for the purposes of viewing the location of Southern Water plant only. Any other uses of the map data or further copies is not permitted.

WARNING: BAC pipes are constructed of Bonded Asbestos Cement.

WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement.



jaxton@ardent-ce.co.uk

Oxted

WATER for LIFE from Southern Water.

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
5101	C	0.00	0.00	
5102	C	0.00	0.00	
5103	C	0.00	0.00	
5104	C	0.00	0.00	
6101	C	0.00	0.00	
6202	C	0.00	0.00	
0201	F	107.96	105.80	
0202	F	109.53	105.38	
0203	F	0.00	0.00	
0204	F	0.00	0.00	
0205	F	0.00	0.00	
0206	F	0.00	0.00	
0207	F	0.00	0.00	
0208	F	0.00	0.00	
0209	F	0.00	0.00	
0301	F	110.35	108.14	
0302	F	0.00	0.00	
0303	F	0.00	0.00	
0401	F	117.23	115.19	
0402	F	112.61	110.18	
0403	F	112.96	110.52	
0501	F	122.16	119.91	
0502	F	120.83	118.70	
0505	F	0.00	0.00	
0506	F	0.00	0.00	
0507	F	0.00	0.00	
0508	F	0.00	0.00	
0601	F	123.23	121.73	
1101	F	110.67	104.97	
1102	F	105.95	103.98	
1104	F	0.00	0.00	
1201	F	0.00	0.00	
1202	F	0.00	0.00	
1301	F	111.68	109.58	
1302	F	109.31	107.45	
1501	F	119.67	116.92	
1502	F	119.24	116.73	
1503	F	118.92	116.67	
1504	F	119.66	116.29	
1505	F	118.32	116.09	
1506	F	0.00	0.00	
1507	F	0.00	0.00	
1508	F	0.00	0.00	
1509	F	0.00	0.00	
1510	F	0.00	0.00	
1511	F	0.00	0.00	
1512	F	0.00	0.00	
1601	F	120.98	119.10	
1602	F	119.30	117.47	
1603	F	118.74	0.00	
1604	F	123.93	122.47	
1605	F	121.85	119.90	
1609	F	0.00	0.00	
1610	F	0.00	0.00	
1701	F	122.79	120.75	
1702	F	0.00	0.00	
1703	F	0.00	0.00	
1704	F	0.00	0.00	
1705	F	0.00	0.00	
1706	F	0.00	0.00	
2003	F	0.00	0.00	
2101	F	109.44	106.53	
2102	F	0.00	0.00	
2104	F	0.00	0.00	
2105	F	0.00	0.00	
2106	F	0.00	0.00	
2201	F	114.64	112.72	
2202	F	114.60	0.00	
2601	F	0.00	0.00	
2602	F	0.00	0.00	
3201	F	0.00	0.00	
3202	F	0.00	0.00	
3203	F	0.00	0.00	
3601	F	115.97	113.73	
4601	F	114.53	112.83	
4602	F	113.76	112.29	
4603	F	113.49	111.81	
4604	F	113.37	111.41	
4605	F	114.34	112.38	
4701	F	119.66	117.59	
4702	F	117.51	115.59	
4801	F	121.55	119.41	
5301	F	104.84	102.81	
5401	F	109.36	106.28	
5402	F	108.13	106.03	
5403	F	107.18	105.28	
5501	F	110.13	0.00	
5502	F	109.16	107.18	
5504	F	0.00	0.00	
5505	F	0.00	0.00	
5506	F	0.00	0.00	
5601	F	114.76	113.10	
5701	F	120.13	118.78	
5702	F	117.74	116.23	
5703	F	0.00	0.00	
6201	F	103.51	101.79	
6301	F	103.59	102.06	
6401	F	109.62	106.97	
6402	F	108.97	106.50	
6501	F	110.27	108.80	
6601	F	112.26	110.77	
6602	F	0.00	0.00	
6603	F	0.00	0.00	
6701	F	121.42	119.72	
6702	F	117.26	115.85	
6801	F	0.00	0.00	
6802	F	0.00	0.00	
7201	F	103.52	101.56	
7202	F	103.97	101.39	
7203	F	103.60	101.11	
7204	F	103.95	100.87	
7401	F	110.25	107.45	
7402	F	110.46	107.14	
7501	F	112.34	110.14	
7502	F	111.85	108.93	
7601	F	113.27	111.95	
7602	F	115.09	113.64	
7603	F	115.29	112.78	
7604	F	0.00	0.00	
7605	F	0.00	0.00	
7606	F	0.00	0.00	
7801	F	122.36	120.28	
8101	F	104.29	100.37	
8301	F	112.10	110.87	
8302	F	111.71	109.14	
8303	F	111.42	108.49	
8304	F	111.63	108.76	
8305	F	112.11	108.23	
8306	F	109.08	107.51	
8307	F	106.88	105.35	
8309	F	0.00	0.00	
8310	F	0.00	0.00	
8401	F	114.19	111.03	
8402	F	112.68	0.00	
8403	F	0.00	0.00	
8501	F	115.01	112.20	
8502	F	0.00	0.00	
8503	F	0.00	0.00	
8504	F	0.00	0.00	
8601	F	117.89	116.37	
8602	F	115.94	114.41	
8603	F	0.00	0.00	
8604	F	119.82	118.96	
8701	F	121.88	120.45	
8702	F	118.93	117.50	
8703	F	0.00	0.00	
8801	F	0.00	0.00	
9201	F	109.46	0.00	
9202	F	109.68	0.00	
9203	F	0.00	0.00	
9301	F	112.33	108.02	
9302	F	111.01	107.86	

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
9601	F	122.00	120.07	
9602	F	120.33	118.03	
9603	F	120.20	118.78	
9604	F	120.35	118.40	
9701	F	124.76	123.34	
9702	F	123.17	121.42	
0350	S	110.31	108.58	
0351	S	113.70	112.16	
0450	S	117.39	115.53	
0451	S	113.39	111.24	
0452	S	112.46	110.22	
0453	S	113.82	112.58	
0550	S	122.09	120.16	
0551	S	121.11	119.53	
0552	S	120.77	118.86	
0553	S	117.37	116.13	
0650	S	124.08	122.37	
0651	S	125.22	0.00	
0652	S	0.00	0.00	
1350	S	110.37	109.12	
1351	S	0.00	0.00	
1352	S	109.47	108.56	
1353	S	109.65	108.30	
1354	S	109.33	107.82	
1355	S	109.67	108.48	
1450	S	112.95	112.12	
1550	S	119.53	116.90	
1551	S	119.21	116.88	
1552	S	117.75	116.76	
1650	S	121.03	119.43	
1651	S	119.24	117.92	
1652	S	118.69	117.63	
1653	S	123.74	0.00	
1654	S	121.74	119.09	
1750	S	123.55	121.89	
1751	S	122.86	121.17	
2350	S	0.00	0.00	
5350	S	0.00	0.00	
5450	S	107.25	105.48	
5451	S	0.00	0.00	
6150	S	102.64	100.19	
6251	S	103.38	101.32	
6252	S	103.55	100.62	
6350	S	0.00	0.00	
6351	S	0.00	0.00	
6352	S	104.70	0.00	
6450	S	109.16	107.29	
6650	S	0.00	0.00	
6750	S	118.00	116.47	
6850	S	121.68	119.87	
7450	S	110.21	108.35	
7451	S	110.58	108.64	
7550	S	112.38	110.78	
7551	S	111.87	0.00	
7650	S	115.42	113.90	
7651	S	115.14	113.24	
7652	S	112.79	0.00	
7653	S	113.19	111.32	
7654	S	112.76	111.24	
7750	S	118.82	117.35	
7751	S	118.73	116.65	
7850	S	122.40	120.39	
8550	S	118.97	117.56	
8551	S	119.04	117.20	
8552	S	118.50	116.90	
8650	S	118.02	116.16	
8651	S	117.34	115.58	
8652	S	117.18	115.63	
8653	S	0.00	0.00	
8654	S	117.28	116.39	
8656	S	118.50	116.81	
8657	S	118.00	116.60	
8658	S	120.20	118.14	
8751	S	121.85	120.02	
9350	S	114.17	112.44	
9651	S	122.10	120.17	
9652	S	120.40	118.10	
9653	S	120.40	118.87	
9654	S	120.39	118.38	
9750	S	123.07	121.54	
9751	S	124.90	123.53	

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Appendix D – 1% AEP plus climate change ReFH2 outputs

UK Design Flood Estimation

Generated on 27 November 2024 13:45:27 by jaxton
Printed from the ReFH2 Flood Modelling software package, version 4.1.8879.22310

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH2)

Site details Checksum: F423-9362

Site name: FEH_Catchment_Descriptors_538600_152450_v5_0_1_Edit

Easting: 538600

Northing: 152450

Country: England, Wales or Northern Ireland

Catchment Area (km²): 2.28

Using plot scale calculations: No

Model: 2.3

Site description: None

Model run: 30 year

Summary of results

Rainfall - FEH22 (mm):	43.75	Total runoff (ML):	15.92
Total Rainfall (mm):	27.56	Total flow (ML):	40.71
Peak Rainfall (mm):	7.50	Peak flow (m³/s):	1.58

Parameters

Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.
** Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH22)

Name	Value	User-defined?
Duration (hh:mm:ss)	02:15:00 [03:15:00]	Yes
Timestep (hh:mm:ss)	00:15:00	No
SCF (Seasonal correction factor)	0.66	No
ARF (Areal reduction factor)	0.96	No
Seasonality	Winter	No

Loss model parameters

Name	Value	User-defined?
Cini (mm)	83.47	No
Cmax (mm)	508.54	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	1.78	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.05	No
BL (hr)	38.87	No
BR	2.43	No

Urbanisation parameters

Name	Value	User-defined?
Sewer capacity (m^3/s)	0	No
Exporting drained area (km^2)	0	No
Urban area (km^2)	0.63	No
Effective URBEXT2000	0.18	n/a
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m³/s)	Net Rain (mm)	Runoff (m³/s)	Baseflow (m³/s)	Total Flow (m³/s)
00:00:00	0.788	0.000	0.178	0.000	0.041	0.041
00:15:00	1.478	0.000	0.343	0.004	0.041	0.045
00:30:00	2.748	0.000	0.648	0.019	0.041	0.060
00:45:00	5.020	0.000	1.218	0.057	0.041	0.097
01:00:00	7.496	0.000	1.905	0.136	0.041	0.177
01:15:00	5.020	0.000	1.332	0.283	0.042	0.325
01:30:00	2.748	0.000	0.749	0.499	0.045	0.544
01:45:00	1.478	0.000	0.408	0.752	0.050	0.802
02:00:00	0.788	0.000	0.219	1.011	0.057	1.068
02:15:00	0.000	0.000	0.000	1.245	0.066	1.310
02:30:00	0.000	0.000	0.000	1.414	0.077	1.491
02:45:00	0.000	0.000	0.000	1.488	0.089	1.578
03:00:00	0.000	0.000	0.000	1.473	0.103	1.576
03:15:00	0.000	0.000	0.000	1.384	0.117	1.501
03:30:00	0.000	0.000	0.000	1.254	0.131	1.385
03:45:00	0.000	0.000	0.000	1.108	0.143	1.251
04:00:00	0.000	0.000	0.000	0.968	0.155	1.122
04:15:00	0.000	0.000	0.000	0.838	0.164	1.003
04:30:00	0.000	0.000	0.000	0.720	0.173	0.893
04:45:00	0.000	0.000	0.000	0.614	0.180	0.794
05:00:00	0.000	0.000	0.000	0.520	0.186	0.706
05:15:00	0.000	0.000	0.000	0.435	0.191	0.626
05:30:00	0.000	0.000	0.000	0.357	0.195	0.553
05:45:00	0.000	0.000	0.000	0.288	0.199	0.487
06:00:00	0.000	0.000	0.000	0.228	0.202	0.430
06:15:00	0.000	0.000	0.000	0.181	0.205	0.385
06:30:00	0.000	0.000	0.000	0.141	0.206	0.347
06:45:00	0.000	0.000	0.000	0.106	0.207	0.314
07:00:00	0.000	0.000	0.000	0.076	0.208	0.283
07:15:00	0.000	0.000	0.000	0.048	0.208	0.256
07:30:00	0.000	0.000	0.000	0.027	0.207	0.234
07:45:00	0.000	0.000	0.000	0.013	0.206	0.219
08:00:00	0.000	0.000	0.000	0.005	0.205	0.210
08:15:00	0.000	0.000	0.000	0.002	0.204	0.205

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
08:30:00	0.000	0.000	0.000	0.000	0.203	0.203
08:45:00	0.000	0.000	0.000	0.000	0.201	0.201
09:00:00	0.000	0.000	0.000	0.000	0.200	0.200
09:15:00	0.000	0.000	0.000	0.000	0.199	0.199
09:30:00	0.000	0.000	0.000	0.000	0.197	0.197
09:45:00	0.000	0.000	0.000	0.000	0.196	0.196
10:00:00	0.000	0.000	0.000	0.000	0.195	0.195
10:15:00	0.000	0.000	0.000	0.000	0.194	0.194
10:30:00	0.000	0.000	0.000	0.000	0.192	0.192
10:45:00	0.000	0.000	0.000	0.000	0.191	0.191
11:00:00	0.000	0.000	0.000	0.000	0.190	0.190
11:15:00	0.000	0.000	0.000	0.000	0.189	0.189
11:30:00	0.000	0.000	0.000	0.000	0.187	0.187
11:45:00	0.000	0.000	0.000	0.000	0.186	0.186
12:00:00	0.000	0.000	0.000	0.000	0.185	0.185
12:15:00	0.000	0.000	0.000	0.000	0.184	0.184
12:30:00	0.000	0.000	0.000	0.000	0.183	0.183
12:45:00	0.000	0.000	0.000	0.000	0.182	0.182
13:00:00	0.000	0.000	0.000	0.000	0.180	0.180
13:15:00	0.000	0.000	0.000	0.000	0.179	0.179
13:30:00	0.000	0.000	0.000	0.000	0.178	0.178
13:45:00	0.000	0.000	0.000	0.000	0.177	0.177
14:00:00	0.000	0.000	0.000	0.000	0.176	0.176
14:15:00	0.000	0.000	0.000	0.000	0.175	0.175
14:30:00	0.000	0.000	0.000	0.000	0.174	0.174
14:45:00	0.000	0.000	0.000	0.000	0.172	0.172
15:00:00	0.000	0.000	0.000	0.000	0.171	0.171
15:15:00	0.000	0.000	0.000	0.000	0.170	0.170
15:30:00	0.000	0.000	0.000	0.000	0.169	0.169
15:45:00	0.000	0.000	0.000	0.000	0.168	0.168
16:00:00	0.000	0.000	0.000	0.000	0.167	0.167
16:15:00	0.000	0.000	0.000	0.000	0.166	0.166
16:30:00	0.000	0.000	0.000	0.000	0.165	0.165
16:45:00	0.000	0.000	0.000	0.000	0.164	0.164
17:00:00	0.000	0.000	0.000	0.000	0.163	0.163

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m³/s)	Net Rain (mm)	Runoff (m³/s)	Baseflow (m³/s)	Total Flow (m³/s)
17:15:00	0.000	0.000	0.000	0.000	0.162	0.162
17:30:00	0.000	0.000	0.000	0.000	0.161	0.161
17:45:00	0.000	0.000	0.000	0.000	0.160	0.160
18:00:00	0.000	0.000	0.000	0.000	0.159	0.159
18:15:00	0.000	0.000	0.000	0.000	0.158	0.158
18:30:00	0.000	0.000	0.000	0.000	0.157	0.157
18:45:00	0.000	0.000	0.000	0.000	0.156	0.156
19:00:00	0.000	0.000	0.000	0.000	0.155	0.155
19:15:00	0.000	0.000	0.000	0.000	0.154	0.154
19:30:00	0.000	0.000	0.000	0.000	0.153	0.153
19:45:00	0.000	0.000	0.000	0.000	0.152	0.152
20:00:00	0.000	0.000	0.000	0.000	0.151	0.151
20:15:00	0.000	0.000	0.000	0.000	0.150	0.150
20:30:00	0.000	0.000	0.000	0.000	0.149	0.149
20:45:00	0.000	0.000	0.000	0.000	0.148	0.148
21:00:00	0.000	0.000	0.000	0.000	0.147	0.147
21:15:00	0.000	0.000	0.000	0.000	0.146	0.146
21:30:00	0.000	0.000	0.000	0.000	0.145	0.145
21:45:00	0.000	0.000	0.000	0.000	0.144	0.144
22:00:00	0.000	0.000	0.000	0.000	0.143	0.143
22:15:00	0.000	0.000	0.000	0.000	0.142	0.142
22:30:00	0.000	0.000	0.000	0.000	0.141	0.141
22:45:00	0.000	0.000	0.000	0.000	0.140	0.140
23:00:00	0.000	0.000	0.000	0.000	0.139	0.139
23:15:00	0.000	0.000	0.000	0.000	0.139	0.139
23:30:00	0.000	0.000	0.000	0.000	0.138	0.138
23:45:00	0.000	0.000	0.000	0.000	0.137	0.137
24:00:00	0.000	0.000	0.000	0.000	0.136	0.136
24:15:00	0.000	0.000	0.000	0.000	0.135	0.135
24:30:00	0.000	0.000	0.000	0.000	0.134	0.134
24:45:00	0.000	0.000	0.000	0.000	0.133	0.133
25:00:00	0.000	0.000	0.000	0.000	0.132	0.132
25:15:00	0.000	0.000	0.000	0.000	0.132	0.132
25:30:00	0.000	0.000	0.000	0.000	0.131	0.131
25:45:00	0.000	0.000	0.000	0.000	0.130	0.130

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
26:00:00	0.000	0.000	0.000	0.000	0.129	0.129
26:15:00	0.000	0.000	0.000	0.000	0.128	0.128
26:30:00	0.000	0.000	0.000	0.000	0.127	0.127
26:45:00	0.000	0.000	0.000	0.000	0.127	0.127
27:00:00	0.000	0.000	0.000	0.000	0.126	0.126
27:15:00	0.000	0.000	0.000	0.000	0.125	0.125
27:30:00	0.000	0.000	0.000	0.000	0.124	0.124
27:45:00	0.000	0.000	0.000	0.000	0.123	0.123
28:00:00	0.000	0.000	0.000	0.000	0.123	0.123
28:15:00	0.000	0.000	0.000	0.000	0.122	0.122
28:30:00	0.000	0.000	0.000	0.000	0.121	0.121
28:45:00	0.000	0.000	0.000	0.000	0.120	0.120
29:00:00	0.000	0.000	0.000	0.000	0.120	0.120
29:15:00	0.000	0.000	0.000	0.000	0.119	0.119
29:30:00	0.000	0.000	0.000	0.000	0.118	0.118
29:45:00	0.000	0.000	0.000	0.000	0.117	0.117
30:00:00	0.000	0.000	0.000	0.000	0.116	0.116
30:15:00	0.000	0.000	0.000	0.000	0.116	0.116
30:30:00	0.000	0.000	0.000	0.000	0.115	0.115
30:45:00	0.000	0.000	0.000	0.000	0.114	0.114
31:00:00	0.000	0.000	0.000	0.000	0.114	0.114
31:15:00	0.000	0.000	0.000	0.000	0.113	0.113
31:30:00	0.000	0.000	0.000	0.000	0.112	0.112
31:45:00	0.000	0.000	0.000	0.000	0.111	0.111
32:00:00	0.000	0.000	0.000	0.000	0.111	0.111
32:15:00	0.000	0.000	0.000	0.000	0.110	0.110
32:30:00	0.000	0.000	0.000	0.000	0.109	0.109
32:45:00	0.000	0.000	0.000	0.000	0.109	0.109
33:00:00	0.000	0.000	0.000	0.000	0.108	0.108
33:15:00	0.000	0.000	0.000	0.000	0.107	0.107
33:30:00	0.000	0.000	0.000	0.000	0.106	0.106
33:45:00	0.000	0.000	0.000	0.000	0.106	0.106
34:00:00	0.000	0.000	0.000	0.000	0.105	0.105
34:15:00	0.000	0.000	0.000	0.000	0.104	0.104
34:30:00	0.000	0.000	0.000	0.000	0.104	0.104

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
34:45:00	0.000	0.000	0.000	0.000	0.103	0.103
35:00:00	0.000	0.000	0.000	0.000	0.102	0.102
35:15:00	0.000	0.000	0.000	0.000	0.102	0.102
35:30:00	0.000	0.000	0.000	0.000	0.101	0.101
35:45:00	0.000	0.000	0.000	0.000	0.100	0.100
36:00:00	0.000	0.000	0.000	0.000	0.100	0.100
36:15:00	0.000	0.000	0.000	0.000	0.099	0.099
36:30:00	0.000	0.000	0.000	0.000	0.099	0.099
36:45:00	0.000	0.000	0.000	0.000	0.098	0.098
37:00:00	0.000	0.000	0.000	0.000	0.097	0.097
37:15:00	0.000	0.000	0.000	0.000	0.097	0.097
37:30:00	0.000	0.000	0.000	0.000	0.096	0.096
37:45:00	0.000	0.000	0.000	0.000	0.095	0.095
38:00:00	0.000	0.000	0.000	0.000	0.095	0.095
38:15:00	0.000	0.000	0.000	0.000	0.094	0.094
38:30:00	0.000	0.000	0.000	0.000	0.094	0.094
38:45:00	0.000	0.000	0.000	0.000	0.093	0.093
39:00:00	0.000	0.000	0.000	0.000	0.092	0.092
39:15:00	0.000	0.000	0.000	0.000	0.092	0.092
39:30:00	0.000	0.000	0.000	0.000	0.091	0.091
39:45:00	0.000	0.000	0.000	0.000	0.091	0.091
40:00:00	0.000	0.000	0.000	0.000	0.090	0.090
40:15:00	0.000	0.000	0.000	0.000	0.089	0.089
40:30:00	0.000	0.000	0.000	0.000	0.089	0.089
40:45:00	0.000	0.000	0.000	0.000	0.088	0.088
41:00:00	0.000	0.000	0.000	0.000	0.088	0.088
41:15:00	0.000	0.000	0.000	0.000	0.087	0.087
41:30:00	0.000	0.000	0.000	0.000	0.087	0.087
41:45:00	0.000	0.000	0.000	0.000	0.086	0.086
42:00:00	0.000	0.000	0.000	0.000	0.086	0.086
42:15:00	0.000	0.000	0.000	0.000	0.085	0.085
42:30:00	0.000	0.000	0.000	0.000	0.084	0.084
42:45:00	0.000	0.000	0.000	0.000	0.084	0.084
43:00:00	0.000	0.000	0.000	0.000	0.083	0.083
43:15:00	0.000	0.000	0.000	0.000	0.083	0.083

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
43:30:00	0.000	0.000	0.000	0.000	0.082	0.082
43:45:00	0.000	0.000	0.000	0.000	0.082	0.082
44:00:00	0.000	0.000	0.000	0.000	0.081	0.081
44:15:00	0.000	0.000	0.000	0.000	0.081	0.081
44:30:00	0.000	0.000	0.000	0.000	0.080	0.080
44:45:00	0.000	0.000	0.000	0.000	0.080	0.080
45:00:00	0.000	0.000	0.000	0.000	0.079	0.079
45:15:00	0.000	0.000	0.000	0.000	0.079	0.079
45:30:00	0.000	0.000	0.000	0.000	0.078	0.078
45:45:00	0.000	0.000	0.000	0.000	0.078	0.078
46:00:00	0.000	0.000	0.000	0.000	0.077	0.077
46:15:00	0.000	0.000	0.000	0.000	0.077	0.077
46:30:00	0.000	0.000	0.000	0.000	0.076	0.076
46:45:00	0.000	0.000	0.000	0.000	0.076	0.076
47:00:00	0.000	0.000	0.000	0.000	0.075	0.075
47:15:00	0.000	0.000	0.000	0.000	0.075	0.075
47:30:00	0.000	0.000	0.000	0.000	0.074	0.074
47:45:00	0.000	0.000	0.000	0.000	0.074	0.074
48:00:00	0.000	0.000	0.000	0.000	0.073	0.073
48:15:00	0.000	0.000	0.000	0.000	0.073	0.073
48:30:00	0.000	0.000	0.000	0.000	0.072	0.072
48:45:00	0.000	0.000	0.000	0.000	0.072	0.072
49:00:00	0.000	0.000	0.000	0.000	0.071	0.071
49:15:00	0.000	0.000	0.000	0.000	0.071	0.071
49:30:00	0.000	0.000	0.000	0.000	0.071	0.071
49:45:00	0.000	0.000	0.000	0.000	0.070	0.070
50:00:00	0.000	0.000	0.000	0.000	0.070	0.070
50:15:00	0.000	0.000	0.000	0.000	0.069	0.069
50:30:00	0.000	0.000	0.000	0.000	0.069	0.069
50:45:00	0.000	0.000	0.000	0.000	0.068	0.068
51:00:00	0.000	0.000	0.000	0.000	0.068	0.068
51:15:00	0.000	0.000	0.000	0.000	0.067	0.067
51:30:00	0.000	0.000	0.000	0.000	0.067	0.067
51:45:00	0.000	0.000	0.000	0.000	0.067	0.067
52:00:00	0.000	0.000	0.000	0.000	0.066	0.066

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m³/s)	Net Rain (mm)	Runoff (m³/s)	Baseflow (m³/s)	Total Flow (m³/s)
52:15:00	0.000	0.000	0.000	0.000	0.066	0.066
52:30:00	0.000	0.000	0.000	0.000	0.065	0.065
52:45:00	0.000	0.000	0.000	0.000	0.065	0.065
53:00:00	0.000	0.000	0.000	0.000	0.064	0.064
53:15:00	0.000	0.000	0.000	0.000	0.064	0.064
53:30:00	0.000	0.000	0.000	0.000	0.064	0.064
53:45:00	0.000	0.000	0.000	0.000	0.063	0.063
54:00:00	0.000	0.000	0.000	0.000	0.063	0.063
54:15:00	0.000	0.000	0.000	0.000	0.062	0.062
54:30:00	0.000	0.000	0.000	0.000	0.062	0.062
54:45:00	0.000	0.000	0.000	0.000	0.062	0.062
55:00:00	0.000	0.000	0.000	0.000	0.061	0.061
55:15:00	0.000	0.000	0.000	0.000	0.061	0.061
55:30:00	0.000	0.000	0.000	0.000	0.060	0.060
55:45:00	0.000	0.000	0.000	0.000	0.060	0.060
56:00:00	0.000	0.000	0.000	0.000	0.060	0.060
56:15:00	0.000	0.000	0.000	0.000	0.059	0.059
56:30:00	0.000	0.000	0.000	0.000	0.059	0.059
56:45:00	0.000	0.000	0.000	0.000	0.059	0.059
57:00:00	0.000	0.000	0.000	0.000	0.058	0.058
57:15:00	0.000	0.000	0.000	0.000	0.058	0.058
57:30:00	0.000	0.000	0.000	0.000	0.057	0.057
57:45:00	0.000	0.000	0.000	0.000	0.057	0.057
58:00:00	0.000	0.000	0.000	0.000	0.057	0.057
58:15:00	0.000	0.000	0.000	0.000	0.056	0.056
58:30:00	0.000	0.000	0.000	0.000	0.056	0.056

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	2.28	No
ALTBAR	140	No
ASPBAR	184	No
ASPVAR	0.69	No
BFIHOST	0.62	No
BFIHOST19	0.59	No
DPLBAR (km)	1.44	No
DPSBAR (mkm^{-1})	95.1	No
FARL	1	No
LDP	2.67	No
PROPWET	0.36	No
RMED1H	11.2	No
RMED1D	33.5	No
RMED2D	44.8	No
SAAR (mm)	795	No
SAAR4170 (mm)	793	No
SPRHOST	30.49	No
URBEXT2000	0.18	No
URBEXT1990	0.07	No
URBCONC	0.79	No
URBLOC	0.73	No
DDF parameter C	-0.03	No
DDF parameter D1	0.36	No
DDF parameter D2	0.43	No
DDF parameter D3	0.27	No
DDF parameter E	0.32	No
DDF parameter F	2.44	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.37	No
DDF parameter D2 (1km grid value)	0.44	No
DDF parameter D3 (1km grid value)	0.28	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.43	No

Appendix E – Sensitivity Analysis

A. It is standard hydraulic modelling practice to undertake a sensitivity analysis of key model parameters to consider any uncertainty attached to the adopted values and understand how sensitive the model is to changes in these parameters.

B. In the absence of any gauged data / recorded flood events / observable historic information, Ardent have undertaken a sensitivity test of key parameters in order to improve confidence in the model outputs and to ensure the model is robust to changes in these parameters. All sensitivity runs have been undertaken on the 1% AEP plus 45% climate change event.

C. Ardent have undertaken a sensitivity analysis on the following parameters for the post development scenario:

- Manning's 'n' roughness values +/- 20%;
- Rainfall Intensity; and
- Blockage analysis.

Manning's 'n' roughness

D. Manning's 'n' roughness values have been adjusted by +/- 20% in the 1D and 2D domains during post-development scenario. The peak modelled extents from the sensitivity testing are shown in **Figure E.1.**, with peak depths at the result points shown in **Figure E.1** presented in **Table E.1**.

Table E.1: Roughness sensitivity peak depths at points shown in Figure E.1

	+20% 'n'	**1% AEP plus 45% CC**	**-20% 'n'**
Point	Depth (m)	Depth (m)	Depth (m)
1	0.27	0.26	0.27
2	0.13	0.13	0.14
3	0.08	0.08	0.09
4	0.10	0.11	0.12
5	0.14	0.15	0.17
6	0.19	0.21	0.22

Figure E.1: Roughness sensitivity extents – 1% AEP plus 45% climate change

E. The results show the model has a negligible sensitivity to the roughness values applied to the model domain, with only minor changes in the peak flood extents and negligible differences in peak flood depths (<+/- up to 20mm) at key locations across the Site.

Rainfall intensity

F. The sensitivity to the rainfall intensity applied to the model have been assessed by increasing the rainfall profiles applied to rural and urban areas by 20%. Peak modelled extents in the sensitivity scenario are shown in **Figure E.2** with peak depths at the points shown in **Figure E.2** presented in **Table E.2**.

Table E.2 Rainfall Intensity sensitivity peak depths at points shown in Figure E.2

	1% AEP plus 45% CC	**Rainfall sensitivity**
Point	Depth (m)	Depth (m)
1	0.26	0.30
2	0.13	0.17
3	0.08	0.12
4	0.11	0.15
5	0.15	0.20
6	0.21	0.25

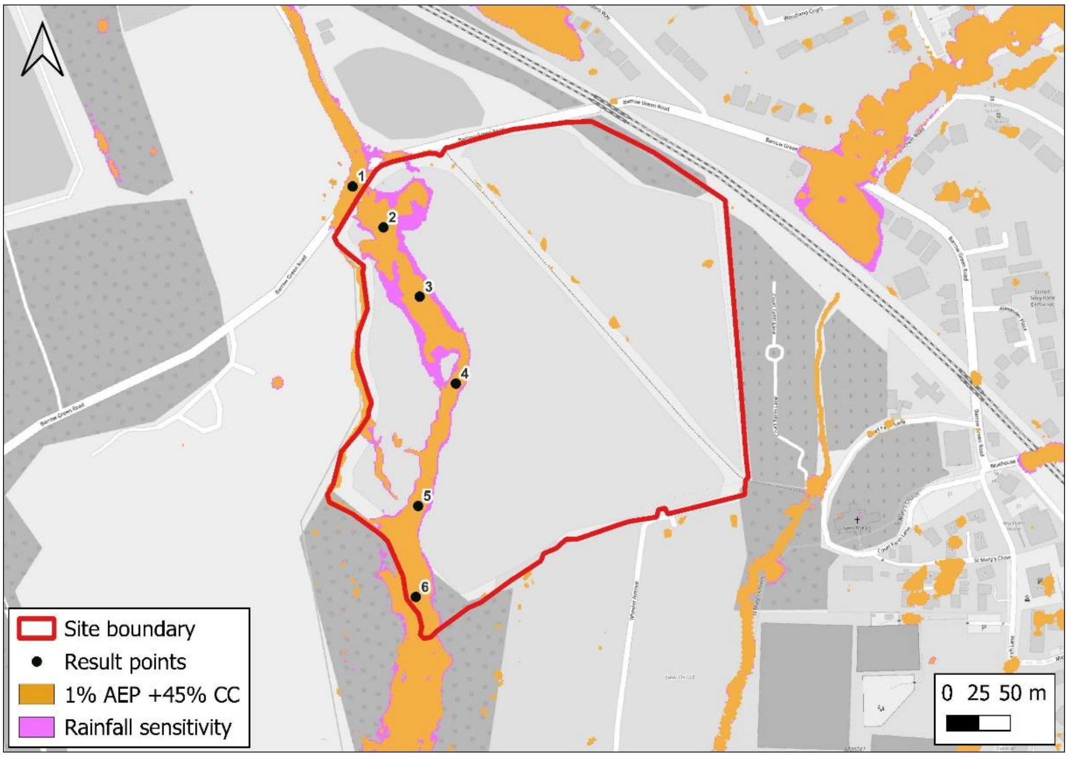


Figure E.2: Rainfall intensity sensitivity extents – 1% AEP plus 45% climate change

G. The results show the model has a low sensitivity to the rainfall intensity applied within the model as the higher volume of flows conveyed along the flow path only results in a slight increase in peak depth of 40-50mm within the Site boundary. The model therefore has a low sensitivity to the rainfall applied and associated losses.

Blockage Analysis

H. Blockage analysis has undertaken on the 225mm culvert linking the ditch north of the Site to the surface water drainage network. A 90% blockage was applied for the duration of the model run. Peak modelled extents in the sensitivity scenario are shown in **Figure E.3** with peak depths at the points shown in **Figure E.3** presented in **Table E.3**.

Table B.3 Blockage sensitivity peak depths at points shown in Figure E.3

	1% AEP plus 45% CC	**Blockage Scenario**
Point	Depth (m)	Depth (m)
1	0.26	0.28
2	0.13	0.14
3	0.08	0.09
4	0.11	0.12
5	0.15	0.16
6	0.21	0.21

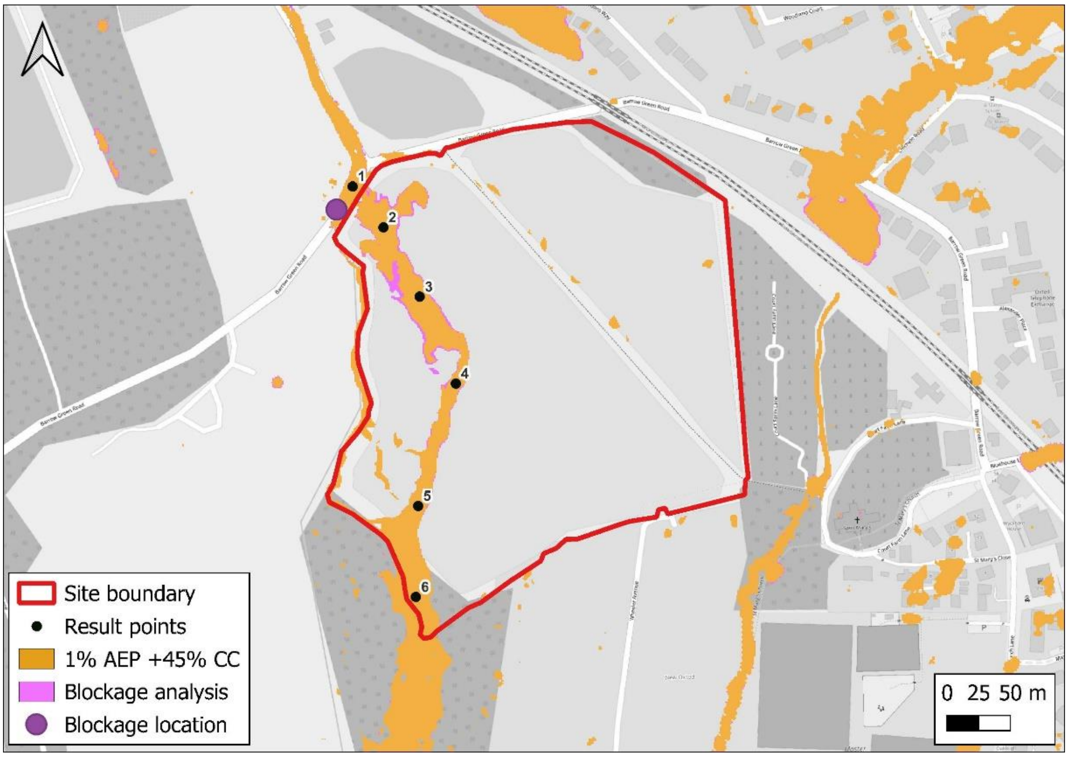


Figure E.3: Blockage sensitivity extents – 1% AEP plus 45% climate change

I. The blockage sensitivity analysis shows that the modelled blockage only has a minor impact on peak depths within the Site boundary, with increases of 10-20mm. This is due to the culvert being surcharged for the majority of the simulation during the baseline scenario. As a result, the residual risk of blockage is low. Additionally, assumptions made regarding the representation of the culvert are shown not to have a notable impact on the results at the Site.

Sensitivity test conclusions

J. Ardent has carried out a range of sensitivity tests on key parameters for the hydraulic model in order to test the validity of the model outputs and ensure that the proposed mitigation measures are appropriate, and that the proposed residential development can be made safe for the duration of its lifetime. The review of the sensitivity test outlined above suggests that the adopted model parameters are appropriate and that the proposed mitigation scheme is appropriate. The maximum uncertainty associated with the model outputs is approximately +/-50mm.

Appendix F – Site Masterplan

0 m 10 m 20 m 30 m 40 m 50 m 100 m

Scale

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Client:
Croudace Homes Group

Project:
Land South of Barrow Green Road, Oxted

Drawing Title:
Illustrative Masterplan

Scale:	Revision	Drawn	Check	Date
1:500 @ A0				

Project No'	Class	Dwg No'	Status	Rev
3129	C	1005	PL	A

CLASS: C - COLOURED, A - BLACK & WHITE
STATUS: SK - SKETCH, PR - PRELIMINARY, PL - PLANNING, WD - WORKING DRAWING