Technical Note - Flood Study

PROJECT: BRIDGNORTH ROAD, SHROPSHIRE

Rev. Ref.	Date	Prep	Chk	App	Amendments	Reason for Issue
1	07/04/2020	MR	DKS	DKS	Original	For Information
2	08/04/2020	MR	DKS	DKS	Minor Amendments	For Information
3	28/04/2020	MR	DKS	DKS	Minor Amendments	For Information

DISCLAIMER

This document has been prepared solely as a flood study technical note for Wenlock Estates. McCloy Consulting Ltd accepts no responsibility or liability for any use that is made of this document other than for the purposes for which it was originally commissioned and prepared, including by any third party.

SUSTAINABILITY

As an environmental consultancy, McCloy Consulting takes its responsibility seriously to try to operate in a sustainable way. As part of this, we try to maintain a paperless office and will only provide printed copies of reports and drawings where specifically requested to do so. We encourage end users of this document to think twice before printing a hard copy - please consider whether a digital copy would suffice. If printing is unavoidable, please consider double sided printing. This report (excluding appendices) contains 21 pages of text – that's equivalent to a carbon footprint of approximately 88.2g CO_2 when printed single sided.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

INTRODUCTION

McCloy Consulting has been engaged by Wenlock Estates to advise on flood risk and drainage matters in relation to an application to allocate lands for development (ongoing) within the Shropshire Council Local Plan Review.

PURPOSE

Environment Agency (EA) mapping for Risk of Flooding from Surface Water (RoFSW) identifies two significant pluvial (surface water) flow routes that traverses the site and converge at the northern corner flows through the adjacent existing Hunters Gate development.

This technical note is intended to summarise the inputs, standards, decision making, and results of the baseline flood modelling exercise undertaken; and to assess the effectiveness of a proposed scheme to relieve flooding on the site and elsewhere to permit appraisal of potential planning gain as a result of the future development of the land.

SITE INFORMATION

Site Location

The key area of interest is shown on the following figure.

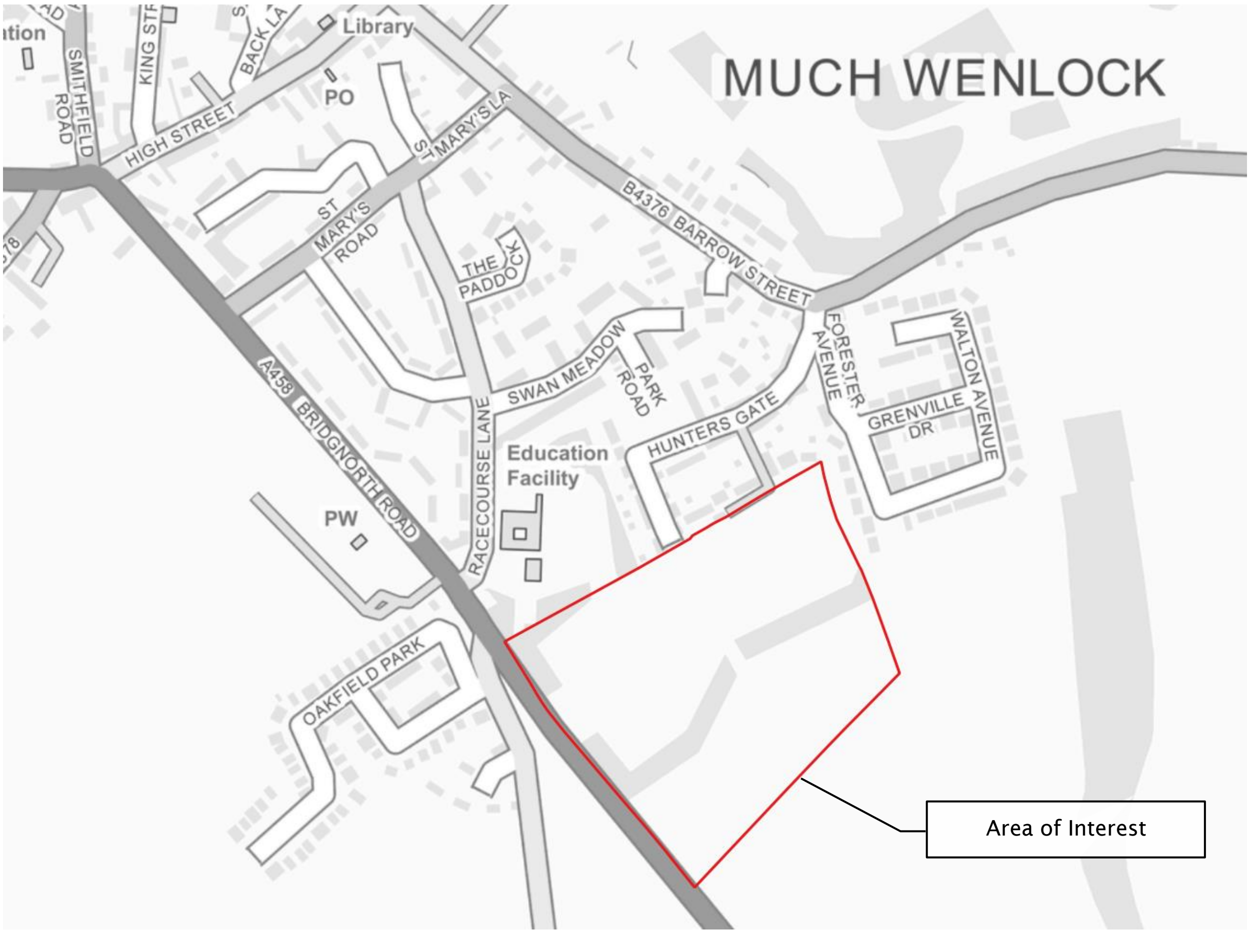


Figure 1 Area of Interest

EA Flood Data

EA surface water flood mapping is shown on the following figure.

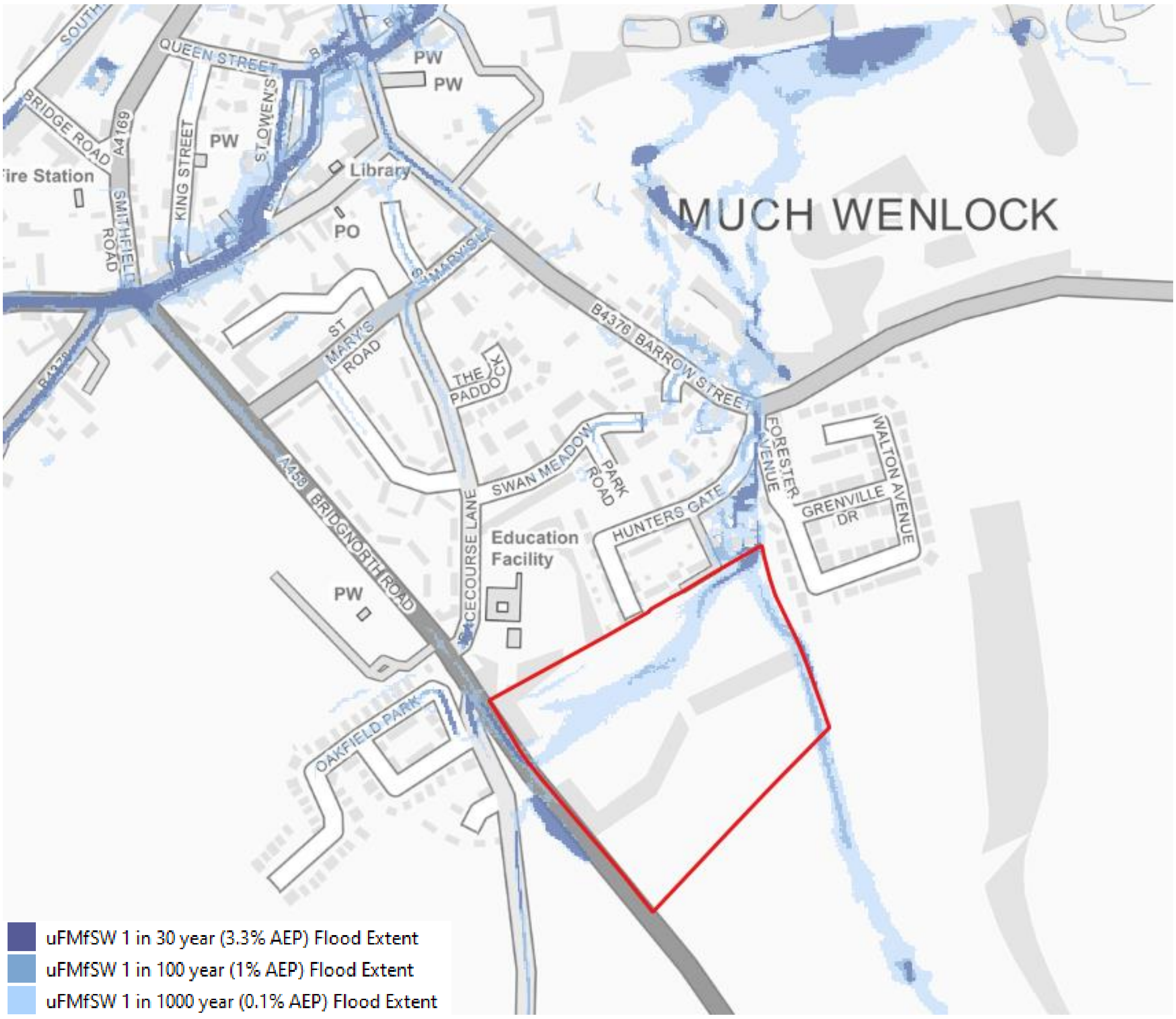


Figure 2 EA Surface Water Flood Mapping

Site Description

A site visit walkover was undertaken on 17th May 2019 and based on a desktop review of site information and site walkover observations we note:

- The site is shown to be affected by surface water flooding based on EA predictive flood data; no known watercourses exists at the site.
- Historic flooding has been experienced at dwellings immediately downgradient of the site at Hunters Gate. A resident at the site confirmed that the two dwellings adjacent to the northern site boundary were affected by flooding. Site observations indicate what is apparently a more recently constructed boundary wall adjacent to the site than adjacent structures.

- The Much Wenlock Integrated Urban Drainage Management Plan (IUDMP) indicates sewerage infrastructure is located along the northern and eastern site boundaries; no evidence of the infrastructure was uncovered in the site visit, particularly for the eastern boundary.
- Property boundary treatments within Hunters Gate typically comprise block or masonry walls and as such would significantly influence overland flood routing downstream of the site.
- Flooding issues are compounded by the underlying soil type which as confirmed by review of BGS borehole records in the locale comprise a significant layer of clay that limits infiltration. This was confirmed during the site visit observations.

Topography

Topography to inform the assessment is derived from a composite digital terrain model comprised of best available EA LiDAR height data and 5m NextMap DTM where no LiDAR was available. The site topographical setting and topography dictating the upgradient hydrological catchment are shown on the following figure.

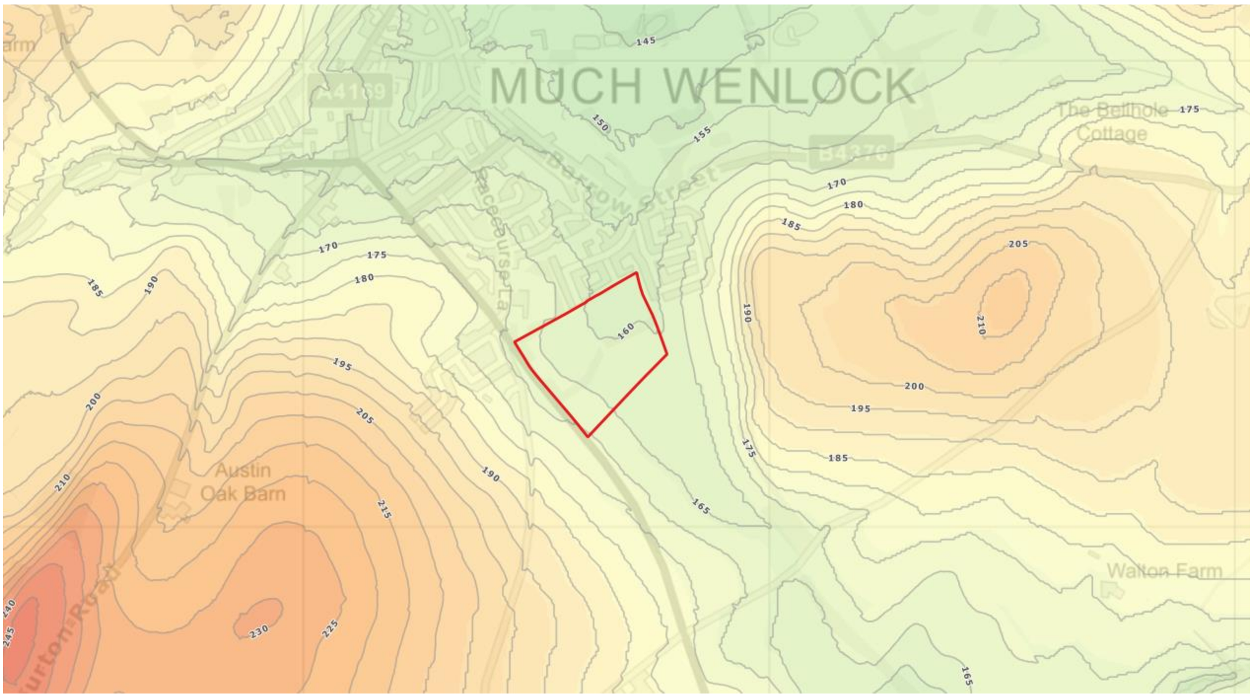


Figure 3 Topography

Hydrological and Drainage Site Setting

Topographical Catchment

The hydrological catchment contributing to potential surface water flooding at the site, dictated by topography and excluding the influence of any arterial or surface water drainage scheme has been established.

The hydrological catchment is determined through analysis of the best available height data in gridded format for the catchment to determine the flow direction and accumulation to each grid cell to delineate the natural catchment. The wider upstream contributing catchment draining to site is c. 74Ha. The catchment with predicted flow channels is shown on the following figure.

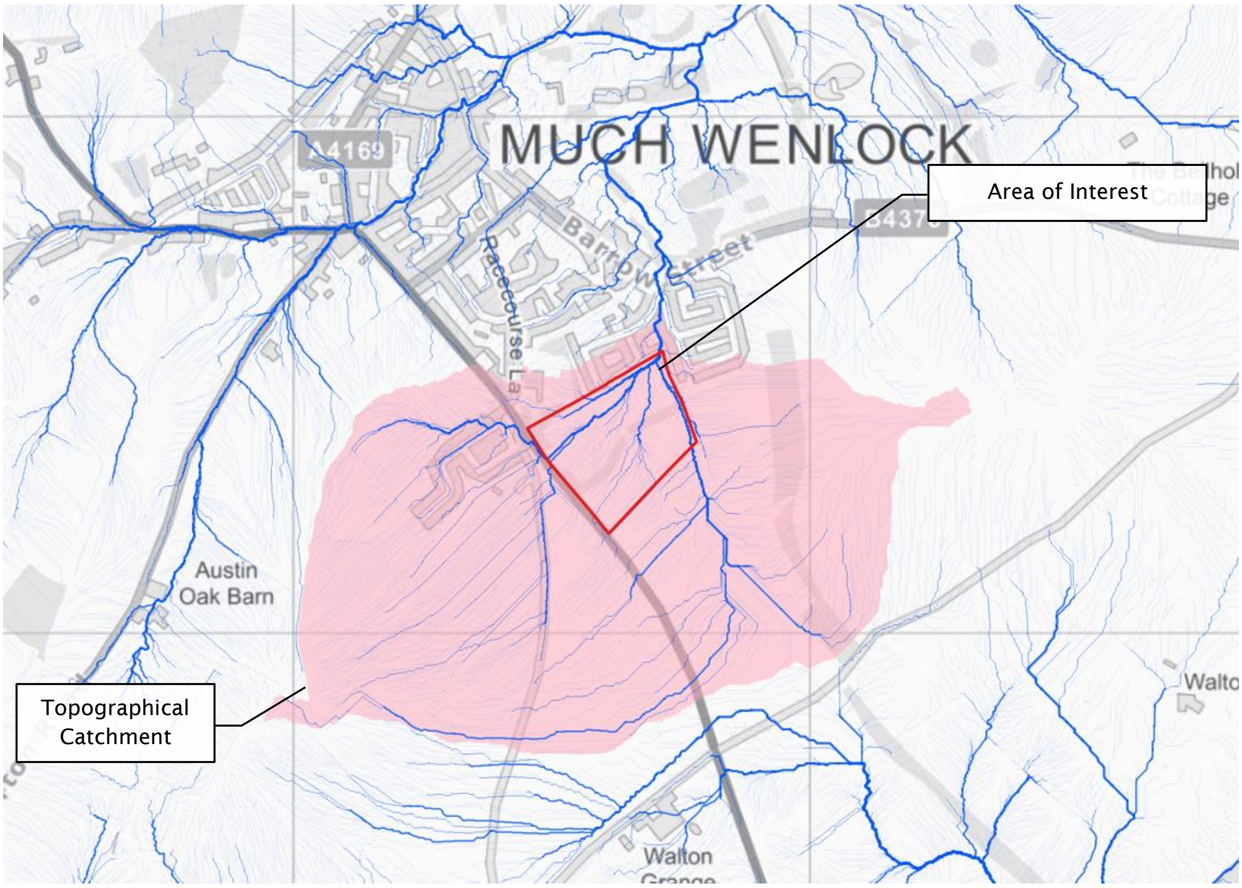


Figure 4: Topographical Catchment and Flow Routing

Sewerage Infrastructure

Severn Trent Water (STW) drainage asset data was obtained in PDF format, digitised and scrutinised in order to determine potential for significant contributing effects from out of sewer flooding or inflow of flows outside of the topographical catchment.

Review of the data indicates the area is served by a separated sewerage system. Sewer information is shown on the following figures.

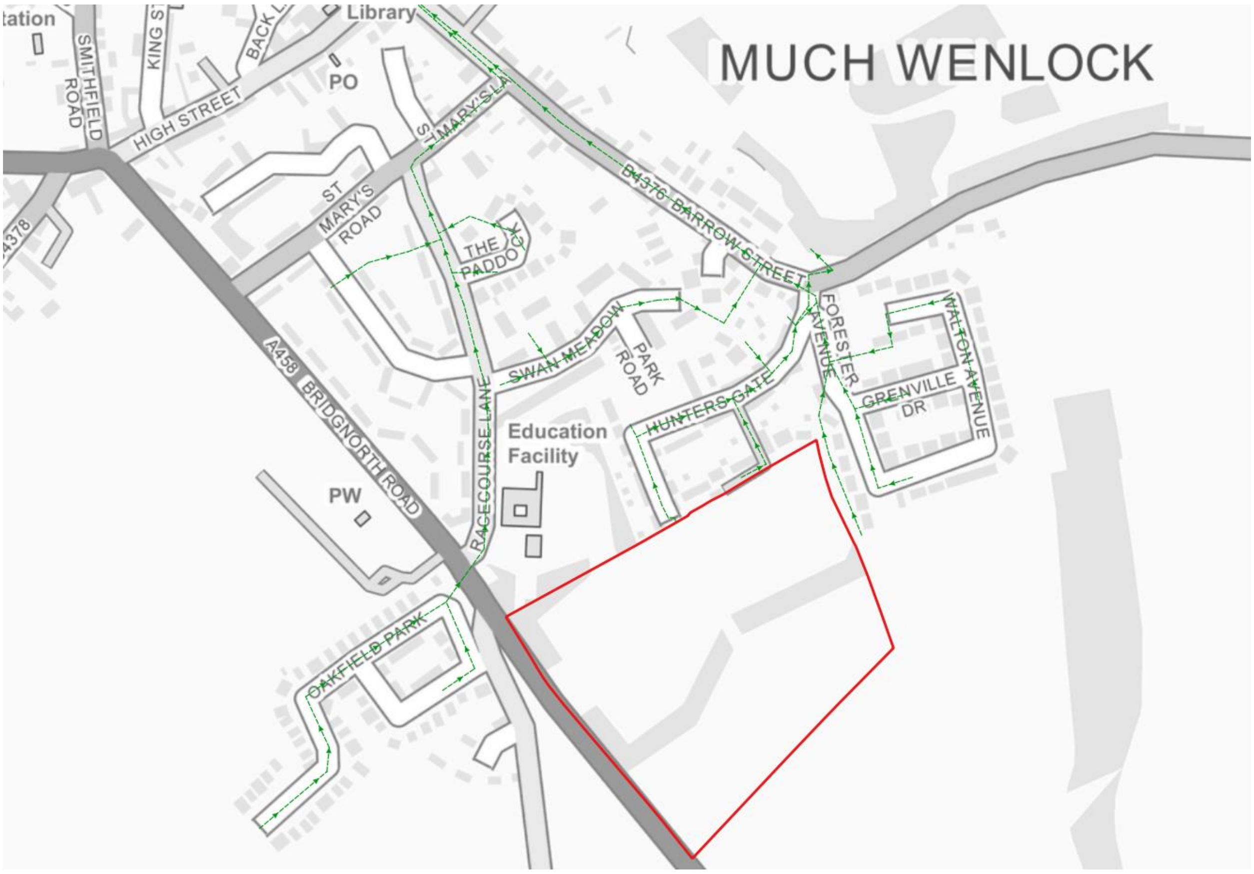


Figure 5 STW Storm Network (Wider Catchment)

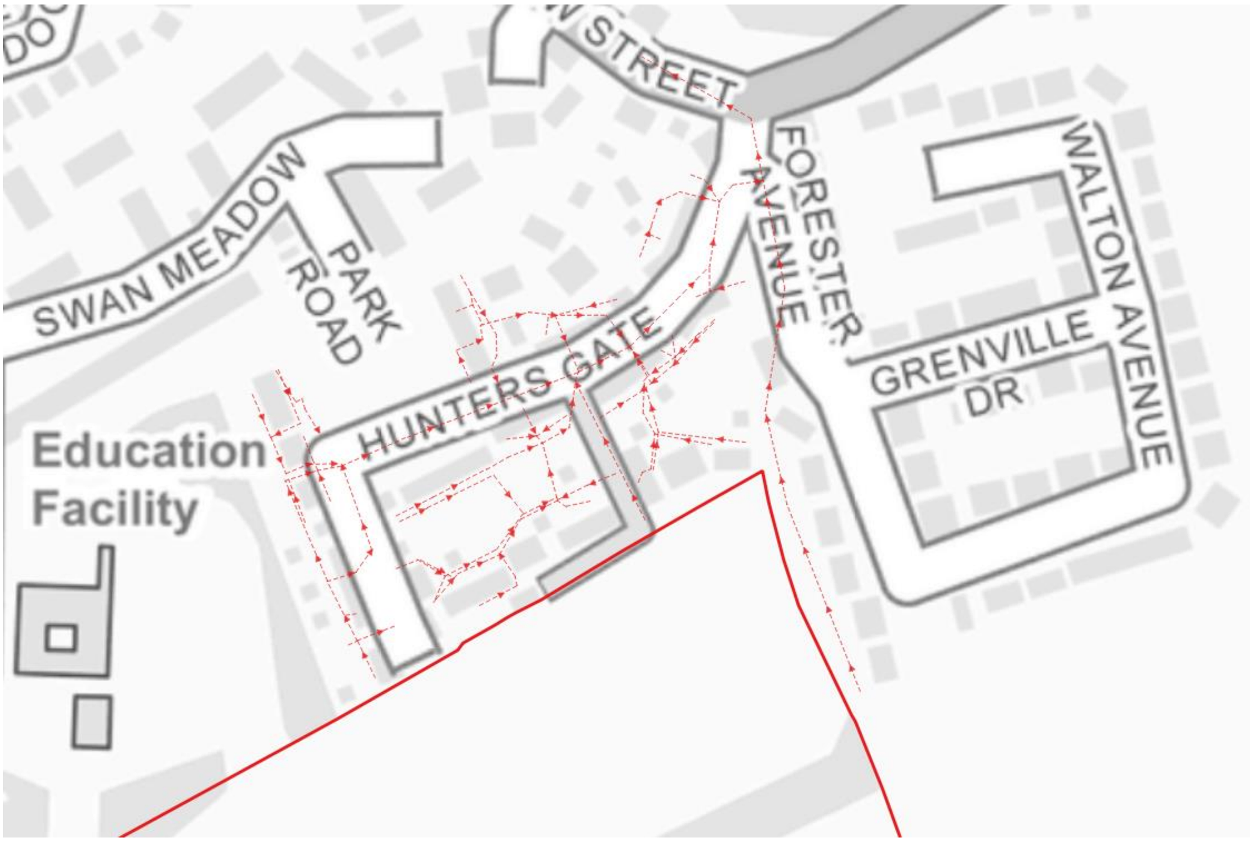


Figure 6 STW Foul Network (Hunters Gate Extract)

Contributing Subcatchments

Subcatchments were calculated and digitised in GIS for each manhole node in the 1D network to represent flows within the 1D system for drained areas in vicinity to the site and are displayed on the following figure.

This method assumes that water will reach the sewer and as such is conservative in estimating flows within the network but may underestimate on-surface ponding or overland direct runoff. As the catchment upstream of the site is predominantly rural, this will have a limited affect at the site itself and the main flow route contributing to downstream flooding.

Figure 7 Contributing Subcatchments

HYDRAULIC MODEL BUILD

A 1D-2D surface water model has been generated for the site using Innovyze ICM V10.0. The model approach was a rainfall fed direct to the 2D zone (outside of subcatchments) and directly to 1D subcatchments to the 1D network. 1D manhole nodes were connected to the 2D surface to represent out of system flooding.

Model Extents

The model boundary encloses the entire surface water catchment draining to the site. The downstream model boundary for the model has been located sufficiently downstream from the area of interest to include the parkland downstream for optioneering measures and to ensure predicted water levels at the site are not susceptible to any backwater effect as a result of the boundary condition.

The model extent is shown on the following figure.

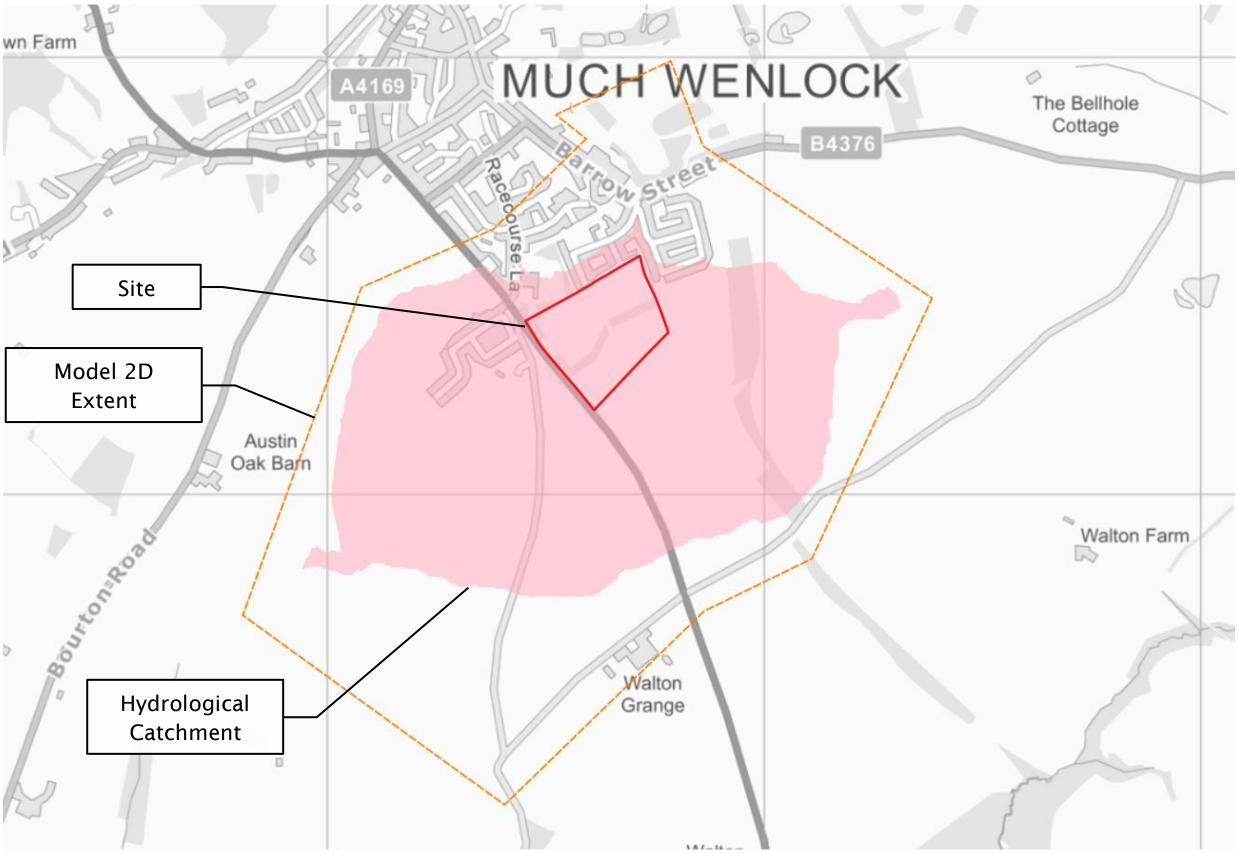


Figure 8 Model 2D Zone

Ground Model

The height data was imported to the modelling software as a ground model, and subsequently converted into 2D mesh elements (the surface used to simulate flows across the topography within the model).

Key obstructions (walls) were built into the ground model within ICM using porous polygons.

Inflow Hydrology

Rainfall was calculated by the Flood Estimation Handbook (FEH) Revitalised Flood Hydrograph 2.3 (ReFH 2.3).

The model was simulated for the following return periods:

- 3.3% AEP / 1:30 year

- 1% AEP / 1:100 year
- 1% AEP / 1:100 year + 25% Climate Change

In order to determine a critical duration as a basis for subsequent analysis, the following durations were considered:

- 1 hour.
- 3 hour.
- 6 hour.

The method used 2013 rainfall from the calibrated ReFH2.3 hydrographic model for each rainfall return period and duration to be assessed. Full rainfall profiles were extracted for application to urban / drained areas and "Net Rainfall" (i.e. effective Rainfall) profiles were extracted for use on rural / undrained areas.

The ReFH2.3 effective rainfall loss model is a calibrated hydrological model, and as such is deemed preferable for use in this preliminary investigation in preference to unverified / uncalibrated applications of losses to suit plot / local scale infiltration characteristics. It is noted that for purposes of detailed design and assessment at a later date, it remains preferable to develop a verified loss model determined to suit measured ground conditions to replace the regional-scale ReFH model.

Model Geometry

Key geometry data sources, assumptions and rationalisations are scheduled in the following table.

Table 1 Model Geometry and Approach Commentary

Parameter	Data Source	Approach
Infiltration Surfaces	OS Promap Vectors	Infiltration zones for all hardstanding 'drained' areas were generated from OS vectors and applied with a drainage removal rate of 12mm/hr, per EA surface water modelling guidance.
Rainfall	FEH	2013 FEH Rainfall catchment descriptors were derived for SO 62700 99650 and ReFH full rainfall hyetographs for the specified return periods at 1 / 3 / 6 hr durations and applied to the 2D zone outside of subcatchments to avoid double counting of flows.
Initial Conditions	N/A	Assumed dry.
Inflows	N/A	No point inflows - rainfall generated.
Ground Model	EA Opendata LiDAR OS NEXTMap 5m DTM	A combination of 1m EA LiDAR, patched with 5m NEXTMap DTM where no LiDAR was available was used as a basis for the ground model.
2D Zone	N/A	The hydrological catchment draining to the site was buffered by minimum 25-50m and used as the model 2D Zone boundary to ensure the entire catchment and areas of interest were covered.
Boundary Conditions	N/A	Normal conditions applied to the boundary of the 2D Zone. The downstream boundary has been carefully sited to ensure any flooding from the retention pond towards the site is accounted for and the site is not influenced by any boundary condition.

Parameter	Data Source	Approach
Buildings	OS Promap Vectors	As per EA Surface Water Flood Mapping guidance, buildings were raised 0.3m above the average height of the building using mesh zones within the model. No surveyed threshold levels were available for existing buildings for the assessment. Buildings also given degree of porosity to allow water to flow through them.
Roads	OS Promap Vectors	Roads were digitised from the vectors and added as mesh zones and lowered by 0.125m (average kerb height) to better delineate flow paths.
Roughness Zones	OS Promap Vectors; Aerial Imagery; and Site Observations.	Roughness differentiated at roads and buildings. Default roughness for grass as defined for the wider 2D Zone given dominant agricultural nature within the wider catchment.
Rivers	N/A	N/A
Culverts	N/A	N/A
Reservoirs / Canals	N/A	N/A
Storm / Foul Network	Severn Trent Water Asset Information	STW asset information was obtained and storm network digitised for integration to the model.
1-D Subcatchments	OS Promap Vectors	1-D subcatchments were digitised for each storm manhole node to represent flows to the network. Area take offs were undertaken for all 'drained' areas within each subcatchment to represent differing runoff from permeable areas (modelled as clay per BGS information).
Gullies	N/A	No data was available for this study for integration into the model.
Sedimentation	N/A	N/A
Mesh Zone		General 2D Zone –Mesh Area 40-10 m^2. Refined Results Area (site) Maximum Mesh Area 10-1 m^2.
Walls / Fences	Site Observations / Site Survey	Walls at the northern boundary of the site were represented by porous walls to represent obstructions to overland flows.

Modelling Assumptions and Limitations

The representation of any complex system by a model requires a number of assumptions to be made. For the purposes of the study it is assumed that:

- The terrain model (based on LiDAR updated with ground based topographical survey within the site) accurately represents the surface topography and associated flow paths.
- The design rainfall is a sufficiently accurate representation of rainfall of a given return period.

- The ReFH2 effective rainfall loss model is a sufficiently accurate representation of runoff from rural / undeveloped lands in the wider catchment.
- Roughness does not vary with time.

The primary limitations of the study are noted as follows:

- The STW sewer network is represented based on STW asset information provided by customer channels. It is acknowledged that more recent as-built information is understood to exist as a result of STW / LLFA investigations in Hunters Gate; however, this information has not been provided for purposes of informing the assessment.
- Representation of the STW network excludes flow controls and other assets not shown on asset information.
- The 1D network was modelled using 1D subcatchments to assess capacity of storm sewerage within the catchment. This assumes that water will reach the sewer and as such is conservative in estimating flows within the network but may underestimate on-surface ponding or overland direct runoff. As the catchment upstream of the site is predominantly rural, this will have a limited affect at the site.
- No gully data information was available for this assessment to create a full 1D-2D integrated model, all out of system flows originate from manhole nodes. Local surface water drainage was represented using a loss model within the catchment, per normal industry best practice in absence of detailed sewer information.
- The model does not seek to refine rural rainfall losses to suit local-scale ground condition observations.
- The model does not represent any topographic features smaller than the minimum resolution of the underlying terrain model derived for the site.

Baseline Results

Result Scenarios

The modelling exercise considered the following rainfall events with the following return periods (Annual Exceedance Probabilities / AEP) and durations:

Table 2 Rainfall Events

3.3% AEP	30 - year
1% AEP	100 – year
1% AEP + 40% CC	100 – year + 25% Climate Change

Simulation durations were per those used in the EA RoFSW modelling methodology and comprise simulations of 1, 3, and 6 hour storm durations. Model simulation durations were set to minimum of either three times the time to peak rainfall hyetograph or time to peak plus three hours in order to provide sufficient time to permit routing of the rainfall across the model area.

Predicted Flooding

Flooding indicates a significant overland flow route from the south adjacent to the eastern site boundary tending northerly towards Hunters Gate. In addition, flood waters build up west of Bridgnorth Road and 'weir' over onto the site creating a second overland flow route which traverses the site tending to the north eastern corner and into Hunters Gate.

Baseline flood extent mapping is included in Appendix A.

Flow measurement lines were situated along each site boundary and one further downstream to incorporate all flows from the site area entering Hunters Gate downstream to indicate the following maximum flow rates at the site.

Table 3 Maximum Flow Rates at the Site

Design Event	Maximum Flow Rates (m^3/s)								
	M30-60	M30-180	M30-360	M100-60	M100-180	M100-360	M100CC-60	M100CC-180	M100CC-360
North Boundary	0.19	0.14	0.11	0.32	0.21	0.14	0.54	0.27	0.18
East Boundary	0.86	0.81	0.75	1.49	1.45	1.14	2.07	2.08	1.59
South Boundary	0.39	0.40	0.39	0.64	0.59	0.55	0.95	0.96	0.74
West Boundary	0.47	0.34	0.25	0.83	0.59	0.47	1.09	0.92	0.69
Total Flow offsite to Hunters Gate Downstream	0.96	1.08	0.93	1.86	1.92	1.47	2.89	2.81	2.11

Severn Trent Water Network Capacity

Additional modelling simulations were conducted, omitting rainfall from all “undrained” areas, in order to test the performance of the STW storm sewers relative to the catchments that they are designed to serve with a view of identifying a justifiable outflow rate from the site. Results indicate that there is no capacity within the existing STW network, as indicated by the following figures for the 1% AEP event.

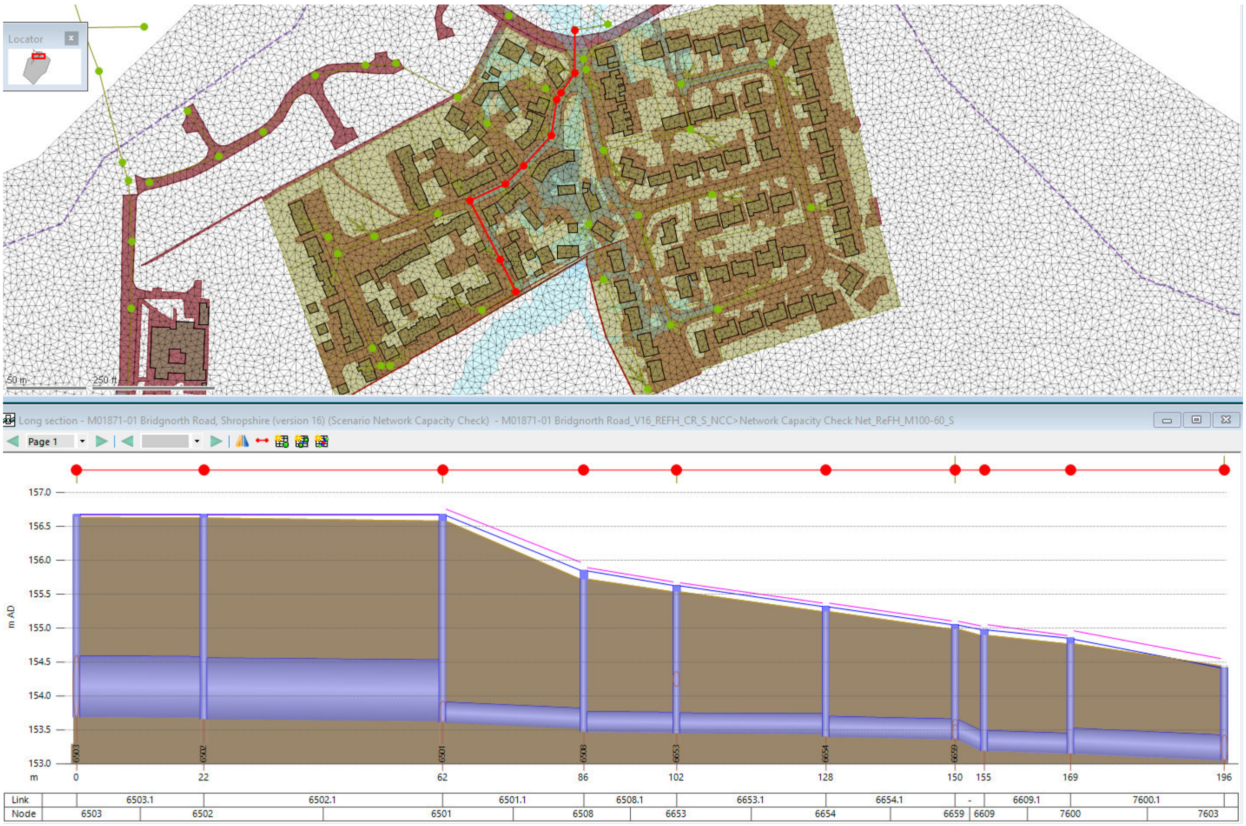


Figure 9 Network Capacity Check - 1% AEP Long Section 1

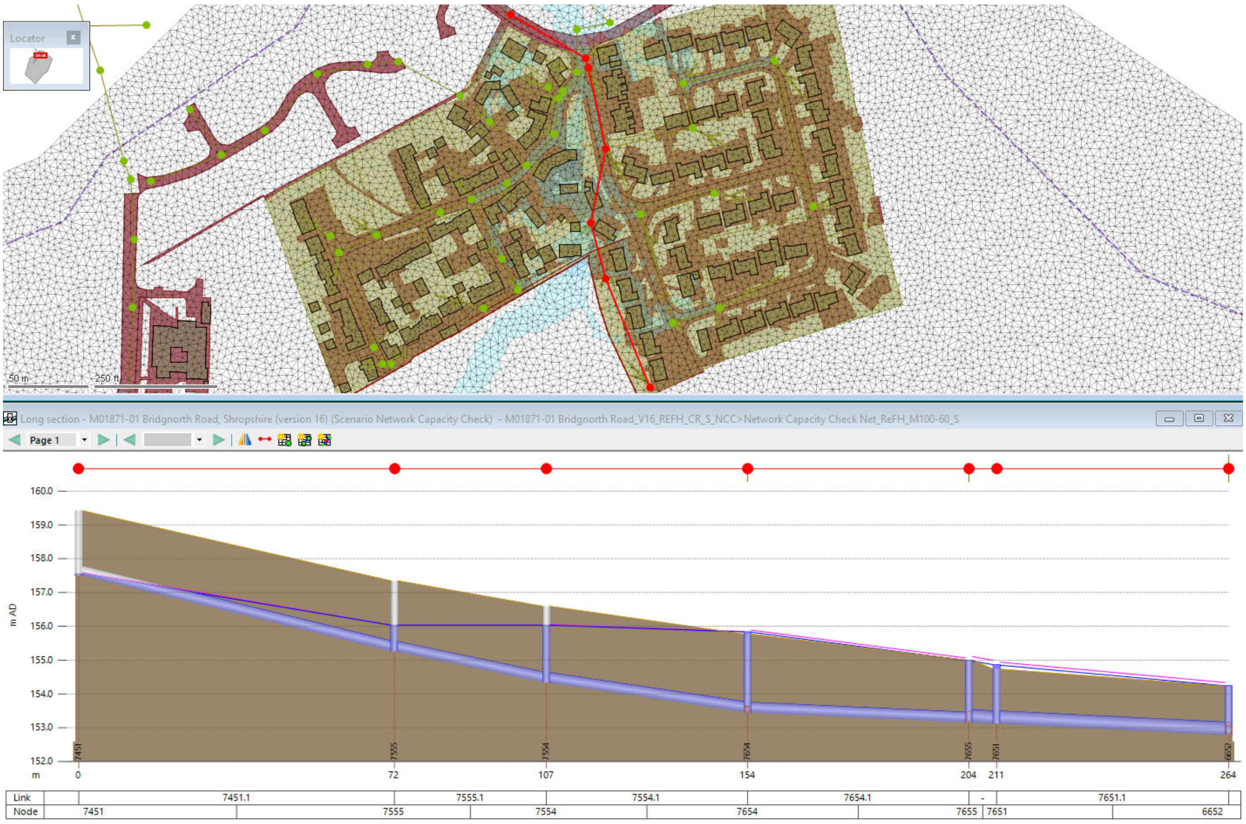


Figure 10 Network Capacity Check - 1% AEP Long Section 2

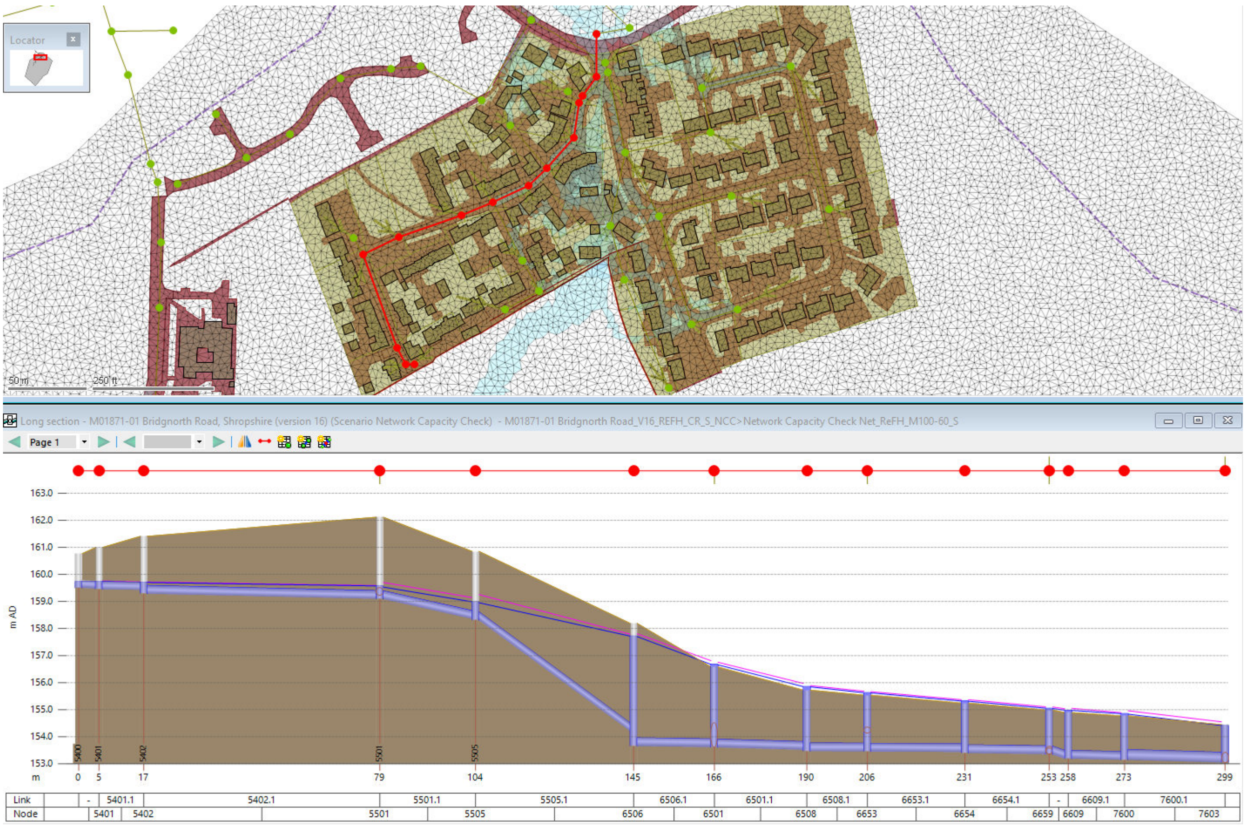


Figure 11 Network Capacity Check - 1% AEP Long Section 3

Flood Alleviation Options - Feasibility

Preferred Option

Options considered to facilitate development were to include measures to capture and convey surface water through the site, and then store or convey it in a controlled manner downstream away from the site with the aim of reducing flood risk downstream.

Prior consultation with Shropshire as LLFA has determined that a preferred option has been identified that would relieve flooding from the lands and Hunters Gate by collecting and conveying floodwater to the parkland downstream of Hunters Gate, north of Barrow Street.

Overland flow onto the site and new runoff from the site would still be required to be attenuated and may be balanced between on /offsite locations to optimise design. It is anticipated that floodwater discharged to the parkland would be attenuated and controlled to mitigate effects to downstream flooding to an agreed standard; this aspect of the option is unlikely to be significantly constrained due to the site space available on those lands and is not considered in detail at this stage.

Preliminary Design

An assessment has been made of the technical viability of overcoming the critical "pinch point" of the option, i.e. to provide new infrastructure to adequately convey floodwater between the site and the park.

As part of this assessment, a design for a horizontal and vertical alignment for an outlet culvert within normal design parameters has been undertaken, taking into account existing sewer networks / pipe clashes based on STW data. Design parameters are summarised below:

- Minimum cover of 1.2m.
- No surcharging for the 1% AEP flood.
- No flooding for the 1% AEP flood + 25% climate change (i.e. Target Standard of Protection for the site and for Hunters Gate).
- Culvert inlet to be no lower than minimum level on the site (56.4m OD).
- No clashes with known existing sewers.

The proposed culvert alignment is shown in the following figure. A detailed long section is enclosed in Appendix B. The preliminary design tends to indicate that the proposed culvert is viable but would cause requirement for significant excavations to permit installation.

Figure 12 Proposed Culvert Alignment

Model Scheme

The proposed culvert alignment was included in the baseline model as a 1D conduit element.

Mesh zones were used to direct overland flows entering the site to the culvert inlet within the site. Pipe diameters were iteratively tested, concluding that a Ø 1200mm culvert would be required to achieve the design parameters set out above.

An indicative assessment of the residual volume of storage required within the site is displayed in the following table, based on the peak water depths in the basin created to direct flows into the culvert.

Table 4 Residual Storage Volume on Site (m^3)

Return Period	Storage Volume (m^3)		
	60min	180min	360min
M30	885	987	926
M100	1269	1289	1147
M100 + 25% CC	1616	1608	1391

Summary of Findings & Outcomes

Flood mapping showing the effect of the option on benefitting lands is included in Appendix C.

For the 1% AEP event the following is noted:

- The flood mechanism of overland flooding from the site and the rural upper catchment is **entirely removed from Hunters Gate.**
- Some residual flooding in Hunters Gate remains, predicted as a result of exceedance of the Hunters Gate network due to inherent incapacity for inflows as well as potential for overland flooding from surface water from lands to the east.
- **All residential properties (6 no.) predicted to flood in the baseline scenario are afforded a standard of protection for internal flooding up to the 1% AEP flood.**
- The model predicts a reduction in STW surface water sewer flows in Barrow Street flowing toward the town centre and as such is **likely to cause betterment to flooding in Barrow Street / High Street / the Town Culvert**.

  The model approach and design is limited in this regard in that it omits interaction between the Hunters Gate surface water collection network and the new relief culvert; and is likely to under-represent drain down of surface water flooding in Hunters Gate back into the STW network due to the model methodology for the STW network (1D sub-catchments with limited 1D-2D integration).

  The scheme is unlikely to reduce peak pass-forward flows which are limited by the pipe capacity, but would reduce the volume hydrograph length) passing to the downstream network.
- The model predicts that the **peak flood downstream of the culvert outlet in the parkland is not substantially affected**, however the proposed scenario would cause a larger flow for a longer duration. The additional volume passed forward downstream to be stored is c. 1610m^3 for the critical 1% AEP event.

Conclusion & Recommendations

A preliminary / conceptual design has been developed to prove that provision of a new relief culvert is likely to be viable between the subject site and open parkland downgradient.

Modelling to appraise proof of concept indicates that such a scheme can offer a standard of protection to Hunters Gate that would alleviate internal flooding to all dwellings predicted to be affected in the present day.

External flooding is predicted to be significantly reduced, with residual flooding as a result of surface water and surface sewer incapacity within the Hunters Gate development.

The following actions are suggested as part of any future development of the scheme:

i. The baseline flood model should be updated to reflect best available STW asset information including more recent asset gathering not reflected on asset maps provided for the basis of this assessment. The model could be expanded to include surface water gullies and internal site surveys to best represent flood routing.

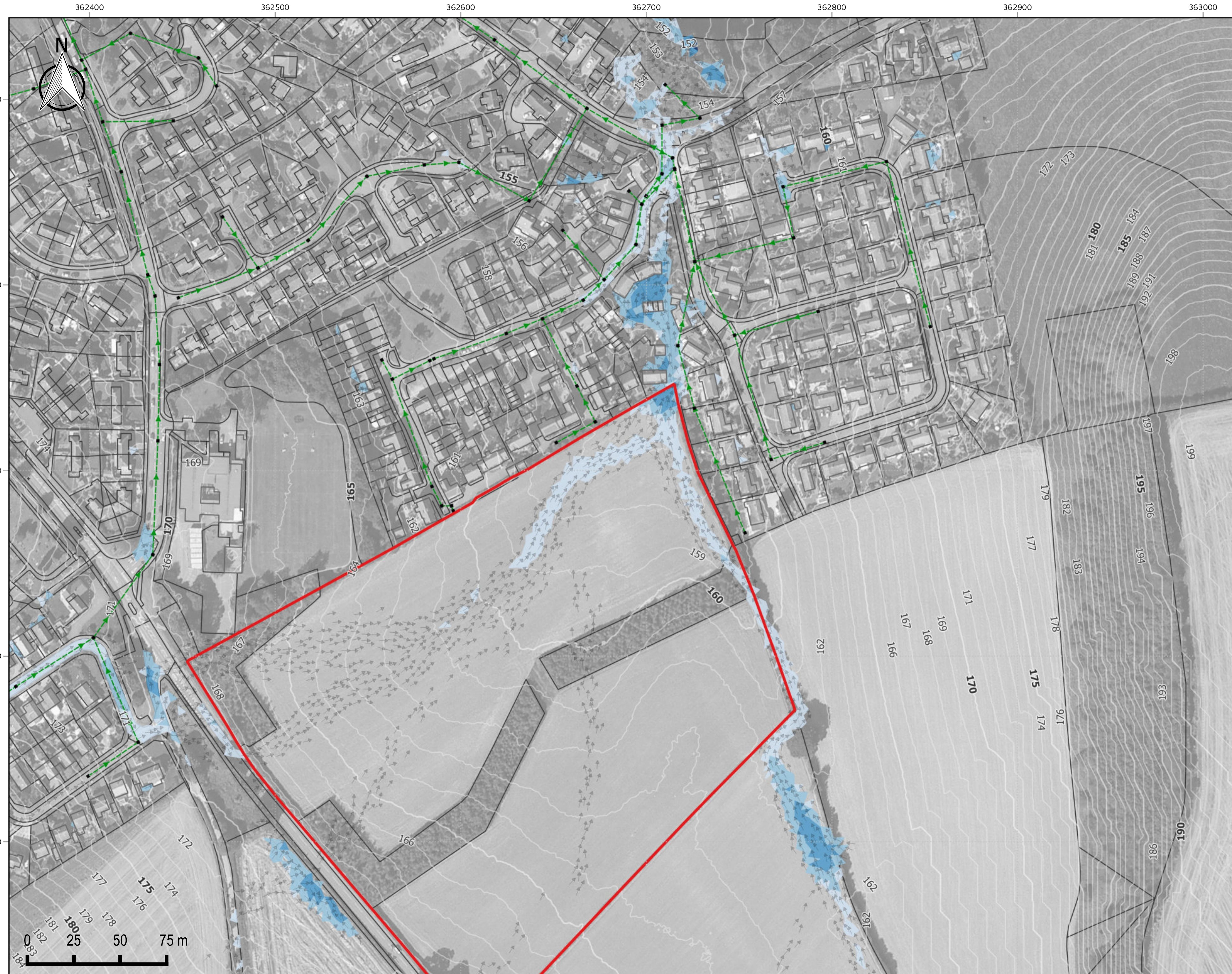
ii. The baseline flood model should be updated to assess local-scale ground conditions and loss models, and should seek to ensure sufficient model verification or validation (potentially in conjunction with STW flow monitoring understood to be in-situ or planned) in order to ensure that the model is fit for purpose of economic or multi-criteria appraisal.

iii. The relief culvert scheme may be subject to significant refinement and may be able to be holistically combined with the Hunters Gate STW surface water sewer network where at present the conceptual proposal is entirely separated from that network.

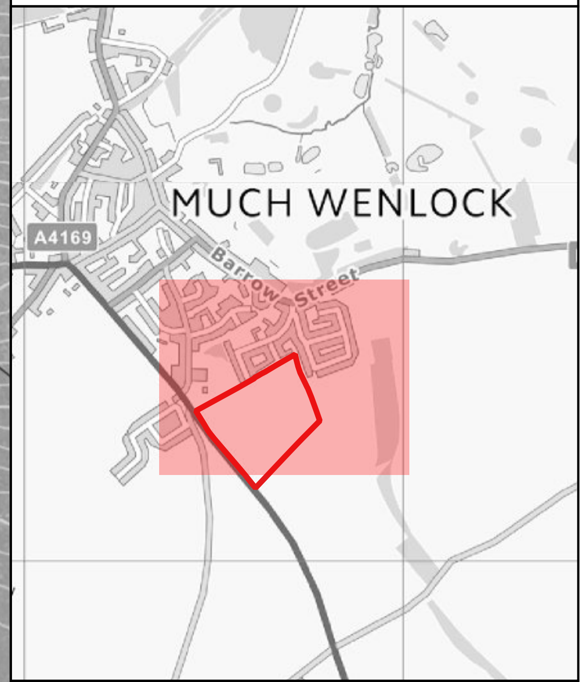
iv. The scheme is subject to development of a flood alleviation / detention scheme on park lands north of Hunters Gate; design and assessment of which is subject to future action to ensure a suitable standard of flood protection to land and watercourses further downstream. The model predicts a peak pass forward flow in the culvert of 1.84 cumecs.

Appendix A

Flood Mapping



MODEL OVERVIEW



LEGEND

- SITE LOCATION
- EXISTING SEVERN TRENT WATER STORM SEWERS
- FLOW ROUTING DIRECTION

FLOOD EXTENTS BANDED BY DEPTH (m)

- < 0.15m
- 0.15 - 0.30m
- 0.30 - 0.60m
- 0.60 - 0.90m
- > 0.90m

NOTES

1. ALL LEVELS INDICATED ARE TO ORDNANCE DATUM NEWLYN.

2. FLOOD EXTENTS WITHIN THE APPLICATION BOUNDARY ARE PLOTTED ON GROUND BASED TOPOGRAPHIC SURVEY; FLOOD EXTENTS OUTWITH THE APPLICATION SITE ARE PLOTTED ON A COMBINATION OF GROUND BASED TOPOGRAPHICAL SURVEY AND EA 1m LIDAR.

3. ALL GRID COORDINATE INFORMATION IS TO OSGB1936 (BRITISH NATIONAL GRID).

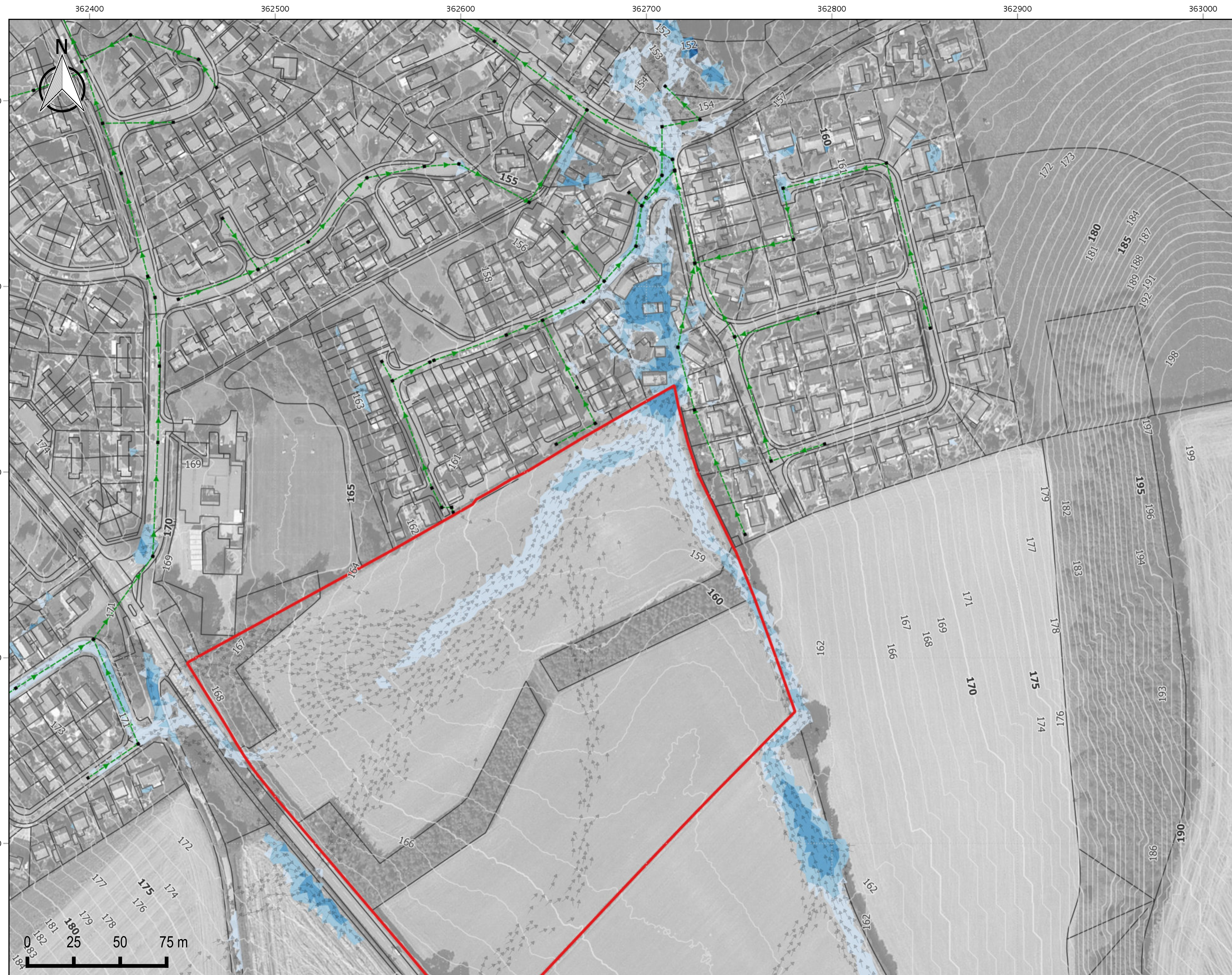
5. RESULTS ARE A COMPOSITE OF ALL DURATIONS SIMULATED TO PROVIDE THE WORST CASE EXTENT / DEPTH MAPPING FOR THE RETURN PERIOD; RESULTS HAVE BEEN PROCESSED TO REMOVE AREAS OF MINIMAL FLOODING (<0.02m) AND OF VERY LOW HAZARD (<0.575).

McCloy Consulting

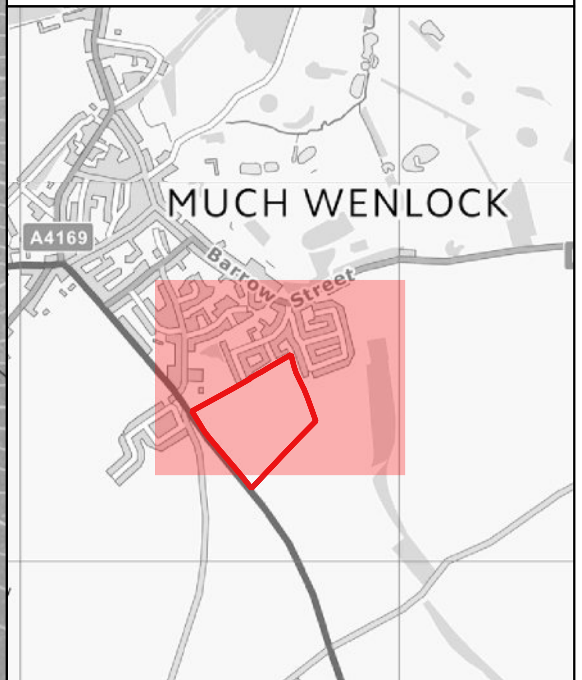
Mossley Mill,
Lower Ground (West),
Carnmoney Road North,
Newtownabbey, BT36 5QA

T: 028 9084 8694
E: info@mccloyconsulting.com
W: www.mccloyconsulting.com

PROJECT		HYDROLOGY SCENARIO	SCALE	ORIGINAL SIZE
BRIDGNORTH ROAD, SHROPSHIRE		PRESENT DAY	1:2000	A3
MAP TYPE		**GEOMETRY SCENARIO**	**DRAWN BY**	**APPROVED**
FLOOD EXTENTS / DEPTH MAPPING		PRESENT DAY	DB	DKS
SOURCE	**FLOOD EVENT**	**FIGURE NUMBER**	**REVISION**	**DATE**
PLUVIAL	3.3% AEP	M01871-01_FIG_FL01	2	08/04/2020



MODEL OVERVIEW



LEGEND

- SITE LOCATION
- EXISTING SEVERN TRENT WATER STORM SEWERS
- FLOW ROUTING DIRECTION

FLOOD EXTENTS BANDED BY DEPTH (m)

- < 0.15m
- 0.15 - 0.30m
- 0.30 - 0.60m
- 0.60 - 0.90m
- > 0.90m

NOTES

1. ALL LEVELS INDICATED ARE TO ORDNANCE DATUM NEWLYN.

2. FLOOD EXTENTS WITHIN THE APPLICATION BOUNDARY ARE PLOTTED ON GROUND BASED TOPOGRAPHIC SURVEY; FLOOD EXTENTS OUTWITH THE APPLICATION SITE ARE PLOTTED ON A COMBINATION OF GROUND BASED TOPOGRAPHICAL SURVEY AND EA 1m LIDAR.

3. ALL GRID COORDINATE INFORMATION IS TO OSGB1936 (BRITISH NATIONAL GRID).

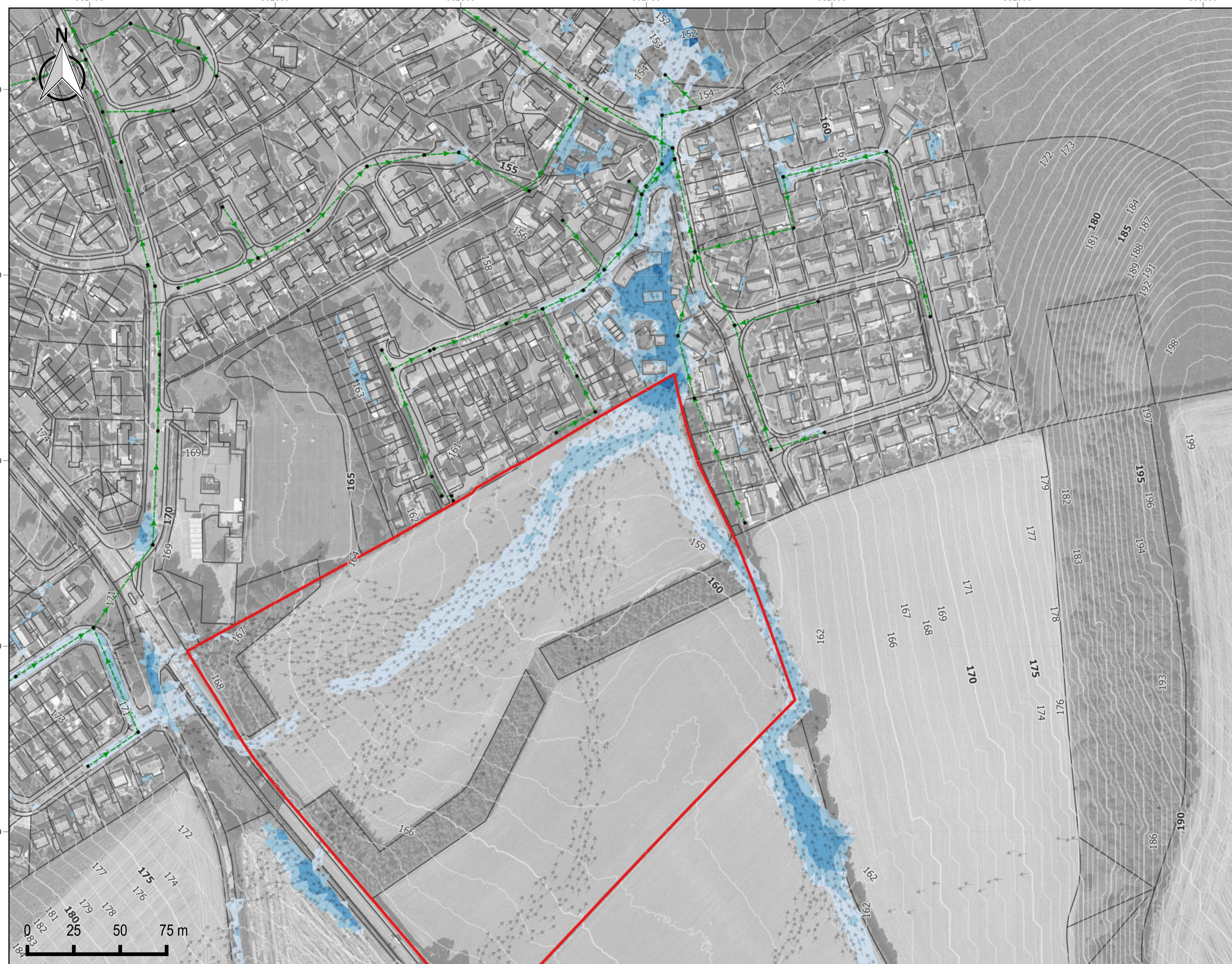
5. RESULTS ARE A COMPOSITE OF ALL DURATIONS SIMULATED TO PROVIDE THE WORST CASE EXTENT / DEPTH MAPPING FOR THE RETURN PERIOD; RESULTS HAVE BEEN PROCESSED TO REMOVE AREAS OF MINIMAL FLOODING (<0.02m) AND OF VERY LOW HAZARD (<0.575).

McCloy Consulting

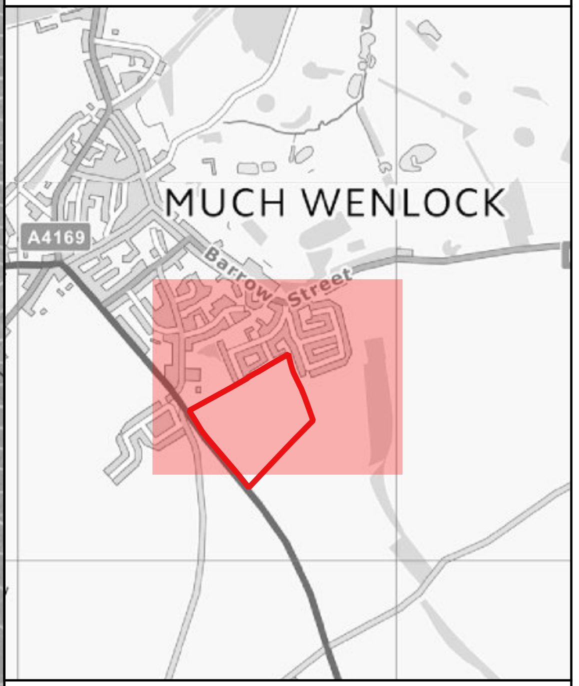
Mossley Mill,
Lower Ground (West),
Carnmoney Road North,
Newtownabbey, BT36 5QA

T: 028 9084 8694
E: info@mccloyconsulting.com
W: www.mccloyconsulting.com

PROJECT		HYDROLOGY SCENARIO	SCALE	ORIGINAL SIZE
BRIDGNORTH ROAD, SHROPSHIRE		PRESENT DAY	1:2000	A3
MAP TYPE		**GEOMETRY SCENARIO**	**DRAWN BY**	**APPROVED**
FLOOD EXTENTS / DEPTH MAPPING		PRESENT DAY	DB	DKS
SOURCE	**FLOOD EVENT**	**FIGURE NUMBER**	**REVISION**	**DATE**
PLUVIAL	1% AEP	M01871-01_FIG_FL02	2	08/04/2020



MODEL OVERVIEW



LEGEND

- SITE LOCATION
- EXISTING SEVERN TRENT WATER STORM SEWERS
- FLOW ROUTING DIRECTION

FLOOD EXTENTS BANDED BY DEPTH (m)

- < 0.15m
- 0.15 - 0.30m
- 0.30 - 0.60m
- 0.60 - 0.90m
- > 0.90m

NOTES

1. ALL LEVELS INDICATED ARE TO ORDNANCE DATUM NEWLYN.

2. FLOOD EXTENTS WITHIN THE APPLICATION BOUNDARY ARE PLOTTED ON GROUND BASED TOPOGRAPHIC SURVEY; FLOOD EXTENTS OUTWITH THE APPLICATION SITE ARE PLOTTED ON A COMBINATION OF GROUND BASED TOPOGRAPHICAL SURVEY AND EA 1m LIDAR.

3. ALL GRID COORDINATE INFORMATION IS TO OSGB1936 (BRITISH NATIONAL GRID).

5. RESULTS ARE A COMPOSITE OF ALL DURATIONS SIMULATED TO PROVIDE THE WORST CASE EXTENT / DEPTH MAPPING FOR THE RETURN PERIOD; RESULTS HAVE BEEN PROCESSED TO REMOVE AREAS OF MINIMAL FLOODING (<0.02m) AND OF VERY LOW HAZARD (<0.575).

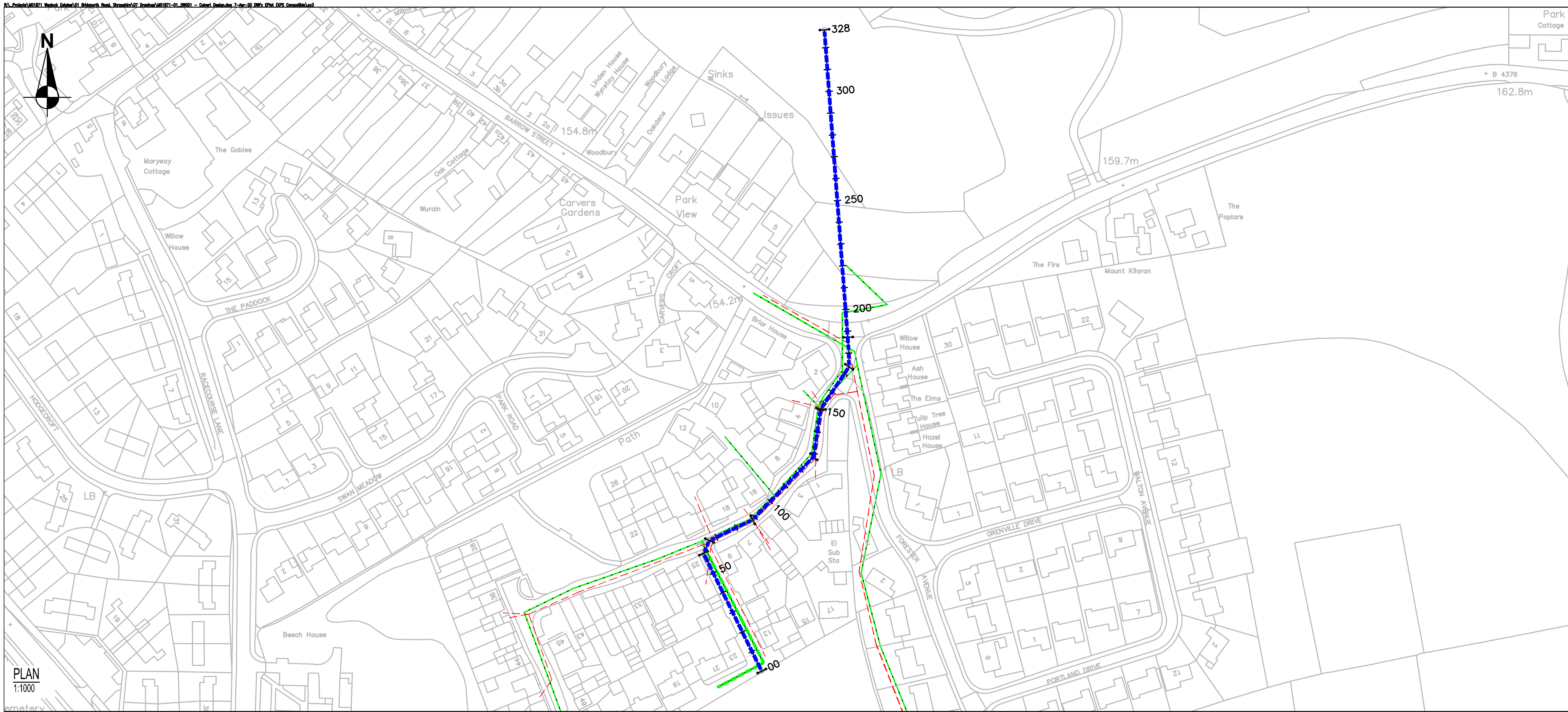
McCloy Consulting
Mossley Mill,
Lower Ground (West),
Carnmoney Road North,
Newtownabbey, BT36 5QA
T: 028 9084 8694
E: info@mccloyconsulting.com
W: www.mccloyconsulting.com

PROJECT		HYDROLOGY SCENARIO	SCALE	ORIGINAL SIZE
BRIDGNORTH ROAD, SHROPSHIRE		CLIMATE CHANGE	1:2000	A3
MAP TYPE		**GEOMETRY SCENARIO**	**DRAWN BY**	**APPROVED**
FLOOD EXTENTS / DEPTH MAPPING		PRESENT DAY	DB	DKS
SOURCE	**FLOOD EVENT**	**FIGURE NUMBER**	**REVISION**	**DATE**
PLUVIAL	1% AEP + 25% CC	M01871-01_FIG_FL03	2	08/04/2020

Appendix B

Proposed Culvert Alignment

R:_Projects\M01871 Wenlock Estates\01 Bridgnorth Road, Shropshire\07 Drawings\M01871-01_DWG01 - Culvert Design.dwg 7-Apr-20 DWFx EPlot (XPS Compatible).pc3

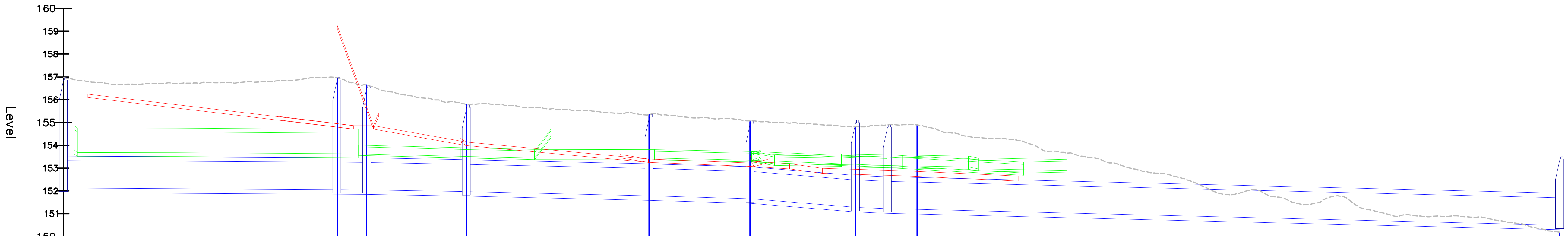


KEY

- STW FOUL
- STW STORM
- PROPOSED CULVERT

PROPOSED CULVERT LONGSECTION

SCALE: H 1:500,V 1:100. DATUM: 150.000



Chainage	Ground Elevation
0.00	156.97
10.00	156.70
20.00	156.72
30.00	156.72
40.00	156.78
50.00	156.85
60.00	156.97
70.00	156.41
80.00	156.06
90.00	155.81
100.00	155.70
110.00	155.58
120.00	155.42
130.00	155.39
140.00	155.22
150.00	155.07
160.00	155.00
170.00	154.85
180.00	154.88
190.00	154.78
200.00	154.35
210.00	154.20
220.00	153.67
230.00	153.23
240.00	152.78
250.00	152.21
260.00	152.03
270.00	151.50
280.00	151.78
290.00	151.01
300.00	150.88
310.00	150.85
320.00	150.55
328.20	150.19

Proposed Pipe Invert	Proposed Gradient
Start Invert 152.13 End Invert 152.060	0.11% 59.984
Start Invert 152.06 End Invert 152.050	0.15% 6.494
Start Invert 152.05 End Invert 151.969	0.37% 21.855
Start Invert 151.97 End Invert 151.787	0.45% 40.096
Start Invert 151.79 End Invert 151.660	0.57% 22.110
Start Invert 151.66 End Invert 151.280	1.64% 23.152
Start Invert 151.28 End Invert 151.222	0.83% 6.971
Start Invert 151.22 End Invert 150.500	0.49% 147.483

ISSUE	DRN	APP	DATE	NOTES / DESCRIPTION
01	MR	DKS	07/04/2020	FOR INFORMATION

STATUS
FOR INFORMATION

McCloy Consulting

T: 028 9084 8694
F: 028 9084 1525
E: info@mccloyconsulting.com
W: www.mccloyconsulting.com
Mossley Mill, Lower Ground (West)
Carnmoney Road North
Newtownabbey
Co. Antrim, BT36 5QA

PROJECT
BRIDGENORTH ROAD
SHROPSHIRE

CLIENT
WENLOCK ESTATES

DRAWING TITLE
1200mm PROPOSED CULVERT ALIGNMENT

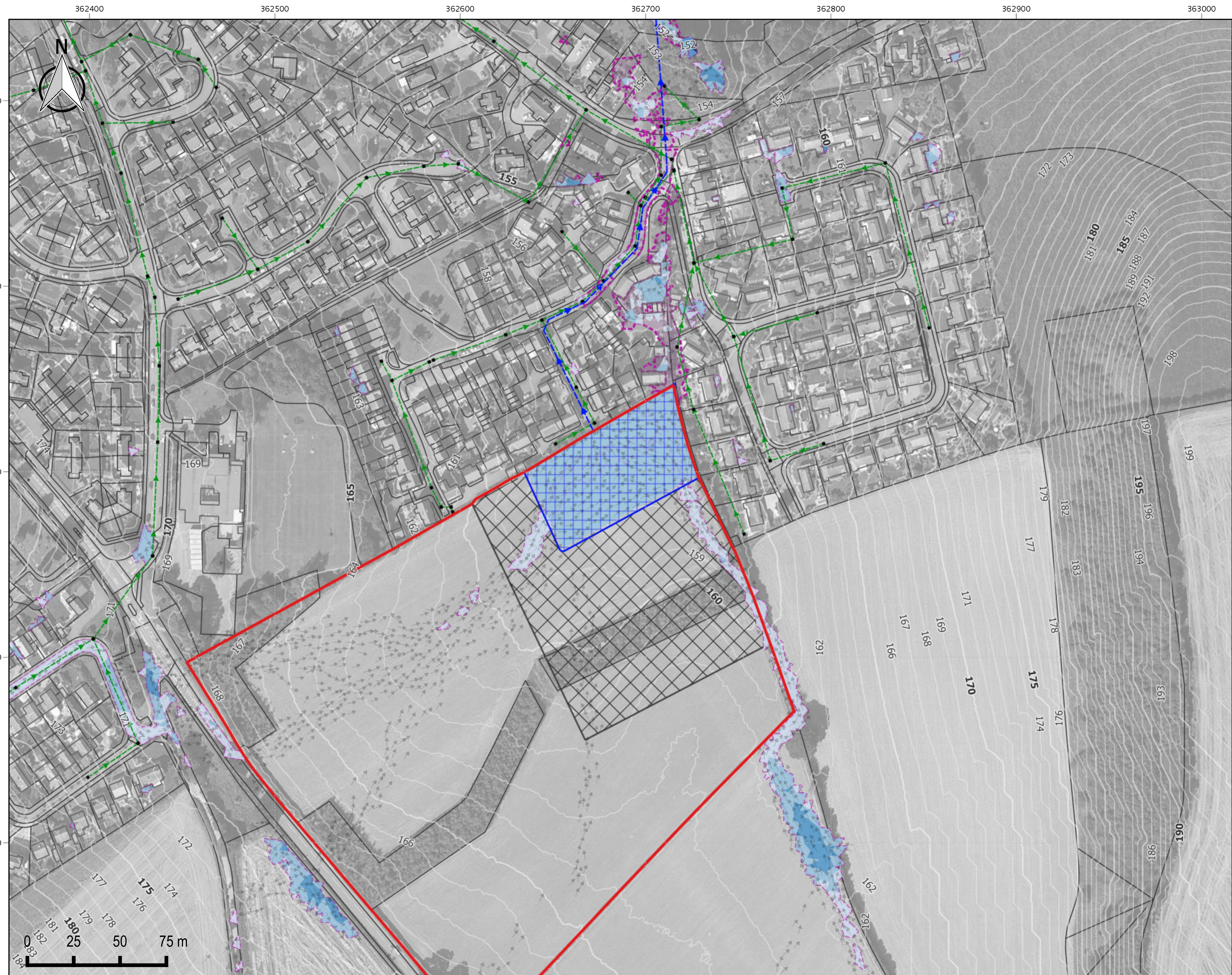
SCALE	ORIGINAL SIZE
AS SHOWN	A1

DRAWN	CHECKED	DATE
MR	DKS	07/04/2020

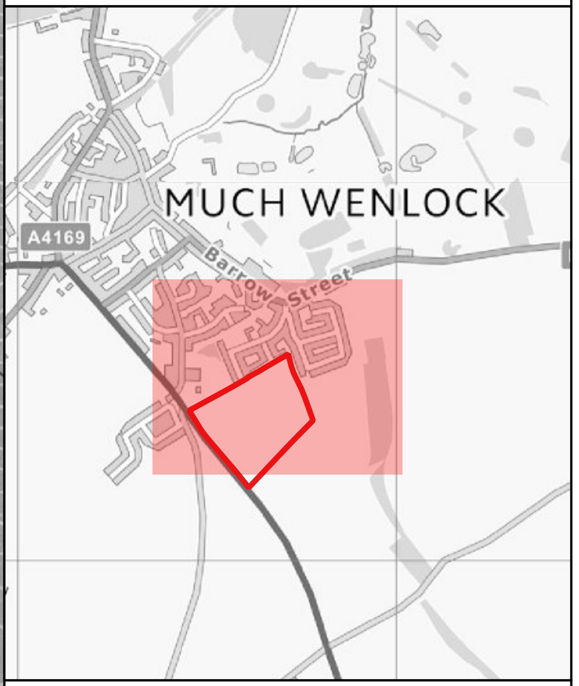
PROJECT No.	DRAWING No.	ISSUE NO.
M01871-01	DWG_01	1

Appendix C

Culvert Option Flood Mapping



MODEL OVERVIEW



LEGEND

- SITE LOCATION
- PROPOSED 1200mm FLOOD RELIEF CULVERT
- EXISTING SEVERN TRENT WATER STORM SEWERS
- FLOOD STORAGE BASIN AREA UPSTREAM OF FLOOD RELIEF CULVERT INLET - SHOWN FOR MODELLING PURPOSES ONLY
- INDICATIVE AREA REQUIRED TO ACCOMMODATE FLOOD STORAGE WITHIN SITE - SUBJECT TO DETAILED DESIGN AND MODEL REFINEMENTS
- BASELINE FLOOD EXTENT FOR COMPARISON
- FLOW ROUTING DIRECTION

FLOOD EXTENTS BANDED BY DEPTH (m)

- < 0.15m
- 0.15 - 0.30m
- 0.30 - 0.60m
- 0.60 - 0.90m
- > 0.90m

NOTES

1. ALL LEVELS INDICATED ARE TO ORDNANCE DATUM NEWLYN.

2. FLOOD EXTENTS WITHIN THE APPLICATION BOUNDARY ARE PLOTTED ON GROUND BASED TOPOGRAPHIC SURVEY; FLOOD EXTENTS OUTWITH THE APPLICATION SITE ARE PLOTTED ON A COMBINATION OF GROUND BASED TOPOGRAPHICAL SURVEY AND EA 1m LIDAR.

3. ALL GRID COORDINATE INFORMATION IS TO OSGB1936 (BRITISH NATIONAL GRID).

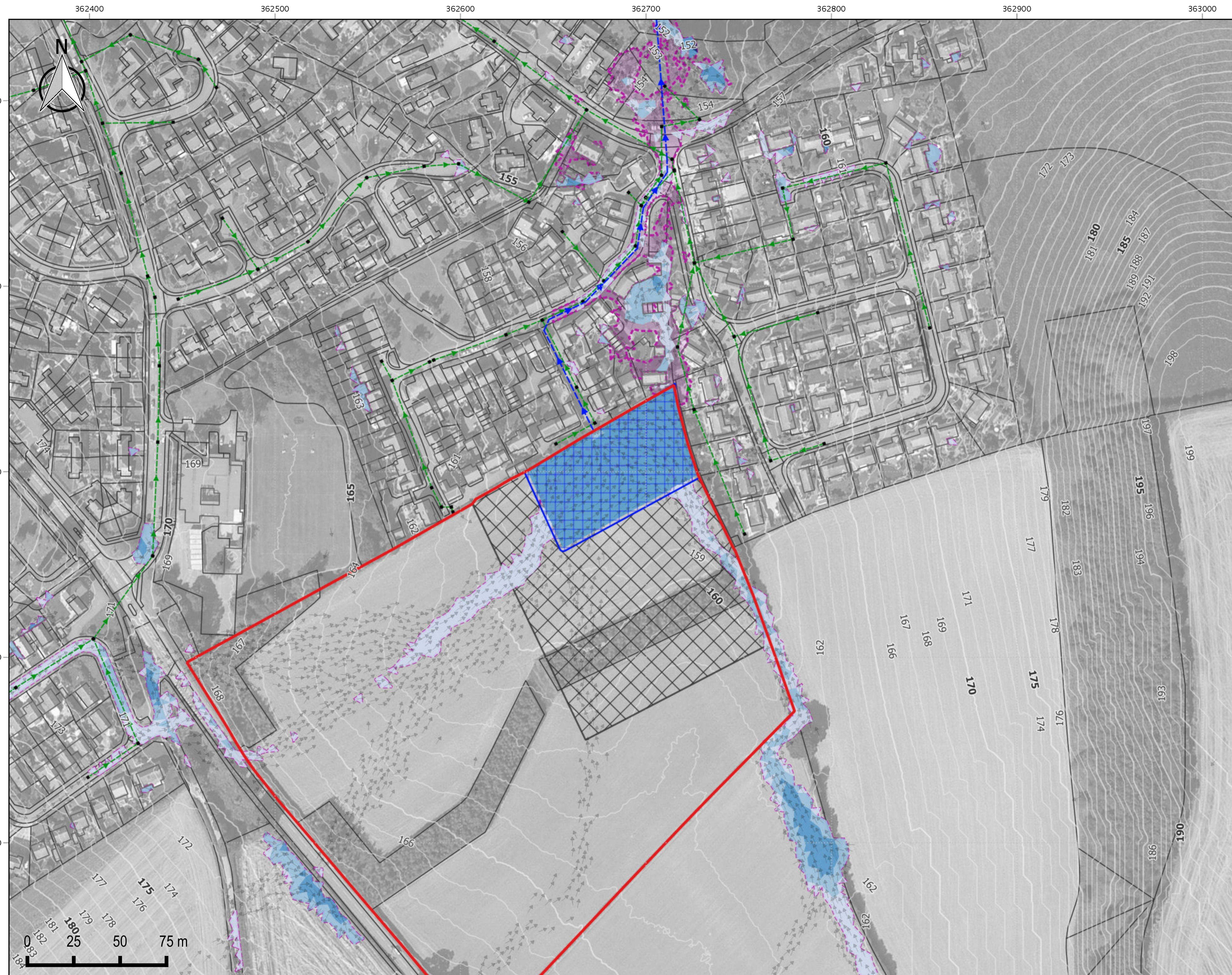
5. RESULTS ARE A COMPOSITE OF ALL DURATIONS SIMULATED TO PROVIDE THE WORST CASE EXTENT / DEPTH MAPPING FOR THE RETURN PERIOD; RESULTS HAVE BEEN PROCESSED TO REMOVE AREAS OF MINIMAL FLOODING (<0.02m) AND OF VERY LOW HAZARD (<0.575).

McCloy Consulting

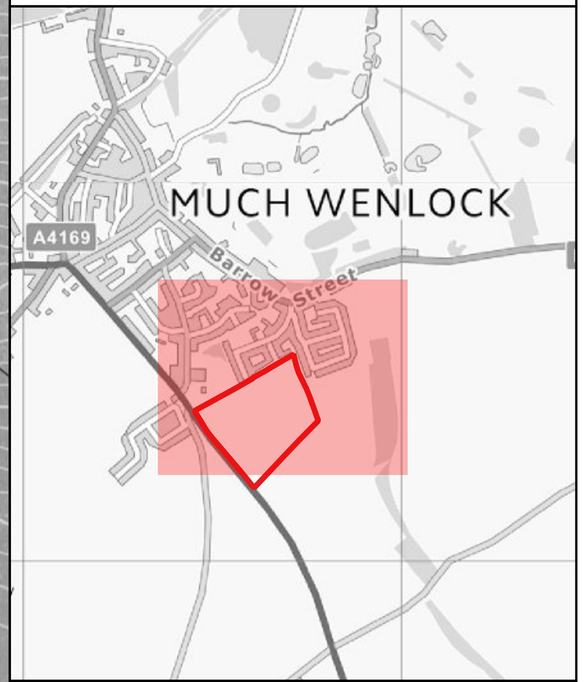
Mossley Mill,
Lower Ground (West),
Carnmoney Road North,
Newtownabbey, BT36 5QA

T: 028 9084 8694
E: info@mccloyconsulting.com
W: www.mccloyconsulting.com

PROJECT		HYDROLOGY SCENARIO	SCALE	ORIGINAL SIZE
BRIDGNORTH ROAD, SHROPSHIRE		PRESENT DAY	1:2000	A3
MAP TYPE		**GEOMETRY SCENARIO**	**DRAWN BY**	**APPROVED**
FLOOD EXTENTS / DEPTH MAPPING		OPTIONEERING - 1200mm CULVERT	MR	DKS
SOURCE	**FLOOD EVENT**	**FIGURE NUMBER**	**REVISION**	**DATE**
PLUVIAL	3.3% AEP	M01871-01_FIG_FL04	3	28/04/2020



MODEL OVERVIEW



LEGEND

- SITE LOCATION
- PROPOSED 1200mm FLOOD RELIEF CULVERT
- EXISTING SEVERN TRENT WATER STORM SEWERS
- FLOOD STORAGE BASIN AREA UPSTREAM OF FLOOD RELIEF CULVERT INLET - SHOWN FOR MODELLING PURPOSES ONLY
- INDICATIVE AREA REQUIRED TO ACCOMMODATE FLOOD STORAGE WITHIN SITE - SUBJECT TO DETAILED DESIGN AND MODEL REFINEMENTS
- BASELINE FLOOD EXTENT FOR COMPARISON
- FLOW ROUTING DIRECTION

FLOOD EXTENTS BANDED BY DEPTH (m)

- < 0.15m
- 0.15 - 0.30m
- 0.30 - 0.60m
- 0.60 - 0.90m
- > 0.90m

NOTES

1. ALL LEVELS INDICATED ARE TO ORDNANCE DATUM NEWLYN.

2. FLOOD EXTENTS WITHIN THE APPLICATION BOUNDARY ARE PLOTTED ON GROUND BASED TOPOGRAPHIC SURVEY; FLOOD EXTENTS OUTWITH THE APPLICATION SITE ARE PLOTTED ON A COMBINATION OF GROUND BASED TOPOGRAPHICAL SURVEY AND EA 1m LIDAR.

3. ALL GRID COORDINATE INFORMATION IS TO OSGB1936 (BRITISH NATIONAL GRID).

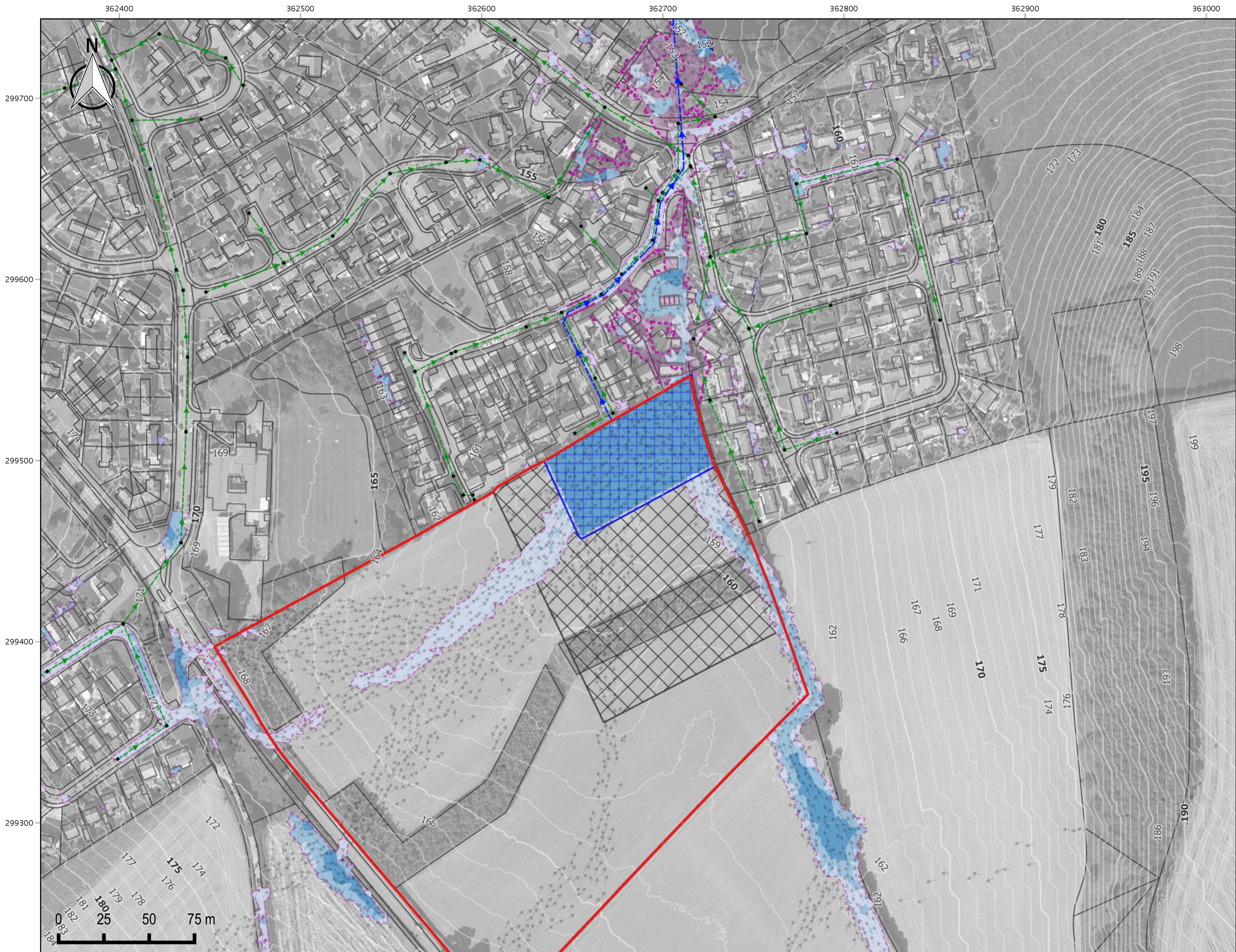
5. RESULTS ARE A COMPOSITE OF ALL DURATIONS SIMULATED TO PROVIDE THE WORST CASE EXTENT / DEPTH MAPPING FOR THE RETURN PERIOD; RESULTS HAVE BEEN PROCESSED TO REMOVE AREAS OF MINIMAL FLOODING (<0.02m) AND OF VERY LOW HAZARD (<0.575).

McCloy Consulting

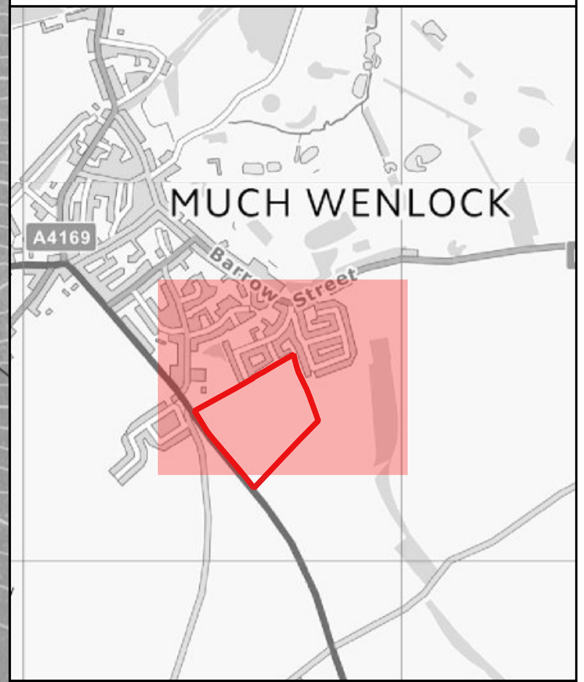
Mossley Mill,
Lower Ground (West),
Carnmoney Road North,
Newtownabbey, BT36 5QA

T: 028 9084 8694
E: info@mccloyconsulting.com
W: www.mccloyconsulting.com

PROJECT		HYDROLOGY SCENARIO	SCALE	ORIGINAL SIZE
BRIDGNORTH ROAD, SHROPSHIRE		PRESENT DAY	1:2000	A3
MAP TYPE		**GEOMETRY SCENARIO**	**DRAWN BY**	**APPROVED**
FLOOD EXTENTS / DEPTH MAPPING		OPTIONEERING - 1200mm CULVERT	MR	DKS
SOURCE	**FLOOD EVENT**	**FIGURE NUMBER**	**REVISION**	**DATE**
PLUVIAL	1% AEP	M01871-01_FIG_FL05	3	28/04/2020



MODEL OVERVIEW



LEGEND

- SITE LOCATION
- PROPOSED 1200mm FLOOD RELIEF CULVERT
- EXISTING SEVERN TRENT WATER STORM SEWERS
- FLOOD STORAGE BASIN AREA UPSTREAM OF FLOOD RELIEF CULVERT INLET - SHOWN FOR MODELLING PURPOSES ONLY
- INDICATIVE AREA REQUIRED TO ACCOMMODATE FLOOD STORAGE WITHIN SITE - SUBJECT TO DETAILED DESIGN AND MODEL REFINEMENTS
- BASELINE FLOOD EXTENT FOR COMPARISON
- FLOW ROUTING DIRECTION

FLOOD EXTENTS BANDED BY DEPTH (m)

- < 0.15m
- 0.15 - 0.30m
- 0.30 - 0.60m
- 0.60 - 0.90m
- > 0.90m

NOTES

1. ALL LEVELS INDICATED ARE TO ORDNANCE DATUM NEWLYN.
2. FLOOD EXTENTS WITHIN THE APPLICATION BOUNDARY ARE PLOTTED ON GROUND BASED TOPOGRAPHIC SURVEY; FLOOD EXTENTS OUTWITH THE APPLICATION SITE ARE PLOTTED ON A COMBINATION OF GROUND BASED TOPOGRAPHICAL SURVEY AND EA 1m LIDAR.
3. ALL GRID COORDINATE INFORMATION IS TO OSGB1936 (BRITISH NATIONAL GRID).
5. RESULTS ARE A COMPOSITE OF ALL DURATIONS SIMULATED TO PROVIDE THE WORST CASE EXTENT / DEPTH MAPPING FOR THE RETURN PERIOD; RESULTS HAVE BEEN PROCESSED TO REMOVE AREAS OF MINIMAL FLOODING (<0.02m) AND OF VERY LOW HAZARD (<0.575).

McCloy Consulting

Mossley Mill,
Lower Ground (West),
Carnmoney Road North,
Newtownabbey, BT36 5QA

T: 028 9084 8694
E: info@mccloyconsulting.com
W: www.mccloyconsulting.com

PROJECT		HYDROLOGY SCENARIO	SCALE	ORIGINAL SIZE
BRIDGNORTH ROAD, SHROPSHIRE		CLIMATE CHANGE	1:2000	A3
MAP TYPE		**GEOMETRY SCENARIO**	**DRAWN BY**	**APPROVED**
FLOOD EXTENTS / DEPTH MAPPING		OPTIONEERING - 1200mm CULVERT	MR	DKS
SOURCE	**FLOOD EVENT**	**FIGURE NUMBER**	**REVISION**	**DATE**
PLUVIAL	1% AEP + 25% CC	M01871-01_FIG_FL06	3	28/04/2020