

APPENDIX I – ADDITIONAL FLOOD MODELLING REPORT JUNE 2021

Proposed Residential Development, Former East Lancashire Paper Mills, Radcliffe

Additional Flood Modelling Report

A112428-68

First Issue

Homes England & Bury Metropolitan Borough Council

June 2021

Prepared on Behalf of Tetra Tech Limited.

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1.0 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

Homes England (HE) and Bury Metropolitan Borough Council (BC) have commissioned Tetra Tech Ltd (formerly WYG Engineering Ltd) to undertake additional hydraulic modelling in respect of a proposed development on a 22.98 ha site on the former site of the East Lancashire Paper Mills in Radcliffe, Bury.

This report has been prepared to provide additional information on the flood risk to the site to remove risk from future developers.

1.2 PROPOSED DEVELOPMENT

Outline planning application referenced 62969 was approved for the development of up to 400 dwellings, and associated works including relocation of cricket pitch, including a pavilion, provision of open space and sports facilities and demolition of existing building and structures.

The proposed Indicative Masterplan is included in Appendix A.

1.3 SCOPE OF THIS REPORT

This report has been prepared in support of the additional modelling completed which included:

1. Preliminary review of the optimum height of wall to be retained along the River Irwell frontage
2. Removal of floodable gardens from the model
3. Reduction of flows into the site via Hutchinson's Goit to levels agreed with the Environment Agency
4. Preliminary review of the proposed retained pond weir control
5. Run the model for the Q10, Q20, Q100, Q100+CC1, Q100+CC2, Q1000 events with the existing site topography in place
6. Run the model for the Q10, Q20, Q100, Q100+CC1, Q100+CC2, Q1000 events with the proposed development in place as amended by items 1 – 4 above
7. Review results of the above and prepare reporting

1.4 LIMITATIONS OF THIS REPORT

This report has been prepared by Tetra Tech Ltd (formerly WYG Engineering Ltd) on behalf of HE & BC in connection with the scope of the report as described in Section 1.3 above and takes into account the particular instructions and requirements set out in our fee proposal and the acceptance. It is not intended for and should not be relied on by any third party and no responsibility is undertaken to any third party.

Tetra Tech accepts no duty or responsibility (including in negligence) to any party other than HE & Bury MBC and disclaims all liability of any nature whatsoever to any such party in respect of this report.

This report cannot be reproduced without Tetra Tech's written consent

2.0 SITE DESCRIPTION

2.1 EXISTING SITE

The application site covers an area of 22.98 ha and is located to the south of Cross Lane, Radcliffe at grid reference SD 79279 07408. The nearest postcode is M26 2PG. A location and site plan are shown in Figure 1 and Figure 2 below.

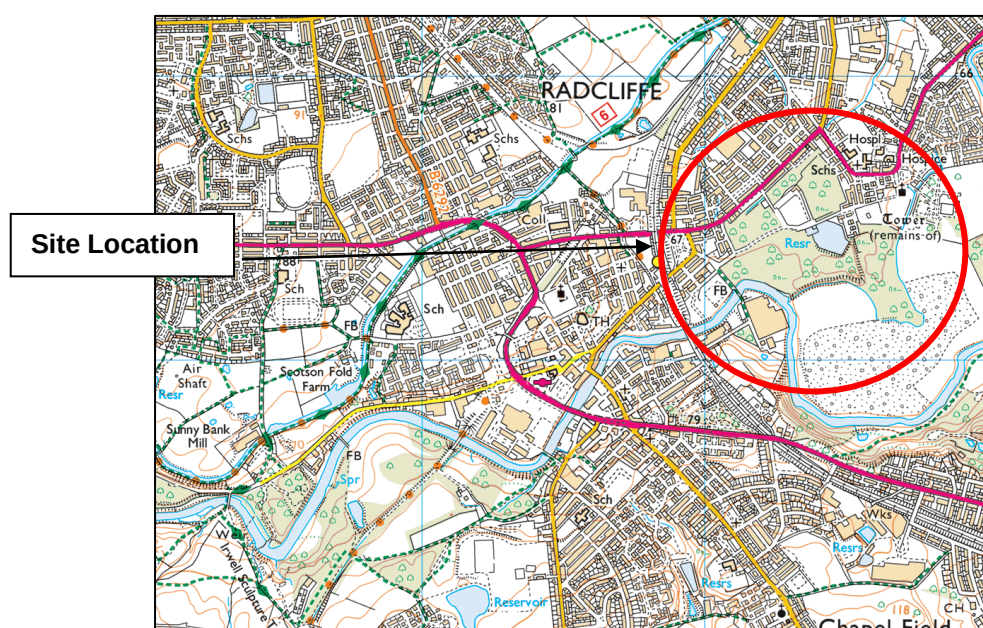


Figure 1 – Site Location Plan

The application site is bounded to the north by Cross Lane and residential developments, to the east by Bury Street and undeveloped land, to the south by a largely abandoned watercourse known as Bealey's Goit, and by the River Irwell.

Due to the former nature of the site, it is considered brownfield in planning terms. However, most of the land is undeveloped, and therefore in terms of surface hydrology it is considered as a greenfield site.

A topographical survey of the site was undertaken. It shows that the highest point lies on the south eastern corner of the application site at a level of 76.20m AOD; whereas the lowest point of the application site is located by the River Irwell and lies at 62.26m AOD. The general direction of the falls and the high and low points across the entirety of the application boundary are illustrated in Figure 3 below.

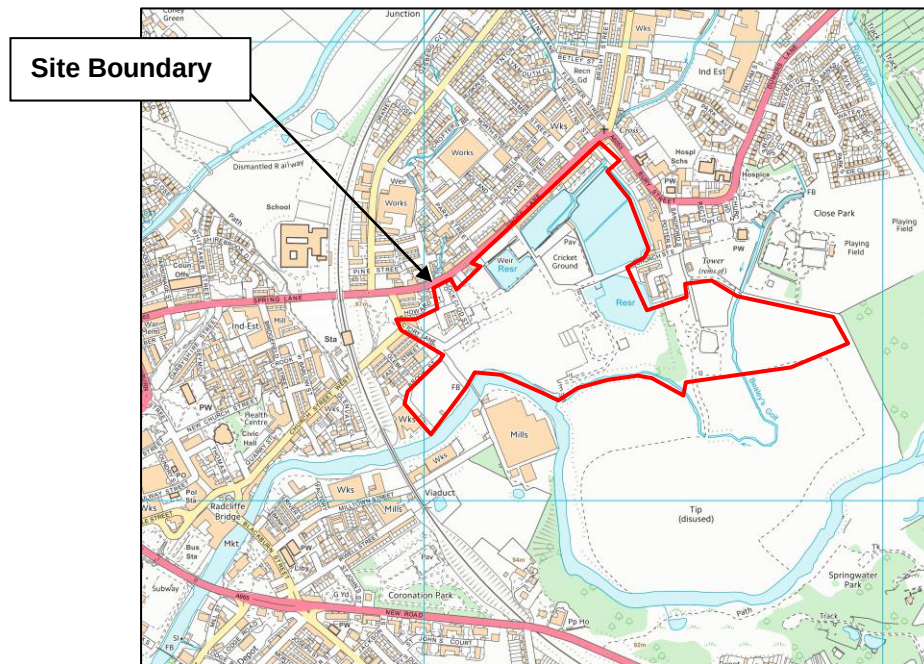


Figure 2 – Site Boundary

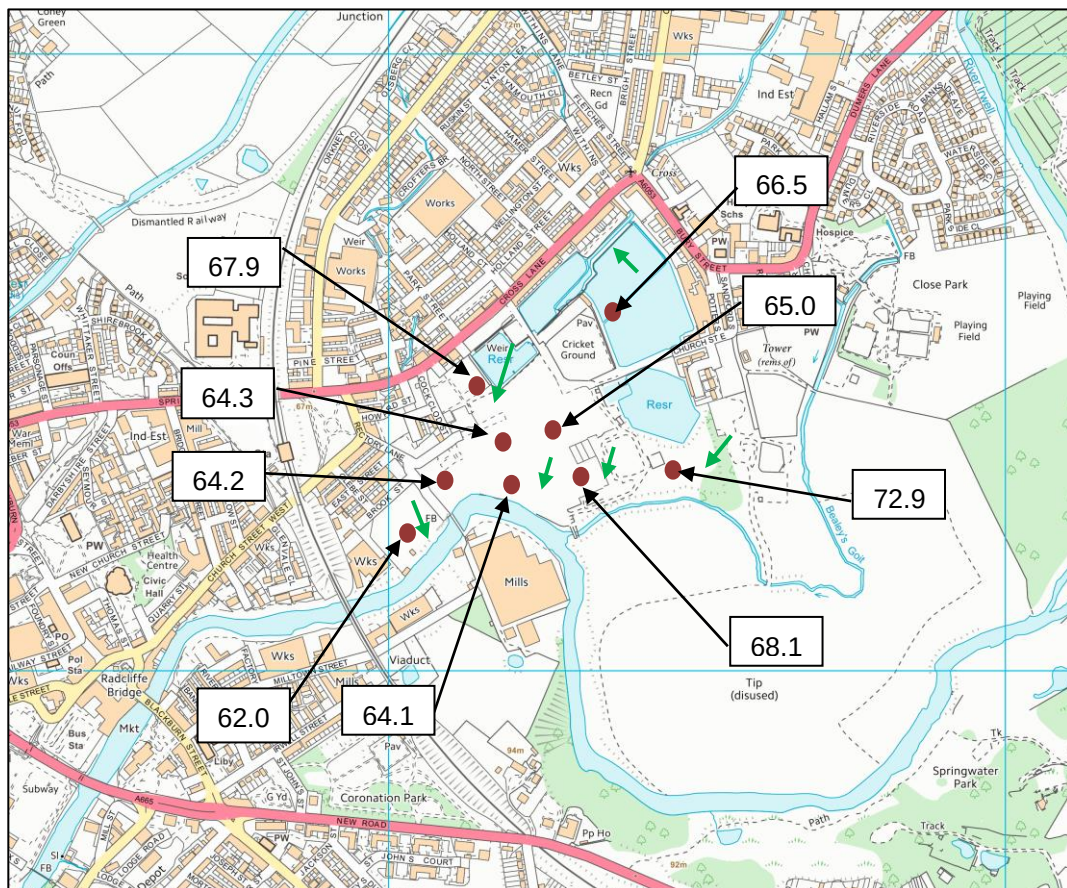


Figure 3 – Ground Levels within the Application Site (m AOD)

2.2 WATERCOURSES

2.2.1 Main Rivers

The nearest Main River to the application site is the River Irwell, which forms the western boundary of the site as explained above.

Crow Trees Farm Brook is classified as main river and it flows culverted from north to south through the western part of the application site. As indicated above, Crow Trees Farm Brook was culverted in the 1800s. Information about the culvert provided by the EA confirmed that the culvert is located within the undeveloped land between Howard Street and Rectory Lane, then continuing under Rectory Lane into the River Irwell.

2.2.2 Ordinary and Manmade Watercourses

In addition to the River Irwell, there are a number of ordinary watercourses within the site.

The Hutchinson's Goit is a manmade ordinary watercourse which was created to supply the paper mills with water from the Irwell. It flows in an open channel from the abstraction point 1.5 km to the north east of the site. The Goit enters the site from the north east, then becomes culverted under the Cricket Club, where it turns south. CCTV surveys were undertaken in 2020 to investigate further the route of the Goit through the site, however these were unable to determine the route of the culvert as it was found to be collapsed within the existing cricket club. Therefore, the exact route by which Hutchinson's Goit flows back to the Irwell is unknown. This is not considered an issue for the site as the preferred solution within the design will be to divert the Goit and create a new channel therefore further investigations to locate the channel to maintain flow will not be required.

Bealey's Goit forms the south eastern boundary of the site. Bealey's Goit fed former industries and allowed the resultant water to be treated prior to its return to the Irwell. Remnants of the open Goit can be seen to the south east of the site. It no longer follows the route shown on the OS mapping; it is diverted back to the Irwell to the east of the site.

3.0 FLUVIAL FLOOD RISK

3.1 INTRODUCTION

Fluvial flood risk is the risk arising from rivers and watercourses.

A floodplain is the area that would naturally be affected by flooding if a river rises above its banks. In England, floodplains are divided into flood zones (FZ) for planning purposes. These areas show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. They are divided as follows:

- Flood Zone 3 shows Land having a 1 in 100 (1%) or greater annual exceedance probability (AEP) of river flooding.
- Flood Zone 2 shows land having between a 1 in 100 and 1 in 1,000 annual exceedance probability of river flooding ($1\% > \text{AEP} > 0.1\%$).
- Flood Zone 1 is the area where flooding from rivers and the sea is very unlikely. There is less than a 0.1% (1 in 1000) chance of flooding occurring each year in Flood Zone 1.

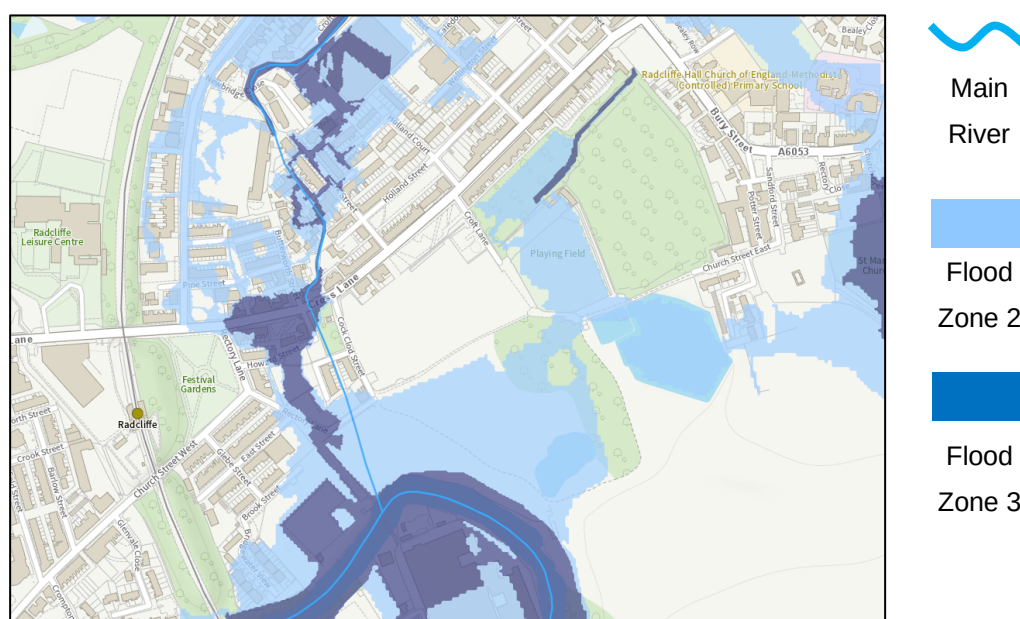


Figure 4 – Extract of the EA's Flood Map for Planning (May 2021)

According to the EA's Flood Map for Planning, the site is located in Flood Zones 1, 2 and 3; as shown in Figure 4 above. Ongoing work by the Environment Agency has led to a revision of the Flood Map for Planning in the area. Figure 5 shows the previous extent of the flood zones as shown by the EA's Flood Map for Planning at the time of the approval of the outline application.

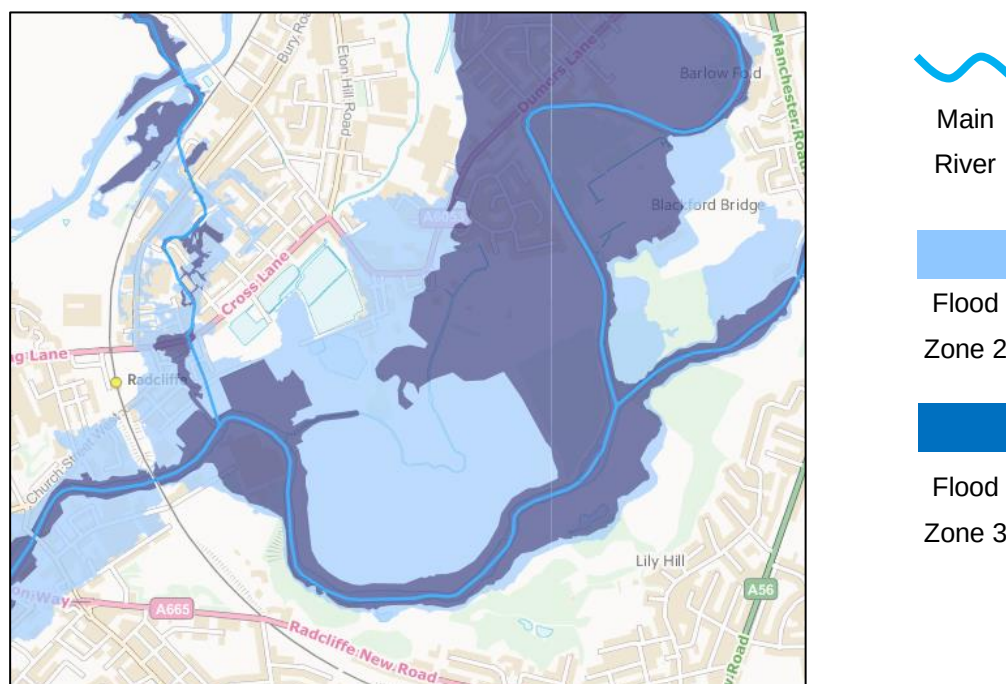


Figure 5 – Extract of the EA's Flood Map for Planning (May 2018)

The EA has confirmed that the flood map outlines were updated in 2019 to reflect the outputs from the initial modelling associated with the Radcliffe & Redvales flood risk management scheme undertaken in 2016. The 2016 model included reviews of hydrology, riverside developments, survey info and included calibration against flood events in 2012 and 2015.

The hydraulic modelling undertaken in support of the outline planning application was based on a version of this model that has been used to update the Flood Map for Planning.

3.1.1 Climate Change

In accordance with the latest EA guidance on Climate Change, 'More Vulnerable' developments located in Flood Zones 2 and 3a need to assess the impact of Climate Change in peak river flows using both the 'higher central' and 'upper end' allowances. The 'higher central' and 'upper end' allowances are +35% and +70% respectively for flow in rivers in the North West of England if the lifetime of the development extends after the 2080s.

The EA indicated in their correspondence that the 'higher central' allowance is sufficient to assess the impact of the proposed development elsewhere. This is discussed in Section 3.3.3 below.

3.1.2 Previous Hydraulic Modelling

Detailed hydraulic modelling was undertaken to investigate the expected impacts of Climate Change within the site both in its current form and with the development proposals in place. A full description of the modelling was

included in the previous FRA and FRA Addendum reports submitted in support of the outline planning application.

3.1.3 Crow Trees Farm Brook

'Cost-recoverable' advice was sought from the Environment Agency in order to obtain further clarification on the risk of flooding from the Brook and any detailed modelling requirements. It was indicated in the meeting that although the EA product 4 data imply that a considerable number of existing properties may be subject to flooding on a 1 in 20 year event, since telemetry and screening at the upstream culvert entry were introduced, there have not been reports of flooding (due to Crow Trees Farm Brook).

It was agreed with the EA that further detailed modelling of the culvert is not required if no modifications to the existing culvert are proposed and finished floor levels (and resilience measures if appropriate) are provided for any properties within the zone of influence of flooding from Crow Trees Farm Brook based on the relevant existing EA model data.

3.2 OUTLINE PLANNING PROPOSALS

3.2.1 Minimum Finished Floor Levels & Flood Resilience Requirements

At the outline planning stage, and as set out in the FRA Addendum, the following was agreed with the Environment Agency:

- (i) FFLs are to be set 600mm above the 1 in 100 year return period plus 35% climate change allowance event (in respect of the River Irwell, Hutchinson's Goit and Crow Trees Farm Brook);
- (ii) Where existing levels and infrastructure mean compliance with (i) above is not achievable a clear rationale for such departure should be provided;
- (iii) It is recommended that consideration of risks and the provision of flood resilience measures be included up to the 1 in 100 year level plus 70% climate change (in respect of the River Irwell, Hutchinson's Goit and Crow Trees Farm Brook) for properties where raising the FFL may not be practical as discussed below in section 3.2.1.1.

3.2.1.1 Proposed Flood Resilience Measures

Flood resilience measures to a level of 65.90m AOD will be provided to the proposed units facing existing streets, as it is not practicable to provide dwellings on one side of an existing street at a higher level than the existing houses. Flood resilience measures include, but are not limited to, providing raised outlets and air bricks, non – return valves in waste and vent pipes, tiled floors, etc. This only applies to approximately 30 units proposed alongside Cross Lane, Rectory Lane and Brook Street.

3.2.2 Proposed Re-Contouring

It was proposed at the outline planning application stage to recontour the site in order to provide higher ground levels in the areas of proposed residential development, whilst providing a larger area of the site dedicated to functional floodplain. This required that flood risk elsewhere does not increase as a result of the proposed development. In order to provide FFLs above 65.90m AOD to all the units, it is proposed to undertake earthworks to realign the boundaries of the flood zones within the site and to reduce the area at risk within the site.

The proposed amendments have been constrained due to the presence of contaminated materials within the site that would not be suitable as fill material in other parts of the site.

The proposed site recontouring strategy is as follows:

- 1) Increased functional floodplain associated with the River Irwell along the riverside
- 2) Open up watercourses within the site to create blue corridors and utilise 'soft engineered' solutions to define channels. This includes:
 - a. Open up Hutchinson's Goit and provide further flood storage alongside the Goit
 - b. Retain the existing pond so it contributes to floodplain storage in large events
- 3) Take due account of the restrictions arising from the landfill above where sports facilities will be located. The former landfill prevents these areas from being lowered as part of the proposals
- 4) Raise the residential development platforms so that finished floor levels (FFLs) are above the Q100 plus 35% plus 600mm minimum FFL
- 5) Permit localised garden flooding on the Q100 plus 70% climate change event in the area to the south of the retained Rectory Lane/Church Street East road (approximately 12 units)

The proposed site contours are included in Appendix B.

3.2.3 River Model

As noted above, the previous model used the model developed in 2016 that included the first phase of the Radcliffe and Redvales Flood Alleviation Scheme (FAS). Further updates to this model have been undertaken by the Environment Agency (EA) as a result of the continuation of the FAS with construction of additional defences starting in 2020 and still ongoing.

The EA were consulted before progressing with additional modelling and confirmed the same model that was used in the modelling work that supported the planning application could be used.

Additional details of the hydraulic modelling are included in the modelling report included in Section 3.3 which reviews the proposed changes to the previous model and in Appendix D.

3.3 REVISED HYDRAULIC MODELLING

3.3.1 Hutchinson's Goit

The previous model included flows over 2 m³/s through Hutchinson's Goit into the site. Following consultations with the EA, they advised they were planning to restrict flows into the Goit to 1.1 m³/s as part of the ongoing FAS. Further enquiry was conducted with the EA to review if it would be practical to restrict flows to the Goit beyond 1.1 m³/s to reduce flood risk across the site. The EA project manager for the FAS confirmed at a meeting with HE and Tetra Tech that a restriction to 0.5 m³/s would be practical and feasible.

Bury Council (BC) as Lead Local Flood Authority (LLFA) advised that the additional long term cost associated with the higher maintenance that may be required by the smaller orifice restricting flows is negligible and that BC has no objection to the proposed restriction to 0.5 m³/s.

There is an additional flow of 250 l/s into Hutchinson's Goit to the east of the site from a small tributary.

It can be seen in the proposed layout plan that the flows from Hutchinson's Goit are to be diverted into the retained pond, and then discharged into the Irwell through an area of open space.

Correspondence with the EA regarding the flow restriction is included in Appendix C.

3.3.2 Retained Pond

As a result of the restricted flows into the site through Hutchinson's Goit, the flood storage volume required at the retained pond is lower than previously anticipated. The water level in the pond can be raised to 64.5m AOD.

The flows in and out of the retained pond will be controlled as follows:

- Inlet from Hutchinson's Goit: 450mm pipe under Church St East, with a 1 in 200 gradient falling to an invert level of 64.5m AOD at the pond side.
- Outlet: it is proposed to provide a 375mm pipe with an invert level of 64.5m AOD; and a high-level spillway (modelled as a weir) with a crest level of 65.5m AOD. A flap valve will be required to prevent high water levels in the Irwell from entering the retained pond.

It is anticipated that there will be a 3m wide maintenance track around the retained pond. The outfall is expected to be formed by standard precast concrete headwalls at either side of the track, with a constant level of the track at 65.5m AOD to serve as spillway. The section of track at 65.5m AOD is to be provided with tarmac or concrete as a crushed aggregate path would likely be eroded if the water levels in the pond were to exceed the level of 65.5m AOD. The modelling results indicate that estimated water levels in the retained pond during the 1 in 20 year return period is 65.55m AOD. Any events with return period higher than the 1 in 20 years are expected to cause the pond to overflow through the spillway and onward to the River Irwell.

A cascade panel or energy dissipation blocks are to be included at the downstream end of the pond outfall pipe's headwall.

3.3.3 Floodable Gardens

'Floodable' gardens were included within the proposed site layout in order to avoid an increase in flood depths downstream during the 1 in 100 year return period event plus the 70% upper end climate change allowance. However, following internal discussions within HE it was advised that the floodable gardens may hinder the developability of the site, and would be preferable to remove them.

The gardens had been designed to provide floodplain compensatory storage, flooding up to a depth of 1m and were expected to remain dry during the majority of flood events, only flooding during the 1 in 100 year return period event plus 70% climate change allowance.

The EA's guidance on climate change allowances has been updated since the previous FRA report was undertaken. The latest guidance indicates that *'the appropriate allowance to assess off-site impacts and calculate floodplain storage compensation depends on land uses in affected areas. In most cases use the higher central allowance to calculate floodplain storage compensation.'*

The guidance indicates that the upper end allowance is to be used if:

- a) catchment is particularly sensitive to small changes in volume, which could cause significant increases in flood depth or hazard; or
- b) affected area contains essential infrastructure or vulnerable uses, such as primary schools, caravans, bungalows or basement dwellings.

The catchment of the River Irwell is not considered to be sensitive to small changes in volume; however it is unclear whether the EA would consider the areas to the west of the site as particularly vulnerable. Further consultation with the EA clarified that the 'higher central' allowance is appropriate at this location to assess impacts off-site.

The correspondence with the EA is included in Appendix C.

3.3.4 River Wall Height

There is an existing stone wall alongside the River Irwell approximately between the former Bealey's Goit outlet and the Crow Trees Farm Brook outlet. Figure 5 shows a recent photograph of the wall taken from the outfall from Crow Trees Farm Brook into the Irwell. The length of the wall is 185m, with Figure 6 below showing the approximate extent of River Wall. The top of the wall level varies between 62.14m AOD at its lowest point and 63.17m AOD at its highest point.

It is proposed to lower the wall to create an additional area of functional flood plain to 61.40m AOD in order to provide the additional storage required. The river bed level is approximately 58.80m AOD.



Figure 5 – View of Existing Wall from Crow Trees Farm Brook outfall

Previous experience in other areas in the North West of England suggests that the wall is likely to have a stepped foundation on the retaining site, with the width of the wall increasing with the depth.

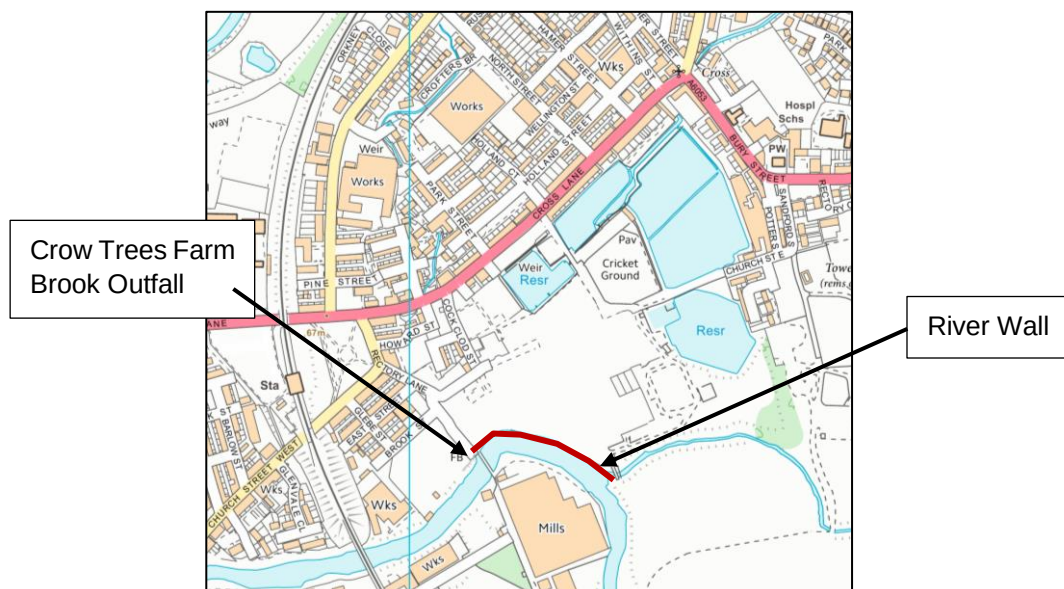


Figure 6 – Extent of River Wall

The reduction in the ground levels retained by the wall is expected to be of benefit as it would significantly reduce the load acting on the wall. It is therefore assumed that the river wall can be lowered and retained in its current condition, however this is to be confirmed by further structural surveys by specialist engineers.

3.4 MODELLING RESULTS

The previous hydraulic model was updated to incorporate the above changes. Appendix D includes the updated hydraulic modelling report. The main results are discussed below.

3.4.1 Functional Floodplain – 1 in 20 year return period event (5% AEP)

The revised modelling results indicate that the proposed development platforms would be at low risk of flooding during this event. Flows from Hutchinson's Goit are shown to be retained within the new proposed opened channel and the retained pond. The results also show greater depths of flooding within the lowered areas of the site proposed to increase the area of functional floodplain. The results show a slight increase in depth within the Irwell between the site and the Pioneers Mill site. This is a complex area as it is the confluence of:

- The outfall of Hutchinson's Goit is re-located upstream to a point opposite the Pioneer Mills
- The opening up of Hutchinson's Goit re-directs water back to the Irwell more directly
- The re-direction of Hutchinson's Goit removes some storage from the Goit system

It is also important to note that the model results show flood depths associated with the retained pond extending into the areas to the west of the retained pond. The proposed contours plan indicates that this area is designed to retain water during flood events and it is dedicated to public open space associated with the retained pond and car parking areas.

3.4.2 1 in 100 year return period event (1% AEP)

a) Present-Day outline

The revised modelling results indicate that the proposed development platforms would be at low risk of flooding during this event. The results show a reduction in flood depths to the east of the southern part of the Pioneer Mills site; with a small increase in the north eastern part of this site. It is important to note that flood depths in the area accepted are expected to be over 1.2m and therefore the small increase of 20mm is considered negligible, particularly as the existing Hazard Rating within this area during this event is 'Danger for Most'. This was also agreed with the EA during the determination of the outline planning application as noted in the FRA addendum report.

b) 35% Climate Change Allowance

Similarly to the results for the lower return period events, the results show that the proposed development platforms would not be affected by flooding during this event, with depths within the lowered area exceeding 2.4m. It can be seen that a small part of the north western part of the site near Cock Clod Street would be at risk, this is associated with Crow Trees Farm Brook and it is proposed to be mitigated with the provision of flood resilience measures as discussed above in section 3.2.1.1.

The results also show a negligible increase in depths in the Pioneers Mill site, for the reasons outlined above. During this event, flood depths in the Pioneers Mill site are expected to exceed 2.4m in the existing situation, with the Hazard Rating indicating 'Danger for All'.

It is important to note that the difference mapping indicates an increase in flood depths to the north east of the site in the business park by the A6053 bridge. This discrepancy is explained further in the modelling report and is a result of a difference in equations used across different versions of the modelling software packages (i.e. a later version was used to run the model for this exercise than the version when the model was produced) as water depths approach the deck of the bridge. It is therefore considered that this is an inconsistency in the model and not expected to take place.

The results confirm that the removal of the floodable gardens does not have an impact on the

c) 70% Climate Change Allowance

As noted above, the EA advised that the use of the 35% allowance for peak river flows would be adequate to assess impacts off-site and to set finished floor levels. However, the EA also requested a check of the 70% peak river flow allowance to confirm whether the proposed FFLs would be sufficient to mitigate against this event. It can be seen in the results that flood waters would not extent into the proposed development platforms, and that the proposed FFLs provide adequate mitigation against this event too.

The results show that during this return period event, with the upper end climate change allowance (which is higher than the EA guidance on climate change requires), there is small increase slightly over 20mm in the modelled depths in the Irwell to the west of the site. This would have a minor impact on the flood depths in the areas affected by flooding, and the results show that the Hazard Rating remains as 'Danger for Most' or 'Danger to All' in these areas.

3.4.3 1 in 1000 year return period event (0.1% AEP)

The results show depths being slightly higher during the 1 in 1000 year return period event in comparison to the 1 in 100 year plus 35% climate change event, but slightly lower than the 1 in 100 year plus 70% climate change allowance. Therefore, the comments made above for the 1 in 100 year plus 70% climate change events apply.

4.0 CONSENTS REQUIRED

4.1 LAND DRAINAGE ACT 1991

Any modifications to the ordinary watercourses within the site that may affect the flows or the channel and any new outfalls into a watercourse will need to obtain Land Drainage Consent as per Section 23 of the Land Drainage Act 1991.

The proposed works to Hutchinson's Goit will require to be consented under the LDA 1991.

4.2 ENVIRONMENTAL PERMIT

Any activity within 8m from a Main River needs to be consented by the Environment Agency. The following activities will require environmental permits:

- Amendments to the banks of the River Irwell;
- Extension and improvement of the functional floodplain of the River Irwell; and
- Proposals to open up and realign Crow Trees Farm Brook.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This report has identified the following conclusions:

1. The development site is shown on the EA Statutory Flood Maps for Planning as being partly in Flood Zones 1, 2 and 3
2. An outline planning application was approved in December 2018 for the development of up to 400 dwellings, sports pitches, landscaping and infrastructure
3. Detailed hydraulic modelling was been undertaken in support of the outline application and this showed a significantly reduced footprint of Flood Zone 3 due to the River Irwell. However, other areas of Flood Zone 3 are identified associated with Hutchinson's Goit
4. The previous hydraulic modelling has been updated as follows:
 - a) It has been agreed with the Environment Agency that flows in the inlet of Hutchinson's Goit will be restricted to $0.5\text{m}^3/\text{s}$ in the Bury Road bridge as part of the overall Radcliffe and Redvales FAS. The previous modelled flows were in excess of $2\text{m}^3/\text{s}$
 - b) The previously proposed 'floodable gardens' have been removed from the proposals
 - c) The water level in the retained pond has been altered to 64.5m AOD
 - d) The level of the public open space between the proposed development platforms and the Irwell has been lowered to 61.40m AOD
5. The EA climate change allowances have been updated and indicate that the higher central (35%) climate change allowance is adequate
6. The revised modelling results indicate the following:
 - a) The proposed development platforms remains outside the flood extents during both the 1 in 100 year return period event plus 35% and 70% climate change allowances
 - b) The results show no increase in flood risk elsewhere during the 1 in 100 year plus 35% climate

Based on the above, the following recommendations are made:

1. Finished Floor Levels of the new buildings are to be set at a level of 65.90m AOD, which is approximately 1.3m above the modelled 1 in 100 year plus 35% climate change allowance fluvial flood level on the River Irwell. This level is also slightly above the modelled 1 in 100 year plus 70% climate change allowance on the River Irwell. The exceptions to the above are in respect of a number of properties to be located alongside existing retained roads, where relative levels make this approach impractical. In these locations FFLs are to be set as high as practically possible and above the 1 in 100 year flood with flood resilience measures provided to a level of 65.90m AOD.

6.0 APPENDICES

6.1 APPENDIX A – INDICATIVE MASTERPLAN



WYG Group

WYG

REVISIONS

REV	AMENDMENTS	BY	DATE

KEY

Land Ownership Boundary

Nett Developable Area

North

Homes England

East Lancashire Paper Mill

Illustrative Masterplan with Nett Developable Area

DATE: 18.03.19

SCALE: 1:1250 @ A1

DRAWN BY / REVIEWED BY: RR / SP

PROJECT NO: A090070-193

DRAWING NO: SP-05

REVISION:

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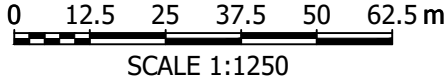
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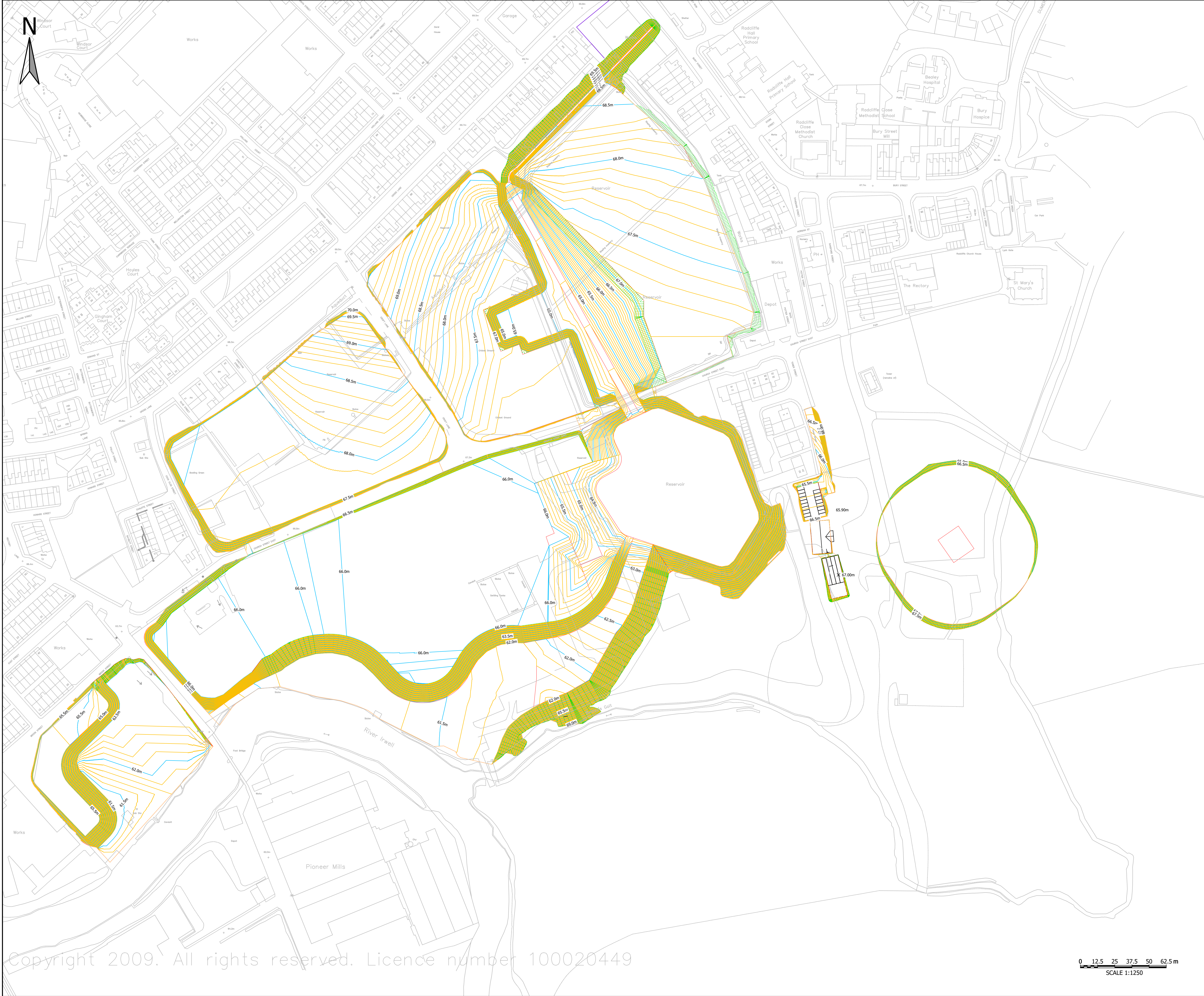
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6.2 APPENDIX B – PROPOSED CONTOURS



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FILENAME : N:\PROJECTS\A090001-4095000\A090070-193\ACAD\DWGS\A090070-193-21-C-SK11 - PROPOSED CONTOUR PLANDWG | PLOTTED BY : AGUILARFUERTES, FRANCISCO | PLOTTED DATE : 12 April 2021 12:28:29



DO NOT SCALE: CONTRACTOR TO CHECK ALL DIMENSIONS AND REPORT ANY OMISSIONS OR ERRORS

NOTES

1. ALL LEVELS IN METRES A.O.D.
2. REFER TO SK10 FOR GENERAL ARRANGEMENT
3. THE PROPOSED LEVELS ARE INDICATIVE ONLY AND FOR PRELIMINARY DESIGN AND COSTING PURPOSES ONLY.

THIS DRAWING IS FOR PRELIMINARY DESIGN PURPOSES ONLY AND SUBJECT TO FURTHER DETAILED DESIGN

FOR INFORMATION ONLY

P2	REVISED FOLLOWING REMOVAL OF FLOODABLE GARDENS	FA	RC	RC	12.04.21
P1	PRELIMINARY ISSUE	RM	MSE	MSE	30.10.17
REV	DESCRIPTION	BY	CHK	APP	DATE

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Project:
FORMER LANCASHIRE PAPER MILLS
RADCLIFFE

Drawing Title:
PROPOSED GENERAL ARRANGEMENT
CONTOUR PLAN

Scale @ 1:1250	Drawn RM	Date OCT 2017	Checked MSE	Date OCT 2017	Approved MSE	Date OCT 2017
Project No. A090070-193	Office 21	Type C	Drawing No. SK11	Revision	P2	

6.3 APPENDIX C – EA CORRESPONDENCE

Tetra Tech Limited
3 Sovereign Square
Unit 3 Sovereign Street
Leeds
LS1 4ER

Our ref: SO/2019/119662/02-L01
Your ref: Tetra Tech Limited
Date: 12 February 2021

Dear Sir/Madam

**EMAIL ENQUIRY REGARDING CLIMATE CHANGE ALLOWANCE FIGURES EAST
LANCS PAPER MILL SITE, RADCLIFFE**

Thank you for your email enquiry dated 11 February 2021.

In response to the two points raised in your email:

- (i) *Can the EA confirm if the 'compensatory storage' impacts should be based on the Q100 CC1 event or the Q100 CC2 event?*
- (ii) *If the latter, can the EA confirm if offsite impacts of the Q100 CC2 results should be taken into account is an increase in the range (25 -50mm) if the floodable gardens are removed acceptable, given that there will be no earlier onset of flooding in terms of event severity required to trigger a flood and given that existing depths of flooding in the areas concerned are of the order of 1.0m, so the percentage increase is small.*

Environment Agency position

The guidance on GOV.UK in relation to compensatory floodplain storage can be somewhat confusing. Our general approach is that compensatory flood plain storage should be based on the "higher central" climate change figure (35% for North West basin). Use of the "upper end" allowance would be an exception if there were very sensitive areas with acute concerns. For the site location the higher central allowance should be acceptable.

Should you wish us to review any technical documents or want further advice to address the environmental issues raised/meet the requirements of the conditions recommended, we may do this as part of our charged for planning advice service.

As part of our charged for service we will provide a dedicated project manager to act as a single point of contact to help resolve any problems. We currently charge £100 per hour, plus VAT. We will provide you with an estimated cost for any further discussions or review of documents. The terms and conditions of our charged for service are available [here](#).

If you would like more information on our planning advice service, including a cost estimate, please contact me on the number below.

I look forward to hearing from you.

Yours faithfully

Mrs SYLVIA WHITTINGHAM
Planning Advisor

Direct dial 0203 0251059

Direct e-mail sylvia.whittingham@environment-agency.gov.uk

AguilarFuertes, Francisco

From: Van, Rob <Rob.Van@environment-agency.gov.uk>
Sent: 12 February 2021 15:46
To: Carr, Robert
Cc: Natalie.Webster@homesengland.gov.uk; Shannon, Peter;
Hannah.Waite@homesengland.gov.uk; AguilarFuertes, Francisco; Jonathan
Starling
Subject: Hutchinson's Goit/ East Lancs Paper Mill [Filed 12 Feb 2021 16:14]

Robert,

Thanks for the meeting earlier, it was useful to discuss the works and a suitable way forward.

I mentioned that I had discussions with Bury Council yesterday and when talking about this goit and increased restrictions, there were concerns about whether this would have any impact on the provision of SuDS or surface water storage on the development site. Are you able to have a discussion with the Council and let me have confirmation that they are supportive of the proposals to restrict the flows through Hutchinson's Goit to 0.5 m³/s.

In addition, although there might have been a conversation earlier, could I also confirm that Bury Council are fully aware of the increased chance of blockage as a result of the restriction from 1 m³/s to 0.5 m³/s. As I've mentioned before, as the goit is not main river, the EA would not be able to clear any blockages that occur during or after flood events.

We plan to submit planning for this structure w/c 15/02/21. If you could let me know that week, we will endeavour to incorporate the increased restriction in our planning submission.

Regards,

Robert Van BSc MSc MCIWEM C.WEM
Project Manager, Programme & Contract Management (PCM)
part of Operations, Assets & Programme Management
Environment Agency | Richard Fairclough House, Knutsford Road, Warrington, WA4 1HT

Next period of leave: Friday 19th February, Friday 5th March, Friday 19th March

rob.van@environment-agency.gov.uk

External: 020 302 51408

Visit the Flood Hub website for information on the [Radcliffe and Redvales Flood Alleviation Scheme](#)

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6.4 APPENDIX D – REVISED HYDRAULIC MODELLING REPORT



TETRA TECH

East Lancashire Paper Mill, Radcliffe

Hydraulic Modelling Report

May 2021

Project Information	
Project:	East Lancashire Paper Mill
Report Title:	Hydraulic Modelling Report
Client:	Tetra Tech (Formerly WYG)
Instruction:	The instruction to carry out this Hydraulic Modelling Study was received from Mr Matthew Elliott of Tetra Tech (formerly WYG)
File Ref:	12168-HMR-02.pdf

Approval Record	
Author:	Dr. Sandeep Bomminayuni PhD
Checker:	David Hughes MEng (Hons)
Approver:	Alun Roberts BEng (Hons) CEng MICE

Document History	
Date	Comment
11/07/18	First issue
14/11/18	Revised development layout
11/05/21	Hydraulic Modelling and Report updated following revision to the proposed development layout
27/05/21	Report updated to address minor comments from the Client

Form Ref:

W042-F-57.4-Report-HMR-1D2D New Model EXG DEV1

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Introduction

Waterco Consultants have been commissioned to undertake a detailed hydraulic modelling study of the River Irwell through Radcliffe adjacent to a proposed development site on Cross Lane (A6053) Radcliffe, Manchester, M26 2RF.

The outputs of the hydraulic modelling study provide a detailed, up-to-date assessment of the existing fluvial flood risk at the site and quantify the change in flood risk elsewhere as a result of the development (if any). This report also supports the Flood Risk Assessment (FRA) being prepared by TetraTech for the development.

A location plan and an aerial photograph of the site are included in Appendix A. The grid reference of the site is NGR 379200 407400.

Site Description

The site is currently derelict land, previously containing the East Lancashire Paper Mill which has now been demolished. The derelict site is mostly open space covered with grasslands. At the centre of the site is East Lancashire Paper Mill Cricket Club. The site is bordered by open space / grasslands and the River Irwell to the south, and residential areas to the north, east and west. Cross Lane (A6053) borders the site to the north, Rectory Lane / Cock Clod Street to the west, and Bealey Community Hospital to the east.

A topographical survey of the site was undertaken by ELLUC Projects in May 2009 and is provided in Appendix B for information. The survey shows existing site levels fall south-east to south, from a level of approximately 76.35m AOD in south-east corner to 61.09m AOD along the southern side of the site.

Nearby Watercourses and Existing Flood Risk Data

The site is situated on the northern bank of the River Irwell – an Environment Agency (EA) designated ‘main river’. Hutchinson’s Goit, also a designated EA main river, flows through the site. Hutchinson’s Goit is an overflow of the River Irwell (previously feeding the demolished paper mill). Hutchinson’s Goit starts immediately downstream of the Ramsbottom to Manchester Victoria railway line (NGR 379670 408950) and flows roughly parallel to the River Irwell through the site. The watercourse is culverted for much of its length through the development site until it discharges into the River Irwell. The culvert is understood to be a 670mm x 590mm box culvert. The exact discharge point into the River Irwell is unknown, however it is estimated to be location at the Pioneer Mills footbridge at NGR 379110 407230. The River Roch, a tributary of the River Irwell and also an EA main river, flows from the north-east and joins the River Irwell at approximately 400m south-east of the site. The River Irwell, Hutchinson’s Goit and the River Roch are considered the primary sources of fluvial flood risk at the site.

Tidal flood risk has not been considered during this study given the sites relative elevation (>61m AOD) and distance from the coast (~50km).

The EA Historical Flood Map included in Appendix D do not show past records of flooding at the site. Information publicly available online¹ shows areas local to the south-western site boundary to be flooded

¹ https://www.greatermanchester-ca.gov.uk/downloads/file/199/boxing_day_flood_report_2015

during the Boxing Day flood of 2015. A map of these areas is included in Appendix D. An existing metal footbridge which provides access between the former East Lancashire Paper Mill site and the Pioneer Mills site to the south was severely damaged during this event. An extract from the Boxing Day flood report and photograph is included in Appendix D. There are plans to replace the footbridge but it will be constructed above modelled flood levels and so it has not been included in this assessment.

The current EA Flood Maps for Planning (April 2021) show less than 5% of the site area to be located within Flood Zone 3 – an area considered to be at relatively high risk of fluvial flooding with an annual probability of the flooding greater than 1% (1 in 100) AEP (annual exceedance probability). Nearly half of the site is located within Flood Zone 2 – an area considered to be at medium risk of fluvial flooding with an annual probability of the flooding between 1% and 0.1% (1 in 1000) AEP. The remaining site area is in Flood Zone 1 – an area considered to be at relatively low risk of fluvial flooding with an annual probability of the flooding lower than 0.1% AEP. An extract of the current EA Flood Zones is included in Appendix D for reference.

It is understood that the current River Irwell flood maps are based on the outputs of a detailed EA 1D/2D² Flood Modeller Pro (FMP)-TUFLOW model of the River Irwell built in 2017. To provide a site-specific assessment of fluvial flood risk from the River Irwell, the current EA model has been obtained and updated to include detailed site layout and level information. In addition to providing an assessment of fluvial flood risk at the existing site, the change in flood risk elsewhere (if any) arising as a result of the proposed development has also been quantified.

Proposed Development

The proposed development is in the early master planning stages and so final details are not available. The site will likely comprise several residential units including garden areas, maintained grassland, sports fields, access roads and associated parking. It is also proposed to re-align, de-culvert and widen a stretch of Hutchinson's Goit, a tributary of the River Irwell flowing through the site. The newly opened up Hutchinson's Goit will be connected through the existing pond on site to provide flood storage. A flow control structure is proposed at Bury Road culvert (NGR 379660 408965) to limit overflow from the River Irwell into Hutchinson's Goit to a maximum of 0.5m³/s. Further flow control structures with associated overflow weirs are proposed at both the inlet and outlet locations of the existing pond. In addition to this, a flood storage area (FSA) is proposed near to the southern site boundary to provide flood compensatory storage and mitigate flood risk. The site layout is designed to prevent any proposed properties including garden areas from flooding during all simulated events. Sports pitches are proposed in the far eastern area of the site (NGR 379720 407385 and NGR 379600 407450). These are designed to be flood free up to the 1% AEP event and provide flood storage during the more extreme flood events. A proposed development plan is included in Appendix C. Further detail of the proposed plans is included in the TetraTech FRA.

² A 1D/2D hydrodynamic model is comprised of a 1-Dimensional (1D) river network model (based on surveyed river cross-sections) coupled with a 2-Dimensional (2D) Digital Terrain Model (DTM) of the potential floodplain (created from LiDAR).

Hydraulic Modelling

A copy of the current EA River Irwell model produced as part of the 2017 Lower Irwell Flood Mapping Study has been sourced and used as the base for this study.

Following an initial assessment of the existing fluvial flood risk at the development site, simulation outputs will be compared against those generated using the proposed development levels and layout to quantify the change in flood risk elsewhere as a result of the development (if any).

The latest version(s) of hydraulic modelling software FMP and TUFLOW available at the start of the project have been used for all simulations; 4.3 and 2018-03-AA respectively. Although there have been several minor updates to the software since, there have been no significant changes that would impact confidence in the model outputs.

Events considered

To fully investigate the fluvial flood risk at the site during both the existing (EXG) and proposed development (DEV) scenarios, a range of fluvial events have been simulated; namely the 5%, 1% and 0.1% AEP events. The impact of future climate change (CC) has also been investigated during the 1% AEP event by increasing flows by 35% and 70% respectively. A list of simulations completed is given in Table 1. The flow data within the current EA model was calculated by JBA in 2016 and has not been updated for this study.

Table 1 - Primary Simulation Summary

Fluvial Event (AEP)	River Irwell Peak Flows (m ³ /s)	River Roch Peak Flows (m ³ /s)	Development Scenario
5%	211.1	133.7	Existing Site Layout (EXG) & Proposed Site Layout (DEV)
1%	286.6	176.7	
1% + 35% CC	386.9	238.5	
1% + 70% CC	487.2	300.4	
0.1%	504.0	261.2	

1D Model Details

The current EA 1D FMP network includes representation of the River Irwell, Hutchinson's Goit and the River Roch watercourses. The 1D model network of the River Irwell starts near St Gabriel's RC High School (node ref: IRWE05_1363; NGR 379560 410310) and ends approximately 8.75km further downstream, near Outwood Country Park (node ref: IRWE03_3757, NGR 377720 406720). The 1D model network of Hutchinson's Goit starts downstream of the railway line (node ref: HUTC01_1897; NGR 379670 408950) and ends approximately 1.9km downstream at Pioneer Mills footbridge (node ref: IRWE04_0000u, NGR 379110 407230) where it joins the River Irwell. The 1D model network of the River Roch starts immediately downstream of the A56 Road Bridge (node ref: ROCH01_0779; grid ref: NGR 380730 407810) and ends

approximately 800m downstream at the watercourse's confluence with the River Irwell (node ref: ROCH01_0000; grid ref: NGR 380190 407310). In total, approximately 11.1km of the River Irwell, Hutchinson's Goit and the River Roch watercourses is modelled. The extent of the linked 1D/2D model is presented in Appendix E.

Inflows to the 1D network are applied using hydrographs generated by FMP ReFH boundary units fitted to FEH statistical peak flows and are applied at the most upstream nodes of the River Irwell and the River Roch (i.e. node IRWE05_1363 and ROCH01_0779 respectively). Inflow hydrograph data within the EA model remains unchanged.

The downstream boundary of the current EA 1D model is located approximately 2km downstream of the site and utilises a discharge-stage (QH or Rating Curve) as the boundary condition. The existing boundary condition has been kept unchanged and utilised.

Several additional interpolated sections have been added to the model to increase the resolution within the 1D network and improve stability across the 1D/2D model links. The Pioneer Mills footbridge (EA model node ref: IR04_BR0000u) washed away during the 2015 floods has been removed from 1D model. Following a recommendation from the Flood Modeller software developers, the orifice flow option has been enabled for all bridge units in the vicinity of the study area to allow submerged bridges to be represented appropriately. No other changes have been made to the general 1D model data, including lateral inflow locations, hydrographs, structure representation, Manning's n roughness etc for the existing site layout simulations. Any of the modelled structures considered potentially critical to flooding at the site (i.e. proximity to site, blockage potential etc.) have been subject to blockage assessment – discussed further below.

To represent and model the proposed re-alignment of Hutchinson's Goit watercourse through the site, an alternative 1D model network has been created (DEV). For this model, the existing 1D network of Hutchinson's Goit is truncated at the northern site boundary and connected to dummy HT boundary units linked to standard 2D SX links, in order to allow water to spill into the proposed channel modelled within the 2D domain. A constant inflow of 0.25m³/s from a small, unnamed tributary of Hutchinson's Goit has been included in the DEV model at FMP node HUTC01_1423 (NGR 379565 408586). No other changes have been made to the existing model setup.

2D Model Details

The current EA 2D TUFLOW domain covers a total area of approximately 6.2km². The latest EA LiDAR data levels at the site have been compared to the topographical survey of the site and found to be in good agreement with differences generally less than +/-150mm. As the LiDAR offers a significantly higher resolution, this dataset has been utilised in the model. A review of the remaining model extent has been carried out using aerial mapping and it was found that there are no hydraulically significant structures present within the remaining floodplain.

The 2D cell size has been kept unchanged from the EA model, set at 4m. This resolution is adequate to represent the flow paths on site and within the wider floodplain whilst maintaining a reasonable run time.

OS MasterMap data (provided with the current EA model) has been used to classify land use and assign

Manning's n roughness coefficients throughout the floodplain. The coefficients within the existing EA model were reviewed, deemed acceptable and remain unchanged. The coefficients used are given in Table 2.

Table 2 - 2D Model Manning's n Roughness Coefficients

Land Use	Manning's n Roughness Coefficient (s/m ^{1/3})
General surface	0.050
Buildings	1.000
Inland water	0.025 – 0.030
Woodland	0.050
Coniferous trees	0.150
Roads, paths, rail	0.025 – 0.100
Structures	0.100
Rough grassland	0.075
Marshland, reeds	0.065
General manmade surfaces	0.040

To simulate and compare the proposed development arrangement (DEV), an alternative 2D TUFLOW model domain has been created using the proposed level data provided (Appendix C). The 2D DEV model setup also includes the following updates:

- Z-shapes have been used to remove the floodable garden elements as they are no longer proposed.
- The representation of existing Bury Road culvert has been updated to include a flow regulating rule which limits overflow from the River Irwell into Hutchinson's Goit to a maximum of 0.5m³/s. In practice flows will be restricted by an orifice to be attached to the structure. The 1D FMP network of Hutchinson's Goit which starts immediately downstream of the Bury Road Culvert already includes a sweetener flow of 0.1m³/s for model stability (as per the EA model setup). The rule is therefore designed to limit flow entering the 1D FMP network to a maximum of 0.4m³/s.
- Z-shapes have been used to ensure the bed levels of the proposed open channel section of Hutchinson's Goit through the site are accurately represented within the model domain.
- A '2d_iwl' layer has been used to set the initial water levels in the pond to 64.5m AOD.
- The proposed flow control structures at the inlet and outlet of the existing pond are represented as 450mm and 350mm diameter circular culverts respectively using ESTRY. Z-shapes have been used to represent the proposed overflow weirs at these locations.

- Z-shapes have been used to improve the representation of the ground levels at the flood bund located at Church Street East (NGR 379550 407440).
- Z-shapes have been used to represent the proposed FSA at the southern site boundary along the River Irwell frontage (centre NGRs 379235 407275 & 379045 407225). The grounds levels in the proposed FSA have been set to a level of 61.4m AOD.
- The roughness classification within the DEV models has been altered to represent the proposed land use within the site.

Blockage Scenarios

The A6053 Road culvert (model node: HUTC01_0584c; NGR 379415 407820) is considered potentially critical to flooding at the site given its proximity to the site and potential to block.

To investigate the flood risk at the site in the event of a significant blockage of this structure, blockage scenario simulations for both EXG and DEV scenarios have been undertaken and detailed in Table 3.

Table 3 - Blockage Scenario Simulations

Scenario Ref	Structure	Development Scenario	Fluvial Event (AEP)	% Blockage	Model Ref
BL1	A6053 Road Culvert	Existing Site	1% + 35% CC	80	BL1-80
		Proposed Site			

Sensitivity Testing

In the absence of available calibration data, increased significance has been placed on sensitivity testing to improve confidence in the model outputs and assess the sensitivity of the model parameters. Four sensitivity tests have been carried out (ST1-4) with respect to the 1% AEP + 35% CC fluvial event.

Sensitivity tests “ST1” and “ST2” investigate variation (+/- 20%) of Manning’s roughness coefficients in both the River Wey channel and across the floodplain.

Sensitivity tests “ST3” and “ST4” investigate a +/-200mm variation in the stage values used in the existing QH curve of the downstream boundary conditions of 1D model.

Results & Conclusions

This section of the report documents the results obtained from the primary simulations, both EXG and DEV models, sensitivity tests and blockage scenarios.

Maximum flood depth, velocity and hazard mapping has been provided for each primary simulation in Appendix F. Flood hazard ratings have been calculated in accordance with DEFRA document 'FD2320: Flood Risks to People' and EA guidance document 'Supplementary Note on Flood Hazard Ratings and Thresholds'.

In addition to the mapping, calculated maximum water levels were extracted at each node along the 1D network model and compared for each simulation. A table of this data has been provided in Appendix G. Flood depth and water level data has also been extracted at certain node locations across the site in the 2D domain, and represented in tabulated form in Appendix H.

Detailed below is a summary of the flood mechanisms for the simulated events, which is to be read in conjunction with the above detailed information.

EXG Simulations - Existing Site Layout

The results of the hydraulic modelling show the development site to partially flood during all the simulated events.

During the simulated flood events, floodwater is shown to exceed channel capacity on the northern bank of the River Irwell adjacent to the southern site boundary causing inundation of nearby low-lying site areas. Out-of-bank spilling in the River Irwell at approximately 300m east of the site (NGR 380130 407460) causes floodwater to flow in a westerly direction and enter the site causing inundation of site areas near to the eastern site boundary. The Pioneer Mills site (NGR 379190 407200) south of the site, over the River Irwell's southern bank, is almost entirely flooded during all simulated events including the 5% AEP event, with depths reaching over 2.0m throughout the site during the 0.1% AEP event.

Flooding from Hutchinson's Goit occurs due to the low capacity of the existing Hutchinson's Goit culvert (inlet located on site) which causes floodwaters to reach low-lying site areas.

DEV Simulations - Post-Development Site Layout

When the development levels are considered, the proposed development area including the properties and associated garden areas raised to a minimum of 66m AOD is shown to remain flood free during all simulated events.

During all simulated events, flow is shown to generally remain within the proposed Hutchinson's Goit channel, pond and FSAs on site. A small area on the site at the western site boundary near Rectory Lane (379050 407360) is shown to experience flooding during the 1% AEP + 35%CC and greater events. The proposed road located north of the pond which acts as an overflow weir is flooded during all simulated events. The proposed sports pitches in the far eastern area of the site (NGR 379720 407385 and NGR 379600 407450) remain flood free up to and including the 1% AEP event as designed. As designed, the proposed sports pitches experience flooding during the 1% AEP + 35% CC and greater events.

Similar to the EXG scenario, during the simulated flood events, floodwater is shown to exceed channel capacity on the northern bank of the River Irwell at approximately 300m east of the site causing inundation of the low-lying site areas at the southern and eastern site boundaries respectively. The de-culverting of Hutchinson's Goit culvert on site allows water to flow through the proposed open channel and existing pond on site before entering the FSA and eventually discharging into the River Irwell at the southern site boundary.

Flood Risk Elsewhere

The potential impact of the proposed development on flood risk elsewhere has been quantified by comparing the results of the existing (EXG) site layout simulations with the proposed (DEV). To provide a detailed assessment of the relative changes in flood depths throughout the floodplain, a series of water level difference maps comparing the pre- and post-development maximum water levels have been created and are included in the DEV section of Appendix F.

The impact on flood risk as a result of the post development site layout is largely contained within the site boundary during all simulated flood events. During the 1% AEP + 35%CC and lower AEP events the increase in flood depths elsewhere is generally less than 20mm with only a few isolated locations experiencing a greater than 20mm increase. A review of model results at these locations indicated that a <20mm increase in flood depths nearby has caused a few additional grid cells at the edges of flood extents to flood leading to this local increase in flood depths. During the 1% AEP + 70%CC and 0.1% AEP events the increase in flood depths is generally less than 20mm with the exception of few areas local to the Church Street Rd bridge (NGR 378610 406940) which experience an increase in flood depths of up to 45mm. During the 1% AEP + 70%CC event flood depths in an area (center NGR 378795 407165) located downstream of the railway line and on A6053 Rd at the northwestern site boundary (NGR 378985 407465) are shown to increase by up to 25mm and 55mm respectively. The areas which experience an increase flood depths are shown to already experience flooding with depths ranging from 0.5-2.0m so the relative increase may be considered minimal.

There are some areas where a decrease in flooding is shown when compared to the existing scenario. North of the site boundary, the Bealey Community Hospital (NGR 379610 407740) and playgrounds of Radcliffe Hall C of E Methodist primary school (NGR 379500 407750) experience a general reduction in flood levels by 200mm. Flooding on land west of the site (NGR 378930 407200) is also reduced across a localised stretch by less than 100mm depth.

The Pioneer Mills site, south of the development site experiences both a minor increase and decrease of up to 35mm adjacent to the confluence of Hutchinson's Goit and the River Irwell during the 1% AEP and 1% AEP +35% CC flood events. The area where the slight decrease in flooding is shown is significantly larger than the area where a slight increase in shown. The site is severely inundated during all simulated events, with depths generally around 2.5m, but reaching over 3.0m in depth during the 1% AEP +35% CC event. The main building on site is affected by flooding during all scenarios simulated. Buildings to the south of the Pioneer Mills site experiences a reduction in maximum flood level of 25mm during the same event. During the 1% AEP + 70%CC and 0.1% AEP events the Pioneer Mills site experience an increase in flood depths by 15-25mm, however, the site is already flooded to depths greater than 3.0m during these events so the relative increase may be considered minimal.

The 1% AEP + 35% CC event DEV versus EXG flood depth difference map shows an increase in flood depths by up to 75mm at Warth Industrial Park (NGR 380130 408600) just upstream of the A6053 Rd bridge structure. A review of model results suggests that limiting flows from the River Irwell into Hutchinson's Goit to a maximum of $0.5\text{m}^3/\text{s}$ in the DEV scenario compared to a peak flow of approximately $2.0\text{m}^3/\text{s}$ in EXG causes the difference in flow to enter the River Irwell instead. Whilst the addition of up to $1.5\text{m}^3/\text{s}$ into the Irwell with a peak flow of around $280\text{m}^3/\text{s}$ is relatively minor (approximately 0.5%), enabling the orifice flow option at the bridge structure has had a minor effect on the conveyance capacity of A6053 Rd bridge structure at peak flows. The modest increase in flow within the River Irwell causes a slight change to the time at which the bridge flow equations switch to orifice flow, which in turn is causing minor differences in water levels upstream and therefore minor depth differences at the Warth Industrial Park. The impact shown to Warth Industrial Park is therefore likely entirely due to a modelling quirk that is not easily resolved and can be considered to be negligible and unrelated to the proposed development at the site.

Blockage Scenario Simulations - EXG

Model outputs from blockage scenario EXG BL1-80 (80% blockage of A6053 Road culvert) show flood depths upstream of the site to increase by approximately 150mm with negligible impact on flood depths at the site during the 1% AEP + 35% CC event relative to the unblocked simulation. This increase in flood risk associated with the blockage upstream of the site can be attributed to the significantly reduced flow capacity of the culvert, leading to additional water levels and spilling upstream of the structure, however, the site remains unaffected.

Blockage Scenario Simulations - DEV

Similar to the EXG BL1-80 scenario, model outputs from blockage scenario DEV-BL1-80 that 80% blockage of A6053 Road culvert has negligible impact on flood depths at the site relative to the unblocked simulation. Although reduced flow capacity of the culvert causes additional spilling upstream of the structure, the site remains unaffected.

Sensitivity Tests

Modelled flood extents during the 1% AEP event match the existing EA Flood Zone 3 (Appendix D) outline well. Although data is limited, comparison with available historical flood map (Appendix D) shows that in general the modelled flood outlines match well with historical flood outlines.

The results of sensitivity tests ST1 and ST2 show that a significant variation ($\pm 20\%$) in the Manning's 'n' coefficients used within the channel and floodplain causes an increase/decrease in the maximum water levels by up to 500mm at a small number of 1D nodes, though differences are generally within $\pm 250\text{mm}$ at most locations throughout the model. Although this maximum level change is significant, the selected roughness coefficients used within the model are based on available, industry standard guidance (Chow 1959³) and are still considered to be appropriate. The coefficients are also unchanged from the existing EA model setup. Changes to the flood extent across the site during these tests are minimal.

The results of sensitivity tests ST3 and ST4 show that significantly varying the stage values used at the

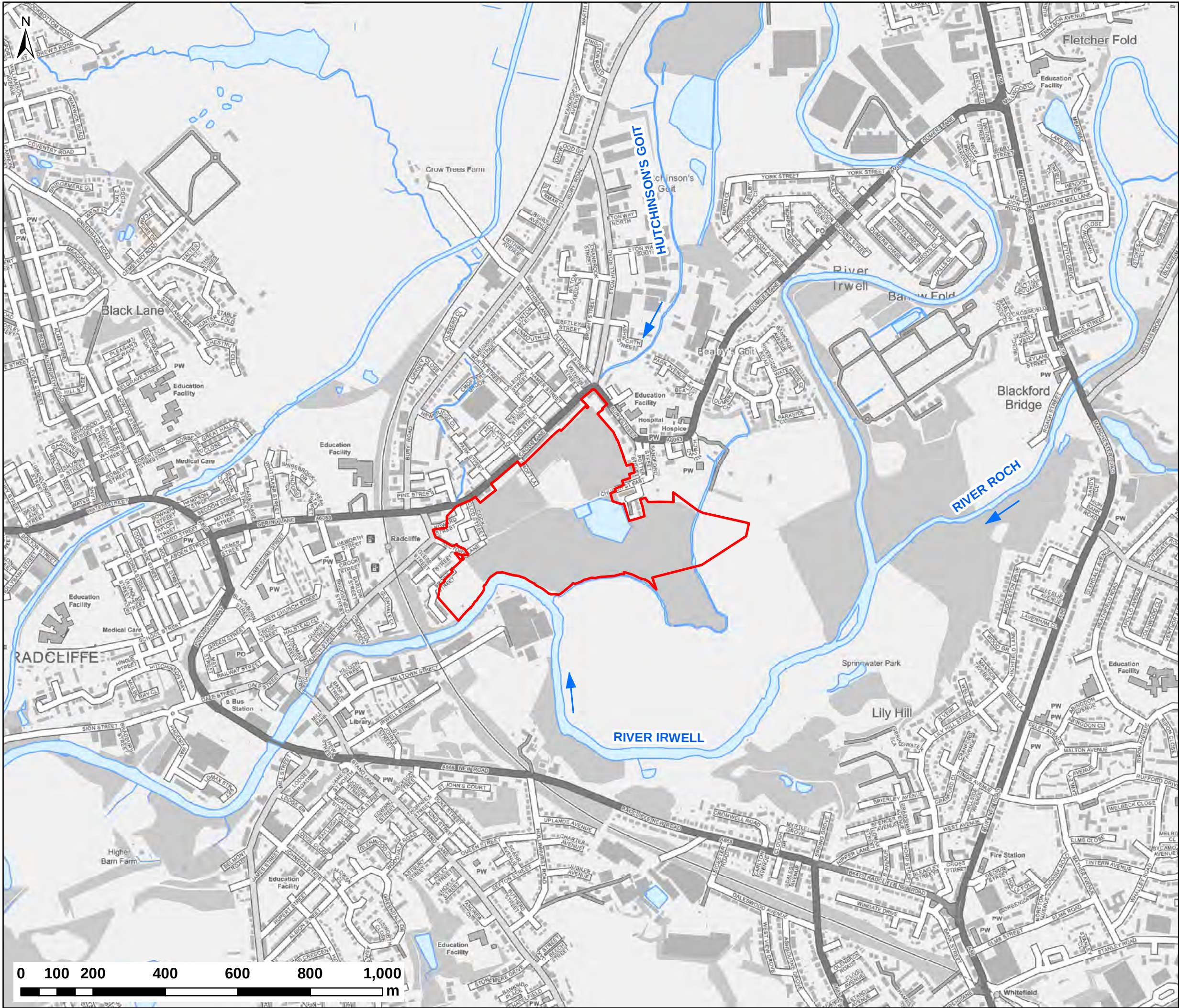
³ Chow, V.T., 1959, Open-channel hydraulics: New York, McGraw-Hill

downstream boundary by +/-200mm does not have any significant effect on the maximum water levels at the site with maximum variation in water levels being less than 20mm at the site. Changes to the flood extent across the site during these tests are minimal.

Recommendations

The hydraulic models and associated report should be submitted to the EA for review and approval as a reasonable representation of the fluvial flood risk at the site from the River Irwell and Hutchinson's Goit when both the existing and proposed development levels / arrangements are considered.

Appendix A Location Plan and Aerial Image



NOTES:
1) ALL DIMENSIONS ARE IN METRES AND ALL LEVELS IN METRES ABOVE ORDNANCE DATUM UNLESS STATED OTHERWISE

LEGEND

- Site Boundary
- Watercourses / Water Bodies



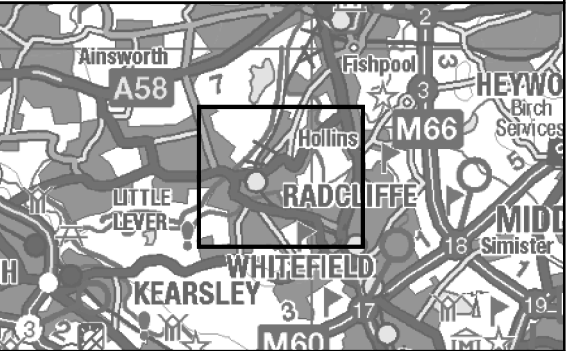
CLIENT:			
			
			
www.waterco.co.uk			
SCHEME:			
EAST LANCASHIRE PAPER MILL			
PLOT TITLE:			
LOCATION PLAN			
PLOT STATUS:		DATE:	
FINAL		01/04/2021	
DRAWN:	CHECKED:	APPROVED:	PLOT SCALE @ A3:
VJ	SB	APR	1:10,000 (UNLESS STATED OTHERWISE)
PLOT NAME:			REV:
12168-Location_Plan			-



NOTES:
1) ALL DIMENSIONS ARE IN METRES AND ALL LEVELS IN METRES ABOVE ORDNANCE DATUM UNLESS STATED OTHERWISE

LEGEND

Site Boundary



CLIENT:



www.waterco.co.uk

SCHEME:

**EAST LANCASHIRE
PAPER MILL**

PLOT TITLE:

AERIAL PLAN

PLOT STATUS:

FINAL

DATE:

01/04/2021

DRAWN:

VJ

CHECKED:

SB

APPROVED:

APR

PLOT SCALE @ A3:

1:10,000

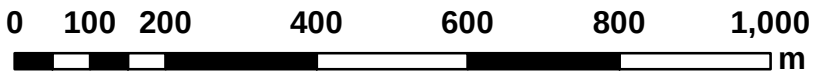
(UNLESS STATED OTHERWISE)

PLOT NAME:

12168-Aerial_Plan

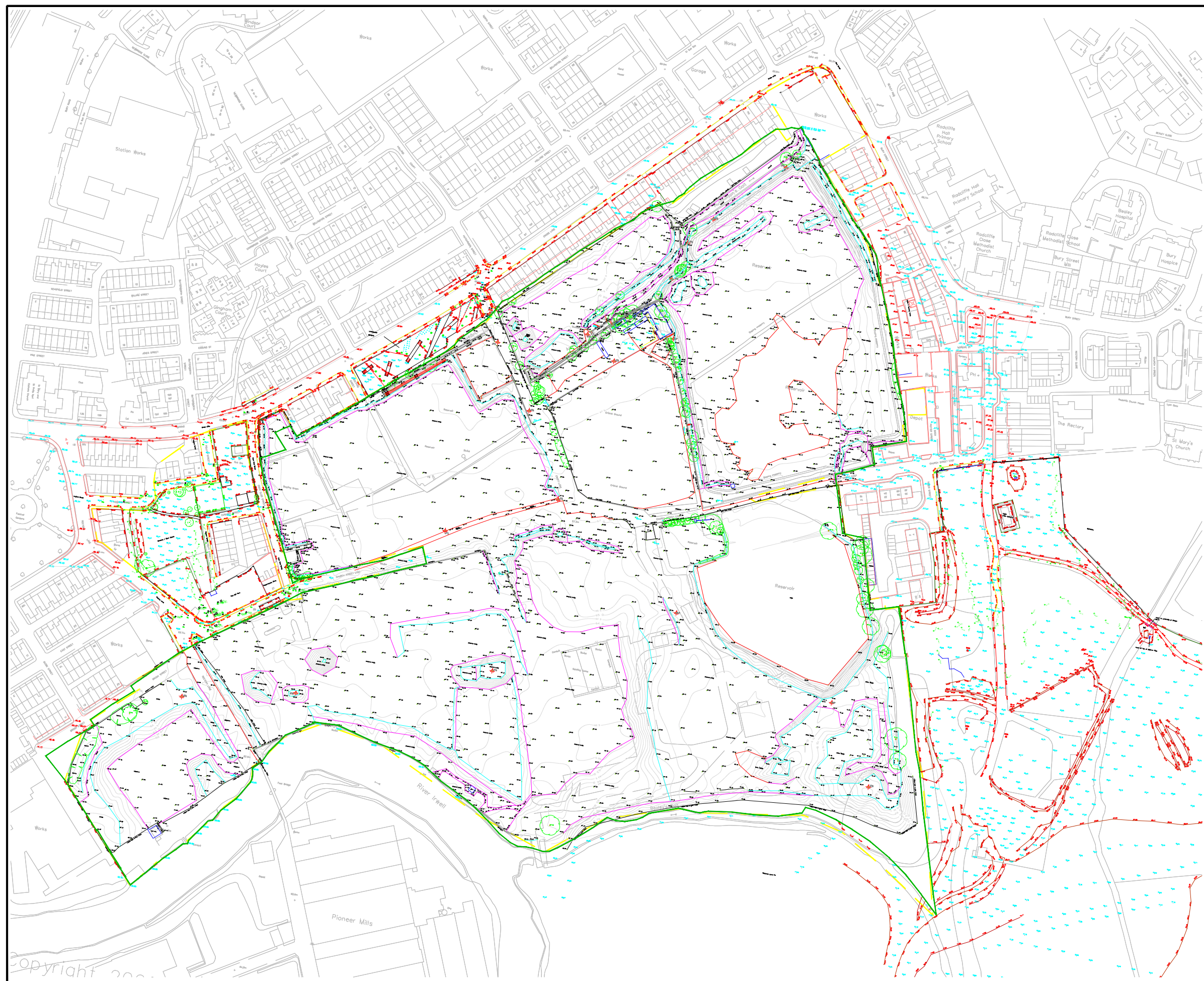
REV:

-



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix B Survey Data



Legend

[illegible]

CLIENT	P&F PROPERTIES
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PROJECT	EAST LANCASHIRE PAPER MILL
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TITLE	SITE AREA TOPOGRAPHICAL SURVEY
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Drawn by Elluc	Scale 1:1250	Drawing No. ELL/103/PFP/012	Rev
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Date MAY/09	@A1		