



**Cummins Turbo
Technologies, St Andrew's
Road, Huddersfield**
Hydraulic Modelling Report



On behalf of **Cummins Turbo Technologies**

Project Ref: 39413/4001 | Rev: - | Date: March 2017

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Document Control Sheet

Project Name: Cummins Turbo Technologies
Project Ref: 39413/4001
Report Title: Hydraulic Modelling Report
Doc Ref: 39413_Cummins_modelling_report
Date: 03/03/17

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Revision	Date	Description	Prepared	Reviewed	Approved
-	03/03/2017	Issue to client	SB	HF	AR

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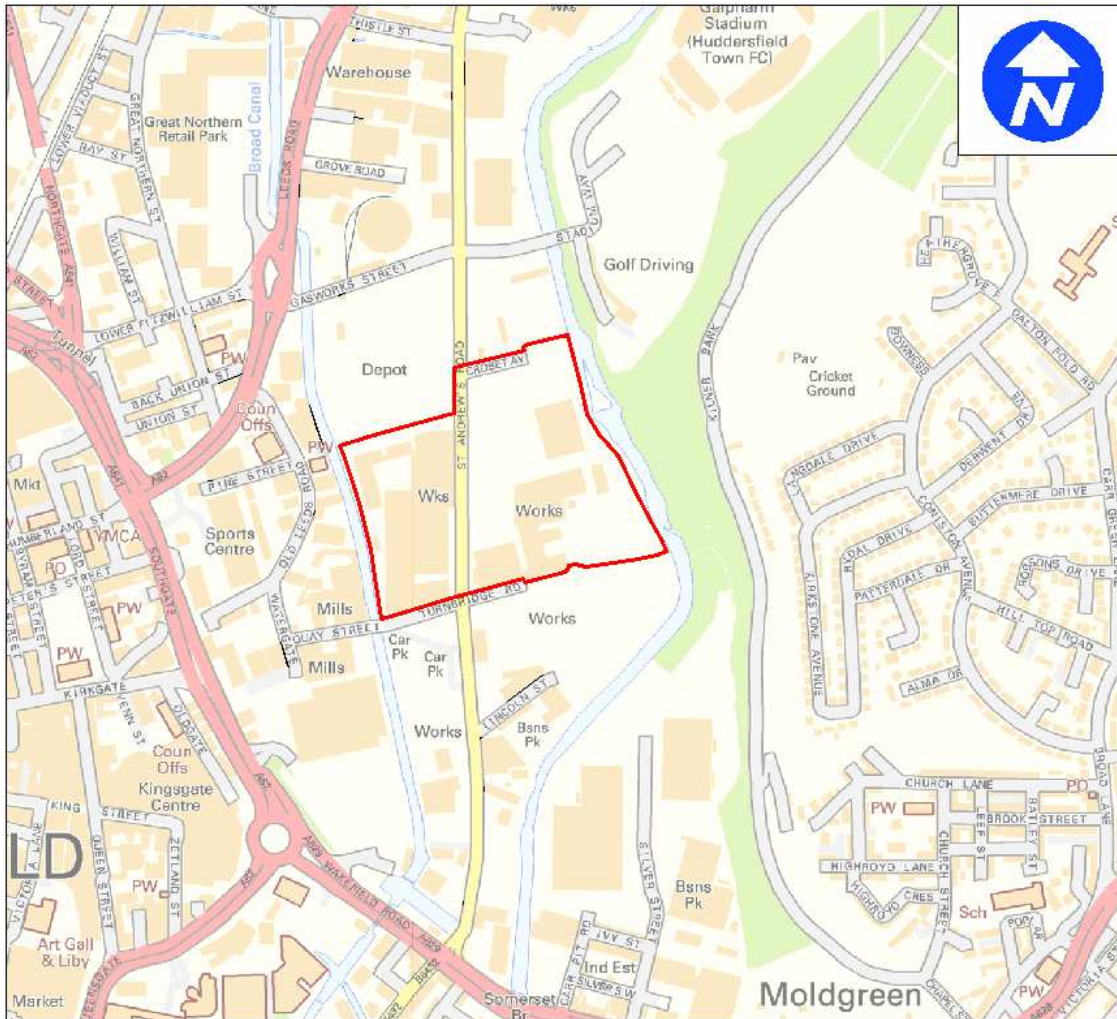
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1 Introduction

1.1 Site location

1.1.1 Peter Brett Associates (PBA) has been commissioned by Cummins Turbo Technologies (CTT) to undertake hydraulic modelling of the River Colne, to assess the fluvial flood risk to their site on St Andrew's Road, Huddersfield.



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Figure 1.1: Site Boundary

- 1.1.2 An approximate site boundary of the CTT site is shown in Figure 1.1. The site is occupied by the CTT plant and offices which are industrial/ commercial development. The local area is occupied by similar commercial/industrial development. The site occupies approximately 8.2 hectares and is approximately 350 m wide and 280 m long.
- 1.1.3 St Andrew's Road divides the site into two halves. The western half of the site contains solely industrial uses and is adjacent to the Huddersfield Broad Canal while the eastern half contains the commercial offices (south) and some industrial units (north), and is adjacent to the River Colne.

- 1.1.4 The southern part of the eastern half of the site is surrounded by a series of flood defence walls which protect the site from overland flooding.
- 1.1.5 The area to the south of the western CTT site is occupied by a recently constructed factory development, while the area to the north is occupied by an area of cleared hardstanding.
- 1.1.6 The area to the north of the eastern CTT site is occupied by a car rental firm and is mostly car park/hardstanding, while the area south of the eastern CTT is occupied by the extensions to Kirklees College.

1.2 Main watercourses

- 1.2.1 The principal watercourse affecting the site is the River Colne which flows from the south to the north through Huddersfield. The River Colne is part of the Humber River Basin.
- 1.2.2 The Huddersfield Broad Canal also flows from south to north but is not considered to represent a flood risk as the water level in the canal is controlled. The Canal is not elevated in the reach alongside the site.

1.3 Scope of works

- 1.3.1 PBA has been commissioned to undertake hydraulic modelling of the River Colne in support of a Flood Risk Assessment for the CTT site. This flood risk assessment will update previous hydraulic modelling undertaken by PBA to include recent local changes (construction of a factory on land adjacent to the south of the western half of the site) and changes in national policy (updated climate change guidance from the EA).
- 1.3.2 The updated EA climate change guidance indicates that a range of allowances should be considered. For the CTT site the allowances to consider are the 'Central' and 'Higher central' allowances. It is general practice to consider the lower climate change allowance for design (i.e. Central) and the higher allowance as a sensitivity to assess the impacts of greater than expected climate change impacts in the future (for between 2070 to 2115).
- 1.3.3 PBA has updated the hydraulic model and rerun the model for the following flood events.
 - 1 in 100 Annual Exceedance Probability (AP) plus 20% climate change (Central climate change estimate for the Humber River Basin area between 2070 to 2115)
 - 1 in 100 AP plus 30% climate change (Higher Central climate change estimate for the Humber River Basin between 2070 to 2115)
 - 1 in 500 AP plus 20% climate change
 - 1 in 500 AP plus 30% climate change
 - 1 in 1000 AP
- 1.3.4 The 1 in 500 AP event hydrology has not been previously generated and will need to be derived for this modelling.

2 Previous hydraulic modelling

2.1 Environment Agency model

2.1.1 The current Environment Agency (EA) hydraulic model for the River Colne is a 1d only ISIS model, constructed in 2009 (Appendix A *EA confirmation and license*). This model was based on an earlier model from 2006 and begins in Moreton approximately 14 km upstream (southwest) of the site and ends at Colnebridge approximate 4.5 km downstream (northeast) of the site.

2.1.2 The EA model only considered fluvial events up to the 1 in 100 AP event.

2.2 PBA modelling from 2011

2.2.1 PBA has previously updated the EA 1d ISIS only model (2009). The EA model considered several flood mitigation schemes and PBA were advised to use the 'do minimum' scenario 1d model as the baseline model. PBA generated the 1 in 100 plus 20% climate change and 1 in 1000 AP flows and applied them to the EA 'do minimum' 1d ISIS only model.

2.3 PBA modelling from 2012/2013

2.3.1 The modelling was updated again in 2012. The 2012 modelling added a 2d TUFLOW model domain on the western bank of the River Colne, and revised the 1 in 1000 AP hydrology, which was considered to overestimate the expected flows. The 2d model domain used a ground model based on 1 m LiDAR and 3d topographic survey of the site.

2.3.2 This model was again updated in 2012/2013 to assess the impact from the construction of the Phase 1 Kirklees College extension on undeveloped land to the south of the site. The Kirklees College extension was included in the 2d TUFLOW model as a change in the materials Manning's 'n' value. 3d topographic survey of the Kirklees College site was also included as the existing ground levels surrounding in this area also changed from the LiDAR data used in the 2d model.

2.3.3 The 2012/2013 modelling also assessed the impacts of a number of flood defence scenarios for the CTT site – from protecting the commercial development on site (eastern side of St Andrew's Road) to one which protected the whole site.

2.3.4 Flooded defence levels were assumed to be set as the higher of the 1 in 100 AP plus climate change flood level and 1 in 1000 AP flood level, plus a 300 mm freeboard.

2.4 PBA modelling from 2015/2016

2.4.1 The last update to the PBA model for the CTT site was in 2015/2016 and looked at the impact of the phase 2 extension to Kirklees college (south of the site) to the site. This model included the as-built flood defences at the CTT site which defended the commercial office on site. The phase 2 extension to Kirklees College was included as a change in the Manning's 'n' values to represent the new building. The new flood defences were included as a z line set to the as-built defence levels.

3 PBA Hydraulic model

3.1 1d model

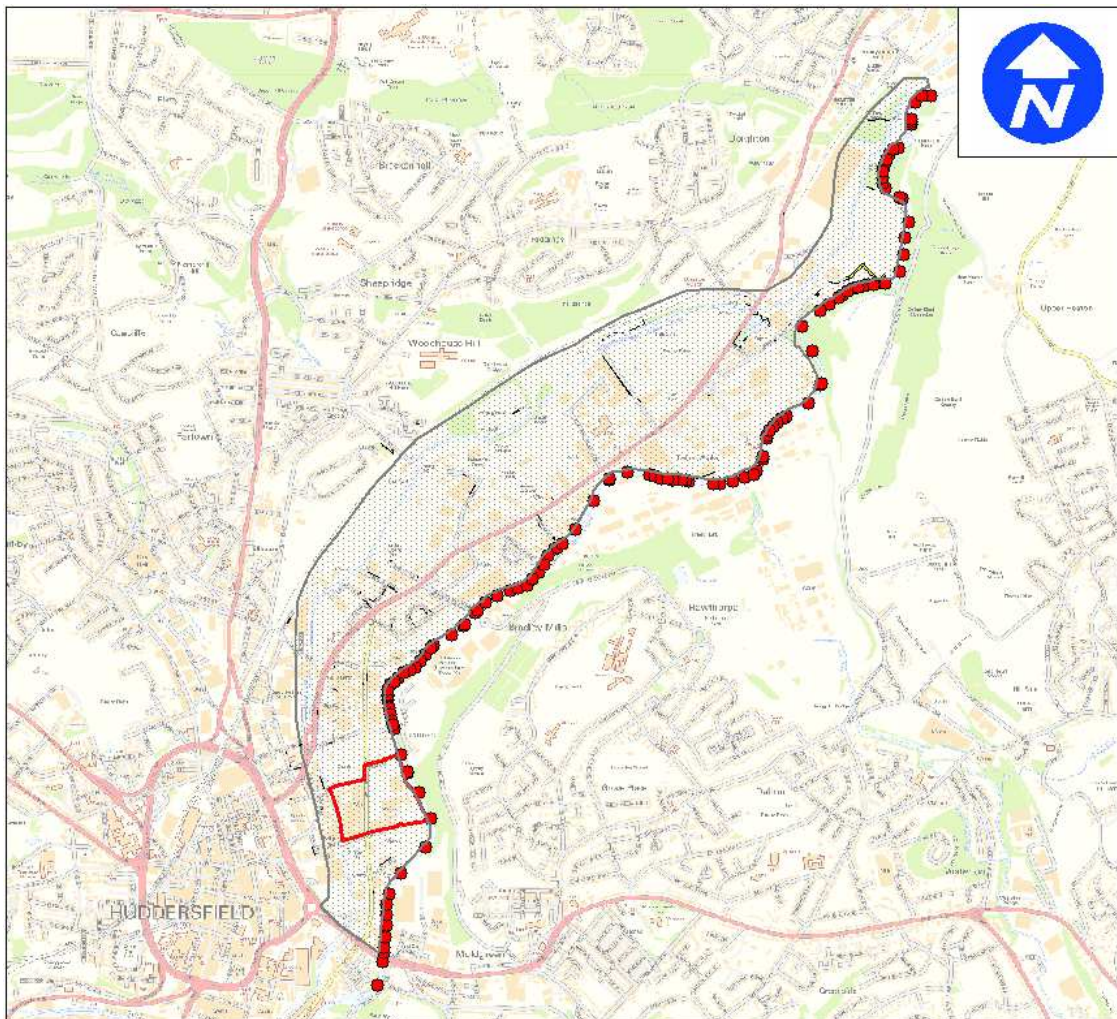
- 3.1.1 The 1d ISIS model used in the PBA model is the current EA model for the River Colne in this reach (2009). The EA have confirmed that this model remains the current model for the River Colne in this region.
- 3.1.2 The EA have also informed us that they are currently updating their modelling for the River Colne. The new EA model will not be available in time for consideration in this study, with an estimated completion date of August 2017.
- 3.1.3 The only amendment to the EA 1d model made by PBA was to trim the left bank for the reach included in the 2d model. This was to improve the link between the 1d and 2d model domains and prevent the 1d model double counting the floodplain in this region.

3.2 1d Boundary conditions

- 3.2.1 The upstream inflows in the EA model were mainly Flood Estimation Handbook (FEH) inflow units in the ISIS model. A flow vs. time (QT) boundary was applied to represent flow from the Holme Reach 1 model at Damside Road footbridge. Another QT boundary applied a constant sweetening inflow along a Mill channel at King's Lane. Both of these QT boundaries are located upstream of the A629 which is upstream of the 2d model domain (section 3.3).
- 3.2.2 The downstream boundary in the EA model (at Colne bridge) is a flow vs. stage rating curve which is described in the EA model as being taken from a s105 model of the River Calder at Dewsbury from 2002. This curve was extended to accommodate the 1 in 1000 AP flows by PBA.

3.3 PBA 2d Model extent

- 3.3.1 A schematic of PBA's 1d-2d ISIS-TUFLOW model is shown in Figure 3.1.
- 3.3.2 The upstream end of the 2d model domain starts upstream of the A629 Wakefield Road, 370 m upstream of the site. The A629 crosses the River Colne at Somerset Bridge and this location is considered a control point on the River Colne.
- 3.3.3 The downstream end of the 2d model domain is upstream of Colne Bridge in the village of Colnebridge. This is where the EA 1d model for the River Colne also ends. Colnebridge has a nearby flow monitoring gauge (Colne Bridge Gauging Station) which was used to generate the 1 in 1000 AP hydrology for the site.

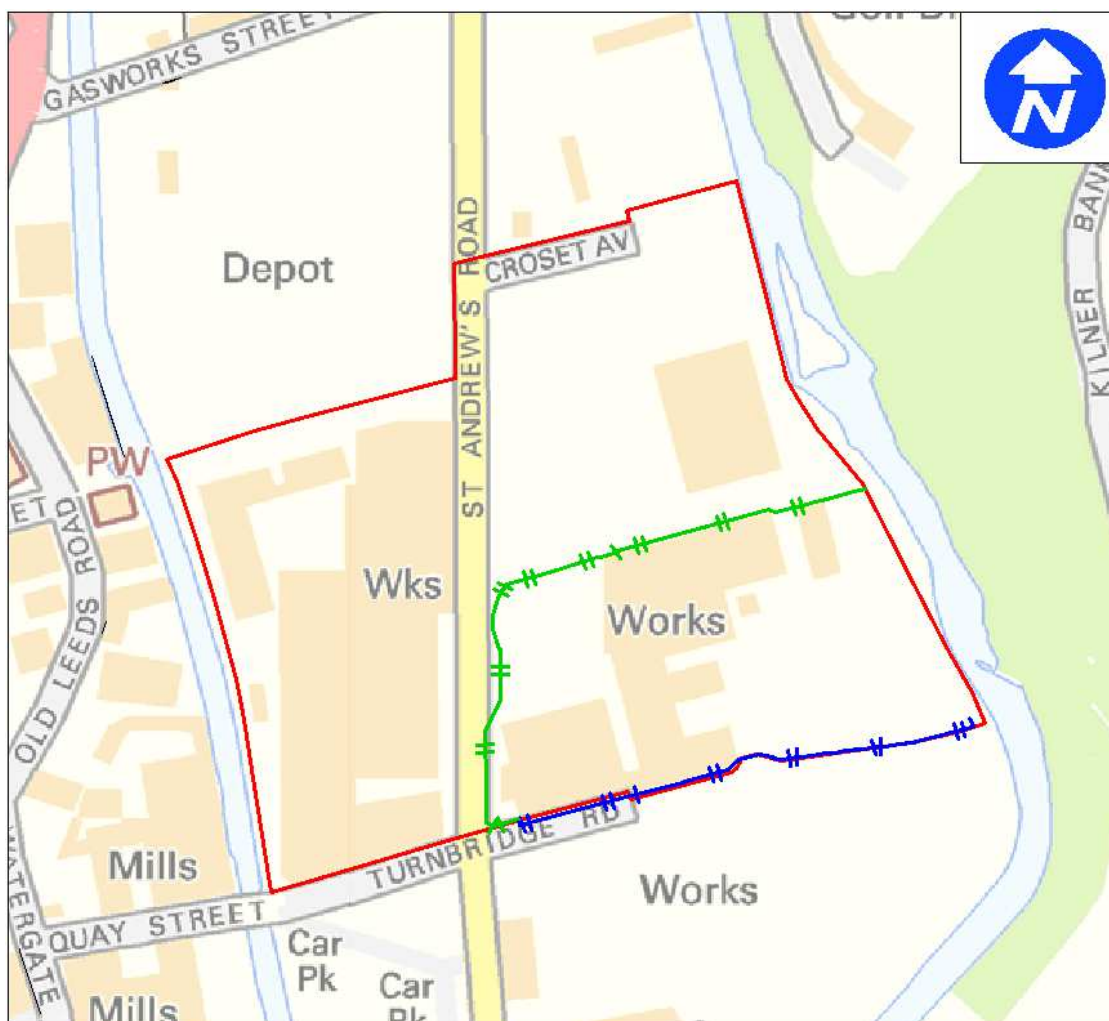


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Figure 3.1: PBA 2012 model domain

3.4 2d model construction

- 3.4.1 The 2d model used 1 m resolution Digital Terrain Map (DTM) LiDAR (Light Distance and Ranging) data and 3d survey of the CTT site to create a topographic ground model. This ground model was updated with 3d survey of the changes in ground level from the Kirklees College Extension in 2012.
- 3.4.2 The 2d model includes a materials layer identifying different Manning's 'n' coefficients for different materials. The materials layer was also used to represent buildings by using a high Manning's 'n' value.
- 3.4.3 The model also included elevated 'z lines' to represent the flood defences which were constructed around the commercial area of the CTT site. Earlier PBA models assessed the impact of various flood defence scenarios. The latest modelling from 2015/2016 included the 'as built' flood defences. Figure 3.2 shows the locations of these flood defence walls in the latest PBA model.
- 3.4.4 The bank levels along the left bank of the River Colne were included as ZP points located along the HX line. The bank levels were based on the levels from the truncated 1d ISIS sections in most locations. However, topographic survey levels were used for the bank levels within the CTT site.



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Figure 3.2: Phase 1 (blue) and Phase 2 (green) flood defence locations

3.4.5 The area inside the flood defences is referred to as the defended area of the site in this report.

3.5 2d model boundary conditions

3.5.1 The 2d model does not include any inflow or outflow boundary conditions.

3.5.2 The 1d model is linked to the 2d model by HX lines along the left bank of the River Colne.

3.6 Software

3.6.1 The previous PBA model was run using TUFLOW version 2013-12-AE-iSP-w32 and ISIS version 3.6.

4 Hydrology

4.1 Current extreme event hydrology

4.1.1 The EA only generated flows up to the 1 in 100 AP event. PBA have previously updated (2011 and 2012) the hydrology to generate the 1 in 1000 AP event.

4.1.2 Based on the modelling reports for the EA River Colne model, it was unclear how the hydrology in the existing EA model was generated. For the 2012 modelling, PBA analysed a variety of methods to determine the most appropriate method to generate the 1 in 1000 AP event.

4.1.3 Figure 4.1 is taken from Appendix 4 of PBA's 2012 hydraulic modelling report and shows the flood frequency curves at Colne Bridge gauging station (National River Flow Archive station 27031 Colne at Colne Bridge) at the downstream end of the EA model, for the following methods:

- WINFAP FEH 3 Single site analysis for Colne Bridge gauging station based on a record of 44 years observed data.
- FEH Rainfall Runoff
- ReFH (Revitalised Flood Hydrograph) Rainfall Runoff
- WINFAP-FEH 3 Pooled analysis (GL (*generalised logistic*)) for Colne Bridge gauging station, and;
- the Observed data (AMAX (*annual maxima*) series) at Colne Bridge gauging station from CEH (Centre for Ecology and Hydrology) HiFlows Data.

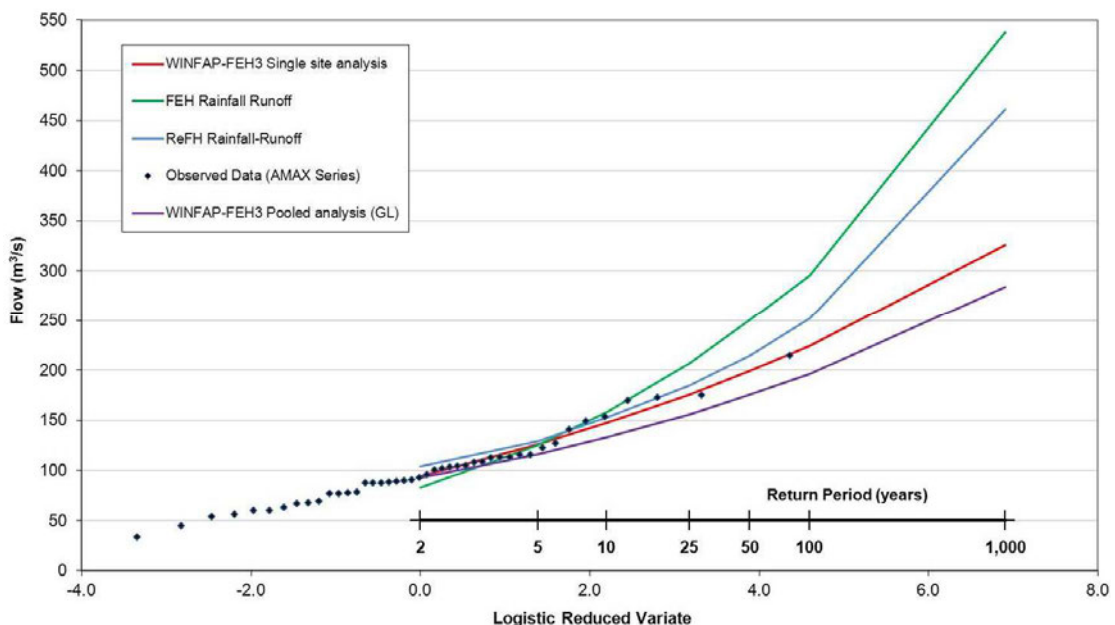


Figure 4.1: Flood Frequency Curves (FFCs) at Colne Bridge Gauging Station

4.1.4 It was noted that the FEH and ReFH rainfall runoff methods produced a sharp step change in the FFCs beyond the 1 in 100 AP event. The WINFAP FEH 3 methods (single site analysis and pooled analysis) did not produce this step increase and the general shape of these curves

corresponded with the observed data. Consequently, the FEH and ReFH rainfall runoff methods were thought to overestimate the 1 in 1000 AP event.

- 4.1.5 The WINFAP FEH 3 single site analysis method for the Colne Bridge gauging station did not produce a step curve and followed the recorded data. However, this method was not considered appropriate as the gauging station was not considered suitable for this method (length of data record was not considered sufficient).
- 4.1.6 Consequently, the FFC from the pooled analysis was considered the best approach to estimate the 1 in 1000 AP flow. While the general shape of the pooled analysis FFC is consistent with the observed data, the peak flows appeared to be underestimated.
- 4.1.7 Because of this apparent underestimation of peak flows from the pooled analysis in comparison to the observed data (AMAX series); PBA used a hybrid method to generate the 1 in 1000 AP flow at Colne Bridge (downstream end of the model).
- 4.1.8 This downstream flow would represent a 'target' flow for each extreme event. The inflows in the hydraulic model would be scaled such that they achieved this 'target' flow at Colne Bridge (downstream end of the model).
- 4.1.9 The downstream 'target' flow was generated by scaling the outflow at Colne Bridge in the 1 in 100 AP event, which was already modelled by the EA. The outflow value was scaled by the ratio of the peak flows for the 1 in 100 AP and 1 in 1000 AP generated by the pooled analysis FFC, to produce a 'target' outflow for the 1 in 1000 AP event.
- 4.1.10 Once a downstream 'target' flow was generated, the upstream inflows in the hydraulic model were all uniformly scaled (apart from the sweetening inflows) to achieve the 'target' flow at Colne Bridge (at the downstream end of the model).
- 4.1.11 The uniform upscaling of the model inflows was considered an appropriate assumption as the EA model report was not clear on the method used in the original EA modelling (2009). Figure 4.2 shows the final flood frequency curves at Colne Bridge gauging station derived by PBA. The figure shows that the hybrid method FFC correlates well with the modelled outflows from the EA 2009 ISIS model for the 1 in10, 1 in 25, 1 in 50 and 1 in 100 AP events. The hybrid FFC also correlates well with the general trend of the observed AMAX data at Colne Bridge.

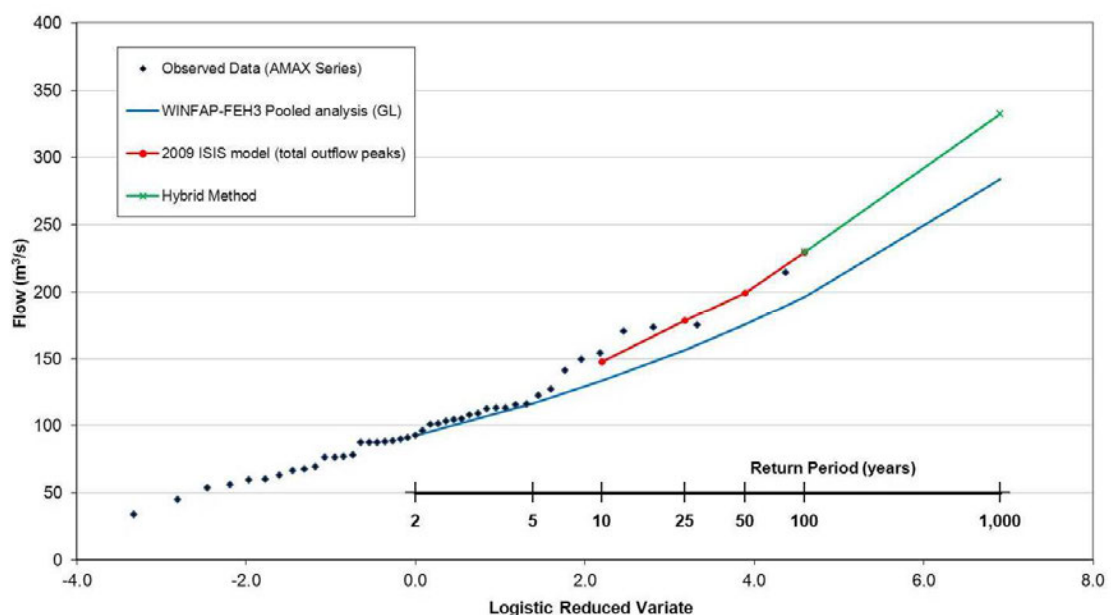


Figure 4.2: Final FFCs at Colne Bridge gauging station

4.2 1 in 500 AP event

- 4.2.1 As part of the scope of works for this hydraulic modelling, PBA included the assessment of the 1 in 500 AP event plus climate change. For this PBA have derived a 1 in 500 AP event.
- 4.2.2 To remain consistent with the 1 in 1000 AP event derived for previous modelling undertaken in 2012, the same WINFAP data (Version 3.1.2) and pooling group was used for the 1 in 500 AP event. This was considered appropriate as the modelling undertaken in 2012 had been submitted to the EA for approval. Consequently, it was not considered necessary to redo the 1 in 1000 AP hydrology with different pooling group data.
- 4.2.3 The pooling group data and FFC and GC (growth curve) data is include in Appendix B.
- 4.2.4 Table 4.1 shows the downstream ‘target’ flows generated at Colne Bridge for the 1 in 500 AP and 1 in 1000 AP event.

Table 4.1: Final FFC ‘target’ flows at Colne Bridge gauging station (downstream end of existing EA model)

Annual Exceedance Probability (AP)	2009 EA ISIS only model peak flow	WINFAP FEH 3 Pooled analysis (GL) peak flow	Ratio to 1 in 100 AP flow from pooled analysis	Hybrid Method peak flow (target flow)
1 in 2 (50%)		92.4 m ³ /s		
1 in 5 (20%)		116.5 m ³ /s		
1 in 10 (10%)	147.3 m ³ /s	133.2 m ³ /s		
1 in 25 (4%)	178.6 m ³ /s	156.3 m ³ /s		
1 in 50 (2%)	119.1 m ³ /s	175.4 m ³ /s		
1 in 100 (1%)	229.9 m ³ /s	196.4 m ³ /s		
1 in 500 (0.2%)		254.3 m ³ /s	1.294	297.5 m ³ /s
1 in 1000 (0.1%)		283.8 m ³ /s	1.445	332.1 m ³ /s

- 4.2.5 Based on these downstream ‘target’ flows it was found that the upstream inflows in the model needed to be scaled by 1.241 for the 1 in 500 AP event and 1.385 for the 1 in 1000 AP event, to achieve the ‘target’ flows in the model. Table 4.2 compares the modelled 1 in 500 and 1 in 1000 AP flows at Colne Bridge compared to the hybrid method ‘target’ flows.

Table 4.2: Comparison of modelled flows and ‘target’ flows at Colne Bridge (COLN01_0789)

AP	Model Inflow Scale Factor	Hybrid ‘target’ flow	Modelled flow	Difference
1 in 500	1.241	297.5 m ³ /s	298.1 m ³ /s	0.6 m ³ /s (0.2 %)
1 in 1000	1.385	332.1 m ³ /s	333.9 m ³ /s	1.8 m ³ /s (0.5 %)

- 4.2.6 The modelled flows at Colne Bridge for the 1 in 500 and 1 in 1000 AP are considered to match well with the target flows - with both being marginally conservative.

5 Updates to model

5.1 2d model

- 5.1.1 The model has been updated with the proposed changes to the Cummins site, these changes are largely internal but include small changes to the building footprints as one of the loading Bay areas is reconfigured at the north of the site.
- 5.1.2 The model also includes the construction of a new sprinkler pump house and water tank on site, and the removal of some storage buildings as part of the refurbishment of the existing buildings.
- 5.1.3 In addition to the changes on site, the hydraulic model has been updated to includes a new development on a carpark located to the south of the western CTT site. A new factory has been constructed on this land.
- 5.1.4 This development (Kirklees Borough Council Planning reference 2015/92014) is an office and factory development. Currently, only the northern half of this site has been developed, with the southern half remaining as a car park. However, *drawing number SK151221_02 Revision A* from the planning proposals submitted to Kirklees Borough Council (Appendix C) indicate that the car park area is considered to be 'Future Expansion Space'. As such, the whole site has been considered as developed in the model. This represents a conservative assumption in the model which considers potential future development of the whole site.
- 5.1.5 Figure 5.1 indicates the changed Manning's n layer which represents the changes from PBA's 2016 model - post the phase 2 Kirklees College extension; to the new model with the proposed changes to the western CTT site and the new factory south of the western CTT site.

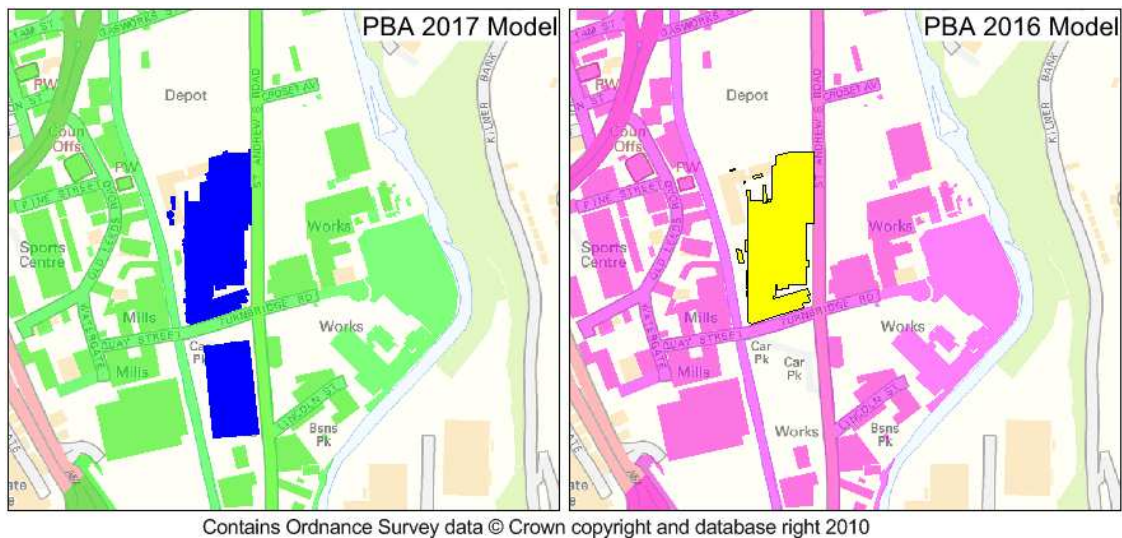


Figure 5.1: Manning's 'n' changes for buildings (yellow buildings from 2016 model replaced with blue buildings in 2017 model)

5.2 Software run versions

- 5.2.1 The previous PBA models have been run using TUFLOW version 2013-12-AE-iSP-w32. The new models will be updated to the latest version of TUFLOW (2016-03-AB-iSP-w32).
- 5.2.2 The previous PBA model was run using ISIS version 3.6, the new model will use ISIS version 3.7.

- 5.2.3 It was not considered practical or necessary to update the 1d model to Flood Modeller Pro, which is the new software which replaces ISIS. The updates to the 1d ISIS software from version 3.6 to 3.7 are not considered to impact the model results significantly.
- 5.2.4 Updating the model to the latest version of TUFLOW may have a greater impact (moving from a 2013 version to the latest 2016 version) on modelled flood levels, but it is good practice to update models to the latest version of TUFLOW where models have not been previously calibrated, to take advantage of the latest bugfixes and stability improvements.
- 5.2.5 A comparison of the modelled flood levels using the earlier version of TUFLOW has been made to consider the significance of any impact and the impact is considered negligible (less than 10 mm and generally +/- 2 mm). Table 6.1 (in section 6.2) shows a comparison of the modelled 1 in 1000 AP event flood levels between the TUFLOW versions for the 2016 and new 2017 models indicating the negligible impact.

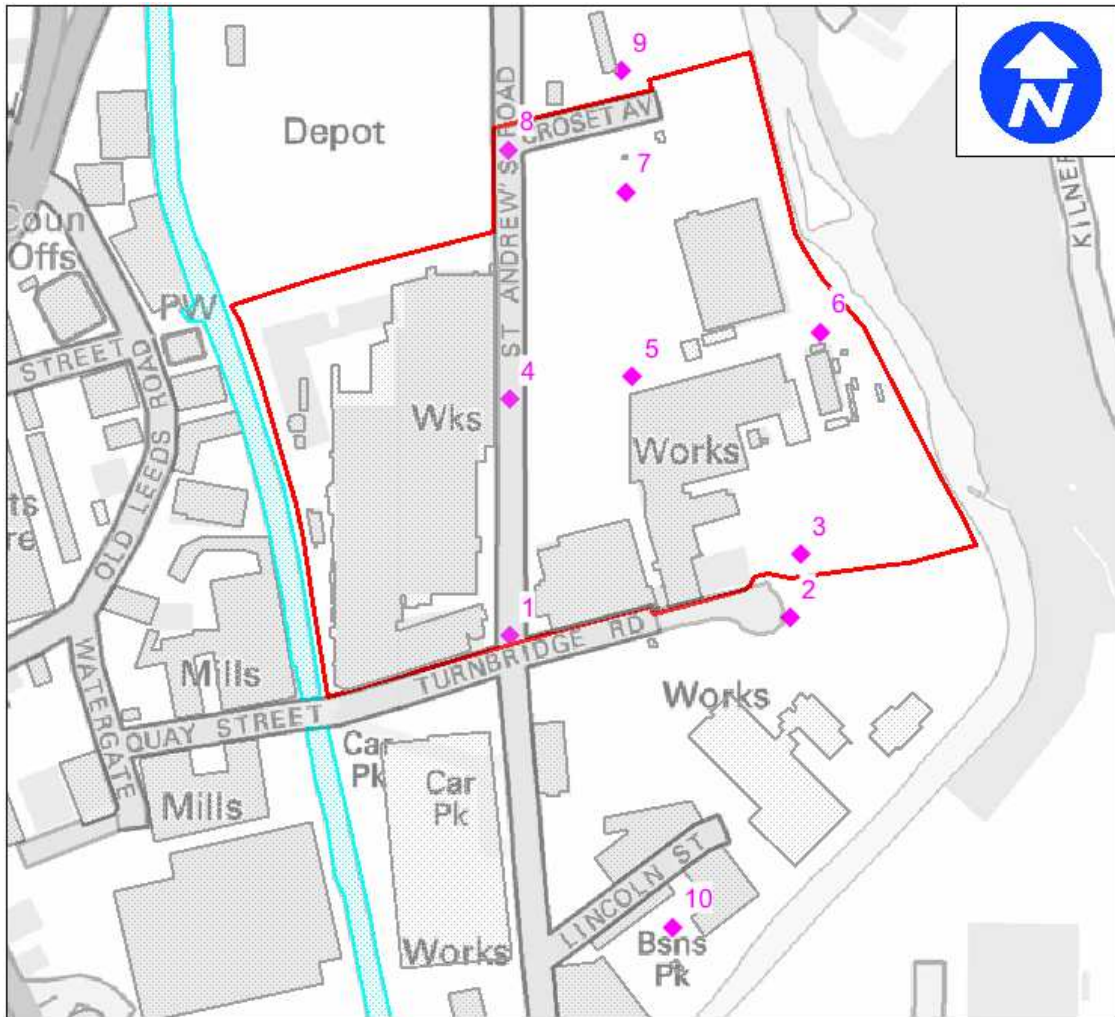
6 Model Results

6.1 PBA 2017 model

- 6.1.1 The PBA 2017 model updates the previous PBA 2016 model and includes all development currently in the vicinity of the site. The 2017 model includes the new factory to the immediate south of the western CTT site and assumes a future extension of the new factory as indicated in the planning documents uploaded on to the LPA planning website.
- 6.1.2 The 2017 modelling also addresses the updates to the EA climate change guidance issued in February 2016. The modelling will address the 20% 'Central' allowance and the 30% 'Higher central' climate change allowances pertinent to 'less vulnerable' uses for the years between 2070 to 2115.
- 6.1.3 The 2017 model considers the 1 in 100 AP and 1 in 500 AP event for both of the climate change allowances mentioned above.
- 6.1.4 The 1 in 1000 AP event is considered without climate change impacts.
- 6.1.5 The 2017 model is considered to represent a conservative estimate of the current flood risk situation at the site, updating the previous assessments carried out by PBA in 2011, 2012/2013 and the previous model update from 2015/2016 which included the extension to Kirklees College and the Phase 2 flood defences at the site.

6.2 Model results

- 6.2.1 Flood extents from the PBA 2017 modelling are included in Appendix D.
- 6.2.2 Spot levels have also been taken at the locations shown in Figure 6.1 These locations correspond to the locations used in the 2016 PBA modelling - post Kirklees College extension. The spot levels are included in Table 6.1 for comparison.
- 6.2.3 The modelled flood extents indicate that the site is still protected in the 1 in 100 AP plus 20% climate change event and also for the new 1 in 100 AP plus 30% climate change event. The site is also protected from the 1 in 1000 AP event.
- 6.2.4 The site is flooded by both of the 1 in 500 AP plus climate change events.
- 6.2.5 Flood depths within the defended site area are included in Appendix D.



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Figure 6.1: Flood level locations for Table 6.1

Table 6.1: Modelled flood levels for locations in Figure 6.1 with PBA 2016 levels for comparison

Location	PBA 2016 modelling		PBA 2017 modelling				
	1 in 100 + 20%	1 in 1000	1 in 100 + 20%	1 in 100 + 30%	1 in 500 + 20%	1 in 500 + 30%	1 in 1000
1	62.63	62.92	62.63	62.79	63.05	63.18	62.91
2	62.62	62.92	62.62	62.79	63.07	63.22	62.92
3	No flooding	No flooding	No flooding	No flooding	61.65	62.62	No flooding
4	62.61	62.82	62.61	62.73	62.90	62.97	62.81
5	62.55	62.75	62.55	62.67	62.82	62.88	62.75
6	62.38	62.49	62.39	62.45	62.55	62.57	62.50
7	62.55	62.72	62.55	62.66	62.78	62.83	62.72
8	62.58	62.71	62.58	62.66	62.77	62.82	62.71
9	62.58	62.68	62.58	62.64	62.72	62.75	62.68
10	63.10	63.30	63.10	63.22	63.40	63.51	63.30

6.2.6 The difference in flood levels between the PBA's 2016 and 2017 modelling for the 1 in 100 AP + 20% and 1 in 1000 AP are negligible (Table 6.1). This indicates that the construction of the factory south of the site has not had a significant impact on flood levels locally.

6.3 Modelled 1 in 500 AP plus climate change events

6.3.1 The site is shown to flood in the modelled 1 in 500 AP plus 20% and 30% climate change events modelled. Figure 6.2 is shows the heights of the flood defence walls and the modelled 1 in 500 AP plus climate change modelled flood levels and extents.

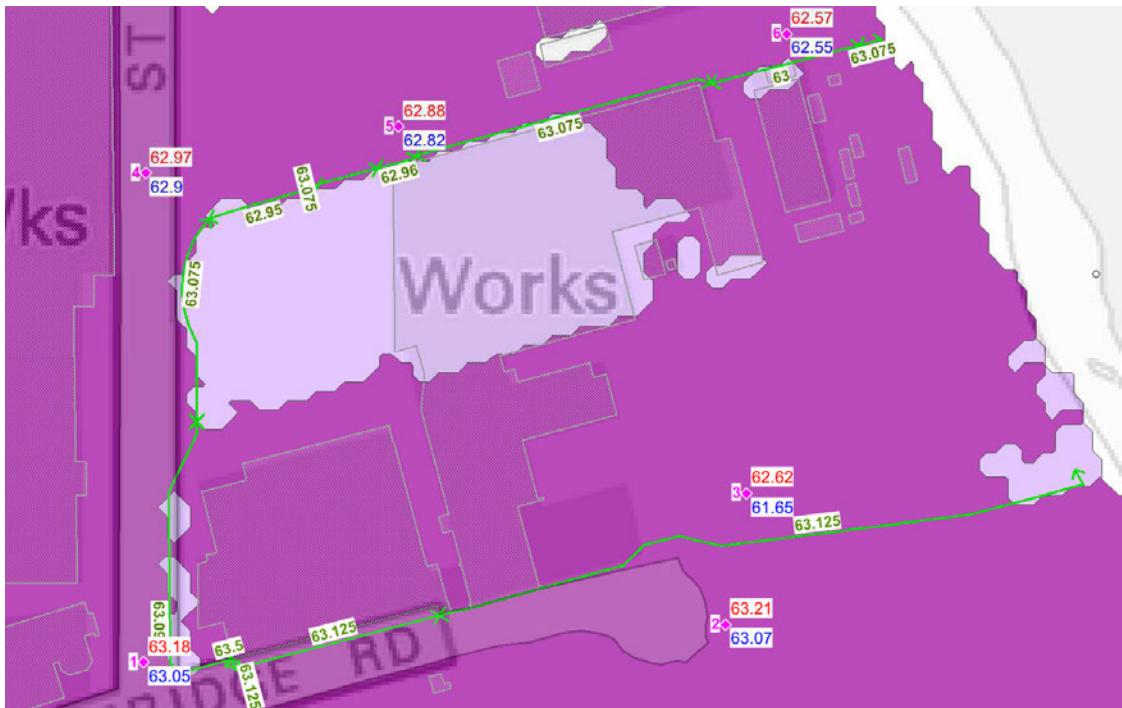


Figure 6.2: Flood defence heights (green) and 1 in 500 AP climate change modelled flood levels (blue = 20%, red = 30%)

- 6.3.2 For the smaller 1 in 500 AP plus 20% (Central) climate change allowance, the flood levels surrounding the site are lower than the flood defence heights. The closest point to overtopping the flood defences is along the flood defence in the southwest corner of the site along St Andrew's Road where the flood defence level (63.09 m AOD) has 40mm freeboard on the modelled 1 in 500 AP plus 20% flood level (63.05 m AOD).
- 6.3.3 The flooding shown inside the site is directly from the River Colne over topping its banks. The bank levels along the River Colne in this reach are based on topographic survey and vary between 61.84 m AOD at the downstream (north) end of the site to 62.67 m AOD at the upstream (south) of the site.
- 6.3.4 Figure 6.3 shows the topographic levels along the left bank of the River Colne.

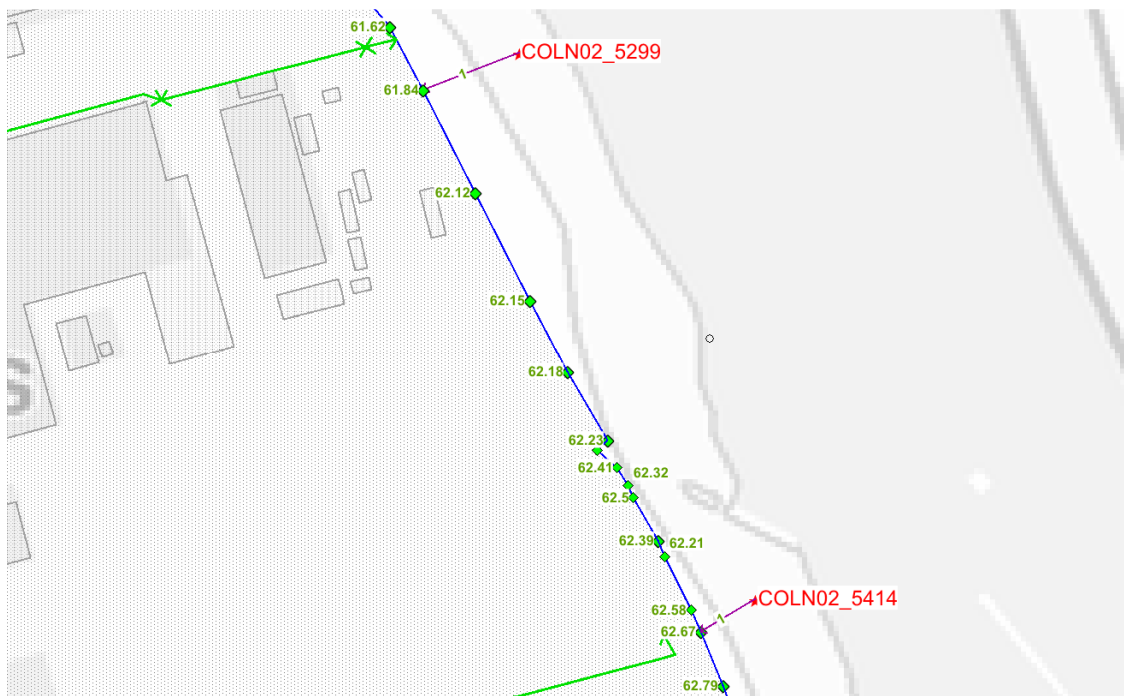


Figure 6.3: Bank levels along the River Colne adjacent to the site.

6.4 1 in 500 AP plus 20% climate change results

- 6.4.1 The modelled peak water level at ISIS node location COLN02_5299 at the downstream end of the defended site is 62.252 m AOD. This is approximately 410 mm above the bank level. The modelled flood level at ISIS node COLN02_5414 at the upstream end of the defended site is 62.415 m AOD, which is below the bank levels in this location (62.67 m AOD).
- 6.4.2 Figure 6.4 shows the extent of overtopping of the left bank of the River Colne. Approximately two thirds of the banks overtop as the flooding of the defended area initiates.



Figure 6.4: Initiation of on-site flooding for the 1 in 500 AP plus 20% event (flow direction in green arrows).

6.4.3 Consequently, the on-site flooding in the 1 in 500 AP plus 20% climate change event is from the River Colne overtopping its banks at the site. No overtopping of the flood defences from upstream flood flow occurs in this event. The lower peak flood levels in the River Colne compared to the flood levels on the floodplain result in the on-site flood level being lower than the surrounding flood levels on Turnbridge Road (south) and St Andrew's Road (west).

6.5 1 in 500 AP plus 30% climate change results

6.5.1 The modelled flood level (63.18 m AOD) for 1 in 500 AP plus 30% (Higher central) climate change allowance event exceeds the height of the flood defence walls on the southwest corner of the site (63.09 m AOD) (location 1 on figures 6.1 and 6.2). This results in a shallow depth of overtopping of the flood defence in this location (90 mm).

6.5.2 Consequently, the on-site flooding shown in the 1 in 500 AP plus 30% event is a combination of a shallow depth of overtopping of the flood defences and the flooding from the River Colne that is shown in the 1 in 500 AP plus 20% event.

7 Conclusion

7.1 Summary

- 7.1.1 PBA have updated the hydraulic model of the River Colne for the Cummins Turbo Technologies (CTT) site in Huddersfield.
- 7.1.2 The model was updated to include changes to the site from the proposed works on the western half of the CTT site (western CCT site). The model also included the recent factory development directly to the south of the western CTT site. These changes were included in the model as an update to the model materials layer to represent the impact of buildings to out of bank flood flow. The new factory is included as a larger building than is currently built on site. This is to assess the potential future extension of the factory, as indicated in the development plans available online (Appendix C).
- 7.1.3 The model also updated the 1 in 100 AP event with the new Environment Agency (EA) 'Central' and 'Higher central' climate change allowances for the Humber River Basin Area for the years between 2070 to 2115. These allowances are appropriate for the continued use of the site as 'less vulnerable' commercial and industrial uses.
- 7.1.4 The model also considered the 1 in 500 AP event with these climate change allowances. The 1 in 500 AP flow was assessed using the same methodology used to generate the 1 in 1000 AP event in 2012. The 1 in 1000 AP flow was accepted for use by the EA and this method was used to generate the 1 in 500 AP flow to remain consistent with the existing 1 in 1000 AP hydrology.
- 7.1.5 The model results indicated that the commercial areas defended by flood defences (defended area) on the eastern half of the CTT site (eastern CTT site) remains unaffected by flooding in the 1 in 100 AP plus climate change events. The undefended area on the eastern CTT site is shown to be mostly flooded. The western CTT site is undefended and around half of the western CTT site shown as flooded (Figure 39413/4001/MI001 Appendix D).
- 7.1.6 The defended area is also unaffected by flooding in the 1 in 1000 AP event. The surrounding undefended areas are shown to be impacted by the 1 in 1000 AP event (figure 39413/4001/MI003 Appendix D).
- 7.1.7 For the 1 in 500 AP event plus 20% climate change, the defended area is shown to be partially affected by flooding (Figure 39413/4001/MI002 Appendix D). Only the northwest corner of the defended area is shown to be outside the modelled flood extent.
- 7.1.8 For this event, the flood defences, continue to protect the defended site from out of bank flow from upstream of the site. The flooding on the defended area is directly from the River Colne overtopping its banks. The 1 in 500 AP plus 20% climate change event results in a maximum flood depth of 1.2 m (Figure 39413/4001/MI004 Appendix D) within the defended area.
- 7.1.9 For the 1 in 500 AP plus 30% climate change, the defended area is shown to be entirely flooded (Figure 39413/4001/MI002 Appendix D). The majority of the flooding on site is from the River Colne overtopping its banks. However, the modelled flood levels indicate that the flood defences are overtopped in the southwest corner of the site. The 1 in 500 AP plus 30% climate change event results in a maximum flood depth of over 1.8 m within the defended area (Figure 39413/4001/MI005 Appendix D).
- 7.1.10 It is recommended that CTT liaise with PBA if the flood defences at the site require updating to the 1 in 500 AP plus climate change plus 300 mm freeboard. This is so PBA can advise on any additional requirements.

Appendix A EA Correspondence

Shumol Bari

From: Redacted
Sent: 22 February 2017 11:18
To: Shumol Bari
Cc: NE Yorkshire, Customer Contact
Subject: RE: 170213/RML09 - License for River Colne Model

Dear Shumol,

This is still our most up to date modelling, though we are in the process of updating our modelling with the outputs expected in late August of this year.

Please see the licence conditions for Colne & Holme 2010 model below:

This information is not available with the Open Government Licence but we may be able to license to you under the [Environment Agency Conditional Licence](#):

Title: Colne & Holme Model
Third Party Rights: Centre for Ecology and Hydrology

The condition below applies to this model:

- 1.1 We are supplying the Information to you without charge in the public interest and request that you likewise agree to the following paragraphs in the public interest
- 1.2 You agree, in the public interest, unless you advise us otherwise in writing within fourteen days of receipt of the data, to supply to the Environment Agency, copies of any assessments/studies and related outputs, modifications or derivatives created pursuant to the supply to you of the Information, all of which are hereinafter referred to as "the Data".
- 1.3 You agree, in the public interest, unless you advise us otherwise in writing within fourteen days of receipt of the data, to the Environment Agency using the Data or any part thereof for its internal purposes or using it in any way as part of Environment Agency derivative products which it supplies free of charge to others such as incorporation into the Environment Agency's Open Data mapping products.
- 1.4 Please be aware that model data is not raw, factual or measured but comprises of estimations or modelled results based on the data available to us.
- 1.5 For technical reasons the Licensed Content you have been supplied may be greater than strictly necessary for the site or project you are working on and so contain more data than specified above. You must not use such additional Licensed Content.

However, you must first check the supporting information above to determine if the conditions on use are suitable for your purposes. If the conditions are not suitable, this information is not provided with a licence for use, and the data is provided for read right only.

I hope this is sufficient, please let me know if you have any further queries.

Tom Wait
FCRM Officer

Flood & Coastal Risk Management - Partnerships and Strategic Overview - Yorkshire

✉ **Environment Agency, Lateral, 8 City Walk, Leeds. LS11 9AT**

☎ **Redacted**
📞

From: Shumol Bari [Redacted](#)
Sent: 08 February 2017 17:49
To: Enquiries, Unit <[Redacted](#)>
Subject: License for River Colne Model

Dear Sir or Madam

We have, in previous years, requested a license to use your 2010 River Colne and Holme pre-feasibility Study Model – Do Nothing and Do minimum models for commercial use.

I am enquiring as to whether the 2010 River Colne and Holme pre-feasibility Study Model remains the most up to date hydraulic model for the attached site location plan. If it is, can I request a new license for this model, I assume it will be free of charge.

The last time we obtained a license was on the 21st January 2016 (agreement signed and returned by us on the 03/02/16), under special license reference RFI/2015/35898.

Our previous license request was processed by **Redacted**) in your York Office if that helps

However, If you have, or are in the process of updating the hydraulic modelling in this region, please can I be advised of the new model and I can I further request the product 7 and product 5 data of that model if possible.

If you have any questions regarding this data request please feel free to contact me.

Kind regards,

Shumol Bari

Assistant Modeller

For and on behalf of Peter Brett Associates LLP - [Reading](#)

  **Redacted**
e
w peterbrett.com



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Appendix B Pooling group data







Station	Distance	Years of da	QMED	AM	L-CV	L-SKEW	Discordancy
27053 (Nidd @ Birstwith)	0.29	33	93.647	0.183	-0.055	2.137	
12008 (Feugh @ Heugh Head)	0.341	21	141.628	0.201	0.11	0.272	
47006 (Lyd @ Lifton Park)	0.371	40	90.136	0.272	0.27	1.518	
54038 (Tanat @ Llanyblodwel)	0.381	37	77.399	0.154	0.16	0.329	
202002 (Faughan @ Drumahoe)	0.405	33	133.678	0.162	0.264	1.557	
50010 (Torrige @ Rockhay Bridge)	0.407	21	100.85	0.08	0.011	2.018	No Pooling
66006 (Elwy @ Pont-y-gwyddel)	0.408	35	71.312	0.192	0.164	0.047	
82001 (Girvan @ Robstone)	0.435	24	103.679	0.111	0	2.36	
69017 (Goyt @ Marple Bridge)	0.438	39	48.531	0.218	0.261	1.171	
84014 (Avon Water @ Fairholm)	0.439	42	163.858	0.178	0.212	0.387	
53007 (Frome(somerset) @ Tellisford)	0.443	48	57.875	0.176	0.115	1.085	
8009 (Dulnain @ Balnaan Bridge)	0.464	54	94.451	0.169	0.097	0.568	
12007 (Dee @ Mar Lodge)	0.466	25	180.223	0.148	0.133	0.309	
45004 (Axe @ Whitford)	0.479	45	106.125	0.24	0.132	0.968	
21012 (Teviot @ Hawick)	0.49	43	190.012	0.154	0.156	0.274	
Total		540					
Weighted means				0.177	0.138		

Pooling-group details Colne @ Colne Bridge

AM Data | Catchment Descriptors

	Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordant
1	27053 (Nidd @ Birstwith)	0.290	33	93.647	0.183	-0.055	2.137
2	12008 (Feugh @ Heugh Head)	0.341	21	141.628	0.201	0.110	0.272
3	47006 (Lyd @ Lifton Park)	0.371	40	90.136	0.272	0.270	1.518
4	54038 (Tanat @ Llanyblodwel)	0.381	37	77.399	0.154	0.160	0.329
5	202002 (Faughan @ Drumahoe)	0.405	33	133.678	0.162	0.264	1.557
6	50010 (Torrige @ Rockhay Bric)	0.407	21	100.850	0.080	0.011	2.018
7	66006 (Elwy @ Pont-y-gwyddel)	0.408	35	71.312	0.192	0.164	0.047
8	82001 (Girvan @ Robstone)	0.435	24	103.679	0.111	0.000	2.360
9	69017 (Goyt @ Marple Bridge)	0.438	39	48.531	0.218	0.261	1.171
10	84014 (Avon Water @ Fairholm)	0.439	42	163.858	0.178	0.212	0.387
11	53007 (Frome(somerset) @ Tellis)	0.443	48	57.875	0.176	0.115	1.085
12	8009 (Dulnain @ Balnaan Bridge)	0.464	54	94.451	0.169	0.097	0.568
13	12007 (Dee @ Mar Lodge)	0.466	25	180.223	0.148	0.133	0.309
14	45004 (Axe @ Whitford)	0.479	45	106.125	0.240	0.132	0.968
15	21012 (Teviot @ Hawick)	0.490	43	190.012	0.154	0.156	0.274
16							
17	Total		540				
18	Weighted means				0.177	0.138	

Key

- Short Records 
- Discordant 
- No Pooling 
- No Pooling, No QMED 

AM Graphs Add Site Remove Site OK

Fitted parameters

	Location	Scale	Shape	Bound
L	1	0.168		
GL	1	0.169	-0.153	-0.105
GEV	0.905	0.261	0.027	10.644

return peri	L	GL	GEV
2	1	1	1
5	1.233	1.261	1.288
10	1.37	1.441	1.474
25	1.535	1.691	1.704
50	1.655	1.898	1.871
100	1.773	2.126	2.034
200	1.891	2.377	2.192
500	2.045	2.751	2.398
1000	2.162	3.071	2.549

Growth Curve Fittings

Standardisation details
Standardised by median

Pooled L-moments
L-CV: 0.177 L-skewness: 0.138

Fitted parameters

	Location	Scale	Shape	Bound
L	1.000	0.168		
GL	1.000	0.169	-0.153	-0.105
GEV	0.905	0.261	0.027	10.644

Return periods

	L	GL	GEV
2	1.000	1.000	1.000
5	1.233	1.261	1.288
10	1.370	1.441	1.474
25	1.535	1.691	1.704
50	1.655	1.898	1.871
100	1.773	2.126	2.034
200	1.891	2.377	2.192
500	2.045	2.751	2.398
1000	2.162	3.071	2.549

Station	Distance	SI AREA	SAAR	FPEXT	FARL	URBEXT 2000
27053 (Nid	0.29	219.28	1218	0.029	0.913	0.004
12008 (Feu	0.341	232.84	1130	0.038	0.998	0
47006 (Lyd	0.371	220.39	1228	0.035	0.996	0.002
54038 (Tan	0.381	240.98	1274	0.038	0.996	0.001
202002 (Fa	0.405	273.03	1219	0.041	1	0.004
50010 (Tor	0.407	258.42	1231	0.049	0.997	0.003
66006 (Elw	0.408	191.38	1185	0.032	0.98	0.001
82001 (Gin	0.435	243.63	1368	0.055	0.942	0.004
69017 (Go)	0.438	184.23	1152	0.03	0.918	0.025
84014 (Avc	0.439	263.01	1264	0.057	0.986	0.01
53007 (Fro	0.443	263.74	965	0.055	0.96	0.023
8009 (Duln	0.464	272.2	1012	0.051	0.994	0.001
12007 (Dec	0.466	291.9	1334	0.033	0.989	0
45004 (Axe	0.479	288.53	994	0.038	0.996	0.011
21012 (Tev	0.49	324.39	1149	0.032	0.993	0.007

Return Peri	L	GL	GEV
2	92.417	92.417	92.417
5	113.973	116.523	119.059
10	126.583	133.182	136.259
25	141.834	156.294	157.503
50	152.933	175.43	172.918
100	163.869	196.441	187.934
200	174.725	219.658	202.62
500	189.02	254.261	221.58
1000	199.814	283.807	235.604

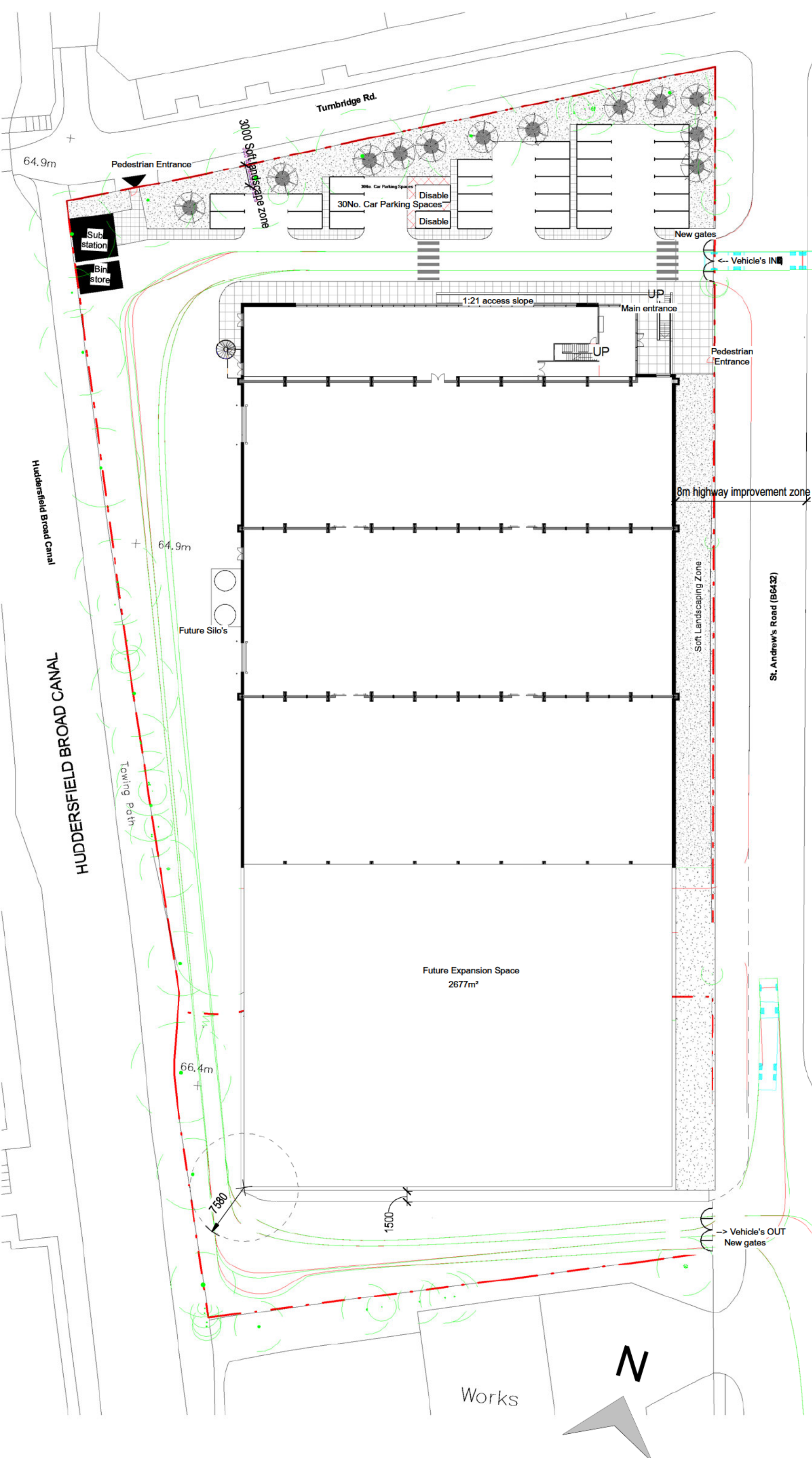
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Return periods	L	GL	GEV
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5	113.973	116.523	119.059
10	126.583	133.182	136.259
25	141.834	156.294	157.503
50	152.933	175.430	172.918
100	163.869	196.441	187.934
200	174.725	219.658	202.620
500	189.020	254.261	221.580
1000	199.814	283.807	235.604

ratio 100:1000 1.444744
ratio 100:500 1.294338

Appendix C Planning application drawings

SK151221_02 Revision A - *taken from Kirklees County Council Planning website*



A	Additional parking omitted. Building extended	04.01.16	MM	MM
Rev	Description	Date	Dr by	App by
original by		date created		approved by
MM		12/22/15		MM

AHR AHR Architects Ltd
 7 Brewery Place
 Brewery Wharf
 Leeds
 LS10 1NE
 United Kingdom

T +44(0)113 3858787
 F +44(0)113 3858777
 E leeds@ahr-global.com
 www.ahr-global.com

client name	Polyseam		
project	New factory & office facility, Huddersfield		
drawing	Option 2 Extension Proposal		
computer file	C:\Users\manias.misty\Documents\00185-AHR-XX-XX-MB-AR-Central-Polyseam_manias.misty.rvt	plot date	
project number	2014.00185.000	scale	1 : 500 @A3
drawing number	SK151221_02	rev	A
		issue status	Information

This drawing is to be read in conjunction with all related drawings. All dimensions must be checked and verified on site before commencing any work or producing shop drawings. The originator should be notified immediately of any discrepancy. This drawing is copyright and remains the property of AHR.

Appendix D Model results

Figure: 39413/4001/MI001 - *modelled 1 in 100 AP plus climate change flood extents*

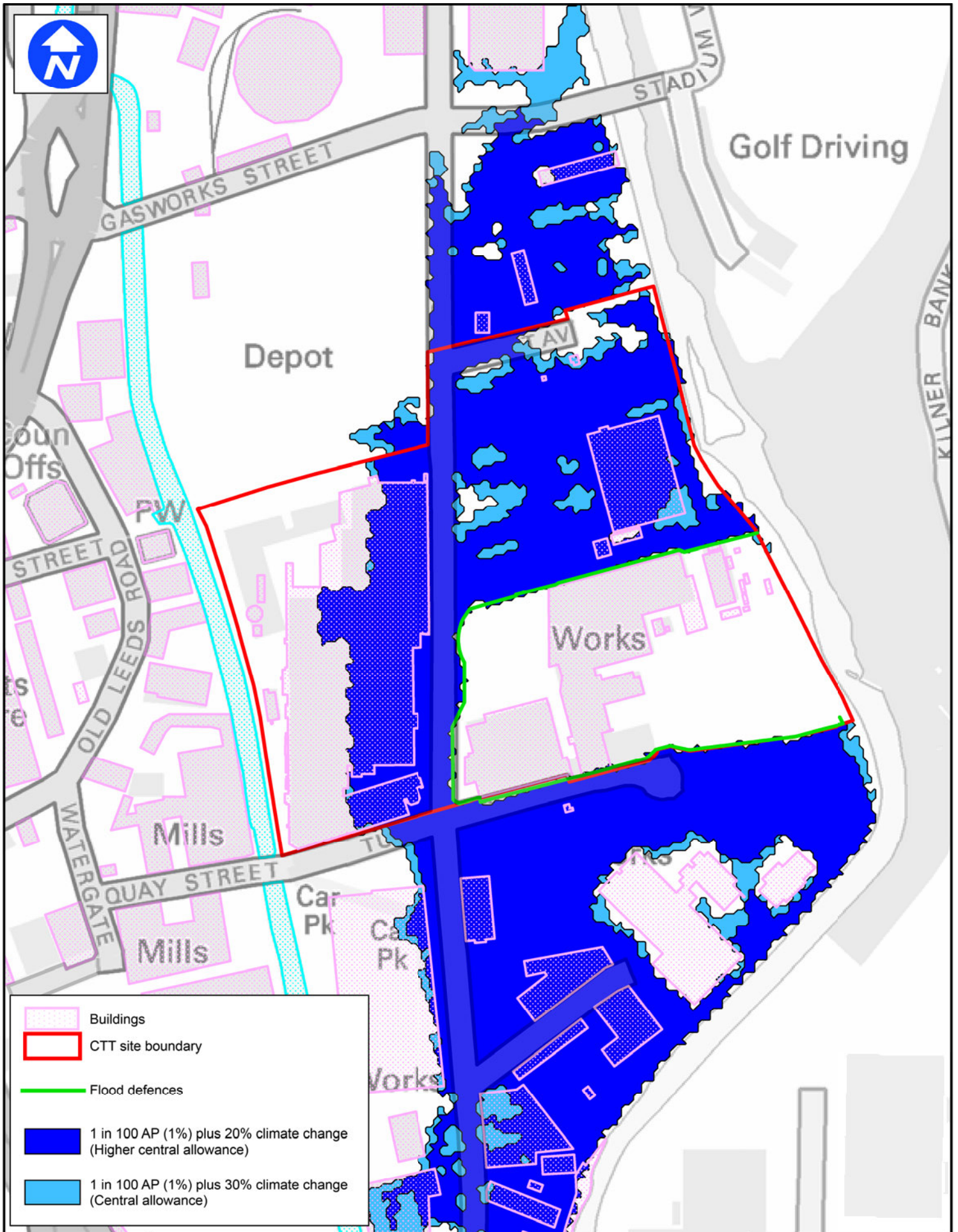
Figure: 39413/4001/MI002 - *modelled 1 in 500 AP plus climate change flood extents*

Figure: 39413/4001/MI003 - *modelled 1 in 1000 AP flood extent*

Figure: 39413/4001/MI004 - *modelled 1 in 500 AP plus 20% climate change flood depths*

Figure: 39413/4001/MI005 - *modelled 1 in 500 AP plus 30% climate change flood depths*





	Buildings
	CTT site boundary
	Flood defences
	1 in 100 AP (1%) plus 20% climate change (Higher central allowance)
	1 in 100 AP (1%) plus 30% climate change (Central allowance)

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Peter Brett Associates LLP
READING
Tel: 0118 950 0761 Fax: 0118 959 7498

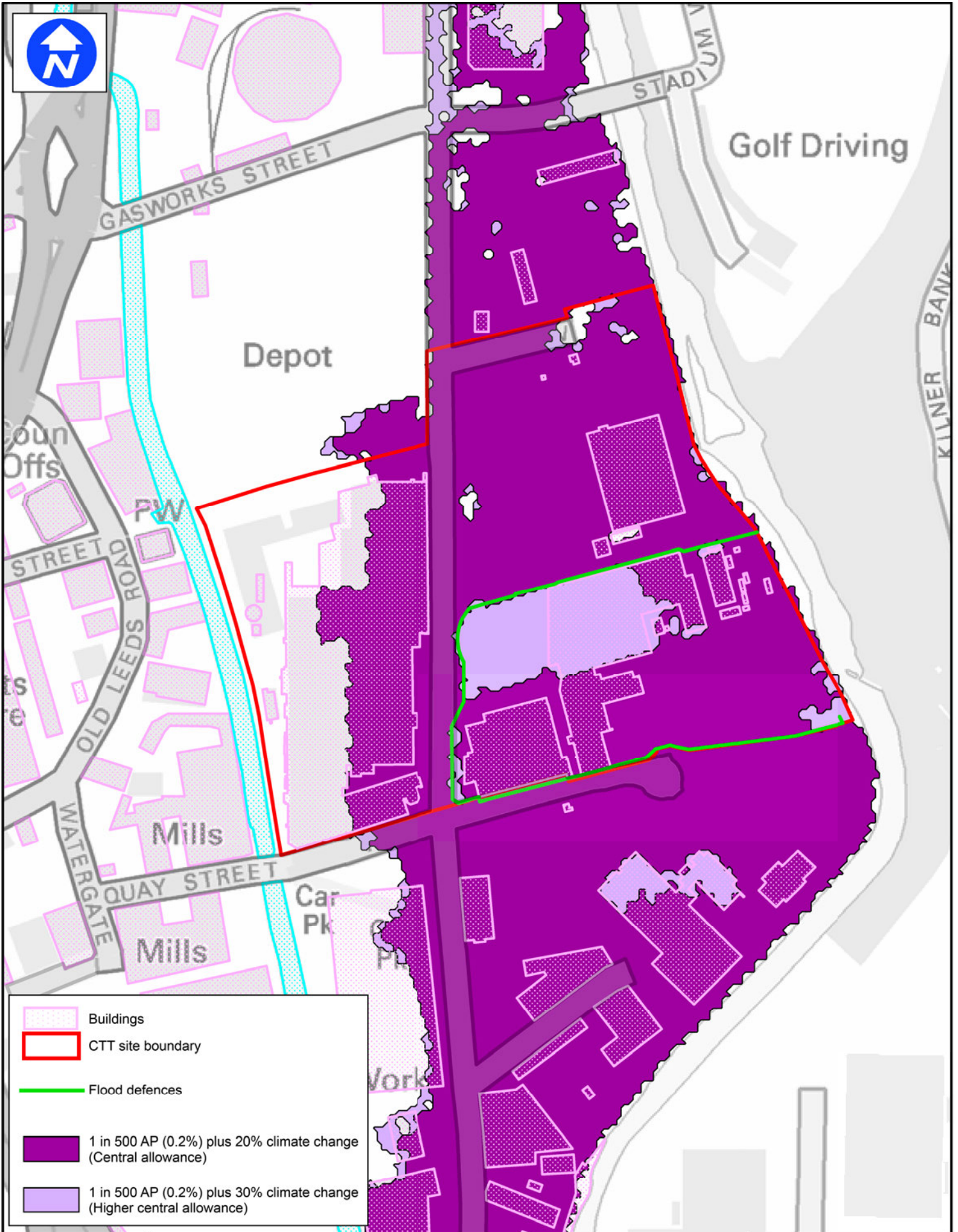
Client
Cummins Turbo Technologies

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PBA 2017 Modelling

Modelled 1 in 100 AP plus climate change flood extents

Date: 24/02/2017
Scale: NTS
Drawn By: SB Checked By: AR
Rev: -
Figure Number 39413/4001/MI001



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PBA 2017 Modelling

Modelled 1 in 500 AP plus climate change flood extents

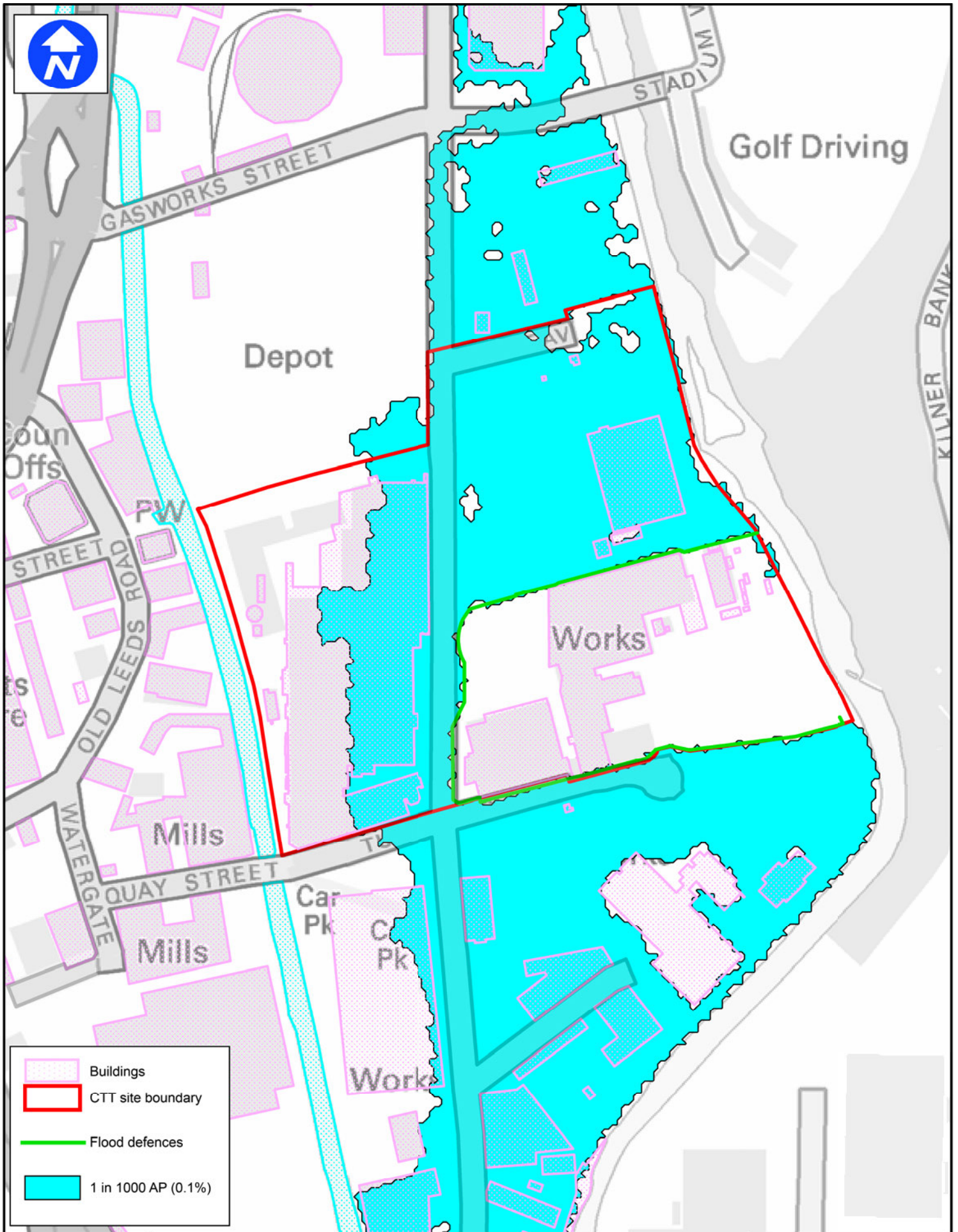
Date: 24/02/2017

Scale: NTS

Drawn By: SB Checked By: AR

Rev: -

Figure Number
39413/4001/MI002



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Modelled 1 in 1000 AP flood extents

Date: 24/02/2017

Scale: NTS

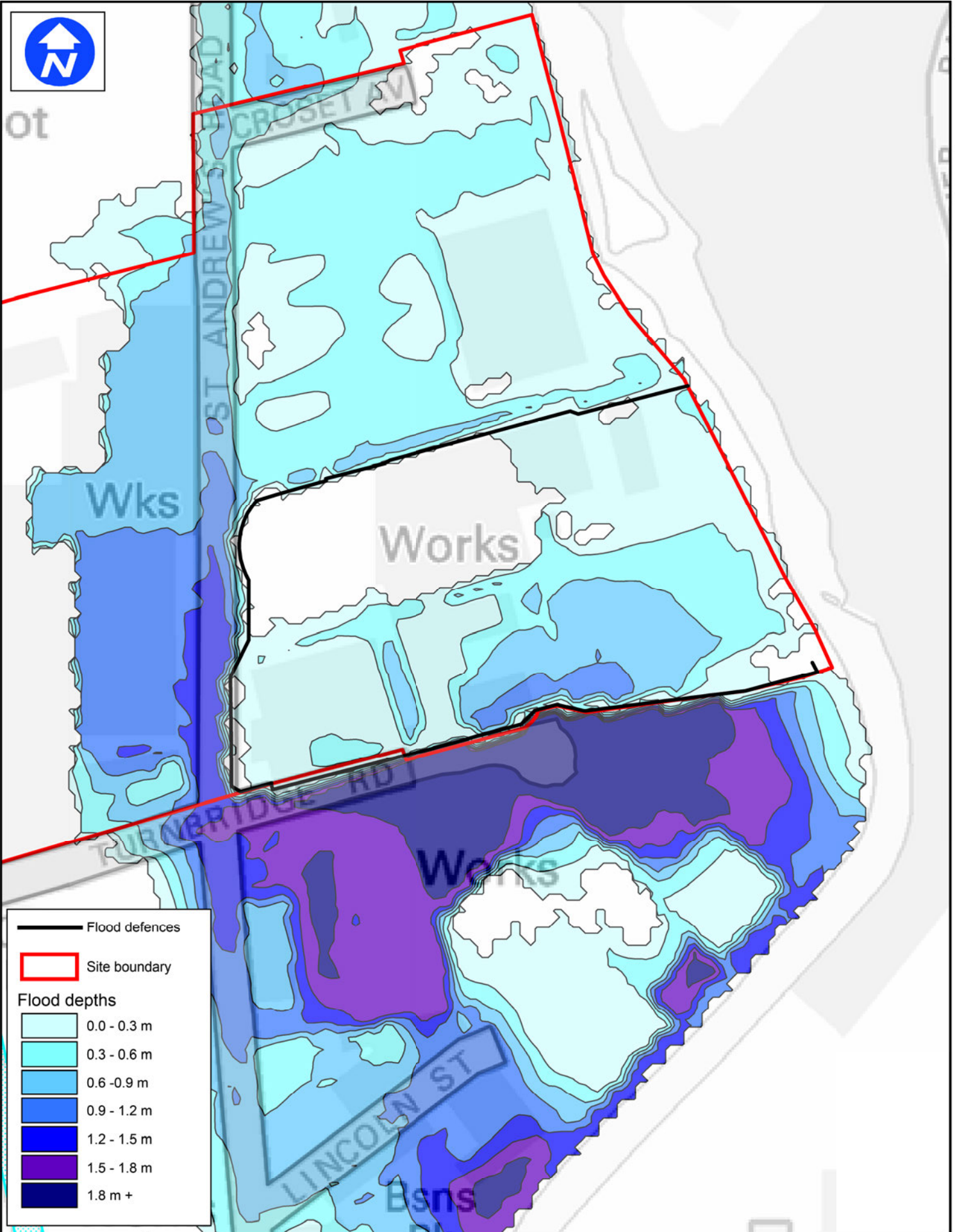
Drawn By: SB Checked By: AR

Rev: -

Figure Number
39413/4001/MI003



ot



— Flood defences

□ Site boundary

Flood depths

- 0.0 - 0.3 m
- 0.3 - 0.6 m
- 0.6 - 0.9 m
- 0.9 - 1.2 m
- 1.2 - 1.5 m
- 1.5 - 1.8 m
- 1.8 m +



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Cummins Turbo Technologies

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PBA 2017 Modelling

Modelled 1 in 500 AP plus 20% climate change flood depths

Date: 24/02/2017

Scale: NTS

Drawn By: SB Checked By: AR

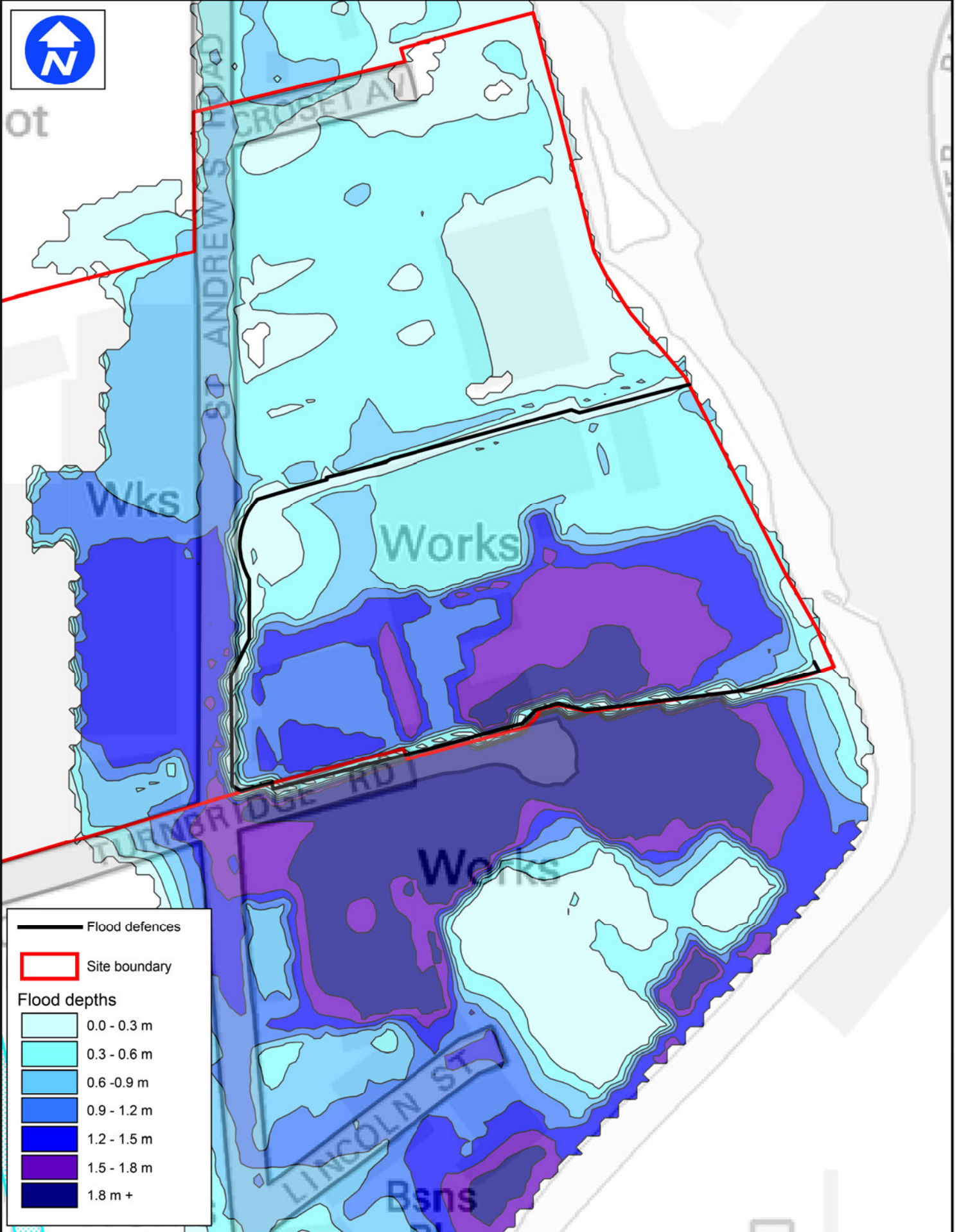
Rev: -

Figure Number

39413/4001/MI004



ot



— Flood defences

□ Site boundary

Flood depths

- 0.0 - 0.3 m
- 0.3 - 0.6 m
- 0.6 - 0.9 m
- 0.9 - 1.2 m
- 1.2 - 1.5 m
- 1.5 - 1.8 m
- 1.8 m +



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Client

Cummins Turbo Technologies

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PBA 2017 Modelling

Modelled 1 in 500 AP
plus 30% climate change
flood depths

Date: 27/02/2017

Scale: NTS

Drawn By: SB Checked By: AR

Rev: -

Figure Number

39413/4001/MI005