Proposed Development at Hatton Mains, by Ratho, Edinburgh

Flood Risk Assessment

Ref: 14932/BC/600

November 2018

PROPOSED DEVELOPMENT AT HATTON MAINS, BY RATHO

FLOOD RISK ASSESSMENT

November 2018

Ref: 14962/BC/600

CLIENT: Inverdunning (Hatton Mains) Ltd.
c/o Greyfriars
56 George street
Edinburgh
EH2 2LR

ENGINEER: Millard Consulting
Inveralmond Business Centre
Auld Bond Road
Perth
PH1 3FX

Tel: 01738 646750

Report Prepared By:

....
Andrew Braid

Report Checked By:

....
Brian Coghlan (Technical Director)

CONTENTS

1.0 Introduction ....

2.0 General Description of Site ....

3.0 General Observations ....

4.0 Estimation of Flood Flows in the Watercourse ....

5.0 Predicted Flood Levels ....

6.0 Proposed Mitigation and Management of Flood Risk ....

7.0 Conclusions ....

8.0 References ....

Appendix A: Results from WINFAP Flow Analysis (FEH Statistical Method)

Appendix B: Results from Flood Modeller Flow Analysis (FEH Rainfall Runoff Method)

Appendix C: Results from ReFH2 Flow Analysis (Revitalised Flood Hydrograph Method – Version 2)

Appendix D: Output from HECRAS Model

PLANS

14962/21/001 PREDICTED Q200 FLOOD EXTENT

14962/21/002 PREDICTED Q200 FLOOD EXTENT – LARGER SCALE, SHEET 1 OF 2

14962/21/003 PREDICTED Q200 FLOOD EXTENT – LARGER SCALE, SHEET 2 OF 2

14962/21/004 MITIGATION PROPOSALS

1.0 Introduction

Millard Consulting have been instructed by Inverdunning (Hatton Mains) Ltd to carry out a Flood Risk Assessment in relation to a proposed residential development at Hatton Mains by Ratho. The development includes the construction of 1,200 homes on the site.

The planning authority have requested a Flood Risk Assessment be carried out for the proposed development. For a development such as is proposed, it is normal to assess flood risk for a return period of 1 in 200 years.

1.1 Scope and Methodology

The scope of this Flood Risk Assessment is to assess and quantify flood risk to the proposed development. Flood risk to the development will be assessed for a 1-in-200-year flood event.

To assess flood risk to the development a topographical survey has been undertaken by Linnen CES Ltd. They have also surveyed cross sections through the watercourse adjacent to the site to enable a hydraulic model to be constructed. The survey was preceded by a site walkover to confirm the extent of survey required.

Using several methods, the Q200 flood flow for the watercourse will be assessed and applied in the hydraulic model. The results provided by the hydraulic model will then be utilised with the topographical survey to assess flood risk to the site.

Once flood risk to the site has been assessed and quantified, recommendations for the site from the perspective of flood risk will then be made.

The assessment is prepared using our best engineering judgement but there are levels of uncertainty implicit in the historical data and methods of analysis. Details of the range of possible error in the methods of flood estimation are given in the Flood Estimation Handbook (FEH).

This Flood Risk Assessment is carried out in accordance with the requirements of the Scottish Planning Policy *(SPP) (Scottish Government, 2014)*. This assessment uses a set of procedures originally set out in the Flood Estimation Handbook *(Institute of Hydrology, 1999)* and embodied in the FEH and WINFAP software packages currently used.

2.0 General Description of Site

The site of the proposed development site to the south of the village of Ratho, and is in a rural part of the Edinburgh Council area.

Please see location plan, Figure 1 below.

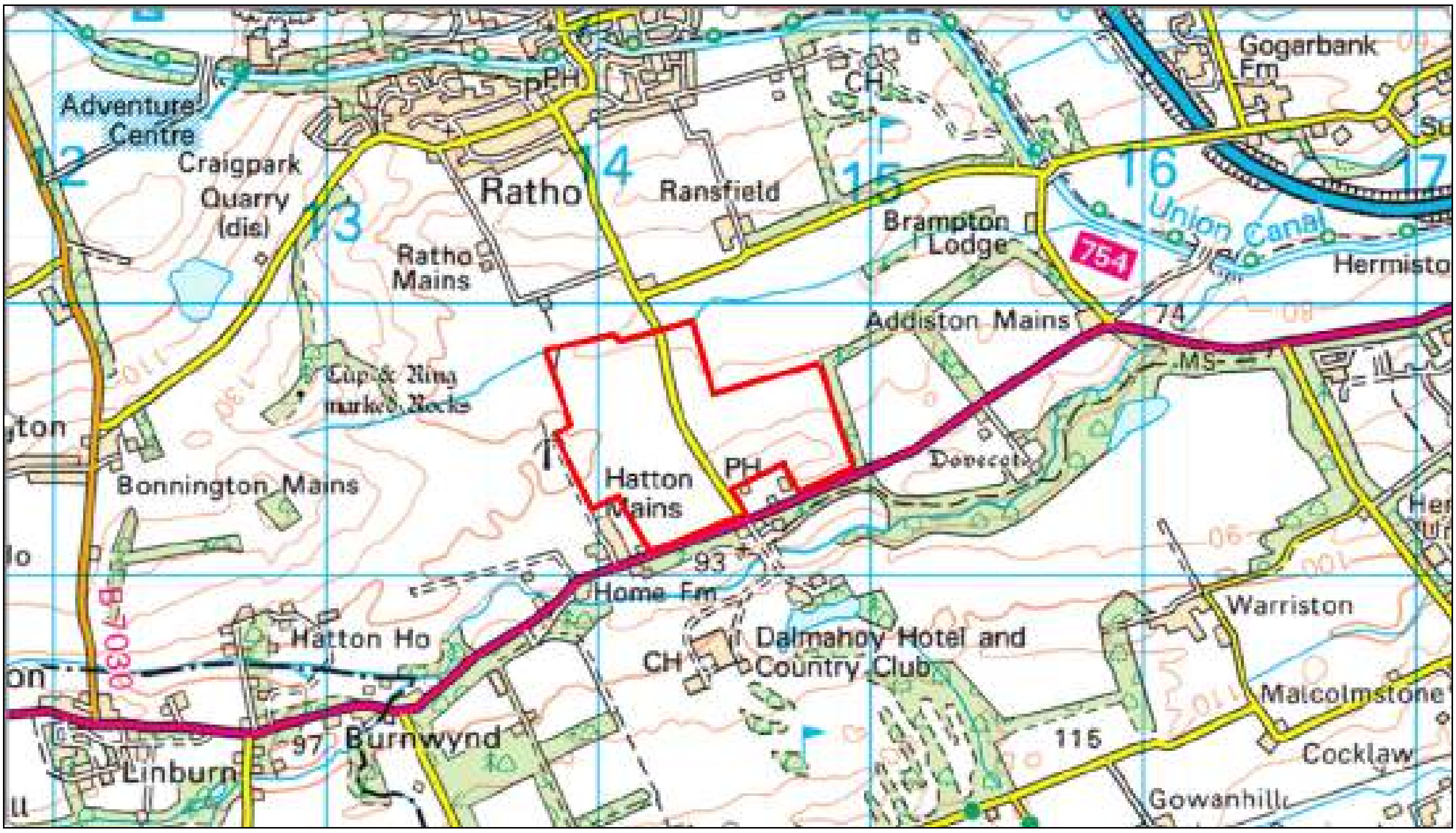


Figure 1 (a) - Location plan

Figure 1 (b) - Location plan detail (excerpt from Masterplan by Clarendon PLC)

The site is bounded to the south by the A71 trunk road, and is bisected by the unclassified Dalmahoy Road. To the west, north and east the site is surrounded by agricultural land. The site comprises a series of large open fields which slope to the north east and south away from a low but prominent central ridge.

There are two watercourses in the vicinity of the site:

- To the north there is a small unnamed watercourse which runs along the northern site boundary from west to east, passing under Dalmahoy Road via a concrete box culvert. This watercourse flow along a well-defined valley along the northern boundary of the site. At the north eastern corner of the site, the watercourse enters a length of culvert which takes it under a field in neighbouring land, before re-emerging in an open channel some 230m downstream. This watercourse has some bearing on the developability of the site, as the floodplain of the watercourse occupies some of the land within the site. However, the fact that the valley and surrounding slopes confine flood flows effectively, coupled with the small size of the catchment mean the constraints posed by associated flood risk are very limited. Flood risk associated with this watercourse is looked into in some detail in the following section of this report. (it should be noted that the floodplain of this watercourse does not show up on SEPA indicative mapping, as the catchment area is too small at just over 1 km^2.

- To the south, separated from the site by a significant distance (and the A71 trunk road), and within a deep and wide valley, lies the Gogar Burn. This is a much more significant watercourse, but by inspection of the separation and relative siting of the watercourse, it is clear there is no likelihood of any flood risk to the site from this source. This is confirmed by inspection of SEPA indicative flood mapping (see Figure 2 below). From this it can be seen that the floodplain at its closest point is some 150m away, as well as several metres higher.

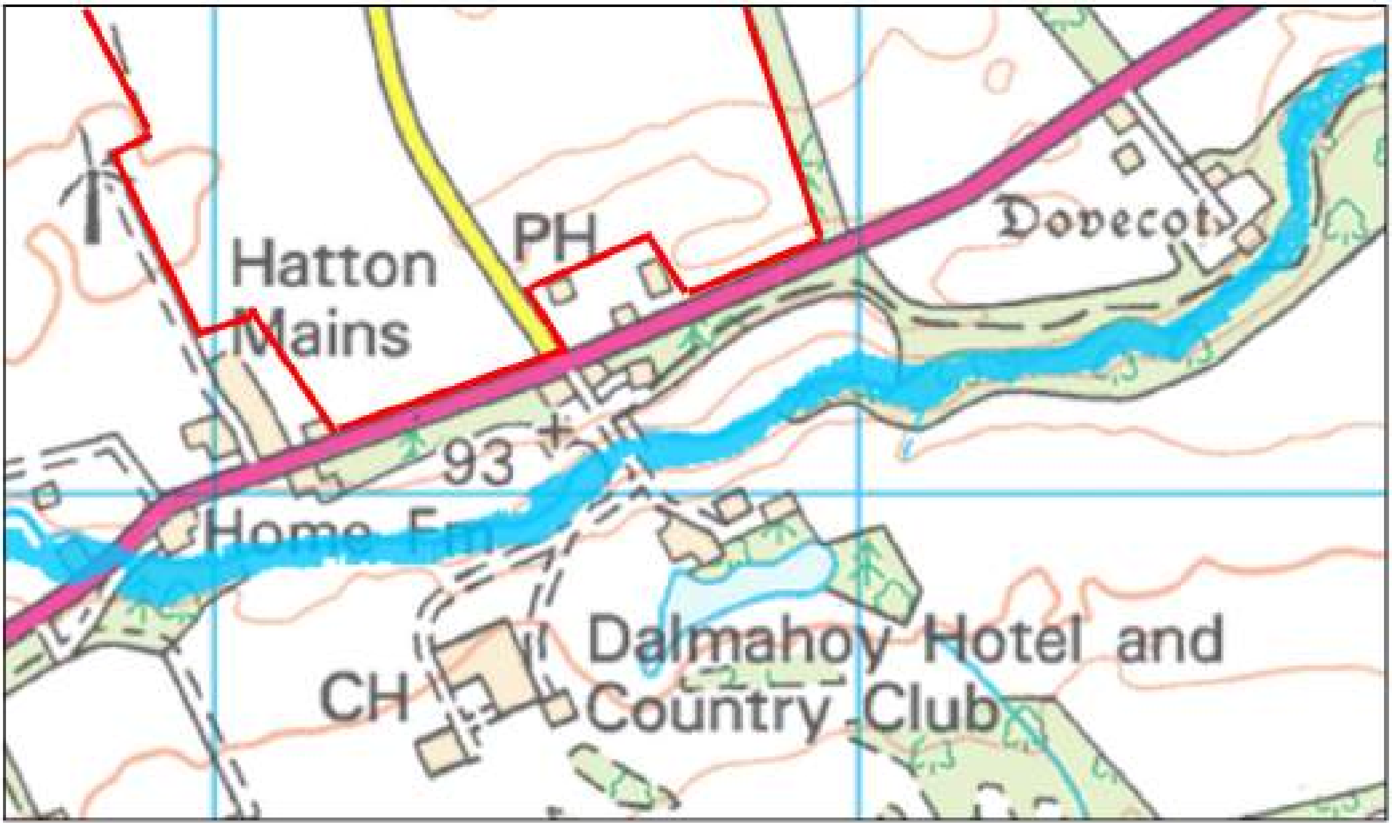


Figure 2 - Excerpt from SEPA indicative flood mapping showing the flood extents of the Gogar Burn associate with the 1-in-200-year- flood event. (site boundary is indicated in red)

The site has been topographically surveyed with reference to Ordnance Datum by Linnen CES Ltd. The topographical data from this survey has been incorporated into Drawing Numbers 14962/21/001 to 004.

Photograph 1 - Looking north along Dalmahoy Road towards high ground in the centre of the site from north west corner of Ratho Park Carvery site.

Photograph 2 - View north west from high point on Dalmahoy Road towards the upper reached of the unnamed watercourse which flows west to east (i.e. left to right in this view) along the line of trees visible in middle distance (northern site boundary)

Photograph 3 - View along Dalmahoy Road towards culvert (at dip/bend in road) over unnamed watercourse under (flow from left to right)

Photograph 4 - Upstream end of culvert at Dalmahoy Road

Photograph 5 - North eastern corner of development site, with route of watercourse downstream of Dalmahoy Road, visible as a line of hedgerow from let to middle of picture. The watercourse carries on under the adjacent field in centre distance in a concrete pipe culvert.

3.0 General Observations

The objective of this flood risk assessment is to analyse the flows in the watercourse and define the appropriate flood levels and flood envelope affecting the site.

There is only one watercourse to consider, that being the unnamed watercourse on the northern site boundary.

The watercourse passes under a wall-type structure via a pipe culvert upstream of the Dalmahoy Road crossing. At the latter location the watercourse passes through a short length of box culvert. Both structures have been fully detailed in the survey of the site, as have the open sections of watercourse. Hence, there are no particular issues involved in modelling these features.

At the downstream end of the modelled stretch, there is a 525mm diameter concrete pipe culvert which carries the watercourse for some 230m under a field before re-emerging. The condition and exact configuration of this culvert is not known apart from at the entrance and exit points. Hence, assumptions are required in order to model it – we have assumed the culvert is of uniform diameter along its long but with the bottom 0.1m of the cross section silted up. It is possible this culvert could be surveyed by CCTV camera but this is not critical as the effect of a near-complete blockage has been modelled as part of the sensitivity analysis discussed in Section 5.3 of this report, and this demonstrates that the effect of blockage on flood depths/extents in not significant. This is a function of the topography in the vicinity of the culvert and the fact that the culvert would be overtopped even when relatively clear.

There are no new structures proposed to be built over the watercourse, and there are no particular issues regarding emergency access and egress from the site during times of flood. Hence, the only particular flood mitigation measures likely to be required, will be to avoid landraising within the floodplain, to allow adequate room along the bank for maintenance purposes, and to set minimum finished floor levels (FFL's) to ensure an adequate freeboard above predicted flood levels, taking into account the possibility of blockages at culverts, and future climate change scenarios.

4.0 Estimation of Flood Flows in the Watercourse

In order to define the extent and water surface level of the 200 year (0.5% annual probability) floodplain, we have made an assessment of flood flows and flood levels in the unnamed watercourse using both the FEH Statistical Method and the FEH Rainfall Runoff Method outlined in the Flood Estimation Handbook (FEH), and the Revitalised Flood Hydrograph Method. The estimated flood levels in the watercourse have then been factored up by 20% to allow for the potential influence of climate change (following established practice, and in line with guidance from the UK Climate Impacts Programme).

4.1 FEH Statistical Method

4.1.1 Estimation of Index Flood QMED

In order to define the extent and water surface level of the 0.5% annual probability floodplain, we must first estimate the Index Flood, Q_{MED}, using the methods outlined in the Flood Estimation Handbook (FEH).

There are no observed records for the unnamed watercourse, hence flows will be estimated using Catchment Descriptors, and adjusted using flow records from suitable donor sites.

An initial estimate of the flood flows for the unnamed watercourse was made using the Catchment Descriptor Method. This method is described in Volume 3, Chapter 13, of the FEH. The catchment descriptors define various physical and hydrological properties and characteristics of the land that forms the catchment upstream of the point of interest. The formula also includes variables that define the statistical rainfall pattern within the catchment. There is a further adjustment to the formula that accounts for the degree of urbanisation of the catchment.

The method produces the mean annual flood Q_{MED} – the index flood – which is the flood flow along the river or floodplain that is statistically "exceeded on average every other year". It is roughly equivalent to the two-year flood. The exercise is done using the FEH and WINFAP software.

The extent of the watercourse catchment upstream of the site, as defined by the FEH software, is shown together with a listing of the catchment descriptors in Figures 2 and 3 below. The catchment size of the unnamed watercourse was checked manually by the inspection of OS mapping, and it was found that the FEH derived catchment size was appropriate.

The WINFAP-FEH estimation of QMED from catchment descriptors is 0.336m^3/s.

Figure 3 – Catchment of unnamed watercourse (FEH Web Service, 2018)

VERSION	"FEH CD-ROM"	Version	3	exportec	11:03:31	GMT
CATCHMENT	GB	314750	670050	NT 14750 70050		
CENTROID	GB	313746	669685	NT 13746 69685		
AREA	1.0125					
ALTBAR	102					
ASPBAR	49					
ASPVAR	0.56					
BFIHOST	0.467					
DPLBAR	1.23					
DPSBAR	46.8					
FARL	1					
FPEXT	0.0617					
FPDBAR	0.659					
FPLOC	0.654					
LDP	2.35					
PROPWET	0.49					
RMED-1H	8.5					
RMED-1D	33.7					
RMED-2D	43.7					
SAAR	736					
SAAR4170	732					
SPRHOST	45.33					
URBCONC1990	-999999					
URBEXT1990	0					
URBLOC1990	-999999					
URBCONC2000	-999999					
URBEXT2000	0					
URBLOC2000	-999999					
C	-0.01547					
D1	0.44234					
D2	0.46					
D3	0.24766					
E	0.23684					
F	2.21899					
C(1 km)	-0.016					
D1(1 km)	0.447					
D2(1 km)	0.459					
D3(1 km)	0.26					
E(1 km)	0.238					
F(1 km)	2.222					

Figure 4 – Catchment Descriptors for unnamed watercourse

4.1.2 Adjustment to QMED from a Donor Site

In order to make the estimation of Q_{MED} more accurate, it is necessary to use flow data from donor sites with similar hydrological characteristics, where gauged information does exist for an adequate number of years. An appropriate local adjustment to the estimate of Q_{MED} at the subject site is then made. The procedure uses several donor sites to estimate an adjusted Q_{MED} value which is then applied to the subject site.

Using WINFAP software, the adjusted Q_{MED} value for the unnamed watercourse at the site becomes 0.416m^3/s.

4.1.3 Flood Growth Curves

In order to estimate the magnitude of the range of possible statistical flood events which will occur in this catchment, for example the flood that will statistically occur once in 200 years (the flood flow which has a 0.5% chance of occurring in any one year), it is necessary to determine a flood growth curve and a flood frequency curve. This is done by forming a “Pooling Group”, i.e. by selecting a group of other catchments across the UK which have very similar characteristics to the subject site and which have existing gauged flow records covering a statistically adequate number of years, and subjecting this group to statistical analysis.

The catchment descriptors from the FEH Web Service are entered as a data file to the WINFAP software, which collates a pooling group of similar catchments, subjects these to a statistical analysis, and calculates a range of flows representing floods of different probabilities at the subject site.

The results can vary slightly, depending upon the chosen weighting of the statistical analysis, but adopting the recommended "Generalised Logistic" (GL) technique, the watercourse flow results are as follows:

Return Period	Flow (m^3/s)
Q200	1.41
Q200+20%	1.69

Table 4.1 Flow calculation results using FEH Statistical Method

The data and results for the WINFAP growth curve derivations are shown in Appendix A.

4.2 Rainfall Runoff Method

The FEH Rainfall Runoff method was also used to estimate the 1-in-200-year flow rate in the unnamed watercourse. The Rainfall Runoff method relies on plentiful rainfall records rather than sometimes scarce river flow records. Hence, if catchment characteristics are known or estimated, the method converts the theoretical design rainfall event of a known return period into a design flood event, with a peak of a known return period.

By selecting the catchment on the FEH Web Service, the catchment descriptors unique to the catchment can be established. Also, by selecting the catchment the design rainfall for the catchment can be established as the software determines the depth-duration-frequency (DDF) relationships for the catchment.

The catchment descriptors are subsequently entered into the Flood Modeller software to produce a hydrograph showing the peak flow rate during a specified flood return period. A storm duration is also required, and involves trial and error to determine the duration of the peak flow.

The following flood flows have been estimated for the unnamed watercourse, using the FEH Rainfall Runoff method (see Flood Modeller output, Appendix B):

Return Period	Flow (m^3/s)
Q200	1.87
Q200+20%	2.24

Table 4.2 Flow calculation results using the Rainfall Runoff Method

Output from the Rainfall Runoff analysis is enclosed within Appendix B.

4.3 Revitalised Flood Hydrograph Method (ReFH2) – Version 2

The third method utilised for the assessment of flood flows in the unnamed watercourse was the Revitalised Flood Hydrograph Method. This method is the second version of a method which was originally established as an update to the FEH Rainfall Runoff method.

The ReFH2 model is comprised of three components; a loss model, a routing model and a baseflow model. The total rainfall, less the losses is input into the routing model, with results from the routing and baseflow models combined to provide a prediction of flow. The ReFH2 model is used in conjunction with a depth-duration-frequency model, either the FEH99 model or FEH13 model. In this instance, the FEH13 model was used to provide the rainfall input.

Using the ReFH2 software, the flood flow estimate for the unnamed watercourse was as follows:

Return Period	Flow (m^3/s)
Q200	1.11
Q200+20%	1.33

Table 4.3 Flow calculation results using ReFH2

Output from the ReFH2 analysis is enclosed within Appendix C.

4.4 Applicable Flowrate

In adherence with the precautionary principle, the largest flood flow estimated above shall be applied in the hydraulic model. The applicable flowrates for the unnamed watercourse are therefore as follows:

Q200 = 1.87m^3/s
Q200 + 20% = 2.24m^3/s

5.0 Predicted Flood Levels

5.1 Initial Model

Having estimated flood flows in the unnamed watercourse, it is necessary to analyse the watercourse channel to see what level the floodwater would reach during the critical 0.5% annual probability flood event.

The watercourse between the sections is analysed using the HEC-RAS river analysis software, which is generally recognised by the relevant authorities as producing verifiable results. The watercourse has been surveyed on site over the length adjacent to the site and for some distance upstream and downstream (see drawing 14962/21/001).

Manning's n coefficients were selected for the site based on inspection of existing conditions, and comparison with tabulated descriptors in tables of Manning's values. Hence the following were selected:

- Main channel: clean, straight, no rifts or deep pools, some weeds and stones (normal value of n = 0.035)

- Banks and flood plains: mature field crops (normal value of n = 0.04), scattered brush, heavy weeds (normal value of n = 0.05), light brush and trees, in summer (normal value of n = 0.06), heavy stand of timber, few down trees, little undergrowth, flow below branches (normal value of n = 0.1)

Once appropriate Manning's values had been selected, boundary conditions at the downstream and upstream ends of the modelled length were modelled based on normal depth commensurate with average channel gradients throughout the model.

The bottom 0.1m of all culverts have been modelled as blocked.

Results of the analysis are contained in Appendix D.

The initial analysis shows the level of the 0.5% (Q200) flood level using the flood flow derived above:

Location	Flood Level (m AOD)
Section 1	81.77
Section 2	82.36
Section 3	82.97
Section 3.1D	83.83
Section 3.1U	86.20
Section 4	86.20
Section 5	86.21
Section 6	86.29
Section 6.1	86.31
Section 6.2D	86.31
Section 6.2U	86.97
Section 6.3	86.97
Section 7	87.01
Section 8	87.06
Section 9	87.40
Section 9.1	87.45
Section 9.2D	88.22
Section 9.2U	88.29
Section 9.3	88.29
Section 10	88.29
Section 11	88.29
Section 12	88.30
Section 13	89.02
Section 14	89.70
Section 15	90.67

Table 5.1 - Flood levels (0.5% (Q200) flow)

The results show that flooding would be limited on site during a 1-in-200-year flood event. A low-lying area in the north western corner of the site is predicted to flood, while the wall crossing the watercourse at cross section 9.2 would be overtopped, as would the downstream culvert. No flooding is predicted over the existing road which splits the site. The predicted flood extents are shown on drawing 14962/21/001, enclosed within the "Plans" section of this report.

Appendix D contains details of the HECRAS analysis, including plots of the watercourse cross-sections and the water surface levels appropriate to the values above.

5.2 Sensitivity Analysis

Sensitivity analyses were carried out to check the effect of a variation in flow rate, of variation in Manning's 'n' values, and of variation on downstream boundary conditions.

The following table compares predicted flood levels for the Q200 and Q200 + 20% (Q200 plus climate change) flood events.

Location	Level (m)		Variation in level (m)
	Flow = Q200	Flow = Q200 + 20%	
Section 1	81.77	81.84	0.07
Section 2	82.36	82.44	0.08
Section 3	82.97	83.05	0.08
Section 3.1D	83.83	83.83	0
Section 3.1U	86.20	86.22	0.02
Section 4	86.20	86.22	0.02
Section 5	86.21	86.23	0.02
Section 6	86.29	86.34	0.05
Section 6.1	86.31	86.40	0.09
Section 6.2D	86.31	87.20	0.89
Section 6.2U	86.97	87.20	0.23
Section 6.3	86.97	87.20	0.23
Section 7	87.01	87.23	0.22
Section 8	87.06	87.24	0.18
Section 9	87.40	87.49	0.09
Section 9.1	87.45	87.55	0.1
Section 9.2D	88.22	88.28	0.06
Section 9.2U	88.29	88.35	0.06
Section 9.3	88.29	88.35	0.06
Section 10	88.29	88.35	0.06
Section 11	88.29	88.35	0.06
Section 12	88.30	88.36	0.06
Section 13	89.02	89.03	0.01
Section 14	89.70	89.71	0.01
Section 15	90.67	90.76	0.09

Table 5.2 Sensitivity Analysis: Variation in Flowrate

The above results show that an increase in flood flow of 20% would have a limited impact on predicted flood levels for the majority of the modelled reach. The largest increase in level is predicted at the existing road which runs through the site. During a Q200 + 20% flood event, a very shallow flood flow is predicted over the road.

As discussed above, sensitivity of the model to changes in Manning's n were tested, by increasing the initial (normal) values for watercourse sections by 0.01, and for culverts by 0.005. This was carried out for all cross sections.

Location	Level (m)		Variation in level (m)
	Q200	Q200 with increased n	
Section 1	81.77	81.87	0.1
Section 2	82.36	82.46	0.1
Section 3	82.97	83.06	0.09
Section 3.1D	83.83	83.81	0.02
Section 3.1U	86.20	86.20	0
Section 4	86.20	86.20	0
Section 5	86.21	86.22	0.01
Section 6	86.29	86.35	0.06
Section 6.1	86.31	86.31	0
Section 6.2D	86.31	86.31	0
Section 6.2U	86.97	86.97	0
Section 6.3	86.97	86.97	0
Section 7	87.01	87.03	0.02
Section 8	87.06	87.12	0.06
Section 9	87.40	87.5	0.1
Section 9.1	87.45	87.55	0.1
Section 9.2D	88.22	88.23	0.01
Section 9.2U	88.29	88.3	0.01
Section 9.3	88.29	88.3	0.01
Section 10	88.29	88.3	0.01
Section 11	88.29	88.31	0.02
Section 12	88.30	88.32	0.02
Section 13	89.02	89.03	0.01
Section 14	89.70	89.71	0.01
Section 15	90.67	90.8	0.13

Table 5.3 Sensitivity Analysis: Variation in Manning's n

The above results show that the increase in roughness values results in a maximum predicted Q200 flood level increase of 0.1m alongside the site.

As discussed above, sensitivity of the model to changes in the downstream boundary conditions were tested, by increasing the initial value by 0.010. This was carried out for all cross sections.

Location	Level (m)		Variation in level (m)
	Initial Gradient (Q200)	Initial Gradient + 0.002	
Section 1	81.77	81.73	0.04
Section 2	82.36	82.38	0.02
Section 3	82.97	82.96	0.01
Section 3.1D	83.83	83.81	0.02
Section 3.1U	86.20	86.20	0
Section 4	86.20	86.20	0
Section 5	86.21	86.21	0
Section 6	86.29	86.29	0
Section 6.1	86.31	86.31	0
Section 6.2D	86.31	86.31	0
Section 6.2U	86.97	86.97	0
Section 6.3	86.97	86.97	0
Section 7	87.01	87.01	0
Section 8	87.06	87.06	0
Section 9	87.40	87.40	0
Section 9.1	87.45	87.45	0
Section 9.2D	88.22	88.22	0
Section 9.2U	88.29	88.29	0
Section 9.3	88.29	88.29	0
Section 10	88.29	88.29	0
Section 11	88.29	88.29	0
Section 12	88.30	88.30	0
Section 13	89.02	89.02	0
Section 14	89.70	89.70	0
Section 15	90.67	90.67	0

Table 5.4 Sensitivity Analysis: Variation in Downstream Boundary Conditions

As can be seen in the results above, the increase in downstream gradient was not predicted to impact predicted flood level alongside the site.

5.3 Flood Levels including Bridge Blockage

The potential for blockages of all culverts has been considered in the assessment. The effect of an almost complete blockage (as much as possible ensuring model stability) of the upstream and downstream culverts has been modelled, as well as a 50% blockage of the culvert below the existing road. The blockages have been modelled simultaneously.

The flood levels predicted by the hydraulic model for the above noted blockage are outlined in the table below.

Location	Level (m)		Variation in level (m)
	Q200 + 20% Flood Level	Q200 + 20% Flood Level with culvert blockages	
Section 1	81.84	81.84	0
Section 2	82.44	82.44	0
Section 3	83.05	83.05	0
Section 3.1D	83.83	83.84	0.01
Section 3.1U	86.22	86.20	0.02
Section 4	86.22	86.20	0.02
Section 5	86.23	86.21	0.02
Section 6	86.34	86.32	0.02
Section 6.1	86.40	86.40	0
Section 6.2D	87.20	87.27	0.07
Section 6.2U	87.20	87.36	0.16
Section 6.3	87.20	87.36	0.16
Section 7	87.23	87.38	0.15
Section 8	87.24	87.38	0.14
Section 9	87.49	87.52	0.03
Section 9.1	87.55	87.57	0.02
Section 9.2D	88.28	88.35	0.07
Section 9.2U	88.35	88.42	0.07
Section 9.3	88.35	88.42	0.07
Section 10	88.35	88.42	0.07
Section 11	88.35	88.42	0.07
Section 12	88.36	88.42	0.06
Section 13	89.03	89.03	0
Section 14	89.71	89.72	0.01
Section 15	90.76	90.73	0.03

Table 5.5 Predicted Q200+20% flood levels with 50% blockage of culvert under Dalmahoy Road, and near complete blockage of culverts upstream and downstream of the road crossing

The above results show that the large blockages would have a limited impact on flood levels, with a maximum predicted increase in Q200 + 20% flood level of 0.16m.

6.0 Proposed Mitigation and Management of Flood Risk

The results of the flow modelling exercise discussed in Section 5 are summarised in Drawing **1**4962/21/001. The results indicate that the right bank of the watercourse would be overtopped over much of its length. However, the extent of predicted flooding within the proposed development site are limited because of the small size of the watercourse and because of the site topography. Hence the mitigation required is relatively limited.

The results of the modelling exercise are set out in the HECRAS output in Appendix D, and drawings 14962/21/001 to 003. The drawings indicate the extent of predicted floodplain associated with the 1-in-200-year flood (also known as the “functional floodplain”). No built development should take place within the functional floodplain. However, alternative uses such as open space, footpaths etc can be considered, provided these uses are compatible with occasional flooding, and providing ground levels are unaltered and flow paths are not obstructed by features such a walls or solid fences.

It is important that access is available to maintain the watercourse (e.g. removing debris or clearing fallen timber, etc). Hence, we recommend a maintenance strip of open ground 5 meters wide along the right hand (southern) bank of the watercourse (this area can of course serve a dual purpose as per the previous paragraph).

It is important to ensure that all FFL’s for new houses are at least 600mm above the predicted 1-in-200-year flood level including a 20% increase in flood flow to allow for the future effects of anticipated climate change. This allows a suitable freeboard to take into account not only predicted flood levels, but also to allow for inherent uncertainties regarding the actual flood levels which could occur.

Drawing 14962/21/004 summarises the likely flood extents and sets out minimum FFL’s for the entire site. It is important to point out that for the majority of the site the minimum FFL’s are irrelevant since the site rises steadily away form the watercourse.

There are no issues with emergency access and egress during a flood event for this site, as can be seen on drawing 14962/21/004, all routes into and out of the site are predicted to remain clear.

In order to avoid any increase in flood risk, surface water runoff generated by the site should be dealt with following the principals of Sustainable Urban Drainage Systems.

As there are no changes proposed to the landforms or structures affecting flood flows, there is no anticipated increase in flood risk to any third-party property.

7.0 Conclusions

- The results of the flow modelling exercise discussed in Section 5 are summarised in Drawing **1**4962/21/001.
- The results indicate that the extent of predicted flooding within the proposed development site relatively small in extent. Hence the mitigation required is relatively limited.
- The results of the modelling exercise and mitigation required are set out in drawings 14962/21/004.
- No built development should take place within the functional floodplain. However, alternative uses such as open space, footpaths etc can be considered, provided these uses are compatible with occasional flooding, and providing ground levels are unaltered and flow paths are not obstructed by features such a walls or solid fences.
- We recommend a maintenance strip of open ground 5 meters wide is incorporated into the masterplan layout, to extend along the right hand (southern) bank of the watercourse (this area can of course serve a dual purpose, e.g. as a footpath).
- All FFL's for new houses to be at least 600mm above the predicted 1-in-200-year flood level including a 20% increase in as per Drawing 14962/21/004.
- There are no issues with emergency access and egress during a flood event for this site, as can be seen on drawing 14962/21/004, all routes into and out of the site are predicted to remain clear.
- In order to avoid any increase in flood risk, surface water runoff generated by the site should be dealt with following the principals of Sustainable Urban Drainage Systems.
- As there are no changes proposed to the landforms or structures affecting flood flows, there is no anticipated increase in flood risk to any third-party property.

We have used our best engineering judgement in this Assessment, and our calculations have been carried out using the Flood Estimation Handbook, WINFAP, HEC-RAS and other standard hydrological methods. We note that as with all such Flood Risk Assessments the accuracy of the results is only as good as the data and statistical techniques used.

8.0 REFERENCES

i. Flood Estimation Handbook, Duncan Reed, CEH Institute of Hydrology, Wallingford, 1999.

ii. FEH CD-ROM, Version 3, CEH Institute of Hydrology, Wallingford, 2009.

iii. WINFAP-FEH, Version 3, Wallingford Hydrosolutions and NERC, 2009

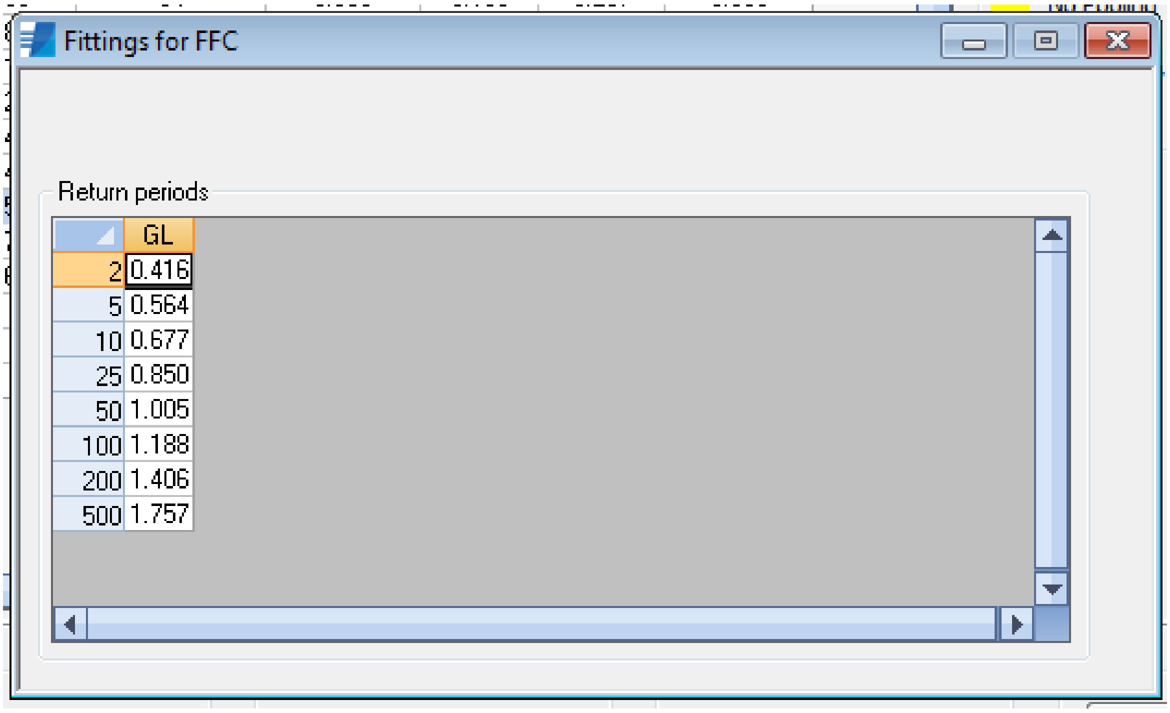
iv. HEC-RAS, Version 4.1.0, January 2010, US Army Corps of Engineers Hydrologic Engineering Centre.

v. ISIS, Version 3.7.0.223 Mode 2, CH2M Hill and Others, 2013

vi. UK Climate Projections for UK Climate Impacts Programme, July 2009.

vii. Scottish Planning Policy, Scottish Government, Crown Copyright, June 2014

Appendix A: Results from WINFAP Flow Analysis (FEH Statistical Method)



	GL
2	0.416
5	0.564
10	0.677
25	0.850
50	1.005
100	1.188
200	1.406
500	1.757

Appendix B: Results from Flood Modeller Flow Analysis (FEH Rainfall Runoff Method)

```
                                                                          FILE=8B04.dat
Flood Modeller VER= 4.0.0.156
 ************************************************************
 Flood Modeller
 ************************************************************

 HYDROLOGICAL DATA

 Catchment: HattonMains
 ************************************************************
 Catchment Characteristics
 ************************************************************
 Easting         :    314750 Northing       :    670050
 Area            :     1.013 km2
 DPLBAR          :     1.230 km
 DPSBAR          :    46.800 m/km
 PROPWET         :     0.490
 SAAR            :   736.000 mm
 Urban Extent    :     0.000
 c               :    -0.015
 d1              :     0.442
 d2              :     0.460
 d3              :     0.248
 e               :     0.237
 f               :     2.219
 SPR             :    45.330 %
 ************************************************************
 Summary of estimate using Flood Estimation Handbook rainfall-runoff method
 ************************************************************
 Estimation of T-year flood
 ==========================
 Unit hydrograph time to peak   :      2.249 hours
 Instantaneous UH time to peak  :      2.199 hours
 Data interval                  :      0.100 hours
 Design storm duration          :      3.900 hours
 Critical storm duration        :      3.904 hours
 Return period for design flood :    200.000 years
 requires rain return period    :    246.667 years
 ARF                            :      0.976
 Design storm depth             :     53.778 mm
 CWI                            :    108.320
 Standard Percentage Runoff     :     45.330 %
 Percentage runoff              :     43.983 %
 Snowmelt rate                  :      0.000 mm/day
 Unit hydrograph peak           :      0.099 (m3/s/mm)
 Quick response hydrograph peak :      1.855 m3/s
 Baseflow                       :      0.017 m3/s
 Baseflow adjustment            :      0.000 m3/s
 Hydrograph peak                :      1.872 m3/s
 Hydrograph adjustment factor   :      1.000

 Flags
 =====
 Unit hydrograph flag           : FSRUH
 Tp flag                        : FEHTP
 Event rainfall flag            : FEHER
 Rainfall profile flag          : WINRP
 Percentage Runoff flag         : FEHPR
 Baseflow flag                  : F16BF
 CWI flag                       : FSRCW
 ************************************************************
```

FILE=8B04.dat

Flood Modeller VER= 4.0.0.156
****
Flood Modeller
****

Catchment: HattonMains

****
Rainfall Profile - Unit and Flow Hydrograph Using
FEH rainfall-runoff method
****
Hydrograph adjustment factor = 1.000
==

TABULAR RESULTS

time (hours)	areal rainfall (mm)	net rainfall (mm)	unit hydrograph (m3/s/mm)	flow hydrograph (m3/s)
0.000	0.273	0.120	0.000	0.017
0.100	0.315	0.138	0.004	0.017
0.200	0.365	0.161	0.009	0.019
0.300	0.422	0.186	0.013	0.020
0.400	0.488	0.215	0.018	0.023
0.500	0.565	0.249	0.022	0.027
0.600	0.651	0.286	0.026	0.031
0.700	0.756	0.332	0.031	0.037
0.800	0.869	0.382	0.035	0.045
0.900	1.007	0.443	0.040	0.054
1.000	1.158	0.510	0.044	0.065
1.100	1.336	0.588	0.048	0.078
1.200	1.539	0.677	0.053	0.094
1.300	1.767	0.777	0.057	0.113
1.400	2.037	0.896	0.062	0.135
1.500	2.326	1.023	0.066	0.162
1.600	2.674	1.176	0.070	0.192
1.700	3.038	1.336	0.075	0.228
1.800	3.451	1.518	0.079	0.270
1.900	3.699	1.627	0.084	0.319
2.000	3.451	1.518	0.088	0.374
2.100	3.038	1.336	0.092	0.437
2.200	2.674	1.176	0.097	0.505
2.300	2.326	1.023	0.098	0.578
2.400	2.037	0.896	0.095	0.654
2.500	1.767	0.777	0.092	0.734
2.600	1.539	0.677	0.089	0.815
2.700	1.336	0.588	0.086	0.898
2.800	1.158	0.510	0.083	0.982
2.900	1.007	0.443	0.080	1.066
3.000	0.869	0.382	0.077	1.150
3.100	0.756	0.332	0.074	1.233
3.200	0.651	0.286	0.071	1.315
3.300	0.565	0.249	0.069	1.394
3.400	0.488	0.215	0.066	1.470
3.500	0.422	0.186	0.063	1.543
3.600	0.365	0.161	0.060	1.611
3.700	0.315	0.138	0.057	1.674
3.800	0.273	0.120	0.054	1.730
3.900			0.051	1.779
4.000			0.048	1.818
4.100			0.045	1.848
4.200			0.043	1.865
4.300			0.040	1.872
4.400			0.037	1.867
4.500			0.034	1.854
4.600			0.031	1.833
4.700			0.028	1.804
4.800			0.025	1.770
4.900			0.022	1.730
5.000			0.019	1.686
5.100			0.016	1.637
5.200			0.014	1.586
5.300			0.011	1.531
5.400			0.008	1.473
5.500			0.005	1.414
5.600			0.002	1.352
5.700			0.000	1.289
5.800				1.224
5.900				1.159

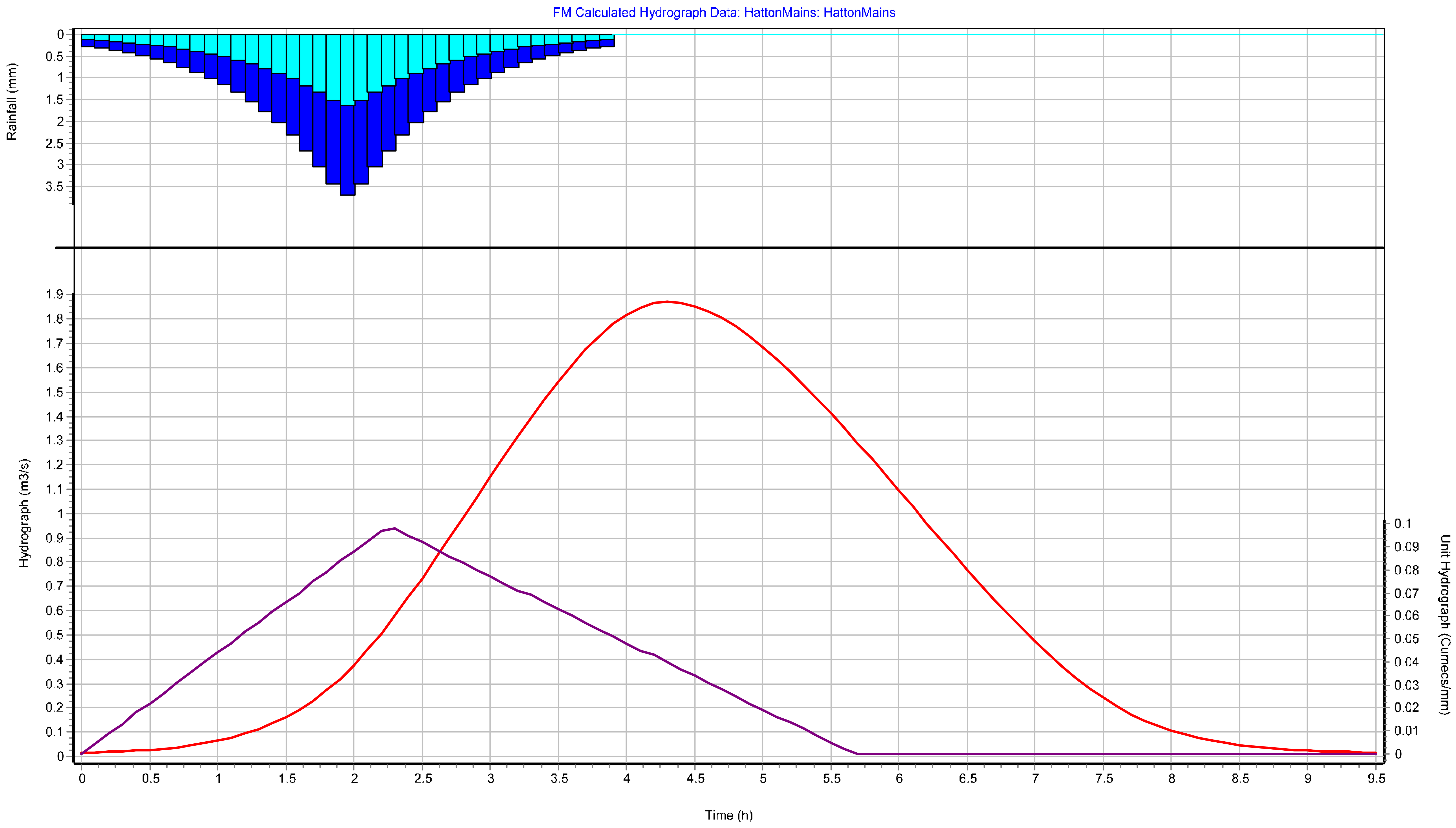
6.000	1.094
6.100	1.027
6.200	0.961
6.300	0.896
6.400	0.832
6.500	0.769
6.600	0.707
6.700	0.646
6.800	0.587
6.900	0.529
7.000	0.474
7.100	0.421
7.200	0.370
7.300	0.323
7.400	0.280
7.500	0.240
7.600	0.205
7.700	0.174
7.800	0.148
7.900	0.126
8.000	0.106
8.100	0.090
8.200	0.076
8.300	0.064
8.400	0.054
8.500	0.046
8.600	0.039
8.700	0.034
8.800	0.029
8.900	0.025
9.000	0.023
9.100	0.020
9.200	0.019
9.300	0.018
9.400	0.017
9.500	0.017

****

Volumetric analysis of results

****

Total volume of rainfall	:	54449.8	m3
Total volume of net rainfall	:	23948.4	m3
Total volume of rain loss	:	30501.4	m3
Total volume of baseflow	:	575.9	m3
Total volume of quick runoff	:	23893.5	m3
Total volume of runoff	:	24469.4	m3



FM Calculated Hydrograph Data: HattonMains: HattonMains
Rainfall (mm)
0
0.5
1
1.5
2
2.5
3
3.5
Hydrograph (m3/s)
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Unit Hydrograph (Cumecs/mm)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 8.5 9 9.5
Time (h)

Appendix C: Results from ReFH2 Flow Analysis (Revitalised Flood Hydrograph Method – Version 2)

UK Design Flood Estimation

Generated on Monday, October 29, 2018 11:29:39 AM by abraid
Printed from the ReFH Flood Modelling software package, version 2.2.5989.21032

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

Site details Checksum: C148-1DD0

Site name: Watercourse at Hatton Mains

Easting: 314750

Northing: 670050

Country: Scotland

Catchment Area (km²): 1.01

Using plot scale calculations: No

Site description: None

Model run: 200 year

Summary of results

Rainfall - FEH 2013 (mm):	62.00	Total runoff (ML):	14.78
Total Rainfall (mm):	40.26	Total flow (ML):	29.24
Peak Rainfall (mm):	4.99	Peak flow (m^3/s):	1.11

Parameters

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

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	03:30:00	No
Timestep (hh:mm:ss)	00:10:00 [00:30:00]	Yes
SCF (Seasonal correction factor)	0.67	No
ARF (Areal reduction factor)	0.98	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	124.13	No
Cmax (mm)	397.83	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	2.12	No
Up	0.65	No
Uk	0.8	No

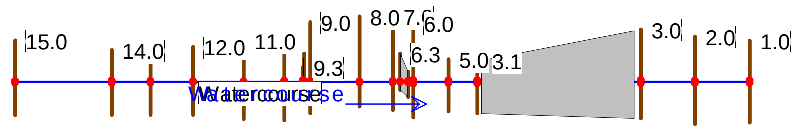
Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.03	No
BL (hr)	23.4	No
BR	0.98	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0	No
Urbext 2000	0	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.3	No
Tp scaling factor	0.5	No
Sewered area (km^2)	0.00	Yes
Sewer capacity (m^3/s)	0.00	Yes

Appendix D: Output from HECRAS Model

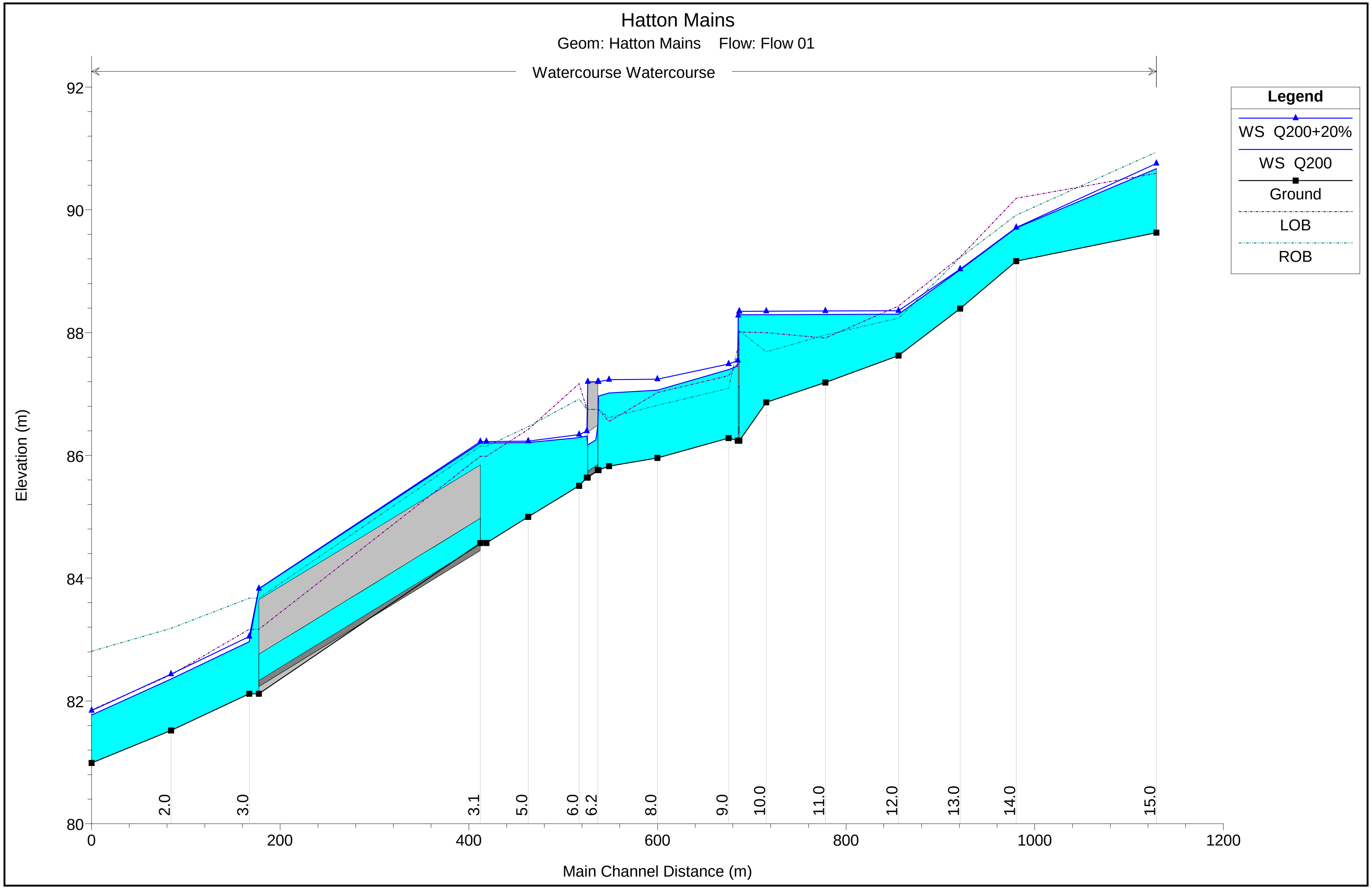

15.0
14.0
12.0
11.0
9.3
9.0
8.0
7.0
6.0
6.3
5.0
3.1
3.0
2.0
1.0
Watercourse

HEC-RAS Plan: Plan 04   River: Watercourse   Reach: Watercourse

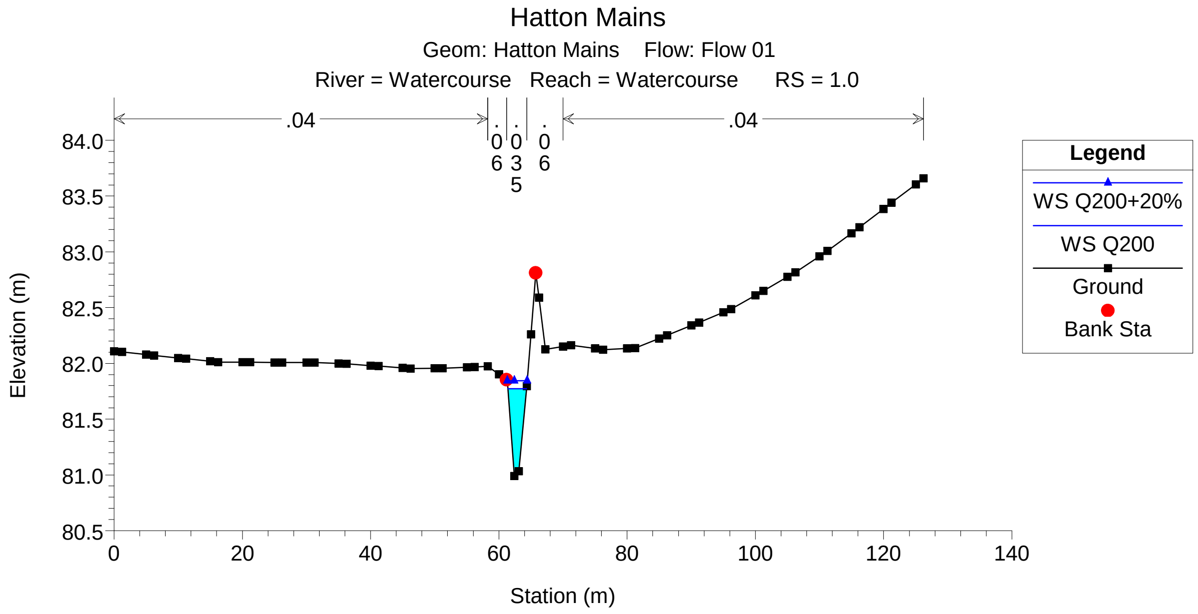
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Watercourse	15.0	Q200	1.87	89.63	90.67		90.74	0.004420	1.17	1.66	4.12	0.46
Watercourse	15.0	Q200+20%	2.24	89.63	90.76	90.40	90.83	0.004697	1.22	2.10	6.20	0.46
Watercourse	14.0	Q200	1.87	89.16	89.70	89.70	89.74	0.011252	1.12	3.15	39.90	0.63
Watercourse	14.0	Q200+20%	2.24	89.16	89.71	89.71	89.75	0.012508	1.17	3.56	42.19	0.66
Watercourse	13.0	Q200	1.87	88.39	89.02	89.02	89.06	0.007888	1.13	3.26	41.43	0.56
Watercourse	13.0	Q200+20%	2.24	88.39	89.03	89.03	89.07	0.008275	1.17	3.80	42.84	0.57
Watercourse	12.0	Q200	1.87	87.63	88.30		88.30	0.001181	0.43	6.51	35.10	0.21
Watercourse	12.0	Q200+20%	2.24	87.63	88.36		88.36	0.000806	0.37	8.59	38.19	0.17
Watercourse	11.0	Q200	1.87	87.19	88.29		88.30	0.000034	0.13	19.79	38.09	0.04
Watercourse	11.0	Q200+20%	2.24	87.19	88.35		88.35	0.000036	0.13	21.94	38.91	0.05
Watercourse	10.0	Q200	1.87	86.86	88.29		88.29	0.000026	0.11	20.14	32.76	0.04
Watercourse	10.0	Q200+20%	2.24	86.86	88.35		88.35	0.000029	0.13	22.03	35.05	0.04
Watercourse	9.3	Q200	1.87	86.24	88.29	87.05	88.29	0.000072	0.23	12.62	29.08	0.07
Watercourse	9.3	Q200+20%	2.24	86.24	88.35	87.12	88.35	0.000076	0.24	14.25	29.49	0.07
Watercourse	9.2		Culvert									
Watercourse	9.1	Q200	1.87	86.24	87.45		87.49	0.002531	0.90	2.07	3.31	0.36
Watercourse	9.1	Q200+20%	2.24	86.24	87.55		87.59	0.002414	0.94	2.43	5.23	0.36
Watercourse	9.0	Q200	1.87	86.28	87.40		87.46	0.003756	1.15	1.71	3.15	0.43
Watercourse	9.0	Q200+20%	2.24	86.28	87.49		87.56	0.003568	1.21	2.06	5.68	0.42
Watercourse	8.0	Q200	1.87	85.96	87.06		87.14	0.004848	1.26	1.55	2.75	0.47
Watercourse	8.0	Q200+20%	2.24	85.96	87.24		87.31	0.003158	1.17	2.13	3.76	0.39
Watercourse	7.0	Q200	1.87	85.83	87.01		87.04	0.000873	0.70	3.91	9.98	0.23
Watercourse	7.0	Q200+20%	2.24	85.83	87.23		87.25	0.000420	0.56	6.77	16.73	0.17

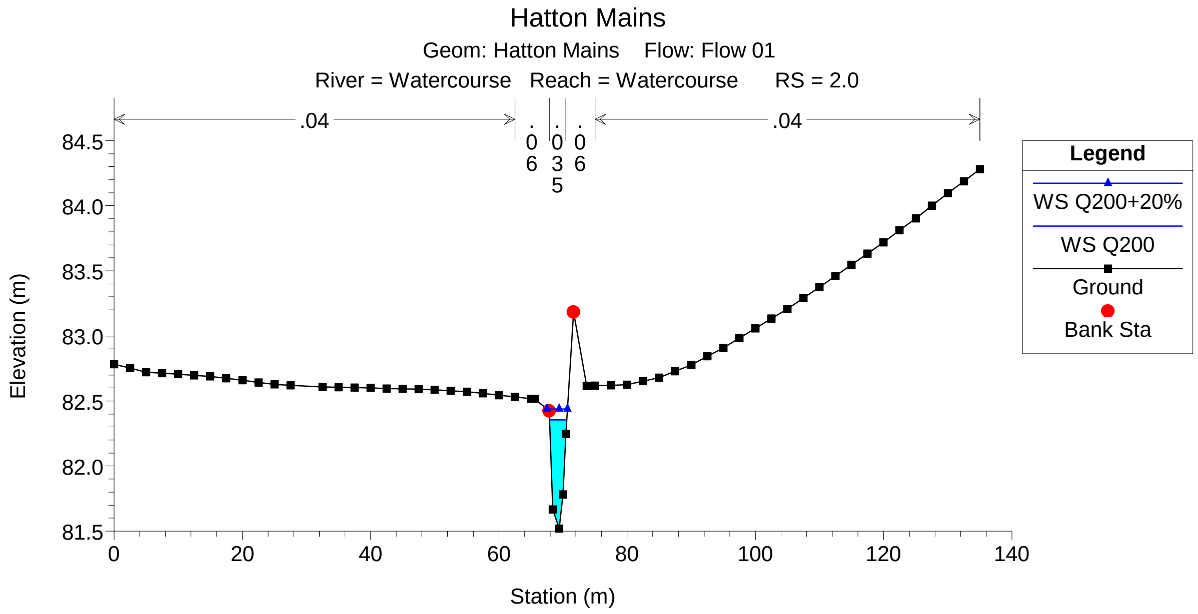
HEC-RAS Plan: Plan 04 River: Watercourse Reach: Watercourse (Continued)

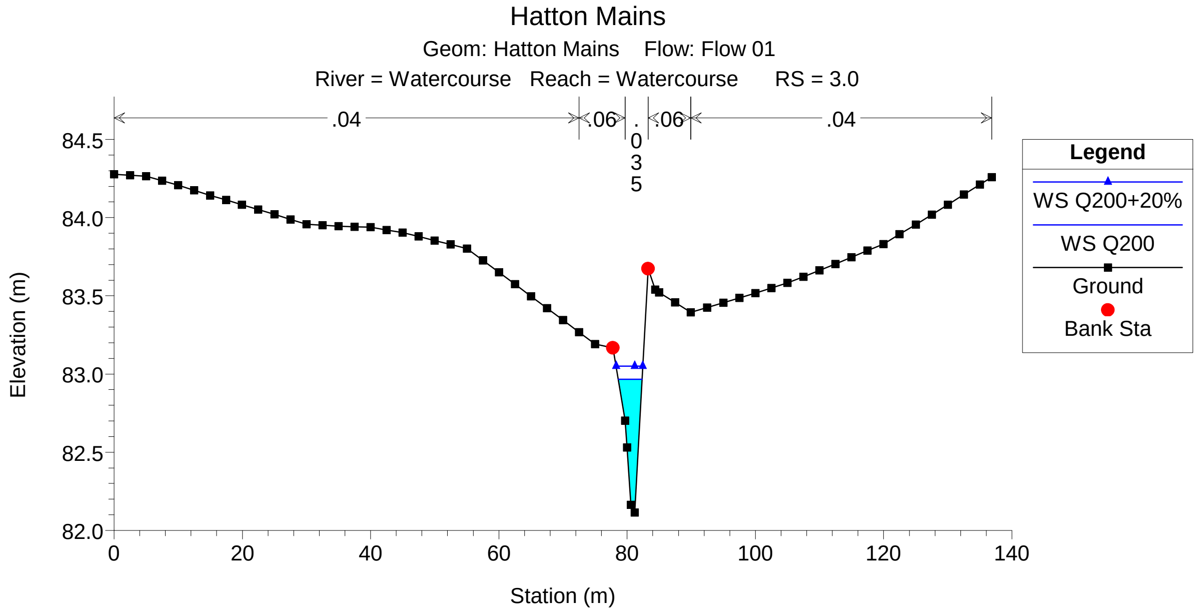
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Watercourse	6.3	Q200	1.87	85.76	86.97	86.36	87.02	0.002708	1.01	2.04	3.85	0.31
Watercourse	6.3	Q200+20%	2.24	85.76	87.20	86.43	87.23	0.001637	0.89	3.18	6.01	0.25
Watercourse	6.2		Culvert									
Watercourse	6.1	Q200	1.87	85.64	86.31	86.31	86.61	0.029995	2.41	0.78	1.33	1.01
Watercourse	6.1	Q200+20%	2.24	85.64	86.40	86.40	86.72	0.030541	2.53	0.88	1.35	1.00
Watercourse	6.0	Q200	1.87	85.50	86.29		86.34	0.003585	0.95	1.98	3.65	0.41
Watercourse	6.0	Q200+20%	2.24	85.50	86.34		86.39	0.004198	1.04	2.16	3.80	0.44
Watercourse	5.0	Q200	1.87	85.00	86.21		86.23	0.001099	0.61	3.07	3.75	0.21
Watercourse	5.0	Q200+20%	2.24	85.00	86.23		86.26	0.001495	0.71	3.15	3.80	0.25
Watercourse	4.0	Q200	1.87	84.57	86.20	85.09	86.21	0.000172	0.34	6.35	24.86	0.11
Watercourse	4.0	Q200+20%	2.24	84.57	86.22	85.15	86.23	0.000226	0.40	6.88	28.64	0.12
Watercourse	3.1		Culvert									
Watercourse	3.0	Q200	1.87	82.11	82.97		83.04	0.009084	1.18	1.58	3.70	0.58
Watercourse	3.0	Q200+20%	2.24	82.11	83.05		83.12	0.008545	1.17	1.91	4.15	0.55
Watercourse	2.0	Q200	1.87	81.52	82.36		82.43	0.005947	1.24	1.51	2.69	0.53
Watercourse	2.0	Q200+20%	2.24	81.52	82.44		82.52	0.006123	1.29	1.74	3.19	0.53
Watercourse	1.0	Q200	1.87	80.99	81.77	81.62	81.87	0.007639	1.36	1.37	2.91	0.64
Watercourse	1.0	Q200+20%	2.24	80.99	81.84	81.67	81.95	0.007654	1.41	1.59	3.11	0.63

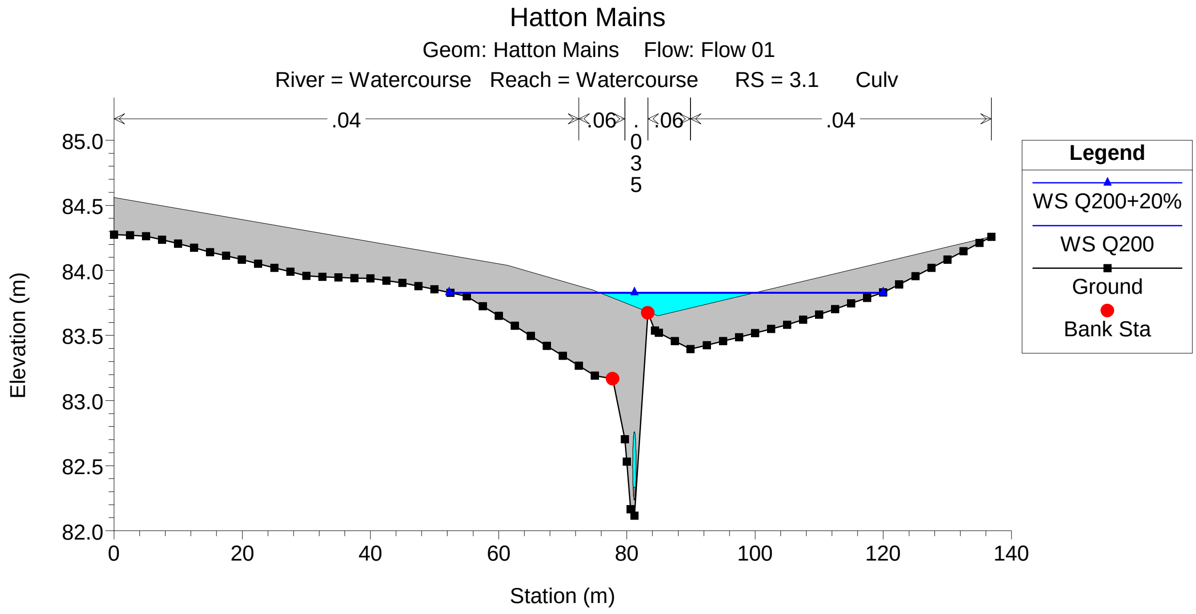


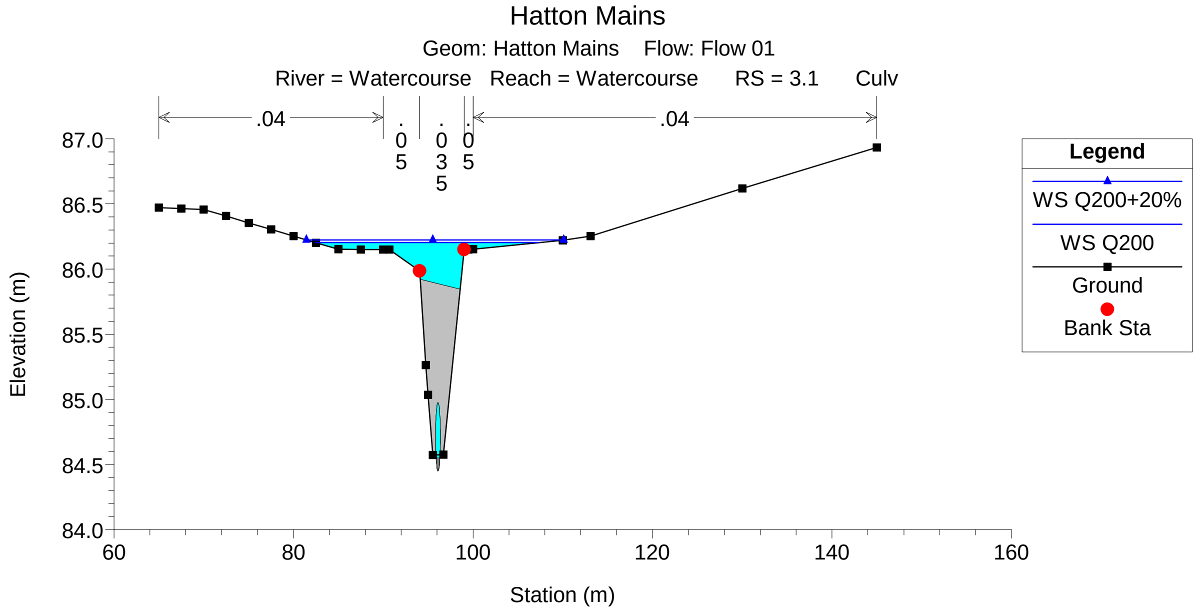
Hatton Mains
Geom: Hatton Mains Flow: Flow 01
Watercourse Watercourse
Legend
WS Q200+20%
WS Q200
Ground
LOB
ROB
Elevation (m)
80
82
84
86
88
90
92
Main Channel Distance (m)
0
200
400
600
800
1000
1200
2.0
3.0
3.1
5.0
6.0
6.2
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0

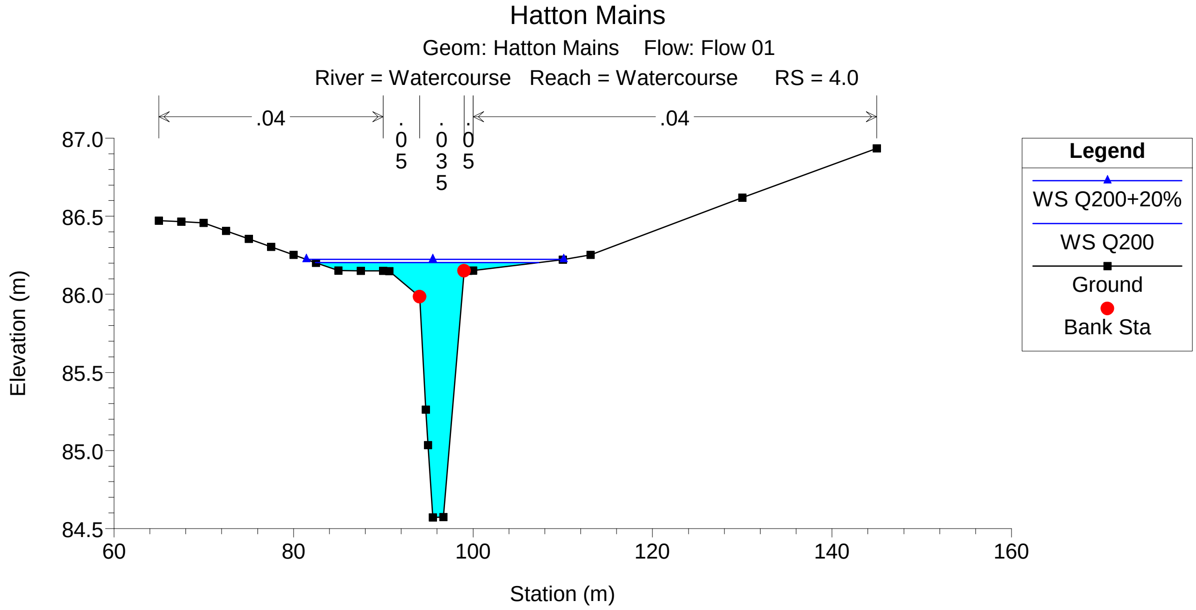

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 1.0
.04
.06
.035
.06
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

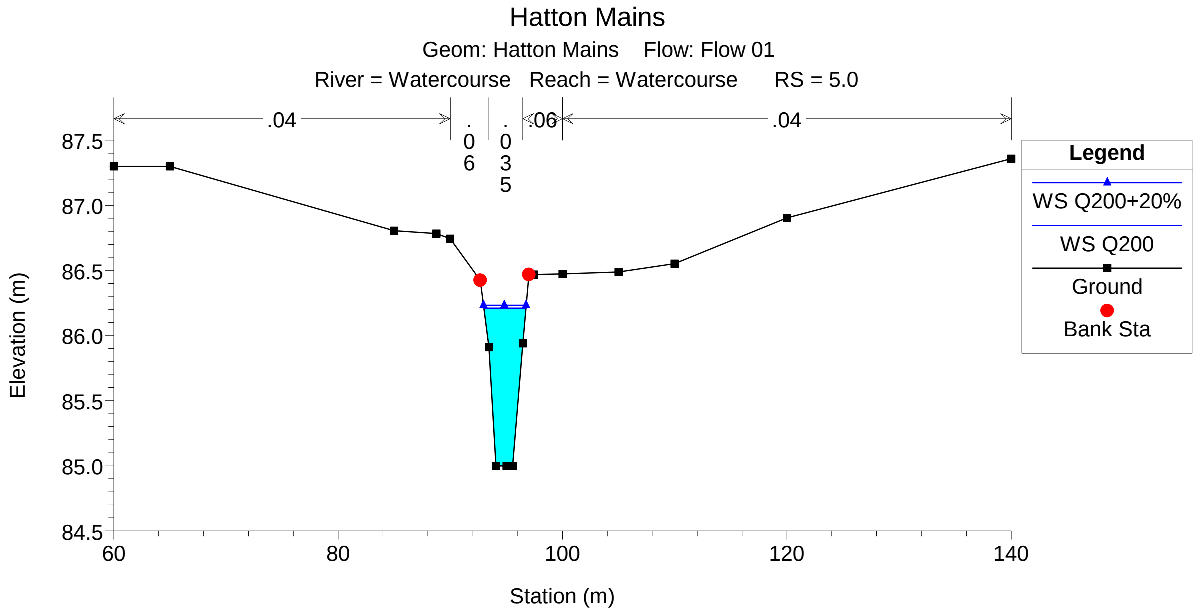

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 2.0
.04
.06
.035
.06
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

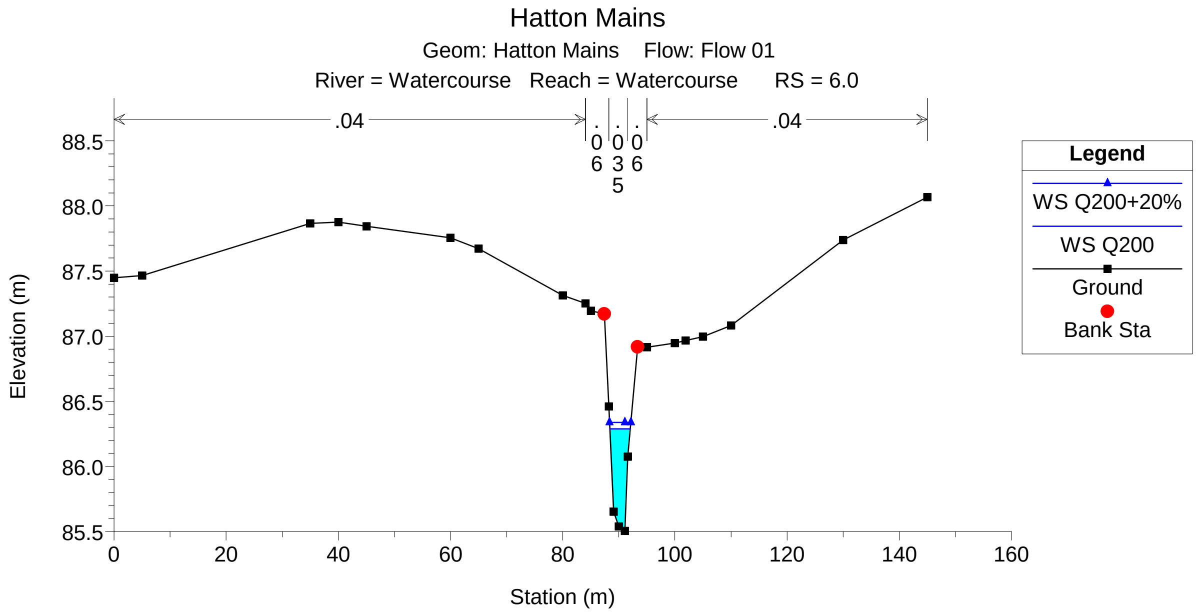

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 3.0
.04
.06
.035
.06
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

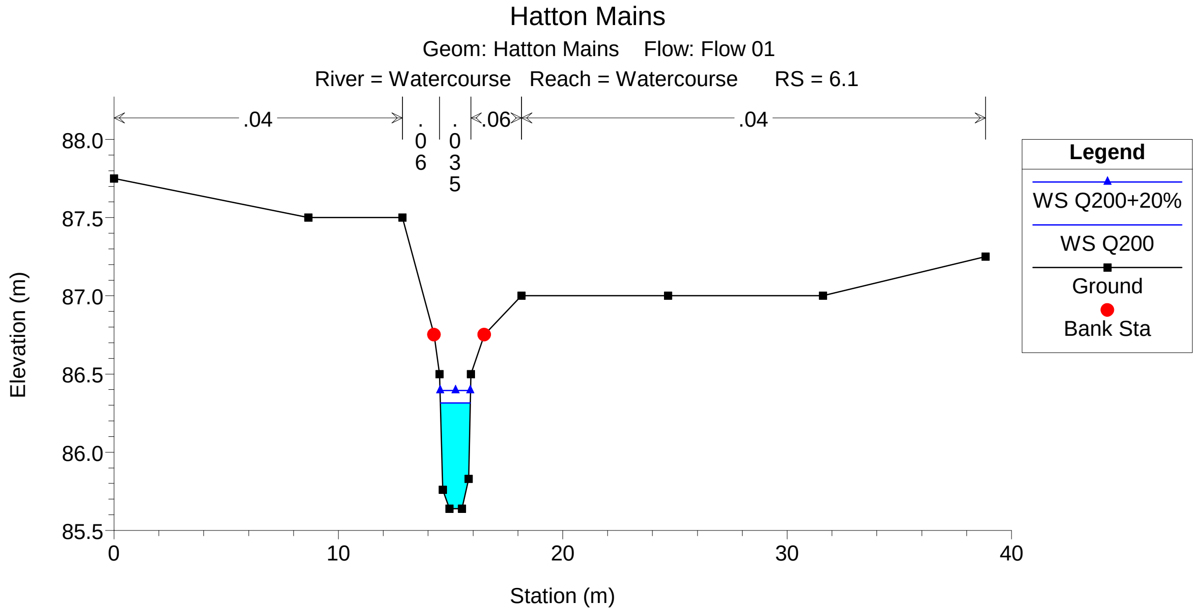

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 3.1 Culv
.04
.06
.035
.06
.04
Elevation (m)
85.0
84.5
84.0
83.5
83.0
82.5
82.0
0
20
40
60
80
100
120
140
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

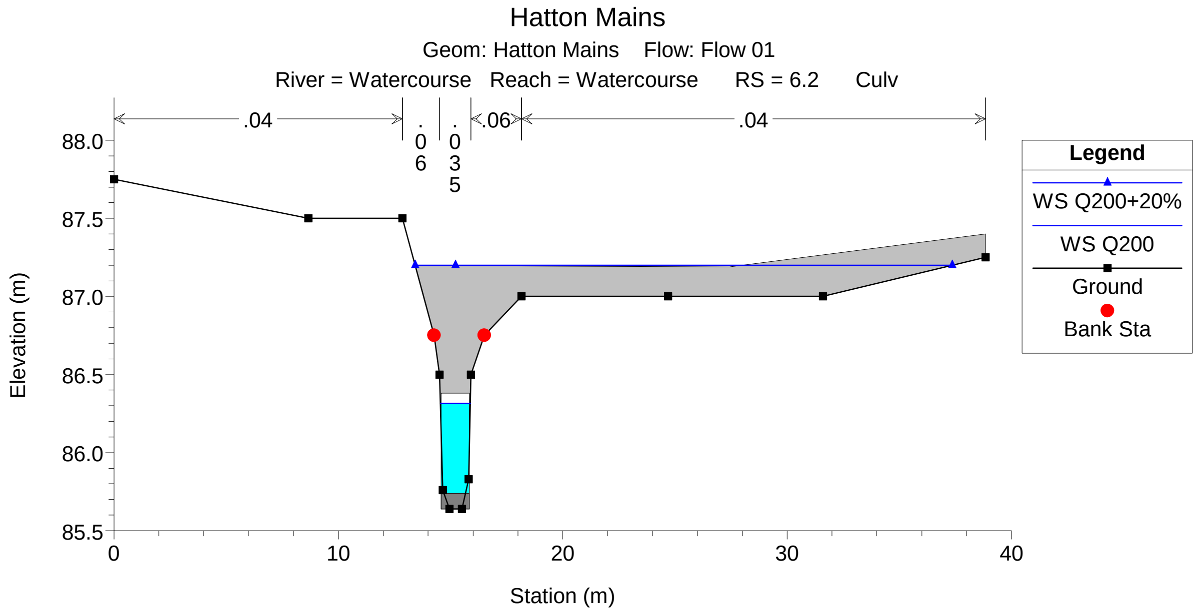

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 3.1 Culv
.04
.05
.035
.05
.04
Elevation (m)
87.0
86.5
86.0
85.5
85.0
84.5
84.0
60
80
100
120
140
160
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

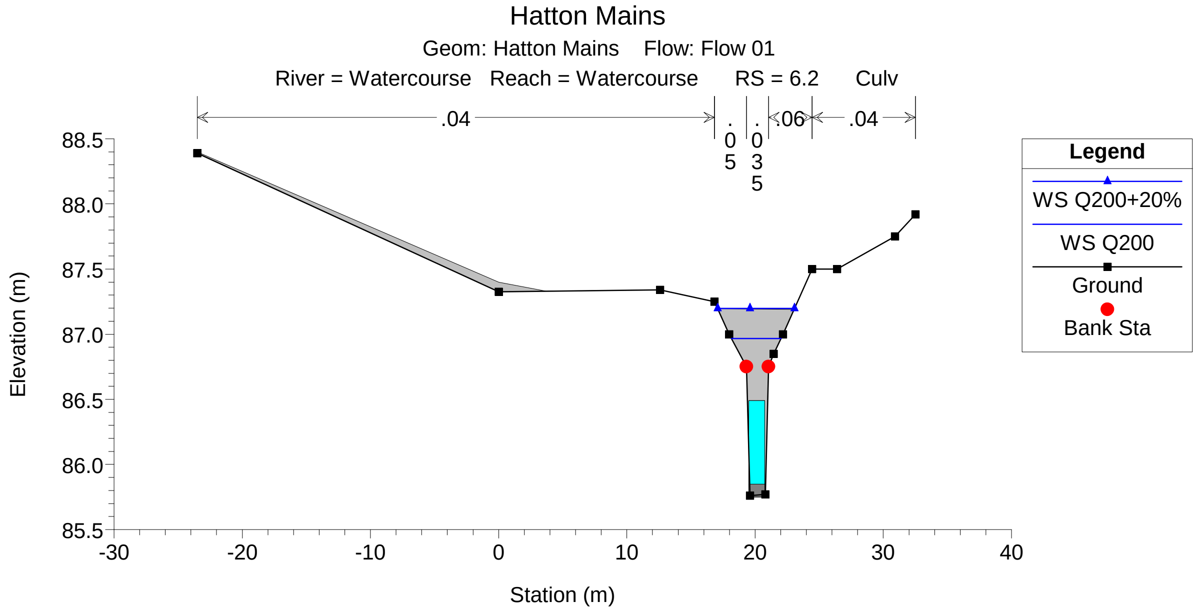

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 4.0
.04
.05
.035
.05
.04
Elevation (m)
87.0
86.5
86.0
85.5
85.0
84.5
60
80
100
120
140
160
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

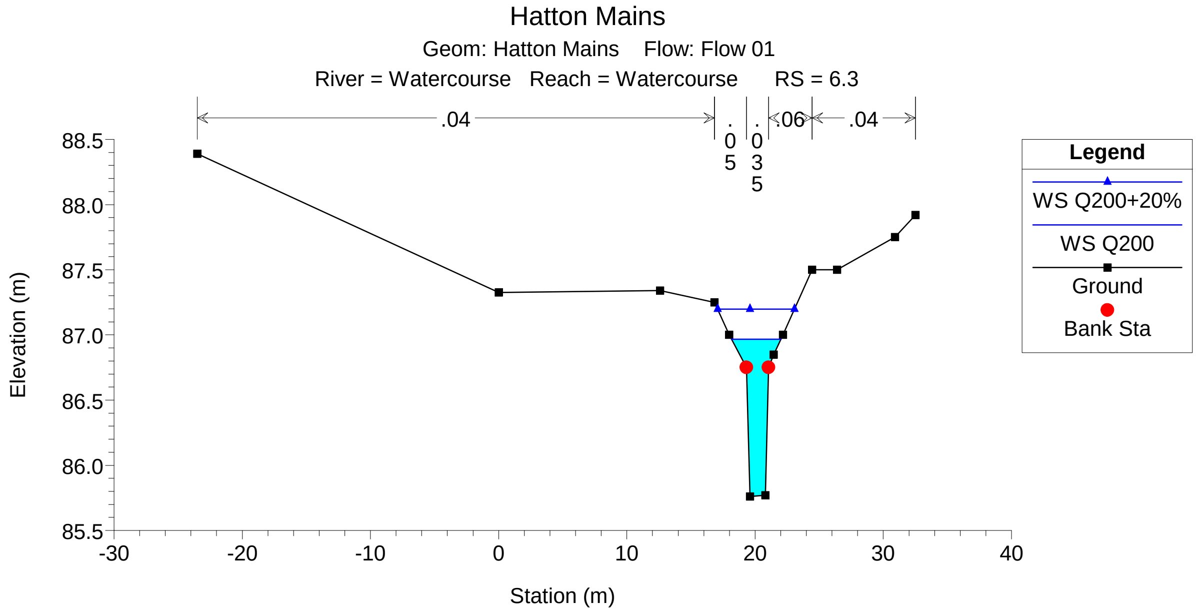

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 5.0
.04
.06
.035
.06
.04
Elevation (m)
87.5
87.0
86.5
86.0
85.5
85.0
84.5
60
80
100
120
140
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

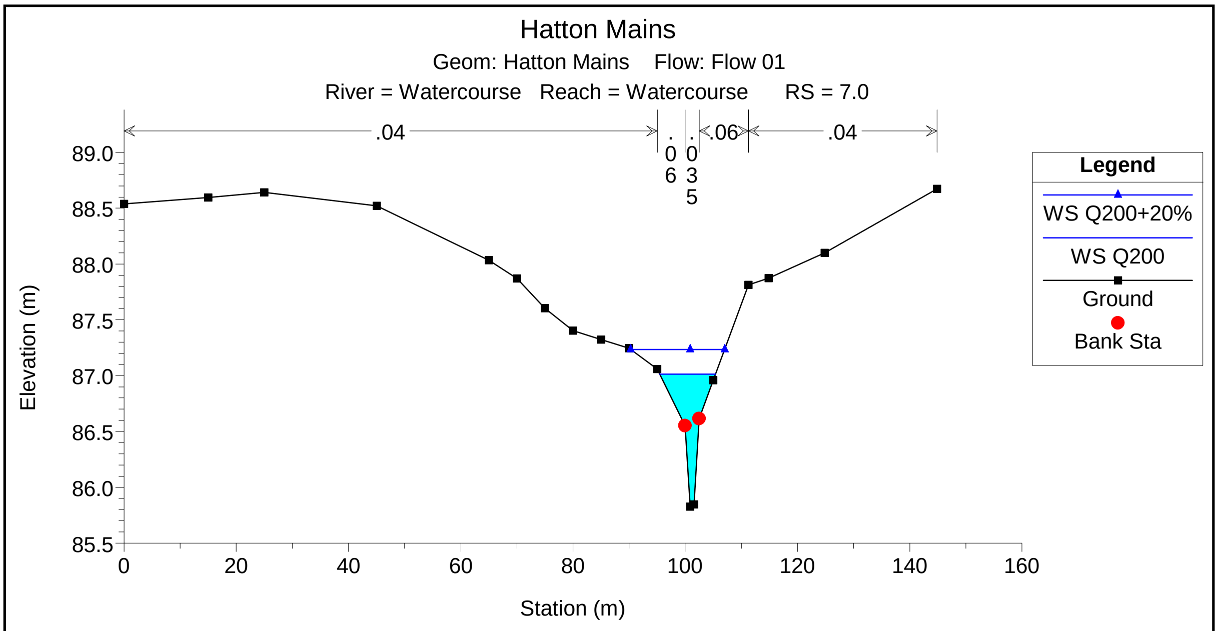

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 6.0
.04
.06
.035
.06
.04
Elevation (m)
88.5
88.0
87.5
87.0
86.5
86.0
85.5
0
20
40
60
80
100
120
140
160
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

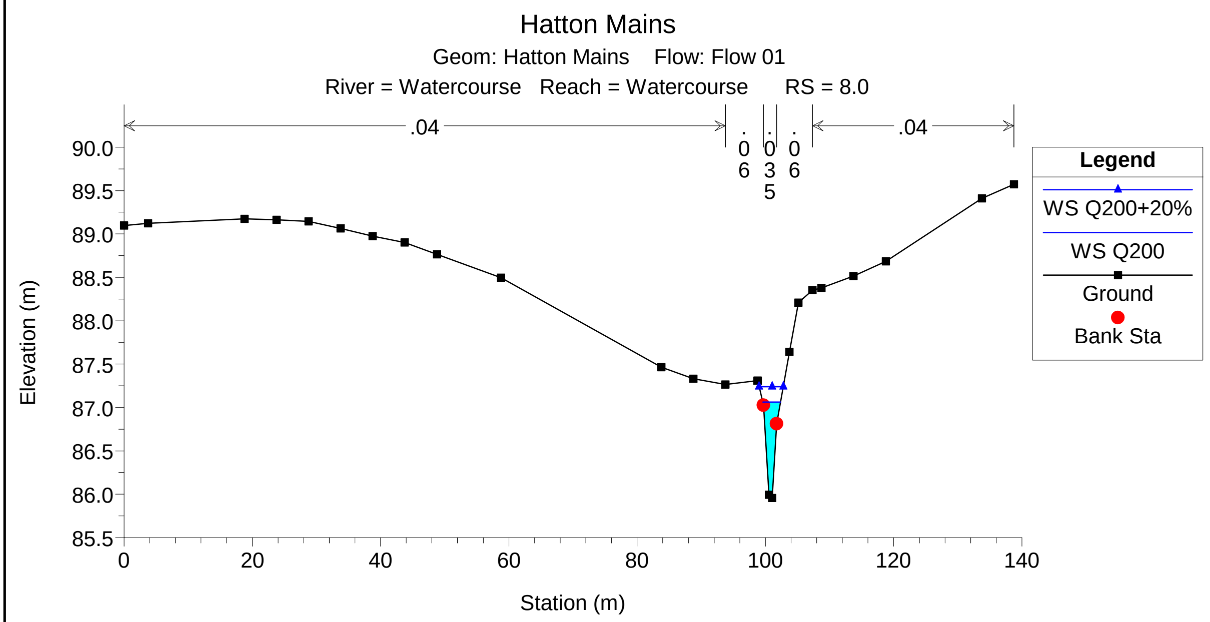

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 6.1
.04
.06
.035
.06
.04
Elevation (m)
88.0
87.5
87.0
86.5
86.0
85.5
0
10
20
30
40
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

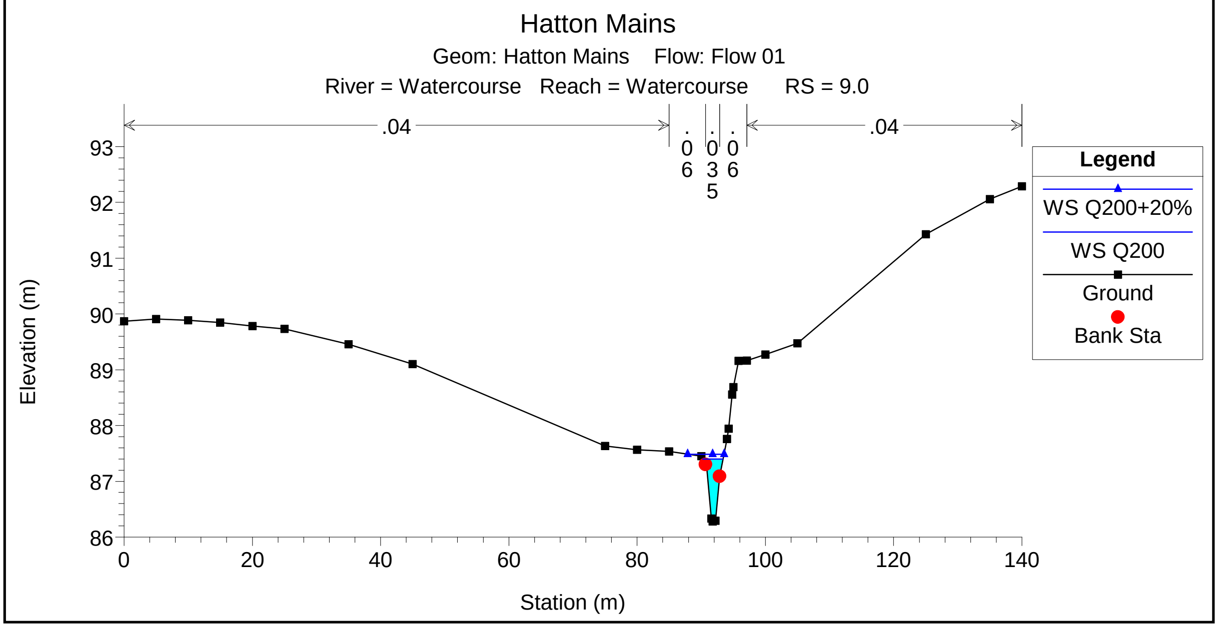

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 6.2 Culv
.04
.06
.035
.06
.04
Elevation (m)
88.0
87.5
87.0
86.5
86.0
85.5
0
10
20
30
40
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

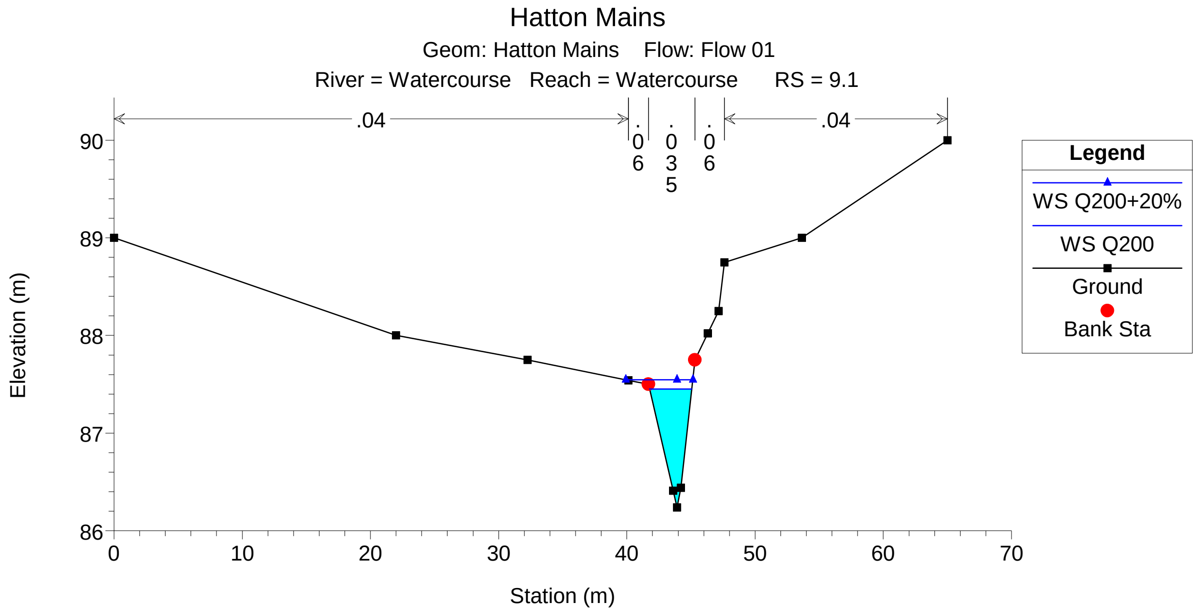

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 6.2 Culv
.04
.05
.035
.06
.04
Elevation (m)
88.5
88.0
87.5
87.0
86.5
86.0
85.5
-30
-20
-10
0
10
20
30
40
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

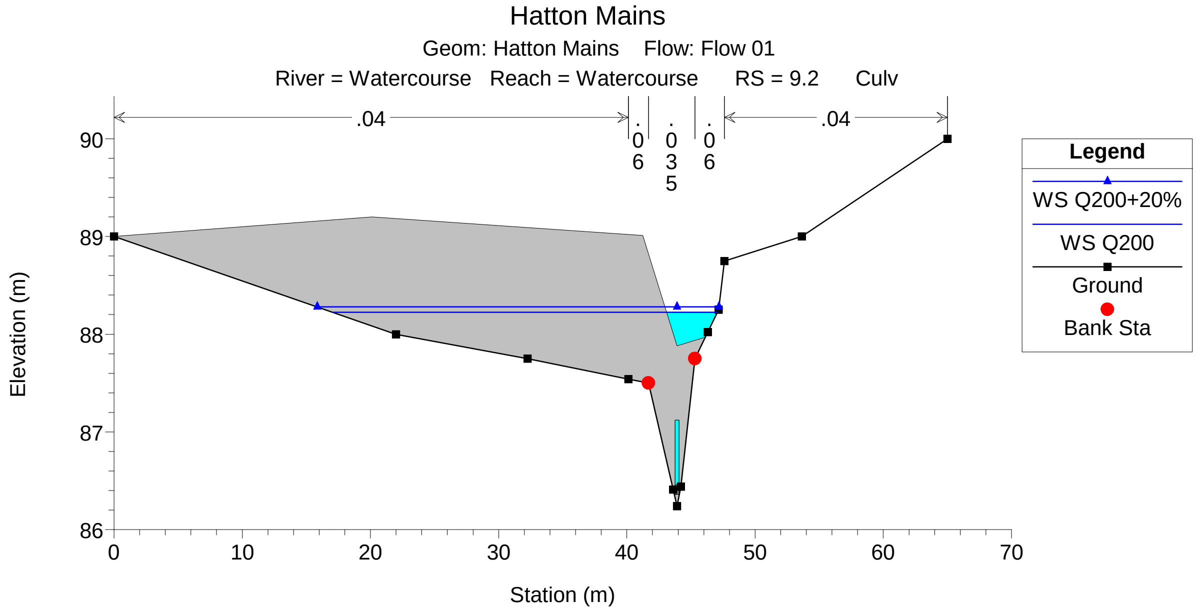

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 6.3
.04
.05
.035
.06
.04
Elevation (m)
88.5
88.0
87.5
87.0
86.5
86.0
85.5
-30
-20
-10
0
10
20
30
40
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

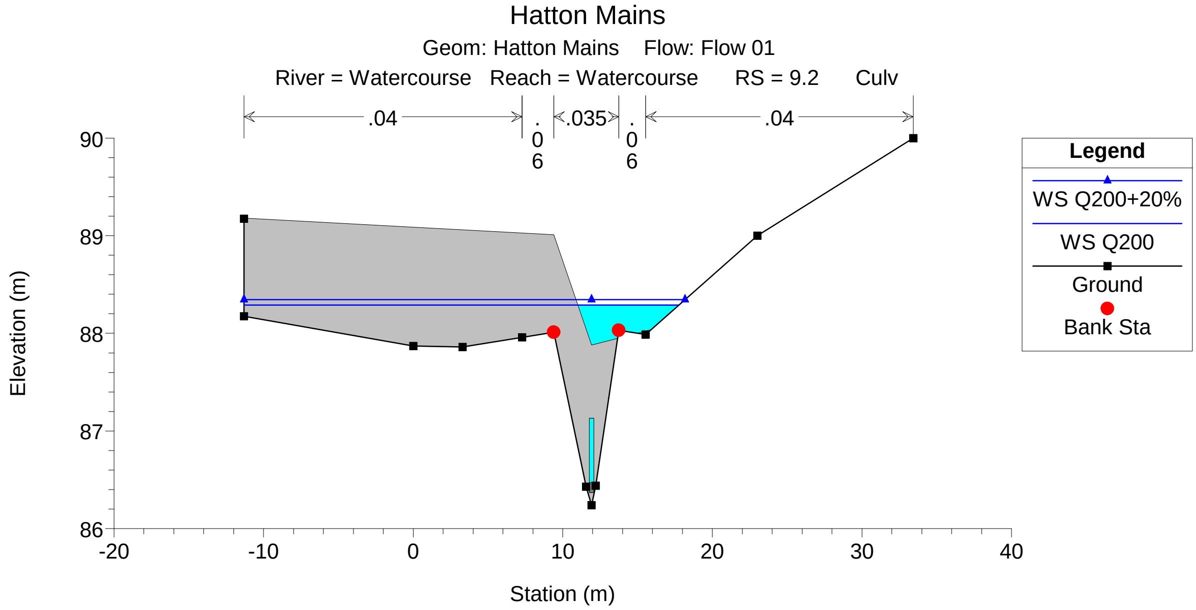

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 7.0
.04
.06
.035
.06
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

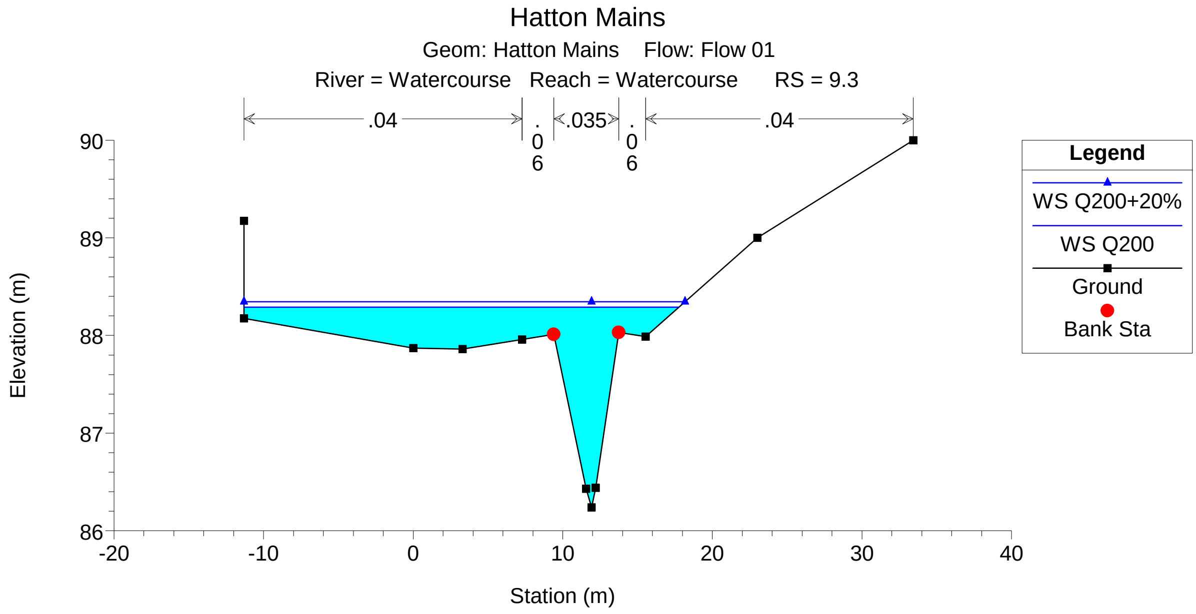

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 8.0
.04
.06
.035
.06
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

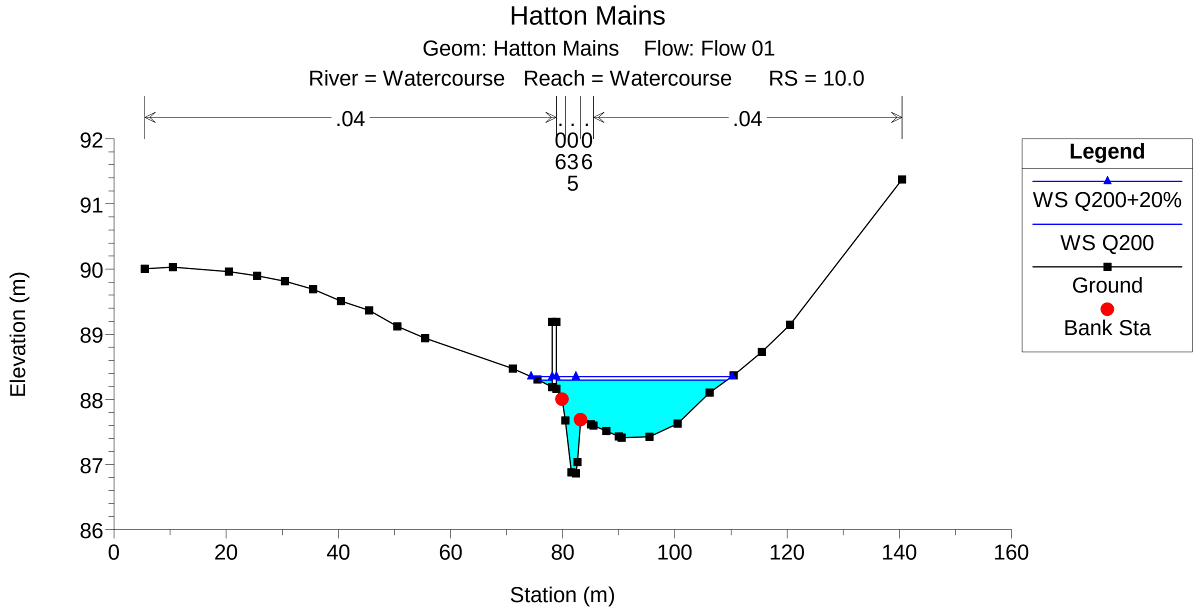

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 9.0
.04
.06
.035
.06
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

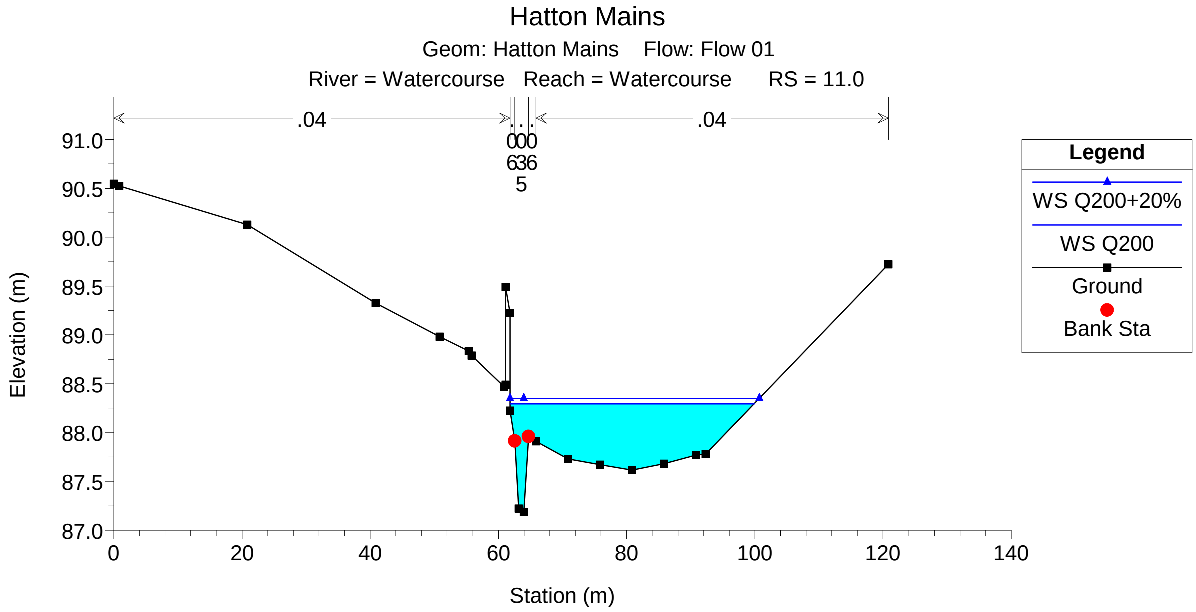

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 9.1
.04
.06
.035
.06
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

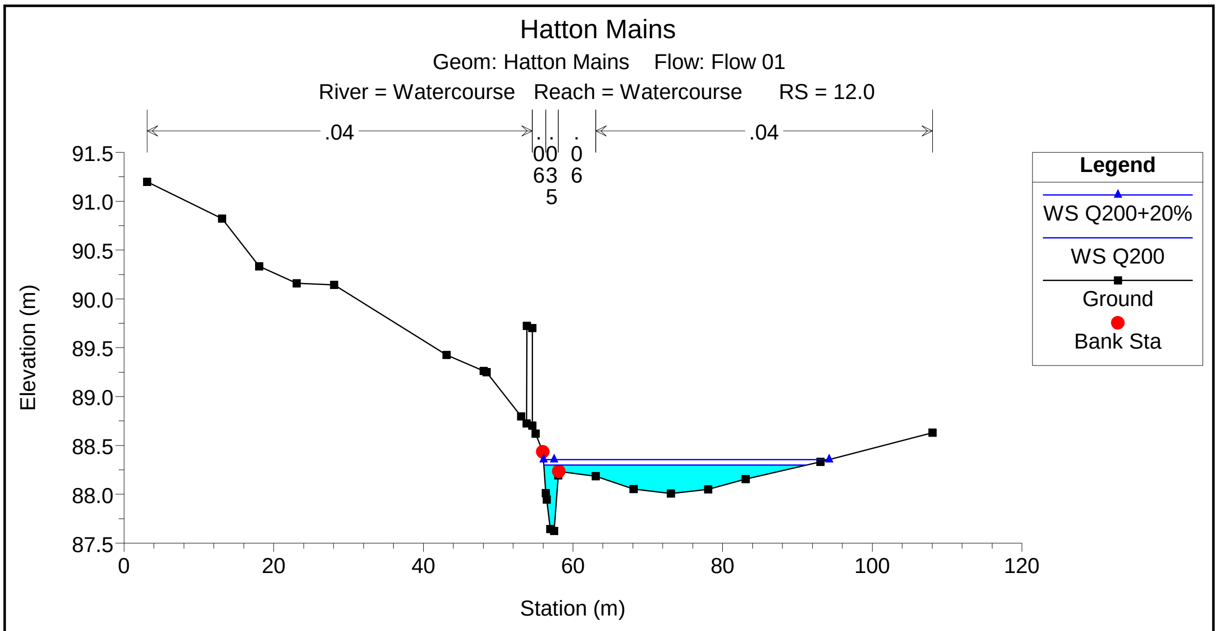

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 9.2 Culv
.04
.06
.035
.06
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

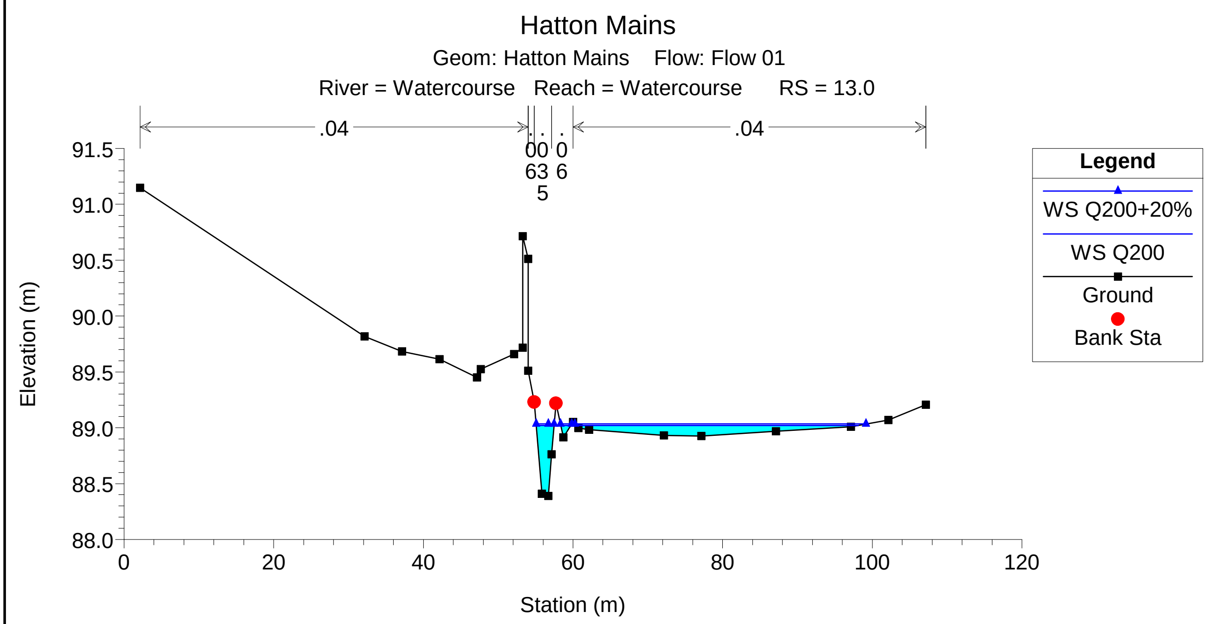

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 9.2 Culv
.04
.06
.035
.06
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

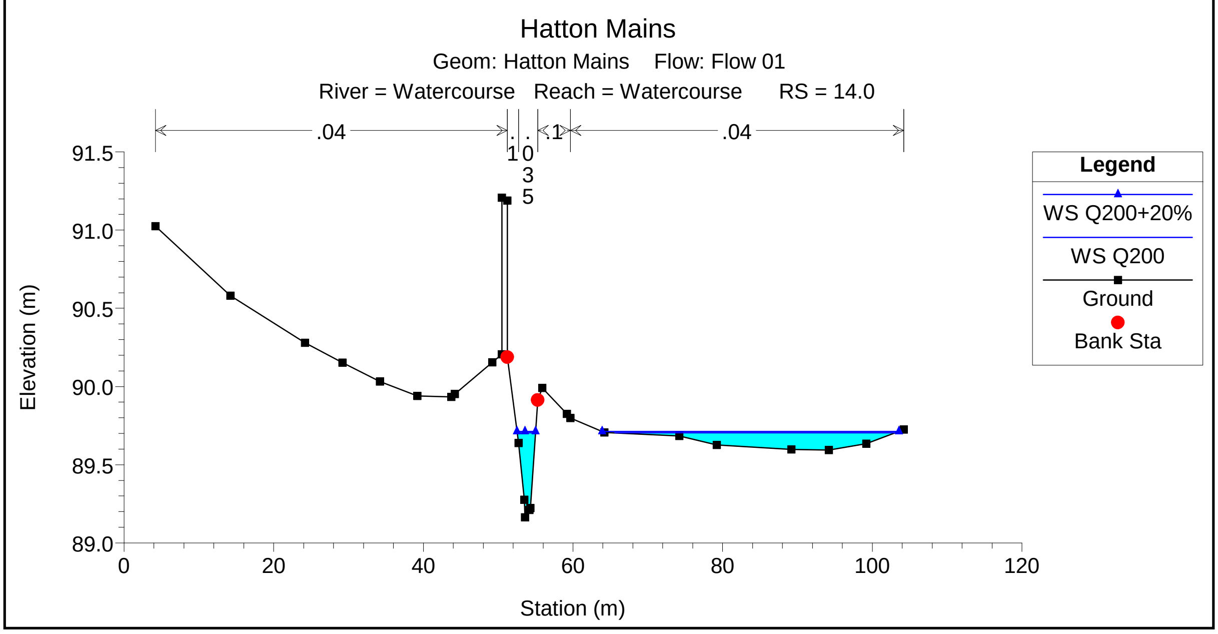

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 9.3
.04
.035
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

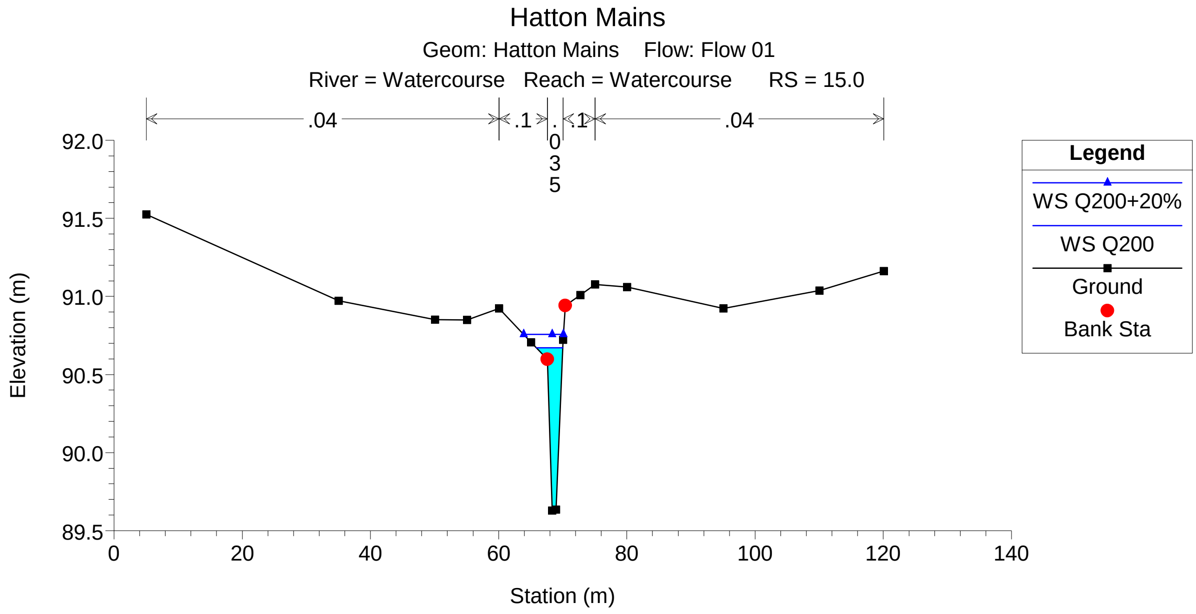

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 10.0
.04
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta


Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 11.0
.04
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta

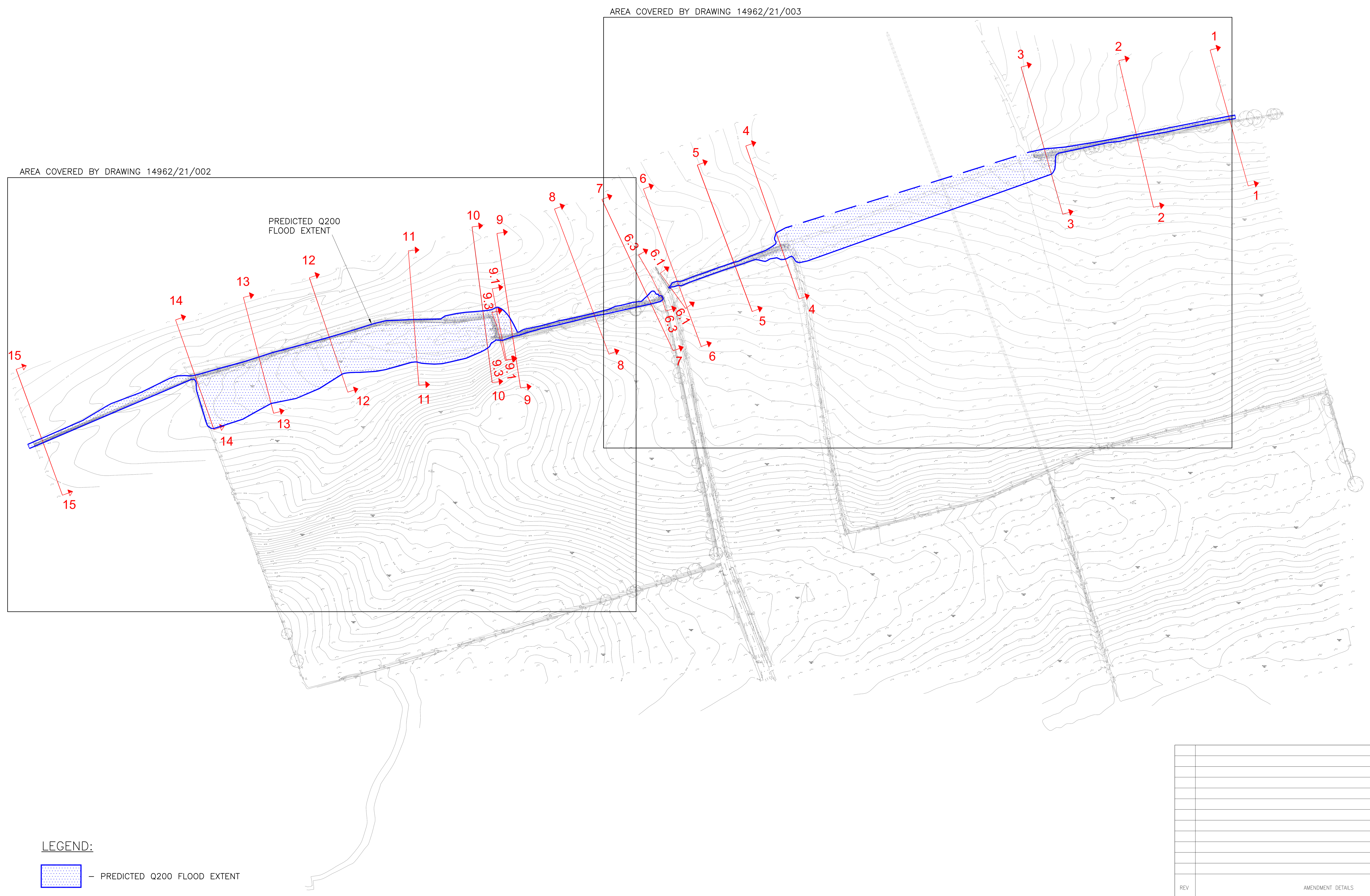

Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 12.0
.04
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta


Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 13.0
.04
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta


Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 14.0
.04
.1
.04
Elevation (m)
Station (m)
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta


Hatton Mains
Geom: Hatton Mains Flow: Flow 01
River = Watercourse Reach = Watercourse RS = 15.0
.04
.1
.035
.1
.04
Legend
WS Q200+20%
WS Q200
Ground
Bank Sta
Elevation (m)
92.0
91.5
91.0
90.5
90.0
89.5
0
20
40
60
80
100
120
140
Station (m)

Plans



LEGEND:

– PREDICTED Q200 FLOOD EXTENT

– CROSS SECTION LOCATIONS

REV	AMENDMENT DETAILS	DRAWN	APPROVED	DATE

PROJECT: PROPOSED DEVELOPMENT AT HATTON MAINS, RATHO, BY EDINBURGH	DESIGNED BY: BPC	DRAWN BY: ASB	SCALE: 1:2000
	CHECKED BY: BPC	APPROVED BY: BPC	
DRAWING TITLE: PREDICTED Q200 FLOOD EXTENT	DRAWING STATUS		DATE: 13.11.18
CLIENT: INVERDUNNING (HATTON MAINS) LTD	DRAWING NUMBER: 14962/21/001		REVISION

Perth Office
Inveralmond Business Centre
Auld Bond Road
Perth
PH1 3FX

tel: 01738 646750
email: perth@millardconsulting.co.uk
web: www.millardconsulting.co.uk

Millard
More than civil engineers

REV	AMENDMENT DETAILS	DRAWN	APPROVED	DATE

PROJECT PROPOSED DEVELOPMENT AT HATTON MAINS, RATHO, BY EDINBURGH	DESIGNED BY	DRAWN BY ASB	SCALE 1:500
	CHECKED BY BPC	APPROVED BY BPC	
DRAWING TITLE PREDICTED Q200 FLOOD EXTENT – LARGER SCALE SHEET 1 OF 2	DRAWING STATUS		DATE 13.11.18
CLIENT INVERDUNNING (HATTON MAINS) LTD	DRAWING NUMBER 14962/21/002		REVISION

Perth Office
Inveralmond Business Centre
Auld Bond Road
Perth
PH1 3FX

tel: 01738 646750
email: perth@millardconsulting.co.uk
web: www.millardconsulting.co.uk

Millard
More than civil engineers

REV	AMENDMENT DETAILS	DRAWN	APPROVED	DATE

PROJECT PROPOSED DEVELOPMENT AT HATTON MAINS, RATHO, BY EDINBURGH	DESIGNED BY	DRAWN BY ASB	SCALE 1:500
	CHECKED BY BPC	APPROVED BY BPC	
DRAWING TITLE PREDICTED Q200 FLOOD EXTENT – LARGER SCALE SHEET 2 OF 2	DRAWING STATUS		DATE 13.11.18
CLIENT INVERDUNNING (HATTON MAINS) LTD	DRAWING NUMBER 14962/21/003		REVISION

Perth Office
Inveralmond Business Centre
Auld Bond Road
Perth
PH1 3FX

tel: 01738 646750
email: perth@millardconsulting.co.uk
web: www.millardconsulting.co.uk

Millard
More than civil engineers

REV	AMENDMENT DETAILS	DRAWN	APPROVED	DATE

PROJECT PROPOSED DEVELOPMENT AT HATTON MAINS, RATHO, BY EDINBURGH	DESIGNED BY	DRAWN BY ASB	SCALE 1:1250
	CHECKED BY BPC	APPROVED BY BPC	
DRAWING TITLE MITIGATION PROPOSALS	DRAWING STATUS		DATE 14.11.18
CLIENT INVERDUNNING (HATTON MAINS) LTD	DRAWING NUMBER 14962/21/004		REVISION

Perth Office
Inveralmond Business Centre
Auld Bond Road
Perth
PH1 3FX

tel: 01738 646750
email: perth@millardconsulting.co.uk
web: www.millardconsulting.co.uk

Millard
More than civil engineers

ORIGINAL SHEET SIZE A0H

Millard Structures

Millard Infrastructure

Millard Flood Risk

Millard Environmental

Millard Hydrology

Millard Transportation

ISO 14001 REGISTERED FIRM

ISO 9001 REGISTERED FIRM

The Scottish Government

Dundee | Perth | Aberdeen
Registered in Scotland No: SC220557
Registered Office: Seabraes, 18 Greenmarket, Dundee DD1 4QB
TA Millard Scotland Ltd trading as Millard Consulting