

APPENDIX G

HYDRAULIC ASSESSMENT OF ORDINARY WATERCOURSES



STEEPLE SOLAR FARM LIMITED

STEEPLE RENEWABLES PROJECT

IDB Watercourse Hydraulic Analysis

680819-R7(01) – Technical Note
April 2025



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RSK GENERAL NOTES

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Steeple Solar Farm Ltd
Steeple Renewables Project
IDB Watercourse Hydraulic Analysis
680819-R7(01) – Technical Note

CONTENTS

1	INTRODUCTION	1
2	MANNINGS ASSESMENT	4
2.1	Methodology	4
2.2	Results.....	7
3	1D HYDRAULIC MODELLING	9
3.1	Model Build.....	9
3.2	Unsteady Simulations.....	9
3.3	Results.....	10
3.4	Discussion	17
4	CONCLUSIONS	19

FIGURES

Figure 2.1:	New Ings Drain Northern Catchment.....	5
Figure 2.2:	New Ings Drain Southern Catchment	5
Figure 2.3:	Location of channels assessed.....	6
Figure 3.1:	Catchwater Drain 1 in 100 year + 23% Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)	10
Figure 3.2:	Catchwater Drain 1 in 100 + 23% Node 2 Cross Section (solid blue hatching represents the baseflow, light blue line represents the top water level)	11
Figure 3.3:	Catchwater Drain node location for single overtopping location	12
Figure 3.4:	Catchwater Drain 1 in 30 year Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)	13
Figure 3.5:	Mother Drain 1 in 100 year + 23% Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)	14
Figure 3.6:	Mother Drain 1 in 30 year Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)	14
Figure 3.7:	New Ings Drain (North) in 100 year + 23% Unsteady Simulation Long Section	15
Figure 3.8:	New Ings Drain (North) Node 11 in 100 year + 23% Unsteady Simulation Cross Section	16
Figure 3.9:	New Ings Drain 1 in 30 year Unsteady Simulation Long Section	16
Figure 3.10:	New Ings Drain (South) in 100 year + 23% Unsteady Simulation Long Section	17
Figure 3.11:	New Ings Drain (South) in 30 year Unsteady Simulation Long Section	17

APPENDICES

APPENDIX A REFH PEAK CHANNEL FLOWS

APPENDIX B MANNINGS ASSESSMENT CHANNEL CAPACITY CALCULATIONS

APPENDIX C 1D CROSS SECTION LOCATIONS

APPENDIX D 1D MODELLED CROSS SECTION DATA

APPENDIX E 1D MODELLED CROSS SECTION WATER RESULTS

1 INTRODUCTION

This technical note provides further detail on the flood risk associated with the three main Internal Drainage Board (IDB) watercourses crossing the Steeple Solar development Site. These watercourses are:

- Catchwater Drain;
- Mother Drain; and
- New Ings Drain.

This exercise has been requested by the Environment Agency (EA) as these watercourses are not included within the EA's Tidal Trent flood model (Jacobs, 2023). The exercise aims to establish whether the watercourses would overtop their channels during the design 1 in 100 year plus 23% climate change event and to determine the potential impacts on the Proposed Development in the event of overtopping should occur.

During a Site inspection undertaken in July 2024, the Catchwater Drain and Mother Drain were noted to be contained within highly defined deep channels with the bed levels generally 3 – 4m below the top of bank level. The New Ings Drain was within a slightly shallower channel with the bed approximately 1.5m below the top of bank level. Flows were minimal within the ditches at the time of the inspection.

The Catchwater Drain and Mother Drain are shown in **Photo 1** and **Photo 2** below. The Catchwater Drain flows entirely within an open channel along its course through the Site, passing beneath a brick span road bridge on Common Lane to the east of Sturton le Steeple. The Mother Drain and New Ings Drain include short culverted (piped) sections to allow for access.



Photo 1: Catchwater Drain looking north from Low Holland Lane / Littleborough Road bridge



Photo 2: Mother Drain looking north from Littleborough Road bridge



Photo 3: Catchwater Drain - Common Lane road bridge south elevation

Source: Principal bridge inspection and strength assessment report, Nottinghamshire County Council, February 2021

This assessment takes a staged risk-based approach to modelling, starting with a high level Mannings Assessment and progressing to more complex hydraulic modelling where appropriate, dependent on the outcomes of the initial modelling exercises. The methods used at each stage are described within the report, together with a description of the modelling outcomes in the context of the Proposed Development.

2 MANNINGS ASSESSMENT

A Mannings Assessment was initially undertaken to provide a high-level estimate of the capacity of the IDB watercourse channels in comparison to the design flows. This assessment was undertaken for all three main IDB watercourses (Catchwater Drain, Mother Drain and New Ings Drain). Manning's equation is a commonly used formula to calculate the flow rate (Q) in open channels and pipes, especially when flow is due to gravity rather than pressure. It is an empirical formula and hence based on observations and experiments rather than derived from fundamental laws of physics.

Manning's Equation Formula:

The standard form of Manning's equation is:

$$Q = (1.486/n) \times A \times R^{(2/3)} \times S^{(1/2)}$$

Where:

- Q: Flow rate (e.g., cubic feet per second or cubic meters per second).
- *n*: Manning's roughness coefficient (dimensionless).
- A: Cross-sectional area of the flow (e.g., square feet or square metres).
- R: Hydraulic radius (e.g., feet or metres).
- S: Slope of the channel or energy grade line (e.g., foot per foot or metres per metre).

2.1 Methodology

This analysis of the capacity of the IDB watercourses has been completed using FEH catchment data and Mannings channel flow calculations.

The catchment data from the FEH website for each of the respective watercourses was taken from the downstream points at which that watercourse discharges into another body of water, be it the River Trent or another IDB watercourse. Taking the downstream point for the points of assessment is a conservative approach for the upper sections of each of the assessed watercourses. This catchment data was then input into the ReFH2 flood modelling software in order to provide peak flow rates (m³/s) for the design 1 in 100 year + 23% climate change event. Outputs can be found within **Appendix A** of this technical note.

Based on the levels information within the topographic survey, it was determined that the New Ings Drain flows both northward and southward within the Site boundary, from a localised high point where the IDB watercourse is culverted under Littleborough Road. Both sections of the New Ings Drain discharge to the Mother Drain. Using the catchment tool in the FEH website it was determined that the northern section of New Ings Drain had a catchment size of 1.43km², whilst the southern section was 1.54km². The ReFH2 data for these sections of watercourse were therefore derived using the Mother Drain catchment descriptors and a modified catchment size. Screenshots of the catchment

extents taken from the FEH website have been included as **Figure 2.1** and **Figure 2.2** respectively.

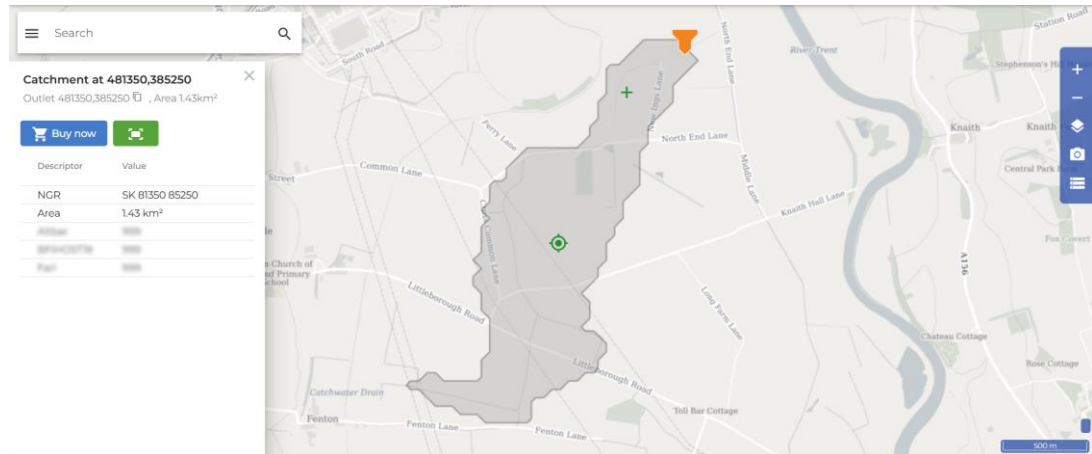


Figure 2.1: New Ings Drain Northern Catchment

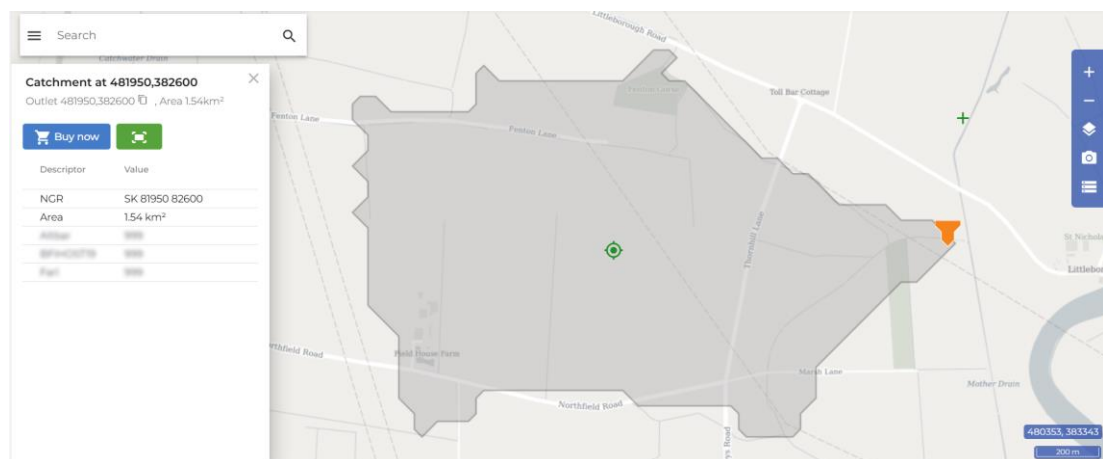


Figure 2.2: New Ings Drain Southern Catchment

This peak flow rate was then compared against the channel capacity of each of the respective IDB watercourses to determine if the peak flows during the design event would exceed the channel capacity and overtop the channel bank.

To calculate the channel capacity using the Mannings channel flow calculator several pieces of information are required. Using the topographic survey data in AutoCAD format it was possible to obtain cross sections of the channels at selected points along the watercourses. From these cross sections it was possible to gain the top of channel height (mAOD), bottom of channel height (mAOD), bank length (m), bottom of channel width (m) and top of channel width (m).

In order to use the Mannings equation for a trapezoid-shaped channel to calculate channel velocity (m/s) and channel discharge (m³/s), the channel slope, water depth, left and right slopes and bottom channel width are required. To calculate channel slope, an

average of the differences between the bottom of channel levels (mAOD) between two cross sections was taken and divided by the distance between them on the channel, then multiplied by 100%.

To calculate water depth, an average of the differences between the bottom of channel height (mAOD) and top of channel heights (mAOD) was taken.

To calculate left and right slope, Pythagoras theorem was used to calculate the distance between bottom and top of bank; as $\text{distance}^2 = \text{channel length}^2 - \text{channel height}^2$. After obtaining the distance, the slope of the bank = distance (change in y) / height (change in x).

Bottom width was obtained from the topographic drawings.

This information was then input into a Mannin s open channel flow calculator with a Mannin s value of 0.03 (as this is considered the best value of straightened vegetated channels), to provide the resultant flow velocity and flow discharge).

The locations where the channel capacity for the watercourses was calculated can be seen in the markup in **Figure 2.3** below.

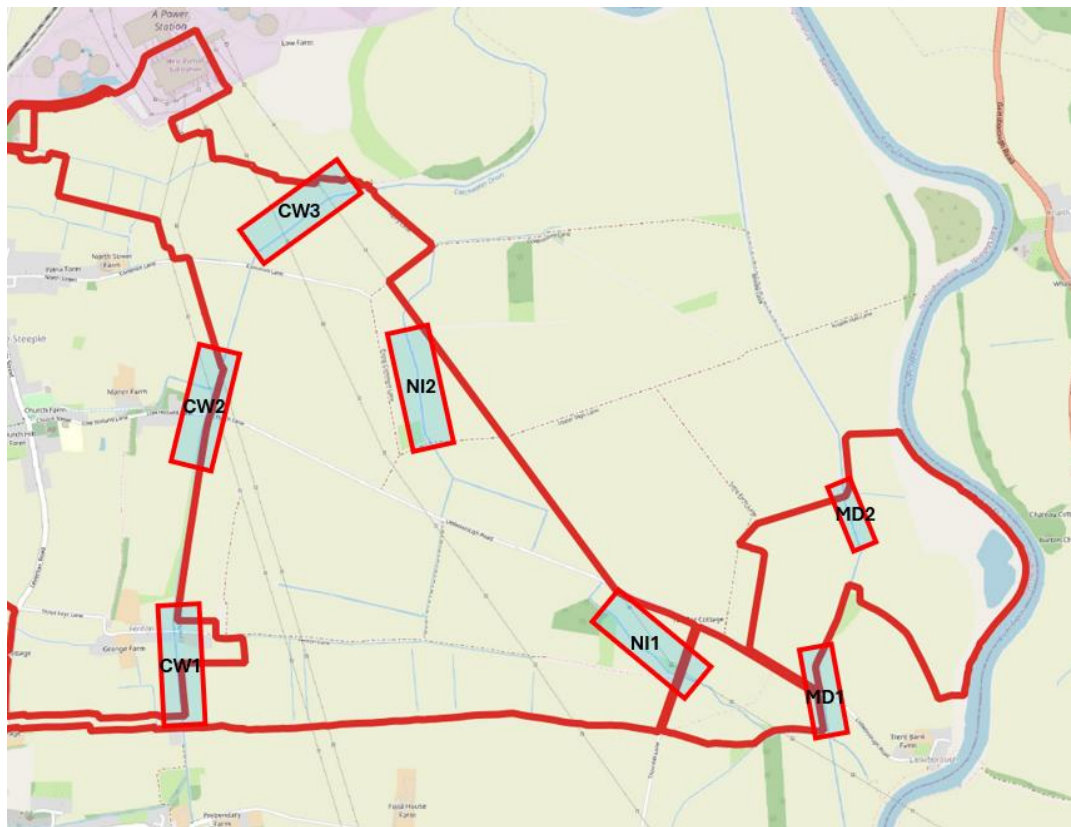


Figure 2.3: Location of channels assessed

2.2 Results

The results of the analysis of channel capacity and peak flow are given below. Calculations for each channel can be found within **Appendix B** of this technical note.

2.2.1 Catchwater Drain

- Catchwater Drain (1) Channel Capacity = **11.04m³/s**
- Catchwater Drain (2) Channel Capacity = **10.87m³/s**
- Catchwater Drain (3) Channel Capacity = **13.76m³/s**
- 1 in 100 year + 23% cc Peak Flow = **15.78m³/s**

Channel Capacity < Q100cc Peak Flow = Flood risk

2.2.2 Mother Drain

- Mother Drain (1) Channel Capacity = **3.96m³/s**
- Mother Drain (2) Channel Capacity = **2.76m³/s**
- 1 in 100 year + 23% cc Peak Flow = **5.38m³/s**

Channel Capacity < Q100cc Peak Flow = Flood risk

2.2.3 New Ings Drain

- New Ings Drain (1) Channel Capacity = **2.18m³/s**

New Ings Drain (1) 1 in 100 year + 23% cc Peak Flow = **0.35m³/s**

Channel Capacity > Q100cc Peak Flow = No Flood risk

- New Ings Drain (2) Channel Capacity = **0.81m³/s**
- New Ings Drain (2) 1 in 100 year + 23% cc Peak Flow = **0.32m³/s**

Channel Capacity > Q100cc Peak Flow = No Flood risk

2.2.4 Discussion

The Mannings Assessment indicates that the sections of the Mother Drain and Catchwater Drain IDB watercourses flowing through the Site may have insufficient channel capacity within the open channel sections assessed to accommodate the peak flows generated during the 1 in 100 year + 23% climate change event. However, it is considered unlikely channel capacity exceedance would occur in the New Ings Drain. Due to the likelihood that this method of assessment provides conservative results (i.e. is likely to over-estimate flows in relation to channel capacity), further assessment has been undertaken for all three watercourses. This is in line with comments received from the EA (Ref: XA/2025/100334/01-L01, 10th April 2025) on review of the draft Mannings Assessment (as part of the draft Flood Risk Assessment) which stated:

Given the potential for channel capacity to be exceeded on the Catchwater Drain and New Ings Drain, an assessment of flood risk to the development should be undertaken. This could be undertaken by either:

1. Correcting the channel capacity calculations and reviewing the in channel water levels for the Catchwater Drain and New Ings drain for the design flood and assessing these against ground elevations within the development area based on the latest composite 1 metre resolution Lidar data available from the Defra Data Services Platform (Defra Data Services Platform). This will likely provide a conservative assessment of flood risk for the development. Or:

2. Constructing hydraulic models for the Catchwater Drain and New Ings drain. These should incorporate channel cross sections, structures, and a representation of the floodplain within the vicinity of the proposed development.”

Approach 2 has been taken, i.e. construction of a hydraulic model for the Catchwater Drain and New Ings Drain. Although not specifically requested by the EA, modelling has also been undertaken for the Mother Drain for completeness. The results of the modelling assessment are described in the following chapters.

3 1D HYDRAULIC MODELLING

As the initial Mannings Assessment identified the potential for exceedance of channel capacity of two of the IDB watercourses, further more detailed assessment has been undertaken for all three watercourses in the form of a 1D hydraulic model.

3.1 Model Build

Topographic survey data has been used to develop the cross section geometry with cross section chainage equally spaced along the watercourses. The chainage (m), elevation data (mAOD), easting and northing of the top of bank and channel points data have been added to the Flood Modeller software. The data used within the 1D models, and the locations selected are shown in **Appendix C**. Cross sections are drawn from left to right bank facing the direction of flow (generally northwards).

Starting at the upstream end, an inflow point was then created using a Flow-Time Hydrograph and inputting the flow results produced in ReFH for the 1 in 100 year plus 23% climate change storm. The river channel cross sections were built into the 1D network using the River Section tool, with the outflow / end point a Normal / Critical Depth boundary set with a slope value of 0.001.

All data points were given a Mannings value of 0.035 which is a value similar to a straight, clear, vegetated channel. The distance to each of the respective next sections were calculated by drawing a polyline between each of the crossings along the centreline of channel bed.

New Ings Drain has been split into northern and southern sections as it was determined using the topographic survey that the New Ings Drain flows both to the north and south from a high point where the watercourse is culverted under Littleborough Road.

It is noted that all three watercourses have a pumped outfall to the River Trent. This assessment assumes a free-flowing outfall from the model extent and does not take account of the rate of pumping as this would be difficult to quantify, and would be unrepresentative at times when the pumps are not active.

3.2 Unsteady Simulations

To represent the full hydrograph for each of the selected watercourses, the unsteady (adaptive timestep) run type was selected, with the finish times set to 50 hours for Catchwater Drain and 90 hours for Mother Drain and New Ings Drain. An initial timestep of 2 seconds was selected with a minimum timestep of 0.5 seconds applied if a smaller timestep was required by the solver. Unsteady simulations were run for both the design event and the 1 in 30 year scenario.

3.3 Results

3.3.1 Catchwater Drain

The long section results from the 1 in 100 year plus 23% climate change storm have been included below as **Figure 3.1**. This long section shows the bed elevation (mAOD), left and right bank elevation (mAOD), as well as the initial water levels (mAOD) and maximum levels (mAOD). These results indicate that during the modelled storm event, peak flows only exceed channel capacity at the right bank of node 2. The elevation of the right bank at this river section is approximately 6.5mAOD, with the modelled maximum water level indicated as approximately 6.6mAOD. The cross section of node 2 has been included as **Figure 3.2** and indicates that only 100mm of out of bank flow would be present at this node location, before flows return back to the channel. All of the modelled cross sections for the 1 in 100 year plus 23% climate change event have been included as **Appendix D**.

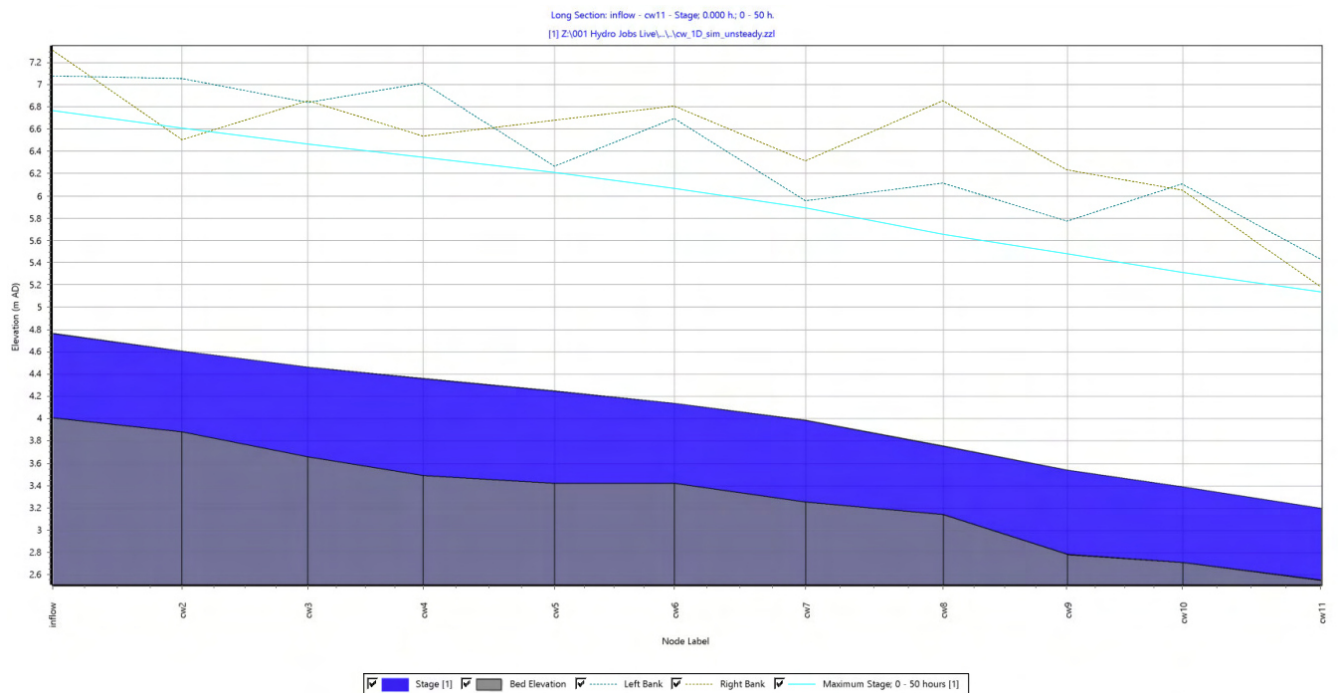


Figure 3.1: Catchwater Drain 1 in 100 year + 23% Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

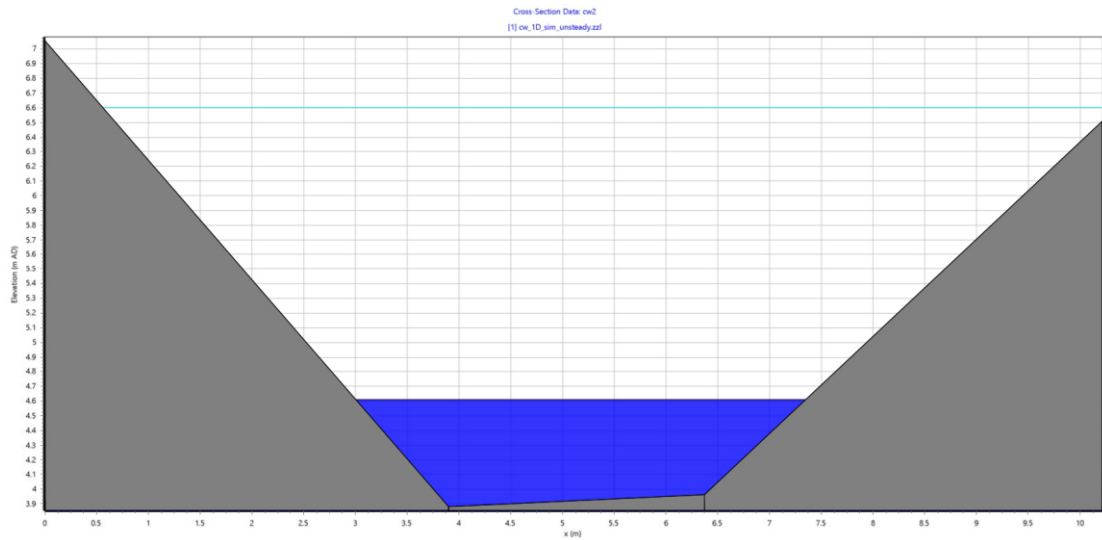


Figure 3.2: Catchwater Drain 1 in 100 + 23% Node 2 Cross Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

The location of the single node location (node 2) that shows overtopping for the 1 in 100 year plus 23% climate change event is shown in **Figure 3.3**. As shown in **Figure 3.3**, the nearest proposed development is an area of solar panels approximately 400m to the east. Given that overtopping occurs in this single location, with no overtopping of nodes 1 and 3 immediately either side, and the relatively shallow depth of water at the overtopping location, the impact on the proposed infrastructure (c.400m from the overtopping location) is considered to be negligible. This overtopping location is located in the south of the Site, a significant distance from the sensitive BESS and Substation locations (located in the north of the Site).



Figure 3.3: Catchwater Drain node location for single overtopping location

Figure 3.4 shows the long section model results from the 1 in 30 year storm event for Catchwater Drain. These results indicate that during the 1 in 30 year storm event, the channel capacity of Catchwater Drain is not exceeded at any of the modelled nodes. This confirms that the functional floodplain (Flood Zone 3b) associated with the Catchwater Drain remains in channel within the Site.

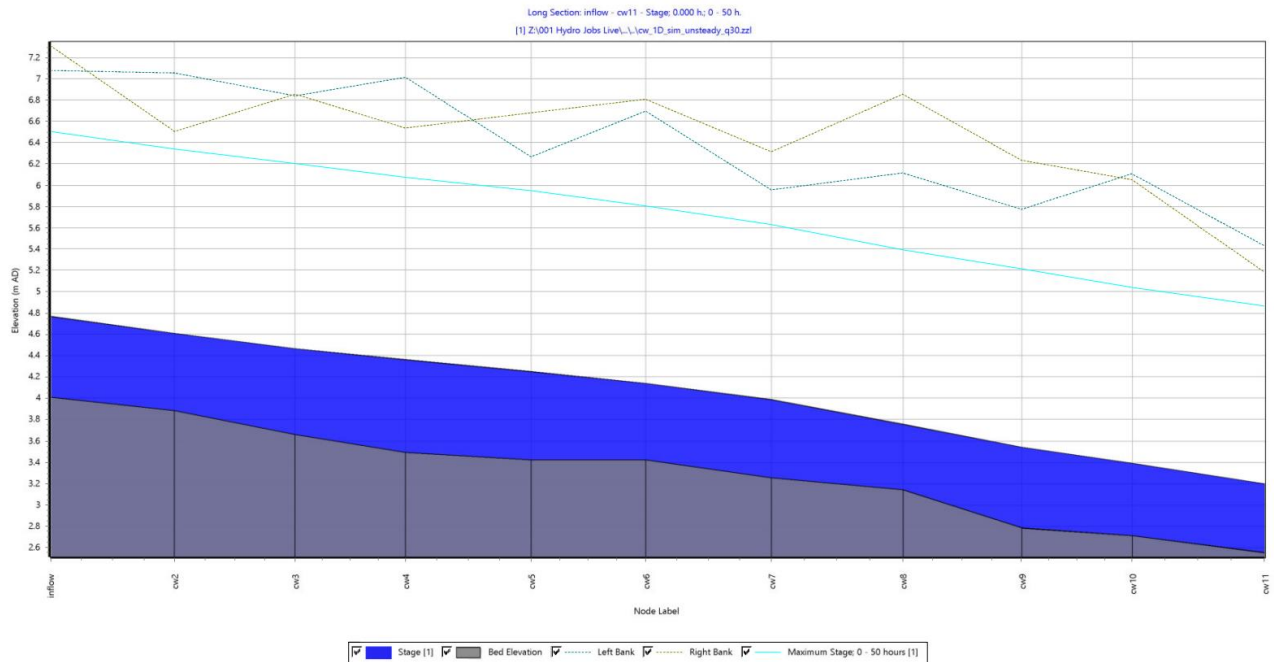


Figure 3.4: Catchwater Drain 1 in 30 year Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

3.3.2 Mother Drain

The long section results from the 1 in 100 year plus 23% climate change storm have been included below as **Figure 3.5**. These results indicate that during the critical storm event the maximum water level within Mother Drain would be approximately 2.9mAOD, this is significantly lower than the lowest bank elevation along the entire modelled section of the watercourse of 3.5mAOD. As such it is considered that the during the 1 in 100 year plus 23% climate change storm, it is unlikely that the channel capacity of Mother Drain would be exceeded. All of the modelled cross sections for the 1 in 100 year plus 23% climate change event have been included as **Appendix D**, with the long section of the 1 in 30 year storm shown in **Figure 3.6**. There is no overtopping of the Mother Drain for the 1 in 30 year storm event and therefore the functional floodplain (Flood Zone 3b) associated with this watercourse remains in channel within the Site.

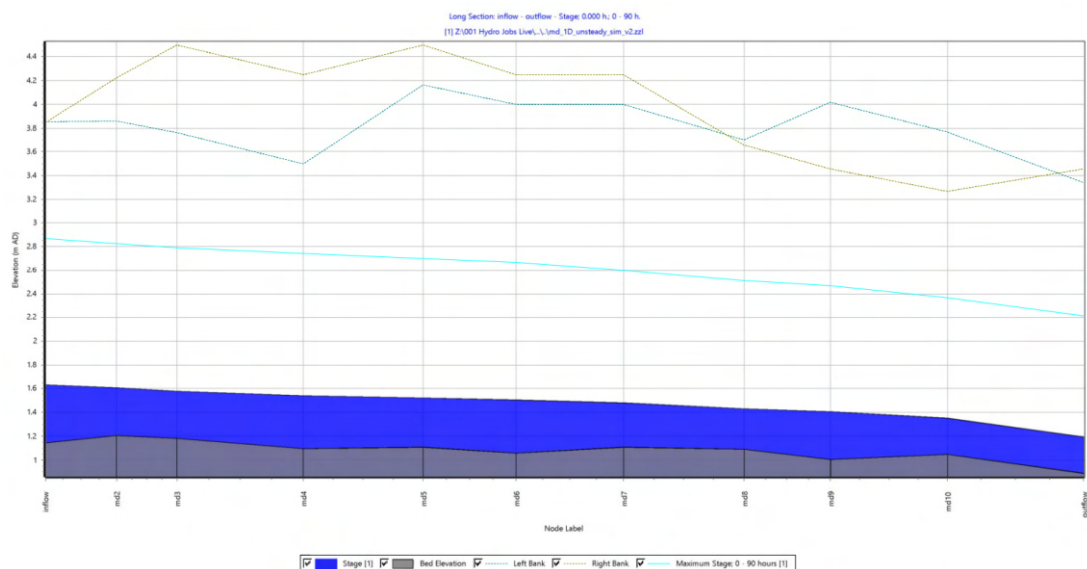


Figure 3.5: Mother Drain 1 in 100 year + 23% Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

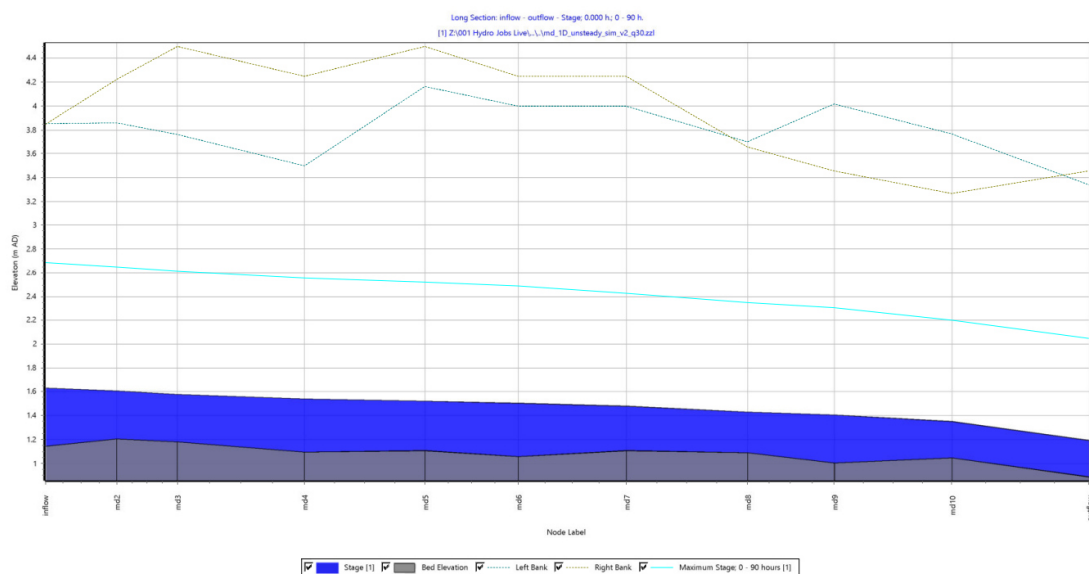


Figure 3.6: Mother Drain 1 in 30 year Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

3.3.3 New Ings Drain (North)

The long section results from the 1 in 100 year plus 23% climate change storm have been included below as **Figure 3.7**. These results indicate that during this storm event the maximum water level in northern section of New Ings Drain would be approximately 3.72m AOD. This flood level would stay in channel for the majority of the northern section of the watercourse apart from a small channel capacity exceedance at node 11. A cross section of node 11 has been included below as **Figure 3.8**, and indicates that the left

bank of the channel would be overtopped by approximately 30mm. This small amount of exceedance is unlikely to result in significant flooding across the areas of the Site surrounding New Ings Drain. A 9m easement is provided between the New Ings Drain and the nearest infrastructure which comprises solar arrays only. The impact on proposed infrastructure is considered to be low. The 1 in 30 year results (**Figure 3.9**) indicate that there would be no out of bank flow during this event, with the maximum water level during this scenario at approximately 2.9m AOD. The cross sections for the 1 in 100 year plus 23% climate change storm have been included in **Appendix D**.

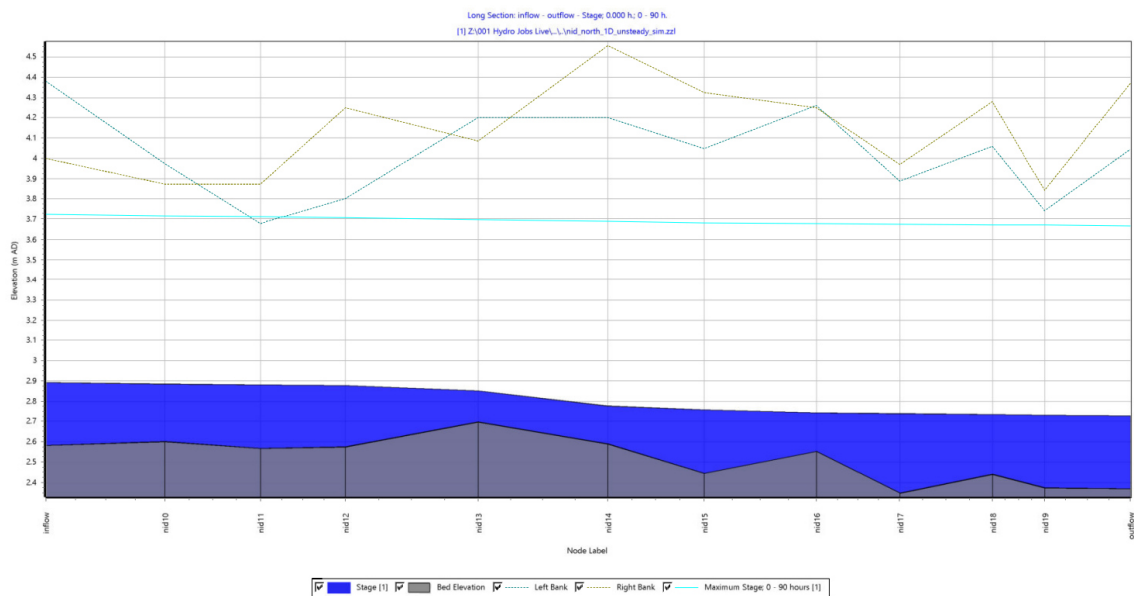


Figure 3.7: New Ings Drain (North) in 100 year + 23% Unsteady Simulation Long Section

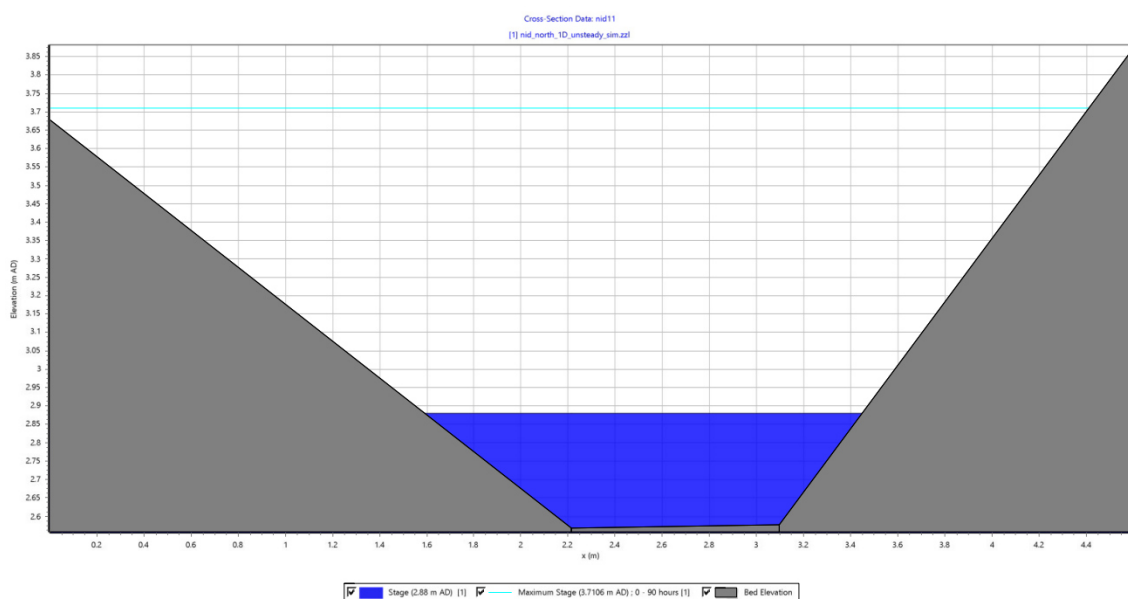


Figure 3.8 New Ings Drain (North) Node 11 in 100 year + 23% Unsteady Simulation Cross Section

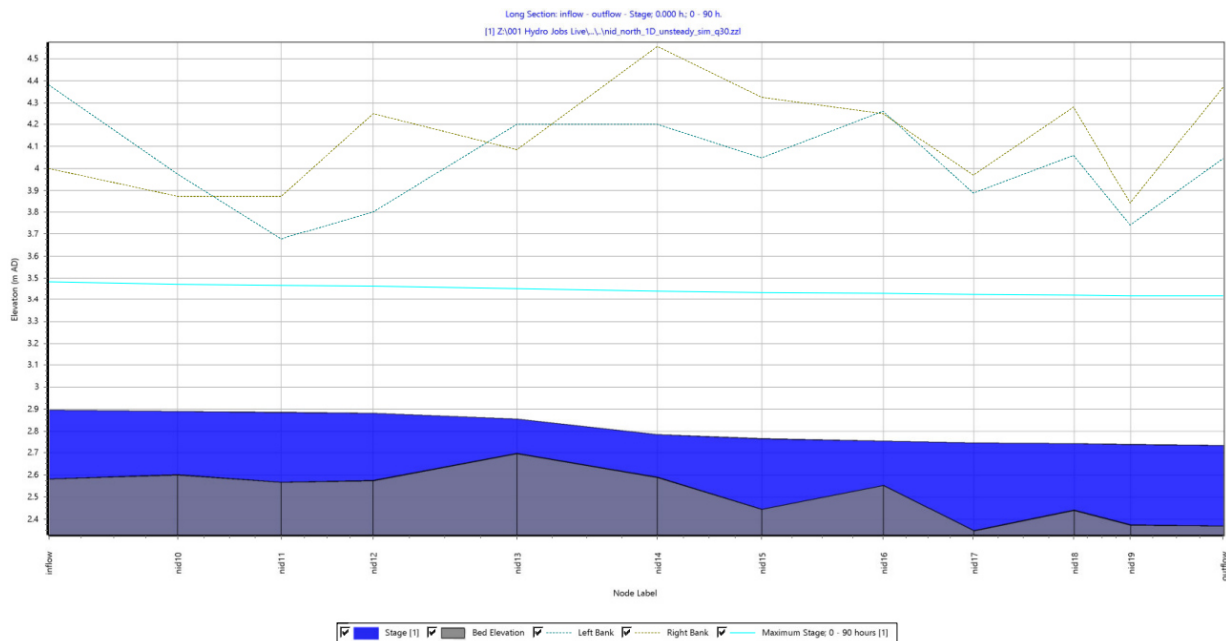


Figure 3.9: New Ings Drain 1 in 30 year Unsteady Simulation Long Section

3.3.4 New Ings Drain (South)

The long section results from the 1 in 100 year plus 23% climate change storm have been included below as **Figure 3.10**. These results indicate that during the critical storm event the maximum water level within the southern section of New Ings Drain would be approximately 2.9mAOD, this is significantly lower than the lowest bank elevation along the entire modelled section of the watercourse of 3.62mAOD. As such it is considered that the during the 1 in 100 year plus 23% climate change storm, it is unlikely that the channel capacity of the southern section of New Ings Drain would be exceeded. All of the modelled cross sections for the 1 in 100 year plus 23% climate change event have been included as **Appendix D**, with the long section of the 1 in 30 year storm shown in **Figure 3.11**. There is no out of bank flooding for the 1 in 30 year event.

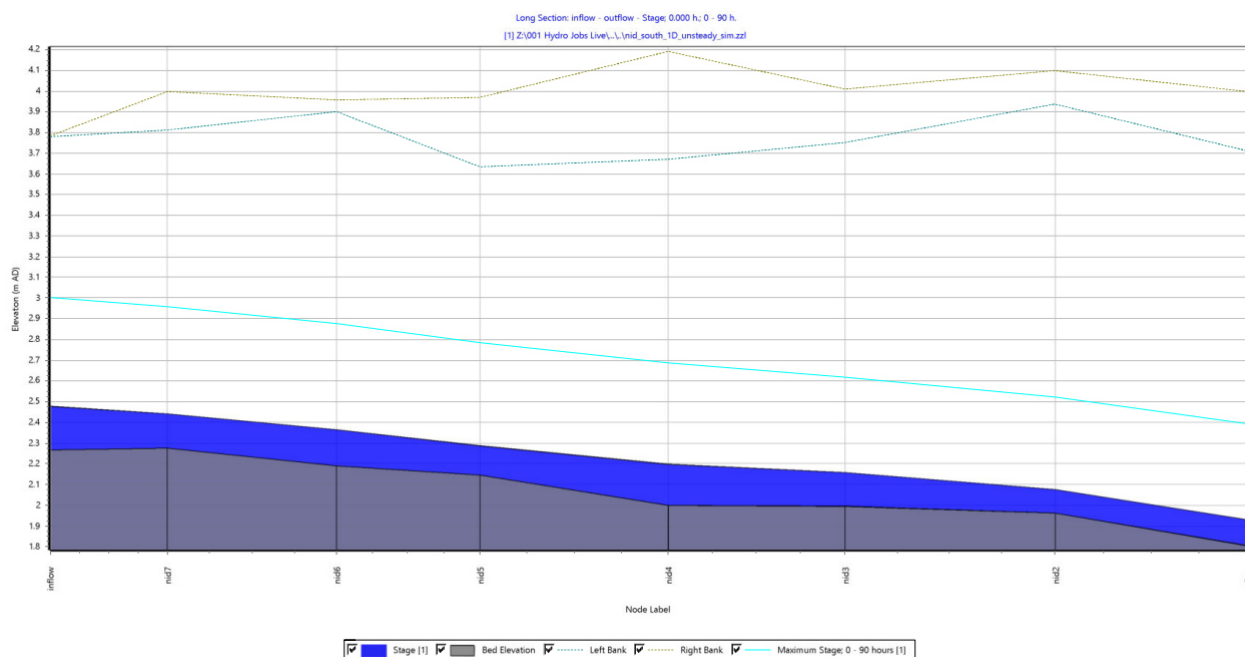


Figure 3.10: New Ings Drain (South) in 100 year + 23% Unsteady Simulation Long Section

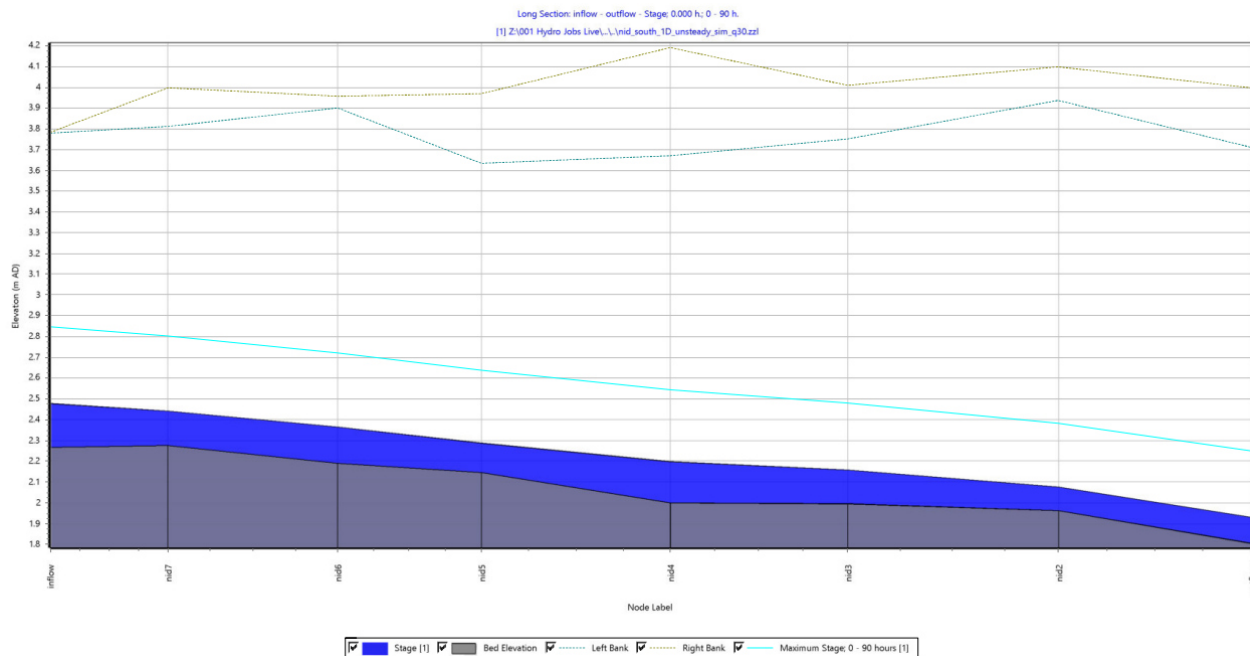


Figure 3.11: New Ings Drain (South) in 30 year Unsteady Simulation Long Section

3.4 Discussion

The 1D modelling results for the Mother Drain show that there is no overtopping of the watercourse for the 1 in 30 year or 1 in 100 year plus 23% climate change event.

Therefore, this watercourse is considered to represent a low risk of flooding to the Proposed Development and no further assessment is required.

The 1D modelling results for the Catchwater Drain show that there is no overtopping of the watercourse for the 1 in 30 year event, and only minimal overtopping at a single location for the 1 in 100 year plus 23% climate change event. Given the significant distance of the nearest proposed infrastructure (c.400m) from this overtopping location, the small volumes of water involved and the raised nature of the solar panels in this location, the impact on the Proposed Development is considered to be low. The more sensitive BESS and Substation areas are a significant distance from the overtopping location and will remain entirely unaffected. Given the low risk of flooding to the Proposed Development from this watercourse, no further assessment is required.

The 1D modelling results for the New Ings Drain (North) indicate that there would be no overtopping during the 1 in 30 year event, and only minimal overtopping at a single location during the 1 in 100 year plus 23% climate change event. At this location there would be approximately 30mm of channel exceedance on the right bank of the channel. Given the insignificant volume of water overtopping the bank as well as the raised nature of the solar panels in this location with a 9m offset between the watercourse and the infrastructure, the impact on the Proposed Development is considered to be low. The more sensitive aspects of the Proposed Development (BESS and Substation) will also remain entirely unaffected by this minor overtopping of the New Ings Drain. Given the low risk of flooding to the Proposed Development from this watercourse, no further assessment is required.

The 1D modelling results for the New Ings Drain (South) show that there is no overtopping of the watercourse for the 1 in 30 year or 1 in 100 year plus 23% climate change event. Therefore, this section of the watercourse is considered to represent a low risk of flooding to the Proposed Development and no further assessment is required.

4 CONCLUSIONS

A high level Mannings Assessment was initially undertaken to assess the flood risk to the three IDB watercourses (Catchwater Drain, Mother Drain and New Ings Drain). The results of this assessment indicated the channel capacity could be exceeded during the design flood event for the Catchwater Drain and the Mother Drain. In order to provide a more refined model, a 1D hydraulic modelling exercise was undertaken for all three watercourses.

For the Mother Drain, the 1D modelling exercise showed that there was no out-of-bank flow for the 1 in 100 year plus 23% climate change event or the 1 in 30 year event. This watercourse is therefore considered to represent a low risk from this source to the Proposed Development.

For the Catchwater Drain, the 1D modelling exercise showed that the 1 in 30 year fluvial flows remain within the channel, confirming that there are no areas of functional floodplain associated with this watercourse within the Site. The 1 in 100 year plus 23% climate change flows remain in-channel for the vast majority of locations assessed, with only one location showing in-channel water levels exceeding the bank level by c.100mm. It is considered that this single exceedance would result in minor localised out of bank flooding. The field adjacent to the watercourse in this located is to be left undeveloped, with the nearest infrastructure proposed approximately 400m from the overtopping location. The impact on the Proposed Development is considered to be negligible. Notably, there is no overtopping of the channel during the design event in the vicinity of the proposed BESS and substation. The overtopping location is located in the south of the Site, in an area proposed as open land, with the nearest proposed infrastructure comprising solar panels which will be inherently raised above ground level.

For New Ings Drain, the 1D modelling exercise indicated that the southern section of the watercourse would not experience out of bank flow during the 1 in 100 year plus 23% climate change event or the 1 in 30 year event. The 1D modelling of the northern section of the watercourse also showed no out of bank flow during the 1 in 30 year event, but limited potential for some channel capacity exceedance at one model node during the 1 in 100 year plus 23% climate change event. The depth of overtopping at the singular node was approximately 30mm. Due to the raised nature of the solar panels in this location, the small volumes of floodwater anticipated and the 9m easement between the watercourse and the proposed panels, the impact on the Proposed Development is considered to be low. This watercourse is therefore considered to represent a low risk to the Proposed Development.

As noted within the assessment, the model assumes a free-flowing outfall from all of the IDB watercourses to the River Trent. In reality, the water levels in these watercourses are managed by the IDB by pumping water into the River Trent. It is considered likely that should water levels in the IDB watercourses come close to overtopping, the IDB would take action to pump water into the River Trent.

Overall, the fluvial flood risk to the Proposed Development from the Catchwater Drain, Mother Drain and New Ings Drain is considered to be low.

APPENDIX A

REFH PEAK CHANNEL FLOWS

VERSION	"FEH CD-R	Version	5.0.1	exported at	15:58:44 GMT	Mon	29-Jul-24
CATCHMENT GB		480550	385700	SK 80550	85700		
CENTROID GB		477690	382048	SK 77690	82048		
AREA	26.84						
ALTBAR	30						
ASPBAR	81						
ASPVAR	0.49						
BFIHOST	0.371						
BFIHOST19	0.364						
DPLBAR	7.34						
DPSBAR	23.2						
FARL	1						
FPEXT	0.161						
FPDBAR	0.963						
FPLOC	0.727						
LDP	14.47						
PROPWET	0.24						
RMED-1H	11.7						
RMED-1D	31.1						
RMED-2D	39.5						
SAAR	603						
SAAR4170	574						
SPRHOST	44.35						
URBCONC	0.497						
URBEXT19	0.0268						
URBLOC19	0.856						
URBCONC	0.655						
URBEXT20	0.0148						
URBLOC20	0.838						
C	-0.02319						
D1	0.29252						
D2	0.33087						
D3	0.25861						
E	0.30239						
F	2.55665						
C(1 km)	-0.022						
D1(1 km)	0.298						
D2(1 km)	0.33						
D3(1 km)	0.247						
E(1 km)	0.3						
F(1 km)	2.535						

VERSION	"FEH CD-R	Version	5.0.1	exported at	15:59:58 GMT	Mon	29-Jul-24
CATCHMENT GB		481500	385550	SK 81500	85550		
CENTROID GB		480400	380191	SK 80400	80191		
AREA	24.465						
ALTBAR	10						
ASPBAR	78						
ASPVAR	0.55						
BFIHOST	0.527						
BFIHOST19	0.587						
DPLBAR	7.79						
DPSBAR	7.1						
FARL	0.964						
FPEXT	0.4847						
FPDBAR	2.347						
FPLOC	0.896						
LDP	16.09						
PROPWET	0.24						
RMED-1H	11.5						
RMED-1D	30						
RMED-2D	38.8						
SAAR	588						
SAAR4170	578						
SPRHOST	32.94						
URBCONC	0.582						
URBEXT19	0.0304						
URBLOC19	1.376						
URBCONC	0.779						
URBEXT20	0.0267						
URBLOC20	1.233						
C	-0.02396						
D1	0.28635						
D2	0.33857						
D3	0.24955						
E	0.30864						
F	2.54228						
C(1 km)	-0.022						
D1(1 km)	0.297						
D2(1 km)	0.323						
D3(1 km)	0.249						
E(1 km)	0.3						
F(1 km)	2.537						

UK Design Flood Estimation

Generated on Friday, February 21, 2025 11:27:13 AM by [REDACTED]
Printed from the ReFH2 Flood Modelling software package, version 4.0.8560.23190

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

Site detailsChecksum: CEDD-9458

Site name: FEH_Catchment_Descriptors_480550_385700_v5_0_1

Easting: 480550

Northing: 385700

Country: England, Wales or Northern Ireland

Catchment Area (km²): 26.84

Using plot scale calculations: No

Model: 2.3

Site description:None

Model run: 100 year 1.23 CC

Summary of results

Rainfall - FEH22 (mm):	107.26	Total runoff (ML):	1019.95
Total Rainfall (mm):	69.48	Total flow (ML):	1868.43
Peak Rainfall (mm):	18.90	Peak flow (m³/s):	15.78

Parameters

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

Rainfall parameters (Rainfall - FEH22)

Name	Value	User-defined?
Duration (hh:mm:ss)	18:00:00	No
Timestep (hh:mm:ss)	02:00:00	No
SCF (Seasonal correction factor)	0.68	No
ARF (Areal reduction factor)	0.96	No
Seasonality	Winter	No
Climate change factor	1.23	Yes

Loss model parameters

Name	Value	User-defined?
Cini (mm)	133.23	No
Cmax (mm)	308.76	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	11.23	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m ³ /s)	1.11	No
BL (hr)	49.79	No
BR	0.84	No

Urbanisation parameters

Name	Value	User-defined?
Sewer capacity (m ³ /s)	0	No
Exporting drained area (km ²)	0	No
Urban area (km ²)	0.62	No
Urbext 2000	0.01	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
00:00:00	1.985	0.000	0.870	0.000	1.099	1.099
02:00:00	3.725	0.000	1.667	0.034	1.057	1.091
04:00:00	6.927	0.000	3.219	0.168	1.018	1.187
06:00:00	12.653	0.000	6.279	0.495	0.989	1.484
08:00:00	18.895	0.000	10.335	1.195	0.977	2.172
10:00:00	12.653	0.000	7.563	2.547	0.998	3.545
12:00:00	6.927	0.000	4.358	4.588	1.073	5.660
14:00:00	3.725	0.000	2.408	6.991	1.216	8.207
16:00:00	1.985	0.000	1.302	9.440	1.431	10.872
18:00:00	0.000	0.000	0.000	11.615	1.714	13.329
20:00:00	0.000	0.000	0.000	13.073	2.045	15.118
22:00:00	0.000	0.000	0.000	13.385	2.394	15.779
24:00:00	0.000	0.000	0.000	12.757	2.725	15.482
26:00:00	0.000	0.000	0.000	11.580	3.015	14.595
28:00:00	0.000	0.000	0.000	10.142	3.252	13.394
30:00:00	0.000	0.000	0.000	8.644	3.432	12.076
32:00:00	0.000	0.000	0.000	7.304	3.559	10.863
34:00:00	0.000	0.000	0.000	6.196	3.641	9.837
36:00:00	0.000	0.000	0.000	5.254	3.687	8.940
38:00:00	0.000	0.000	0.000	4.411	3.702	8.112
40:00:00	0.000	0.000	0.000	3.627	3.690	7.317
42:00:00	0.000	0.000	0.000	2.882	3.653	6.534
44:00:00	0.000	0.000	0.000	2.165	3.593	5.758
46:00:00	0.000	0.000	0.000	1.493	3.513	5.007
48:00:00	0.000	0.000	0.000	0.906	3.415	4.321
50:00:00	0.000	0.000	0.000	0.466	3.304	3.769
52:00:00	0.000	0.000	0.000	0.207	3.185	3.392
54:00:00	0.000	0.000	0.000	0.076	3.064	3.140
56:00:00	0.000	0.000	0.000	0.018	2.945	2.963
58:00:00	0.000	0.000	0.000	0.000	2.829	2.830
60:00:00	0.000	0.000	0.000	0.000	2.718	2.718
62:00:00	0.000	0.000	0.000	0.000	2.611	2.611
64:00:00	0.000	0.000	0.000	0.000	2.508	2.508
66:00:00	0.000	0.000	0.000	0.000	2.409	2.409
68:00:00	0.000	0.000	0.000	0.000	2.315	2.315

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
70:00:00	0.000	0.000	0.000	0.000	2.223	2.223
72:00:00	0.000	0.000	0.000	0.000	2.136	2.136
74:00:00	0.000	0.000	0.000	0.000	2.052	2.052
76:00:00	0.000	0.000	0.000	0.000	1.971	1.971
78:00:00	0.000	0.000	0.000	0.000	1.893	1.893
80:00:00	0.000	0.000	0.000	0.000	1.819	1.819
82:00:00	0.000	0.000	0.000	0.000	1.747	1.747
84:00:00	0.000	0.000	0.000	0.000	1.679	1.679
86:00:00	0.000	0.000	0.000	0.000	1.612	1.612
88:00:00	0.000	0.000	0.000	0.000	1.549	1.549
90:00:00	0.000	0.000	0.000	0.000	1.488	1.488
92:00:00	0.000	0.000	0.000	0.000	1.429	1.429
94:00:00	0.000	0.000	0.000	0.000	1.373	1.373
96:00:00	0.000	0.000	0.000	0.000	1.319	1.319
98:00:00	0.000	0.000	0.000	0.000	1.267	1.267
100:00:00	0.000	0.000	0.000	0.000	1.217	1.217
102:00:00	0.000	0.000	0.000	0.000	1.169	1.169
104:00:00	0.000	0.000	0.000	0.000	1.123	1.123

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km ²)	26.84	No
ALTBAR	30	No
ASPBAR	81	No
ASPVAR	0.49	No
BFIHOST	0.37	No
BFIHOST19	0.36	No
DPLBAR (km)	7.34	No
DPSBAR (mkm ⁻¹)	23.2	No
FARL	1	No
LDP	14.47	No
PROPWET	0.24	No
RMED1H	11.7	No
RMED1D	31.1	No
RMED2D	39.5	No
SAAR (mm)	603	No
SAAR4170 (mm)	574	No
SPRHOST	44.35	No
Urbext2000	0.01	No
Urbext1990	0.03	No
URBCONC	0.66	No
URBLOC	0.84	No
DDF parameter C	-0.02	No
DDF parameter D1	0.29	No
DDF parameter D2	0.33	No
DDF parameter D3	0.26	No
DDF parameter E	0.3	No
DDF parameter F	2.56	No
DDF parameter C (1km grid value)	-0.02	No
DDF parameter D1 (1km grid value)	0.3	No
DDF parameter D2 (1km grid value)	0.33	No
DDF parameter D3 (1km grid value)	0.25	No
DDF parameter E (1km grid value)	0.3	No
DDF parameter F (1km grid value)	2.54	No

UK Design Flood Estimation

Generated on Friday, February 21, 2025 11:29:42 AM by [REDACTED]
Printed from the ReFH2 Flood Modelling software package, version 4.0.8560.23190

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

Site detailsChecksum: 5F89-CB8B

Site name: FEH_Catchment_Descriptors_481500_385550_v5_0_1

Easting: 481500

Northing: 385550

Country: England, Wales or Northern Ireland

Catchment Area (km²): 24.47

Using plot scale calculations: No

Model: 2.3

Site description:None

Model run: 100 year 1.23 CC

Summary of results

Rainfall - FEH22 (mm):	114.41	Total runoff (ML):	440.92
Total Rainfall (mm):	74.45	Total flow (ML):	1303.87
Peak Rainfall (mm):	20.25	Peak flow (m³/s):	5.38

Parameters

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

Rainfall parameters (Rainfall - FEH22)

Name	Value	User-defined?
Duration (hh:mm:ss)	27:00:00	No
Timestep (hh:mm:ss)	03:00:00	No
SCF (Seasonal correction factor)	0.67	No
ARF (Areal reduction factor)	0.97	No
Seasonality	Winter	No
Climate change factor	1.23	Yes

Loss model parameters

Name	Value	User-defined?
Cini (mm)	91.22	No
Cmax (mm)	551.05	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	16.91	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m ³ /s)	0.34	No
BL (hr)	67.39	No
BR	2.05	No

Urbanisation parameters

Name	Value	User-defined?
Sewer capacity (m ³ /s)	0	No
Exporting drained area (km ²)	0	No
Urban area (km ²)	1.02	No
Urbext 2000	0.03	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m³/s)	Net Rain (mm)	Runoff (m³/s)	Baseflow (m³/s)	Total Flow (m³/s)
00:00:00	2.128	0.000	0.377	0.000	0.330	0.330
03:00:00	3.992	0.000	0.729	0.009	0.316	0.325
06:00:00	7.422	0.000	1.432	0.046	0.304	0.351
09:00:00	13.559	0.000	2.871	0.137	0.298	0.435
12:00:00	20.248	0.000	4.902	0.333	0.304	0.637
15:00:00	13.559	0.000	3.693	0.720	0.332	1.052
18:00:00	7.422	0.000	2.162	1.310	0.399	1.709
21:00:00	3.992	0.000	1.203	2.011	0.515	2.525
24:00:00	2.128	0.000	0.653	2.726	0.684	3.410
27:00:00	0.000	0.000	0.000	3.357	0.903	4.260
30:00:00	0.000	0.000	0.000	3.778	1.160	4.938
33:00:00	0.000	0.000	0.000	3.871	1.431	5.302
36:00:00	0.000	0.000	0.000	3.691	1.689	5.381
39:00:00	0.000	0.000	0.000	3.350	1.917	5.267
42:00:00	0.000	0.000	0.000	2.934	2.104	5.038
45:00:00	0.000	0.000	0.000	2.499	2.248	4.747
48:00:00	0.000	0.000	0.000	2.106	2.350	4.456
51:00:00	0.000	0.000	0.000	1.779	2.417	4.196
54:00:00	0.000	0.000	0.000	1.501	2.457	3.958
57:00:00	0.000	0.000	0.000	1.255	2.473	3.727
60:00:00	0.000	0.000	0.000	1.030	2.468	3.498
63:00:00	0.000	0.000	0.000	0.820	2.444	3.265
66:00:00	0.000	0.000	0.000	0.621	2.404	3.025
69:00:00	0.000	0.000	0.000	0.435	2.348	2.783
72:00:00	0.000	0.000	0.000	0.269	2.278	2.547
75:00:00	0.000	0.000	0.000	0.142	2.198	2.340
78:00:00	0.000	0.000	0.000	0.065	2.112	2.176
81:00:00	0.000	0.000	0.000	0.024	2.024	2.048
84:00:00	0.000	0.000	0.000	0.006	1.937	1.943
87:00:00	0.000	0.000	0.000	0.000	1.853	1.853
90:00:00	0.000	0.000	0.000	0.000	1.772	1.772
93:00:00	0.000	0.000	0.000	0.000	1.695	1.695
96:00:00	0.000	0.000	0.000	0.000	1.621	1.621
99:00:00	0.000	0.000	0.000	0.000	1.551	1.551
102:00:00	0.000	0.000	0.000	0.000	1.483	1.483

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
105:00:00	0.000	0.000	0.000	0.000	1.419	1.419
108:00:00	0.000	0.000	0.000	0.000	1.357	1.357
111:00:00	0.000	0.000	0.000	0.000	1.298	1.298
114:00:00	0.000	0.000	0.000	0.000	1.241	1.241
117:00:00	0.000	0.000	0.000	0.000	1.187	1.187
120:00:00	0.000	0.000	0.000	0.000	1.136	1.136
123:00:00	0.000	0.000	0.000	0.000	1.086	1.086
126:00:00	0.000	0.000	0.000	0.000	1.039	1.039
129:00:00	0.000	0.000	0.000	0.000	0.994	0.994
132:00:00	0.000	0.000	0.000	0.000	0.950	0.950
135:00:00	0.000	0.000	0.000	0.000	0.909	0.909
138:00:00	0.000	0.000	0.000	0.000	0.869	0.869
141:00:00	0.000	0.000	0.000	0.000	0.832	0.832
144:00:00	0.000	0.000	0.000	0.000	0.795	0.795
147:00:00	0.000	0.000	0.000	0.000	0.761	0.761
150:00:00	0.000	0.000	0.000	0.000	0.728	0.728
153:00:00	0.000	0.000	0.000	0.000	0.696	0.696
156:00:00	0.000	0.000	0.000	0.000	0.666	0.666
159:00:00	0.000	0.000	0.000	0.000	0.637	0.637
162:00:00	0.000	0.000	0.000	0.000	0.609	0.609
165:00:00	0.000	0.000	0.000	0.000	0.582	0.582
168:00:00	0.000	0.000	0.000	0.000	0.557	0.557
171:00:00	0.000	0.000	0.000	0.000	0.533	0.533
174:00:00	0.000	0.000	0.000	0.000	0.510	0.510
177:00:00	0.000	0.000	0.000	0.000	0.487	0.487
180:00:00	0.000	0.000	0.000	0.000	0.466	0.466
183:00:00	0.000	0.000	0.000	0.000	0.446	0.446
186:00:00	0.000	0.000	0.000	0.000	0.426	0.426
189:00:00	0.000	0.000	0.000	0.000	0.408	0.408
192:00:00	0.000	0.000	0.000	0.000	0.390	0.390
195:00:00	0.000	0.000	0.000	0.000	0.373	0.373
198:00:00	0.000	0.000	0.000	0.000	0.357	0.357
201:00:00	0.000	0.000	0.000	0.000	0.341	0.341

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km ²)	24.47	No
ALTBAR	10	No
ASPBAR	78	No
ASPVAR	0.55	No
BFIHOST	0.53	No
BFIHOST19	0.59	No
DPLBAR (km)	7.79	No
DPSBAR (mkm ⁻¹)	7.1	No
FARL	0.96	No
LDP	16.09	No
PROPWET	0.24	No
RMED1H	11.5	No
RMED1D	30	No
RMED2D	38.8	No
SAAR (mm)	588	No
SAAR4170 (mm)	578	No
SPRHOST	32.94	No
Urbext2000	0.03	No
Urbext1990	0.03	No
URBCONC	0.78	No
URBLOC	1.23	No
DDF parameter C	-0.02	No
DDF parameter D1	0.29	No
DDF parameter D2	0.34	No
DDF parameter D3	0.25	No
DDF parameter E	0.31	No
DDF parameter F	2.54	No
DDF parameter C (1km grid value)	-0.02	No
DDF parameter D1 (1km grid value)	0.3	No
DDF parameter D2 (1km grid value)	0.32	No
DDF parameter D3 (1km grid value)	0.25	No
DDF parameter E (1km grid value)	0.3	No
DDF parameter F (1km grid value)	2.54	No

UK Design Flood Estimation

Generated on Friday, February 21, 2025 11:28:46 AM by [REDACTED]
Printed from the ReFH2 Flood Modelling software package, version 4.0.8560.23190

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

Site detailsChecksum: 50AF-C81C

Site name: FEH_Catchment_Descriptors_481500_385550_v5_0_1

Easting: 481500

Northing: 385550

Country: England, Wales or Northern Ireland

Catchment Area (km²): 1.43 [24.47]*

Using plot scale calculations: No

Model: 2.3

Site description:None

Model run: 100 year 1.23 CC

Summary of results

Rainfall - FEH22 (mm):	114.41	Total runoff (ML):	26.47
Total Rainfall (mm):	76.01	Total flow (ML):	78.32
Peak Rainfall (mm):	20.67	Peak flow (m³/s):	0.32

Parameters

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

Rainfall parameters (Rainfall - FEH22)

Name	Value	User-defined?
Duration (hh:mm:ss)	27:00:00	No
Timestep (hh:mm:ss)	03:00:00	No
SCF (Seasonal correction factor)	0.67	No
ARF (Areal reduction factor)	0.99	No
Seasonality	Winter	No
Climate change factor	1.23	Yes

Loss model parameters

Name	Value	User-defined?
Cini (mm)	91.22	No
Cmax (mm)	551.05	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	16.91	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m ³ /s)	0.02	No
BL (hr)	67.39	No
BR	2.05	No

Urbanisation parameters

Name	Value	User-defined?
Sewer capacity (m ³ /s)	0	No
Exporting drained area (km ²)	0	No
Urban area (km ²)	0.06	No
Urbext 2000	0.03	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
00:00:00	2.172	0.000	0.385	0.000	0.019	0.019
03:00:00	4.076	0.000	0.745	0.001	0.018	0.019
06:00:00	7.578	0.000	1.465	0.003	0.018	0.021
09:00:00	13.844	0.000	2.942	0.008	0.017	0.026
12:00:00	20.673	0.000	5.034	0.020	0.018	0.038
15:00:00	13.844	0.000	3.799	0.043	0.020	0.063
18:00:00	7.578	0.000	2.225	0.078	0.023	0.102
21:00:00	4.076	0.000	1.239	0.120	0.030	0.151
24:00:00	2.172	0.000	0.673	0.163	0.041	0.204
27:00:00	0.000	0.000	0.000	0.201	0.054	0.255
30:00:00	0.000	0.000	0.000	0.227	0.069	0.296
33:00:00	0.000	0.000	0.000	0.232	0.085	0.318
36:00:00	0.000	0.000	0.000	0.222	0.101	0.323
39:00:00	0.000	0.000	0.000	0.201	0.115	0.316
42:00:00	0.000	0.000	0.000	0.176	0.126	0.302
45:00:00	0.000	0.000	0.000	0.150	0.135	0.285
48:00:00	0.000	0.000	0.000	0.126	0.141	0.267
51:00:00	0.000	0.000	0.000	0.107	0.145	0.252
54:00:00	0.000	0.000	0.000	0.090	0.147	0.237
57:00:00	0.000	0.000	0.000	0.075	0.148	0.223
60:00:00	0.000	0.000	0.000	0.062	0.148	0.210
63:00:00	0.000	0.000	0.000	0.049	0.146	0.196
66:00:00	0.000	0.000	0.000	0.037	0.144	0.181
69:00:00	0.000	0.000	0.000	0.026	0.141	0.167
72:00:00	0.000	0.000	0.000	0.016	0.136	0.153
75:00:00	0.000	0.000	0.000	0.009	0.132	0.140
78:00:00	0.000	0.000	0.000	0.004	0.127	0.130
81:00:00	0.000	0.000	0.000	0.001	0.121	0.123
84:00:00	0.000	0.000	0.000	0.000	0.116	0.116
87:00:00	0.000	0.000	0.000	0.000	0.111	0.111
90:00:00	0.000	0.000	0.000	0.000	0.106	0.106
93:00:00	0.000	0.000	0.000	0.000	0.102	0.102
96:00:00	0.000	0.000	0.000	0.000	0.097	0.097
99:00:00	0.000	0.000	0.000	0.000	0.093	0.093
102:00:00	0.000	0.000	0.000	0.000	0.089	0.089

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
105:00:00	0.000	0.000	0.000	0.000	0.085	0.085
108:00:00	0.000	0.000	0.000	0.000	0.081	0.081
111:00:00	0.000	0.000	0.000	0.000	0.078	0.078
114:00:00	0.000	0.000	0.000	0.000	0.074	0.074
117:00:00	0.000	0.000	0.000	0.000	0.071	0.071
120:00:00	0.000	0.000	0.000	0.000	0.068	0.068
123:00:00	0.000	0.000	0.000	0.000	0.065	0.065
126:00:00	0.000	0.000	0.000	0.000	0.062	0.062
129:00:00	0.000	0.000	0.000	0.000	0.060	0.060
132:00:00	0.000	0.000	0.000	0.000	0.057	0.057
135:00:00	0.000	0.000	0.000	0.000	0.054	0.054
138:00:00	0.000	0.000	0.000	0.000	0.052	0.052
141:00:00	0.000	0.000	0.000	0.000	0.050	0.050
144:00:00	0.000	0.000	0.000	0.000	0.048	0.048
147:00:00	0.000	0.000	0.000	0.000	0.046	0.046
150:00:00	0.000	0.000	0.000	0.000	0.044	0.044
153:00:00	0.000	0.000	0.000	0.000	0.042	0.042
156:00:00	0.000	0.000	0.000	0.000	0.040	0.040
159:00:00	0.000	0.000	0.000	0.000	0.038	0.038
162:00:00	0.000	0.000	0.000	0.000	0.036	0.036
165:00:00	0.000	0.000	0.000	0.000	0.035	0.035
168:00:00	0.000	0.000	0.000	0.000	0.033	0.033
171:00:00	0.000	0.000	0.000	0.000	0.032	0.032
174:00:00	0.000	0.000	0.000	0.000	0.031	0.031
177:00:00	0.000	0.000	0.000	0.000	0.029	0.029
180:00:00	0.000	0.000	0.000	0.000	0.028	0.028
183:00:00	0.000	0.000	0.000	0.000	0.027	0.027
186:00:00	0.000	0.000	0.000	0.000	0.026	0.026
189:00:00	0.000	0.000	0.000	0.000	0.024	0.024
192:00:00	0.000	0.000	0.000	0.000	0.023	0.023
195:00:00	0.000	0.000	0.000	0.000	0.022	0.022
198:00:00	0.000	0.000	0.000	0.000	0.021	0.021
201:00:00	0.000	0.000	0.000	0.000	0.020	0.020
204:00:00	0.000	0.000	0.000	0.000	0.020	0.020

Appendix

Catchment descriptors *

Name	Value	User-defined value used?
Area (km ²)	1.43 [24.47]	Yes
ALTBAR	10	No
ASPBAR	78	No
ASPVAR	0.55	No
BFIHOST	0.53	No
BFIHOST19	0.59	No
DPLBAR (km)	7.79	No
DPSBAR (mkm ⁻¹)	7.1	No
FARL	0.96	No
LDP	16.09	No
PROPWET	0.24	No
RMED1H	11.5	No
RMED1D	30	No
RMED2D	38.8	No
SAAR (mm)	588	No
SAAR4170 (mm)	578	No
SPRHOST	32.94	No
Urbext2000	0.03	No
Urbext1990	0.03	No
URBCONC	0.78	No
URBLOC	1.23	No
DDF parameter C	-0.02	No
DDF parameter D1	0.29	No
DDF parameter D2	0.34	No
DDF parameter D3	0.25	No
DDF parameter E	0.31	No
DDF parameter F	2.54	No
DDF parameter C (1km grid value)	-0.02	No
DDF parameter D1 (1km grid value)	0.3	No
DDF parameter D2 (1km grid value)	0.32	No
DDF parameter D3 (1km grid value)	0.25	No
DDF parameter E (1km grid value)	0.3	No
DDF parameter F (1km grid value)	2.54	No

Values in square brackets are the original values loaded from the FEH Web Service or FEH CD-ROM

UK Design Flood Estimation

Generated on Wednesday, May 7, 2025 2:46:51 PM by [REDACTED]
Printed from the ReFH2 Flood Modelling software package, version 4.0.8560.23190

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

Site detailsChecksum: 577D-C168

Site name: FEH_Catchment_Descriptors_481500_385550_v5_0_1

Easting: 481500

Northing: 385550

Country: England, Wales or Northern Ireland

Catchment Area (km²): 1.53 [24.47]*

Using plot scale calculations: No

Model: 2.3

Site description:None

Model run: 100 year 1.23 CC

Summary of results

Rainfall - FEH22 (mm):	114.41	Total runoff (ML):	28.31
Total Rainfall (mm):	75.99	Total flow (ML):	83.77
Peak Rainfall (mm):	20.67	Peak flow (m³/s):	0.35

Parameters

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

Rainfall parameters (Rainfall - FEH22)

Name	Value	User-defined?
Duration (hh:mm:ss)	27:00:00	No
Timestep (hh:mm:ss)	03:00:00	No
SCF (Seasonal correction factor)	0.67	No
ARF (Areal reduction factor)	0.99	No
Seasonality	Winter	No
Climate change factor	1.23	Yes

Loss model parameters

Name	Value	User-defined?
Cini (mm)	91.22	No
Cmax (mm)	551.05	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	16.91	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m ³ /s)	0.02	No
BL (hr)	67.39	No
BR	2.05	No

Urbanisation parameters

Name	Value	User-defined?
Sewer capacity (m ³ /s)	0	No
Exporting drained area (km ²)	0	No
Urban area (km ²)	0.06	No
Urbext 2000	0.03	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m³/s)	Net Rain (mm)	Runoff (m³/s)	Baseflow (m³/s)	Total Flow (m³/s)
00:00:00	2.172	0.000	0.385	0.000	0.021	0.021
03:00:00	4.075	0.000	0.745	0.001	0.020	0.020
06:00:00	7.576	0.000	1.465	0.003	0.019	0.022
09:00:00	13.839	0.000	2.941	0.009	0.019	0.027
12:00:00	20.667	0.000	5.032	0.021	0.019	0.040
15:00:00	13.839	0.000	3.798	0.046	0.021	0.067
18:00:00	7.576	0.000	2.224	0.084	0.025	0.109
21:00:00	4.075	0.000	1.239	0.129	0.033	0.161
24:00:00	2.172	0.000	0.672	0.175	0.043	0.218
27:00:00	0.000	0.000	0.000	0.215	0.058	0.273
30:00:00	0.000	0.000	0.000	0.242	0.074	0.316
33:00:00	0.000	0.000	0.000	0.249	0.091	0.340
36:00:00	0.000	0.000	0.000	0.237	0.108	0.345
39:00:00	0.000	0.000	0.000	0.215	0.123	0.338
42:00:00	0.000	0.000	0.000	0.188	0.135	0.323
45:00:00	0.000	0.000	0.000	0.161	0.144	0.304
48:00:00	0.000	0.000	0.000	0.135	0.150	0.286
51:00:00	0.000	0.000	0.000	0.114	0.155	0.269
54:00:00	0.000	0.000	0.000	0.096	0.157	0.254
57:00:00	0.000	0.000	0.000	0.081	0.158	0.239
60:00:00	0.000	0.000	0.000	0.066	0.158	0.224
63:00:00	0.000	0.000	0.000	0.053	0.157	0.209
66:00:00	0.000	0.000	0.000	0.040	0.154	0.194
69:00:00	0.000	0.000	0.000	0.028	0.150	0.178
72:00:00	0.000	0.000	0.000	0.017	0.146	0.163
75:00:00	0.000	0.000	0.000	0.009	0.141	0.150
78:00:00	0.000	0.000	0.000	0.004	0.135	0.139
81:00:00	0.000	0.000	0.000	0.002	0.130	0.131
84:00:00	0.000	0.000	0.000	0.000	0.124	0.125
87:00:00	0.000	0.000	0.000	0.000	0.119	0.119
90:00:00	0.000	0.000	0.000	0.000	0.114	0.114
93:00:00	0.000	0.000	0.000	0.000	0.109	0.109
96:00:00	0.000	0.000	0.000	0.000	0.104	0.104
99:00:00	0.000	0.000	0.000	0.000	0.099	0.099
102:00:00	0.000	0.000	0.000	0.000	0.095	0.095

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
105:00:00	0.000	0.000	0.000	0.000	0.091	0.091
108:00:00	0.000	0.000	0.000	0.000	0.087	0.087
111:00:00	0.000	0.000	0.000	0.000	0.083	0.083
114:00:00	0.000	0.000	0.000	0.000	0.080	0.080
117:00:00	0.000	0.000	0.000	0.000	0.076	0.076
120:00:00	0.000	0.000	0.000	0.000	0.073	0.073
123:00:00	0.000	0.000	0.000	0.000	0.070	0.070
126:00:00	0.000	0.000	0.000	0.000	0.067	0.067
129:00:00	0.000	0.000	0.000	0.000	0.064	0.064
132:00:00	0.000	0.000	0.000	0.000	0.061	0.061
135:00:00	0.000	0.000	0.000	0.000	0.058	0.058
138:00:00	0.000	0.000	0.000	0.000	0.056	0.056
141:00:00	0.000	0.000	0.000	0.000	0.053	0.053
144:00:00	0.000	0.000	0.000	0.000	0.051	0.051
147:00:00	0.000	0.000	0.000	0.000	0.049	0.049
150:00:00	0.000	0.000	0.000	0.000	0.047	0.047
153:00:00	0.000	0.000	0.000	0.000	0.045	0.045
156:00:00	0.000	0.000	0.000	0.000	0.043	0.043
159:00:00	0.000	0.000	0.000	0.000	0.041	0.041
162:00:00	0.000	0.000	0.000	0.000	0.039	0.039
165:00:00	0.000	0.000	0.000	0.000	0.037	0.037
168:00:00	0.000	0.000	0.000	0.000	0.036	0.036
171:00:00	0.000	0.000	0.000	0.000	0.034	0.034
174:00:00	0.000	0.000	0.000	0.000	0.033	0.033
177:00:00	0.000	0.000	0.000	0.000	0.031	0.031
180:00:00	0.000	0.000	0.000	0.000	0.030	0.030
183:00:00	0.000	0.000	0.000	0.000	0.029	0.029
186:00:00	0.000	0.000	0.000	0.000	0.027	0.027
189:00:00	0.000	0.000	0.000	0.000	0.026	0.026
192:00:00	0.000	0.000	0.000	0.000	0.025	0.025
195:00:00	0.000	0.000	0.000	0.000	0.024	0.024
198:00:00	0.000	0.000	0.000	0.000	0.023	0.023
201:00:00	0.000	0.000	0.000	0.000	0.022	0.022
204:00:00	0.000	0.000	0.000	0.000	0.021	0.021

Appendix

Catchment descriptors *

Name	Value	User-defined value used?
Area (km ²)	1.53 [24.47]	Yes
ALTBAR	10	No
ASPBAR	78	No
ASPVAR	0.55	No
BFIHOST	0.53	No
BFIHOST19	0.59	No
DPLBAR (km)	7.79	No
DPSBAR (mkm ⁻¹)	7.1	No
FARL	0.96	No
LDP	16.09	No
PROPWET	0.24	No
RMED1H	11.5	No
RMED1D	30	No
RMED2D	38.8	No
SAAR (mm)	588	No
SAAR4170 (mm)	578	No
SPRHOST	32.94	No
Urbext2000	0.03	No
Urbext1990	0.03	No
URBCONC	0.78	No
URBLOC	1.23	No
DDF parameter C	-0.02	No
DDF parameter D1	0.29	No
DDF parameter D2	0.34	No
DDF parameter D3	0.25	No
DDF parameter E	0.31	No
DDF parameter F	2.54	No
DDF parameter C (1km grid value)	-0.02	No
DDF parameter D1 (1km grid value)	0.3	No
DDF parameter D2 (1km grid value)	0.32	No
DDF parameter D3 (1km grid value)	0.25	No
DDF parameter E (1km grid value)	0.3	No
DDF parameter F (1km grid value)	2.54	No

Values in square brackets are the original values loaded from the FEH Web Service or FEH CD-ROM

Catchwater Drain

Timestep	Timestep	Q30	Timestep	Q100	Timestep	Q100.23	Timestep	Q1000
00:00:00	0.00	1.109622	0.00	1.109622	0.00	1.109622	0.00	1.109622
02:00:00	2.00	1.08741	2.00	1.093374	2.00	1.099683	2.00	1.110022
04:00:00	4.00	1.130036	4.00	1.159606	4.00	1.190951	4.00	1.242465
06:00:00	6.00	1.296088	6.00	1.384008	6.00	1.477609	6.00	1.632347
08:00:00	8.00	1.697522	8.00	1.913204	8.00	2.144657	8.00	2.531351
10:00:00	10.00	2.501768	10.00	2.971063	10.00	3.480372	10.00	4.343727
12:00:00	12.00	3.737981	12.00	4.601303	12.00	5.546921	12.00	7.168603
14:00:00	14.00	5.224018	14.00	6.566493	14.00	8.046126	14.00	10.60324
16:00:00	16.00	6.782555	16.00	8.632449	16.00	10.68	16.00	14.23694
18:00:00	18.00	8.229927	18.00	10.5571	18.00	13.14114	18.00	17.64729
20:00:00	20.00	9.297125	20.00	11.98367	20.00	14.97365	20.00	20.20219
22:00:00	22.00	9.705408	22.00	12.53558	22.00	15.68788	22.00	21.20522
24:00:00	24.00	9.556325	24.00	12.34094	24.00	15.43919	24.00	20.85478
26:00:00	26.00	9.063962	26.00	11.68406	26.00	14.59134	26.00	19.6562
28:00:00	28.00	8.383931	28.00	10.77423	28.00	13.41538	28.00	17.99286
30:00:00	30.00	7.631563	30.00	9.76668	30.00	12.11253	30.00	16.14966
32:00:00	32.00	6.936822	32.00	8.836943	32.00	10.91099	32.00	14.45106
34:00:00	34.00	6.348415	34.00	8.05166	34.00	9.898448	34.00	13.02386
36:00:00	36.00	5.830187	36.00	7.363612	36.00	9.015486	36.00	11.78754
38:00:00	38.00	5.345172	38.00	6.723087	38.00	8.197728	38.00	10.65105
40:00:00	40.00	4.87132	40.00	6.100036	40.00	7.405764	40.00	9.55764
42:00:00	42.00	4.39731	42.00	5.478573	42.00	6.618191	42.00	8.475352
44:00:00	44.00	3.92222	44.00	4.856404	44.00	5.830738	44.00	7.395502
46:00:00	46.00	3.459897	46.00	4.251317	46.00	5.065408	46.00	6.347101
48:00:00	48.00	3.03686	48.00	3.697906	48.00	4.365671	48.00	5.388918
50:00:00	50.00	2.695143	50.00	3.252051	50.00	3.803082	50.00	4.620475
52:00:00	52.00	2.457356	52.00	2.944924	52.00	3.418947	52.00	4.10206
54:00:00	54.00	2.293032	54.00	2.736724	54.00	3.163168	54.00	3.765763
56:00:00	56.00	2.172321	56.00	2.58737	56.00	2.98391	56.00	3.538424
58:00:00	58.00	2.077312	58.00	2.472534	58.00	2.849373	58.00	3.37446
60:00:00	60.00	1.995296	60.00	2.374873	60.00	2.736776	60.00	3.241007
62:00:00	62.00	1.916738	62.00	2.281371	62.00	2.629025	62.00	3.113403
64:00:00	64.00	1.841273	64.00	2.19155	64.00	2.525517	64.00	2.990824
66:00:00	66.00	1.76878	66.00	2.105265	66.00	2.426083	66.00	2.873071
68:00:00	68.00	1.69914	68.00	2.022378	68.00	2.330565	68.00	2.759954
70:00:00	70.00	1.632242	70.00	1.942754	70.00	2.238807	70.00	2.65129
72:00:00	72.00	1.567979	72.00	1.866265	72.00	2.150662	72.00	2.546905
74:00:00	74.00	1.506245	74.00	1.792787	74.00	2.065987	74.00	2.446629
76:00:00	76.00	1.446942	76.00	1.722202	76.00	1.984646	76.00	2.350302
78:00:00	78.00	1.389974	78.00	1.654397	78.00	1.906507	78.00	2.257767
80:00:00	80.00	1.335248	80.00	1.589261	80.00	1.831445	80.00	2.168875
82:00:00	82.00	1.282678	82.00	1.526689	82.00	1.759339	82.00	2.083484
84:00:00	84.00	1.232177	84.00	1.466581	84.00	1.690071	84.00	2.001454
86:00:00	86.00	1.183664	86.00	1.40884	86.00	1.62353	86.00	1.922654
88:00:00	88.00	1.137061	88.00	1.353372	88.00	1.559609	88.00	1.846956
90:00:00	90.00	0	90.00	1.300087	90.00	1.498205	90.00	1.774238
92:00:00	92.00	0	92.00	1.248901	92.00	1.439219	92.00	1.704384

94:00:00	94.00	0	94.00	1.19973	94.00	1.382555	94.00	1.63728
96:00:00	96.00	0	96.00	1.152495	96.00	1.328121	96.00	1.572818
98:00:00	98.00	0	98.00	0	98.00	1.275831	98.00	1.510894
100:00:00	100.00	0	100.00	0	100.00	1.2256	100.00	1.451407
102:00:00	102.00	0	102.00	0	102.00	1.177346	102.00	1.394263
104:00:00	104.00	0	104.00	0	104.00	1.130992	104.00	1.339369
106:00:00	106.00	0	106.00	0	106.00	0	106.00	1.286636
108:00:00	108.00	0	108.00	0	108.00	0	108.00	1.235979
110:00:00	110.00	0	110.00	0	110.00	0	110.00	1.187317
112:00:00	112.00	0	112.00	0	112.00	0	112.00	1.140571

Mother Drain

Time	Timestep	Q30	Timestep	Q100	Timestep	Q100.23	Timestep	Q1000
00:00:00	0	0.335537	0	0.335537	0	0.335537	0	0.335537
03:00:00	3	0.326369	3	0.327929	3	0.329555	3	0.332222
06:00:00	6	0.334167	6	0.342041	6	0.350281	6	0.363874
09:00:00	9	0.374922	9	0.398863	9	0.424106	9	0.46616
12:00:00	12	0.479982	12	0.540343	12	0.604767	12	0.713788
15:00:00	15	0.698748	15	0.834425	15	0.981576	15	1.235554
18:00:00	18	1.046588	18	1.304253	18	1.587329	18	2.083498
21:00:00	21	1.48112	21	1.894269	21	2.352261	21	3.163491
24:00:00	24	1.956927	24	2.543488	24	3.197979	24	4.365983
27:00:00	27	2.424728	27	3.185681	27	4.039265	27	5.571733
30:00:00	30	2.808928	30	3.718139	30	4.742624	30	6.591206
33:00:00	33	3.023342	33	4.020893	33	5.148662	33	7.191136
36:00:00	36	3.080466	36	4.107627	36	5.271188	36	7.383108
39:00:00	39	3.030572	39	4.045939	39	5.197206	39	7.288927
42:00:00	42	2.913123	42	3.89001	42	4.997824	42	7.010926
45:00:00	45	2.758585	45	3.681814	45	4.728299	45	6.628963
48:00:00	48	2.60362	48	3.472235	48	4.456053	48	6.241356
51:00:00	51	2.465667	51	3.28586	51	4.214125	51	5.897176
54:00:00	54	2.338245	54	3.114401	54	3.992361	54	5.583255
57:00:00	57	2.212836	57	2.946222	57	3.775562	57	5.277857
60:00:00	60	2.084198	60	2.774022	60	3.554018	60	4.966751
63:00:00	63	1.949522	63	2.593751	63	3.322182	63	4.641485
66:00:00	66	1.808477	66	2.404597	66	3.078559	66	4.299054
69:00:00	69	1.66485	69	2.211517	69	2.829362	69	3.947808
72:00:00	72	1.525865	72	2.02413	72	2.586859	72	3.60469
75:00:00	75	1.40361	75	1.858914	75	2.372529	75	3.30032
78:00:00	78	1.307593	78	1.729318	78	2.204492	78	3.061701
81:00:00	81	1.232072	81	1.627956	81	2.073644	81	2.876919
84:00:00	84	1.169717	84	1.544822	84	1.96693	84	2.727321
87:00:00	87	1.115842	87	1.473412	87	1.875721	87	2.600312
90:00:00	90	1.067123	90	1.409069	90	1.793796	90	2.486714
93:00:00	93	1.020662	93	1.347721	93	1.715698	93	2.378447
96:00:00	96	0.976224	96	1.289043	96	1.640999	96	2.274894
99:00:00	99	0.933721	99	1.232921	99	1.569553	99	2.175849
102:00:00	102	0.893069	102	1.179242	102	1.501218	102	2.081117
105:00:00	105	0.854186	105	1.1279	105	1.435857	105	1.990509
108:00:00	108	0.816996	108	1.078793	108	1.373343	108	1.903845
111:00:00	111	0.781426	111	1.031824	111	1.31355	111	1.820955
114:00:00	114	0.747404	114	0.986901	114	1.25636	114	1.741674
117:00:00	117	0.714863	117	0.943933	117	1.201661	117	1.665845
120:00:00	120	0.68374	120	0.902836	120	1.149342	120	1.593317
123:00:00	123	0.653971	123	0.863528	123	1.099302	123	1.523947
126:00:00	126	0.625498	126	0.825931	126	1.051441	126	1.457597
129:00:00	129	0.598265	129	0.789972	129	1.005663	129	1.394136
132:00:00	132	0.572218	132	0.755578	132	0.961878	132	1.333438
135:00:00	135	0.547304	135	0.722681	135	0.92	135	1.275382
138:00:00	138	0.523476	138	0.691217	138	0.879944	138	1.219854

141:00:00	141	0.500685	141	0.661123	141	0.841633	141	1.166744
144:00:00	144	0.478886	144	0.632339	144	0.80499	144	1.115946
147:00:00	147	0.458036	147	0.604808	147	0.769942	147	1.06736
150:00:00	150	0.438094	150	0.578476	150	0.73642	150	1.020889
153:00:00	153	0.41902	153	0.55329	153	0.704358	153	0.976441
156:00:00	156	0.400777	156	0.529201	156	0.673692	156	0.933929
159:00:00	159	0.383328	159	0.50616	159	0.64436	159	0.893267
162:00:00	162	0.366638	162	0.484123	162	0.616306	162	0.854376
165:00:00	165	0.350675	165	0.463045	165	0.589473	165	0.817178
168:00:00	168	0	168	0.442885	168	0.563808	168	0.7816
171:00:00	171	0	171	0.423602	171	0.539261	171	0.74757
174:00:00	174	0	174	0.40516	174	0.515783	174	0.715022
177:00:00	177	0	177	0.38752	177	0.493327	177	0.683892
180:00:00	180	0	180	0.370648	180	0.471848	180	0.654116
183:00:00	183	0	183	0.35451	183	0.451305	183	0.625637
186:00:00	186	0	186	0.339076	186	0.431656	186	0.598398
189:00:00	189	0	189	0	189	0.412862	189	0.572345
192:00:00	192	0	192	0	192	0.394887	192	0.547426
195:00:00	195	0	195	0	195	0.377694	195	0.523592
198:00:00	198	0	198	0	198	0.36125	198	0.500796
201:00:00	201	0	201	0	201	0.345522	201	0.478992
204:00:00	204	0	204	0	204	0	204	0.458138
207:00:00	207	0	207	0	207	0	207	0.438191
210:00:00	210	0	210	0	210	0	210	0.419113
213:00:00	213	0	213	0	213	0	213	0.400866
216:00:00	216	0	216	0	216	0	216	0.383413
219:00:00	219	0	219	0	219	0	219	0.36672
222:00:00	222	0	222	0	222	0	222	0.350753

New Ings Drain North (1.43km2)

Time	Timestep	Q30	Timestep	Q100	Timestep	Q100.23	Timestep	Q1000
00:00:00	0	0.019612	0	0.019612	0	0.019612	0	0.019612
03:00:00	3	0.019083	3	0.019176	3	0.019273	3	0.019433
06:00:00	6	0.019566	6	0.020036	6	0.020529	6	0.021341
09:00:00	9	0.022017	9	0.023448	9	0.024957	9	0.027471
12:00:00	12	0.028313	12	0.031923	12	0.035779	12	0.042308
15:00:00	15	0.041416	15	0.049543	15	0.058364	15	0.073602
18:00:00	18	0.062257	18	0.077708	18	0.094698	18	0.124509
21:00:00	21	0.088301	21	0.113095	21	0.140607	21	0.189395
24:00:00	24	0.11683	24	0.152051	24	0.191392	24	0.261683
27:00:00	27	0.144892	27	0.190606	27	0.24194	27	0.334214
30:00:00	30	0.167956	30	0.222599	30	0.284238	30	0.395594
33:00:00	33	0.180848	33	0.240818	33	0.308692	33	0.431769
36:00:00	36	0.184305	36	0.246067	36	0.316108	36	0.443393
39:00:00	39	0.181338	39	0.242395	39	0.311702	39	0.437782
42:00:00	42	0.174314	42	0.233058	42	0.29975	42	0.421092
45:00:00	45	0.16506	45	0.220575	45	0.283572	45	0.398132
48:00:00	48	0.155778	48	0.208005	48	0.267226	48	0.374824
51:00:00	51	0.147515	51	0.196828	51	0.2527	51	0.354128
54:00:00	54	0.139886	54	0.186549	54	0.239391	54	0.33526
57:00:00	57	0.132379	57	0.176469	57	0.226383	57	0.316911
60:00:00	60	0.12468	60	0.166151	60	0.213095	60	0.298224
63:00:00	63	0.116619	63	0.155349	63	0.199189	63	0.278688
66:00:00	66	0.108176	66	0.144013	66	0.184575	66	0.258119
69:00:00	69	0.099576	69	0.13244	69	0.169623	69	0.237016
72:00:00	72	0.091253	72	0.121204	72	0.155068	72	0.216394
75:00:00	75	0.08393	75	0.111296	75	0.142201	75	0.198095
78:00:00	78	0.078179	78	0.103525	78	0.132114	78	0.183749
81:00:00	81	0.073659	81	0.097449	81	0.124262	81	0.172645
84:00:00	84	0.069928	84	0.092469	84	0.117862	84	0.16366
87:00:00	87	0.066706	87	0.088193	87	0.112395	87	0.156036
90:00:00	90	0.063794	90	0.084342	90	0.107486	90	0.149219
93:00:00	93	0.061016	93	0.08067	93	0.102806	93	0.142723
96:00:00	96	0.05836	96	0.077158	96	0.09833	96	0.136509
99:00:00	99	0.055819	99	0.073798	99	0.094049	99	0.130565
102:00:00	102	0.053389	102	0.070585	102	0.089954	102	0.124881
105:00:00	105	0.051064	105	0.067512	105	0.086038	105	0.119444
108:00:00	108	0.048841	108	0.064573	108	0.082292	108	0.114243
111:00:00	111	0.046715	111	0.061761	111	0.078709	111	0.109269
114:00:00	114	0.044681	114	0.059072	114	0.075282	114	0.104512
117:00:00	117	0.042735	117	0.056501	117	0.072005	117	0.099962
120:00:00	120	0.040875	120	0.054041	120	0.06887	120	0.09561
123:00:00	123	0.039095	123	0.051688	123	0.065871	123	0.091447
126:00:00	126	0.037393	126	0.049437	126	0.063003	126	0.087465
129:00:00	129	0.035765	129	0.047285	129	0.06026	129	0.083657
132:00:00	132	0.034208	132	0.045226	132	0.057637	132	0.080015
135:00:00	135	0.032718	135	0.043257	135	0.055127	135	0.076531
138:00:00	138	0.031294	138	0.041374	138	0.052727	138	0.073199

141:00:00	141	0.029932	141	0.039573	141	0.050431	141	0.070012
144:00:00	144	0.028628	144	0.03785	144	0.048236	144	0.066964
147:00:00	147	0.027382	147	0.036202	147	0.046136	147	0.064049
150:00:00	150	0.02619	150	0.034626	150	0.044127	150	0.06126
153:00:00	153	0.02505	153	0.033118	153	0.042206	153	0.058593
156:00:00	156	0.023959	156	0.031676	156	0.040368	156	0.056042
159:00:00	159	0.022916	159	0.030297	159	0.038611	159	0.053602
162:00:00	162	0.021918	162	0.028978	162	0.03693	162	0.051268
165:00:00	165	0.020964	165	0.027716	165	0.035322	165	0.049036
168:00:00	168	0.020051	168	0.02651	168	0.033784	168	0.046901
171:00:00	171	0	171	0.025355	171	0.032313	171	0.044859
174:00:00	174	0	174	0.024251	174	0.030906	174	0.042906
177:00:00	177	0	177	0.023196	177	0.029561	177	0.041038
180:00:00	180	0	180	0.022186	180	0.028274	180	0.039251
183:00:00	183	0	183	0.02122	183	0.027043	183	0.037542
186:00:00	186	0	186	0.020296	186	0.025865	186	0.035908
189:00:00	189	0	189	0	189	0.024739	189	0.034344
192:00:00	192	0	192	0	192	0.023662	192	0.032849
195:00:00	195	0	195	0	195	0.022632	195	0.031419
198:00:00	198	0	198	0	198	0.021646	198	0.030051
201:00:00	201	0	201	0	201	0.020704	201	0.028743
204:00:00	204	0	204	0	204	0.019803	204	0.027491
207:00:00	207	0	207	0	207	0	207	0.026294
210:00:00	210	0	210	0	210	0	210	0.02515
213:00:00	213	0	213	0	213	0	213	0.024055
216:00:00	216	0	216	0	216	0	216	0.023007
219:00:00	219	0	219	0	219	0	219	0.022006
222:00:00	222	0	222	0	222	0	222	0.021048
225:00:00	225	0	225	0	225	0	225	0.020131

New Ings Drain South (1.53km2)

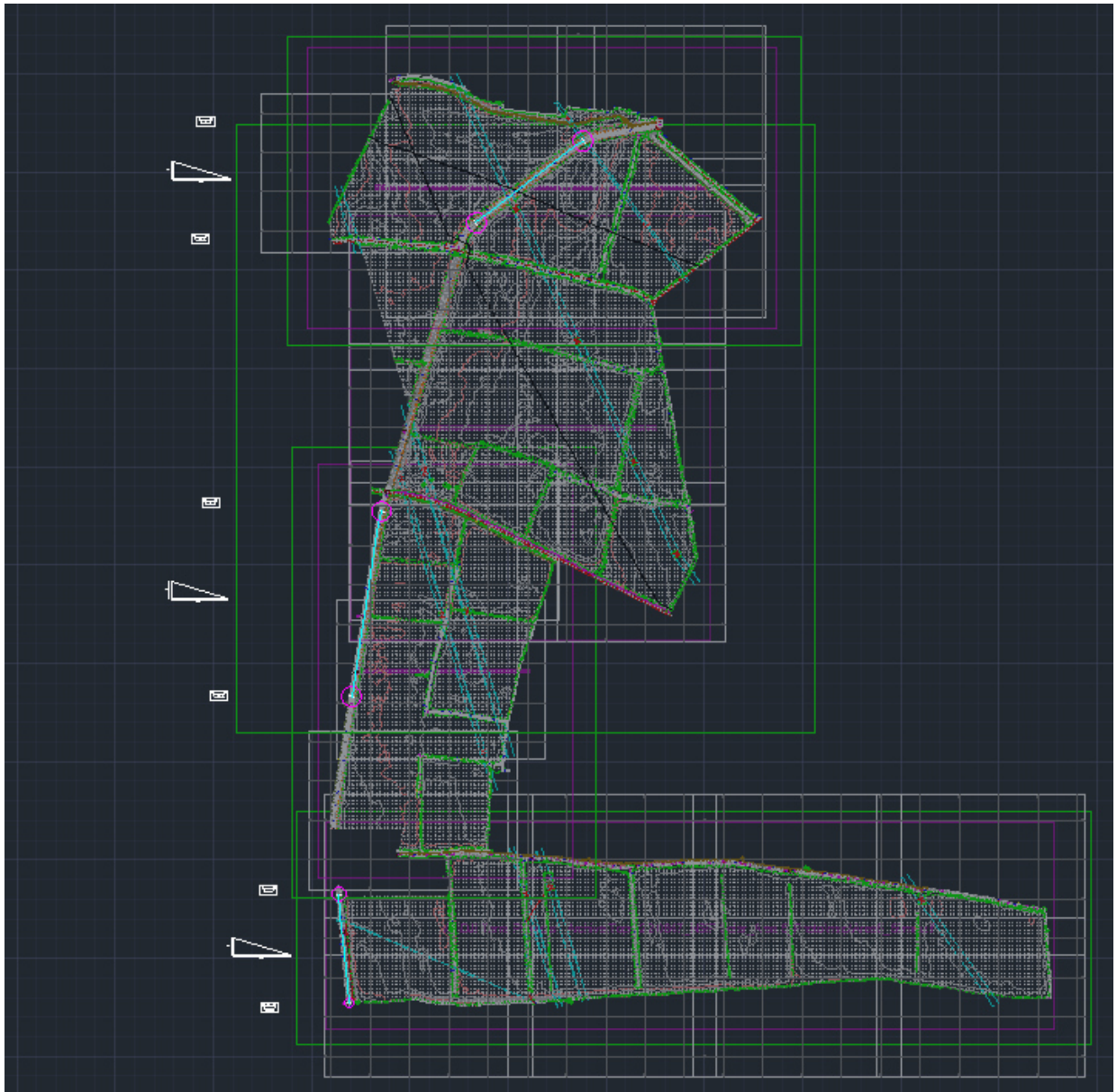
Time	Timestep	Q30	Timestep	Q100	Timestep	Q100.23	Timestep	Q1000
00:00:00	0	0.020984	0	0.020984	0	0.020984	0	0.020984
03:00:00	3	0.020418	3	0.020517	3	0.020621	3	0.020791
06:00:00	6	0.020934	6	0.021437	6	0.021963	6	0.022832
09:00:00	9	0.023555	9	0.025085	9	0.026699	9	0.029389
12:00:00	12	0.030288	12	0.03415	12	0.038274	12	0.045257
15:00:00	15	0.044303	15	0.052995	15	0.062429	15	0.078727
18:00:00	18	0.066593	18	0.083118	18	0.101289	18	0.133172
21:00:00	21	0.094448	21	0.120966	21	0.15039	21	0.202567
24:00:00	24	0.12496	24	0.162629	24	0.204704	24	0.279877
27:00:00	27	0.154973	27	0.203864	27	0.258765	27	0.357447
30:00:00	30	0.179641	30	0.238081	30	0.304001	30	0.423091
33:00:00	33	0.193428	33	0.257565	33	0.330154	33	0.461777
36:00:00	36	0.197125	36	0.263178	36	0.338084	36	0.474208
39:00:00	39	0.193952	39	0.259251	39	0.333372	39	0.468206
42:00:00	42	0.186438	42	0.249264	42	0.320588	42	0.450357
45:00:00	45	0.176541	45	0.235913	45	0.303286	45	0.425801
48:00:00	48	0.166613	48	0.222469	48	0.285803	48	0.400873
51:00:00	51	0.157776	51	0.210515	51	0.270269	51	0.37874
54:00:00	54	0.149616	54	0.199521	54	0.256034	54	0.35856
57:00:00	57	0.141587	57	0.188741	57	0.242122	57	0.338936
60:00:00	60	0.133353	60	0.177705	60	0.22791	60	0.318951
63:00:00	63	0.124731	63	0.166152	63	0.213038	63	0.298058
66:00:00	66	0.115701	66	0.154028	66	0.197407	66	0.276059
69:00:00	69	0.106503	69	0.14165	69	0.181416	69	0.253489
72:00:00	72	0.097601	72	0.129634	72	0.16585	72	0.231434
75:00:00	75	0.089769	75	0.119037	75	0.152088	75	0.211864
78:00:00	78	0.083618	78	0.110725	78	0.1413	78	0.196522
81:00:00	81	0.078783	81	0.104227	81	0.132902	81	0.184646
84:00:00	84	0.074793	84	0.0989	84	0.126057	84	0.175036
87:00:00	87	0.071347	87	0.094327	87	0.12021	87	0.166882
90:00:00	90	0.068232	90	0.090208	90	0.11496	90	0.159592
93:00:00	93	0.065261	93	0.086281	93	0.109955	93	0.152643
96:00:00	96	0.06242	96	0.082524	96	0.105167	96	0.145998
99:00:00	99	0.059702	99	0.078931	99	0.100589	99	0.139641
102:00:00	102	0.057103	102	0.075495	102	0.096209	102	0.133561
105:00:00	105	0.054617	105	0.072208	105	0.09202	105	0.127746
108:00:00	108	0.052239	108	0.069064	108	0.088014	108	0.122184
111:00:00	111	0.049965	111	0.066057	111	0.084182	111	0.116865
114:00:00	114	0.047789	114	0.063181	114	0.080517	114	0.111777
117:00:00	117	0.045709	117	0.06043	117	0.077011	117	0.10691
120:00:00	120	0.043718	120	0.057799	120	0.073658	120	0.102255
123:00:00	123	0.041815	123	0.055283	123	0.070451	123	0.097803
126:00:00	126	0.039994	126	0.052876	126	0.067384	126	0.093545
129:00:00	129	0.038253	129	0.050574	129	0.06445	129	0.089472
132:00:00	132	0.036588	132	0.048372	132	0.061644	132	0.085577
135:00:00	135	0.034995	135	0.046266	135	0.05896	135	0.081851
138:00:00	138	0.033471	138	0.044251	138	0.056393	138	0.078287

141:00:00	141	0.032014	141	0.042325	141	0.053938	141	0.074879
144:00:00	144	0.03062	144	0.040482	144	0.05159	144	0.071619
147:00:00	147	0.029287	147	0.03872	147	0.049344	147	0.068501
150:00:00	150	0.028012	150	0.037034	150	0.047195	150	0.065518
153:00:00	153	0.026792	153	0.035421	153	0.04514	153	0.062666
156:00:00	156	0.025626	156	0.033879	156	0.043175	156	0.059937
159:00:00	159	0.02451	159	0.032404	159	0.041295	159	0.057328
162:00:00	162	0.023443	162	0.030993	162	0.039497	162	0.054832
165:00:00	165	0.022422	165	0.029644	165	0.037778	165	0.052445
168:00:00	168	0.021446	168	0.028353	168	0.036133	168	0.050161
171:00:00	171	0	171	0.027119	171	0.03456	171	0.047977
174:00:00	174	0	174	0.025938	174	0.033055	174	0.045889
177:00:00	177	0	177	0.024809	177	0.031616	177	0.043891
180:00:00	180	0	180	0.023729	180	0.03024	180	0.04198
183:00:00	183	0	183	0.022696	183	0.028923	183	0.040152
186:00:00	186	0	186	0.021708	186	0.027664	186	0.038404
189:00:00	189	0	189	0	189	0.026459	189	0.036732
192:00:00	192	0	192	0	192	0.025307	192	0.035133
195:00:00	195	0	195	0	195	0.024205	195	0.033603
198:00:00	198	0	198	0	198	0.023152	198	0.03214
201:00:00	201	0	201	0	201	0.022144	201	0.030741
204:00:00	204	0	204	0	204	0.021179	204	0.029402
207:00:00	207	0	207	0	207	0	207	0.028122
210:00:00	210	0	210	0	210	0	210	0.026898
213:00:00	213	0	213	0	213	0	213	0.025727
216:00:00	216	0	216	0	216	0	216	0.024607
219:00:00	219	0	219	0	219	0	219	0.023535
222:00:00	222	0	222	0	222	0	222	0.022511
225:00:00	225	0	225	0	225	0	225	0.02153

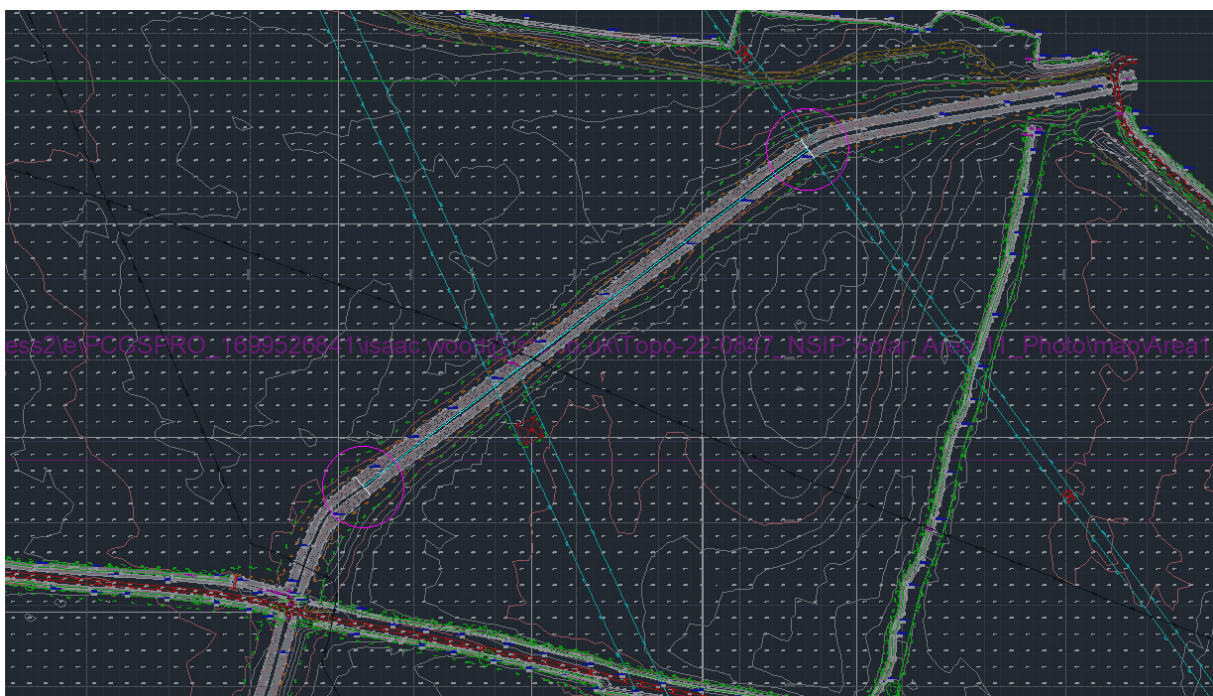
APPENDIX B

MANNINGS ASSESSMENT CHANNEL CAPACITY CALCULATIONS

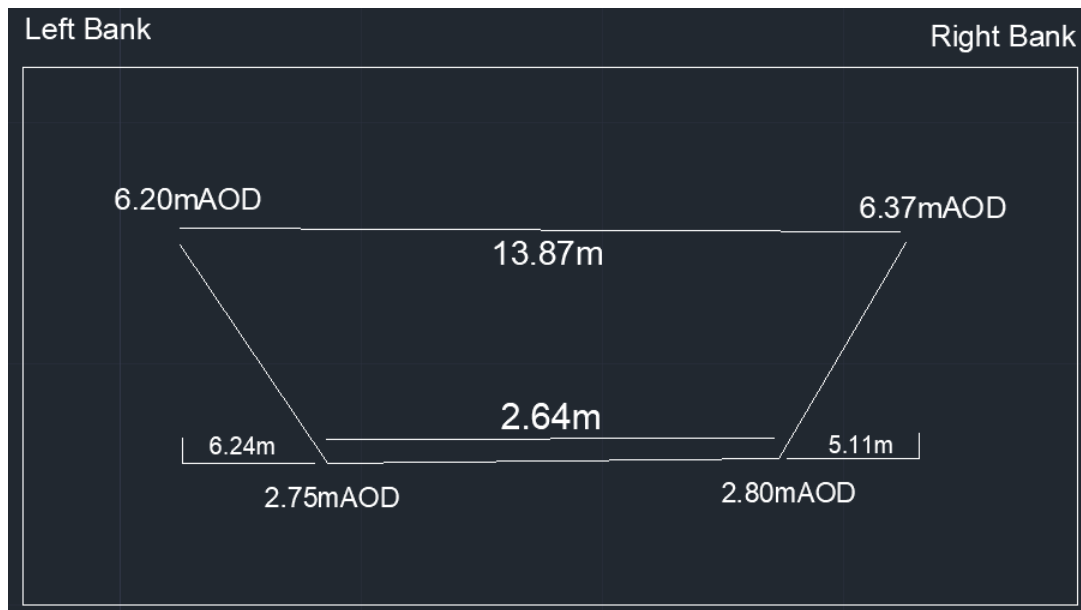
Catchwater Drain



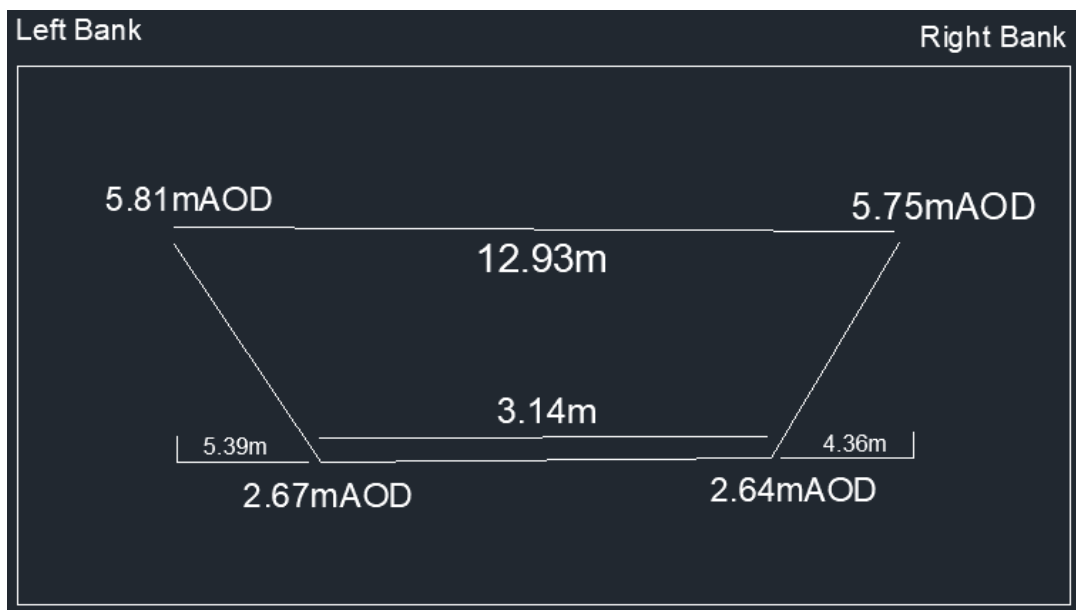
Catchwater Drain (3)



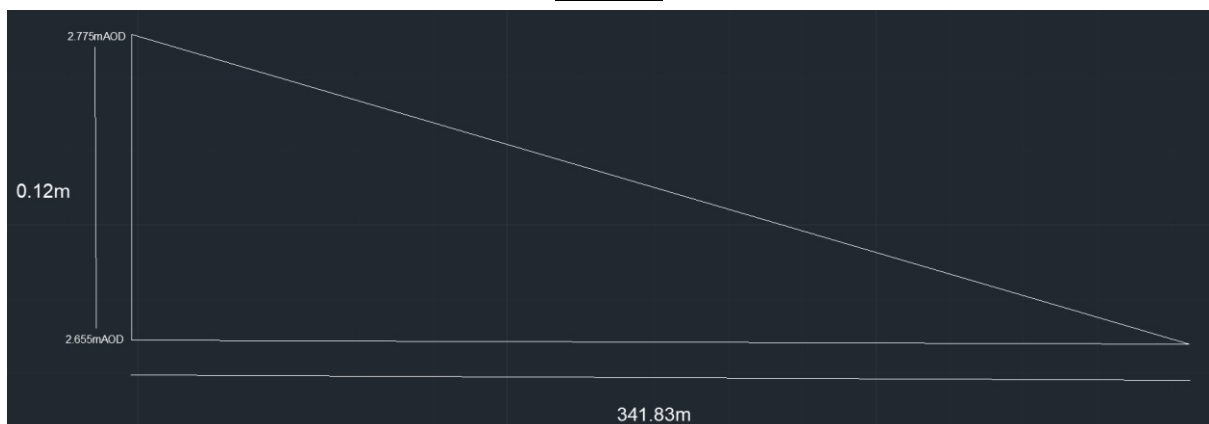
Southern Cross Section



Northern Cross Section



Channel



Inputs

Channel Slope = $dy/dx = 0.12\text{m} / 341.83\text{m} = \mathbf{0.000351}$

Max Water Depth = average of bank depths = $((5.81\text{mAOD} - 2.67\text{mAOD}) + (5.75\text{mAOD} - 2.64\text{mAOD}) + (6.20\text{mAOD} - 2.75\text{mAOD}) + (6.37\text{mAOD} - 2.80\text{mAOD})) / 4 = \mathbf{3.31\text{m}}$

Bed Width = average of north and south = $(3.14\text{m} + 2.64\text{m}) / 2 = \mathbf{2.89\text{m}}$

Left Slope (south) = $dy/dx = (6.20\text{mAOD} - 2.75\text{mAOD}) / 6.24\text{m} = 0.552$

Left Slope (north) = $dy/dx = (5.81\text{mAOD} - 2.67\text{mAOD}) / 5.39\text{m} = 0.582$

Left Slope = $(0.552 + 0.582) / 2 = \mathbf{0.567}$

Right Slope (south) = $dy/dx = (6.37\text{mAOD} - 2.80\text{mAOD}) / 5.11\text{m} = 0.698$

Right Slope (north) = $dy/dx = (5.75\text{mAOD} - 2.64\text{mAOD}) / 4.36\text{m} = 0.713$

Right Slope = $(0.698 + 0.713) / 2 = \mathbf{0.705}$

Mannings Value = **0.03**

The open channel flow calculator			
Select Channel Type: Trapezoid			
Velocity(V)&Discharge(Q)		Select unit system: Meter(m)	
Channel slope: 0.000351 m/m	Water depth(y): 3.31 m	Bottom width(b): 2.89 m	
Flow velocity: 0.8324 m/s	LeftSlope (z1): 0.567 z1/y	RightSlope (z2): 0.705 z2/y	
Flow discharge: 13.7623 m³/s	Input n value: 0.03 or select n	Reset	
Calculate!	Status: Calculation finished	Top width(T): 7.1 m	
Wetted perimeter: 10.74 m	Flow area: 16.53 m²	Flow status: Subcritical flow	
Specific energy: 3.35 m	Froude number: 0.17	Velocity head: 0.04 m	
Critical depth: 1.21 m	Critical slope: 0.0125 m/m		

Channel Capacity = **13.76m³/s**

Model run: 100 year 1.23 CC

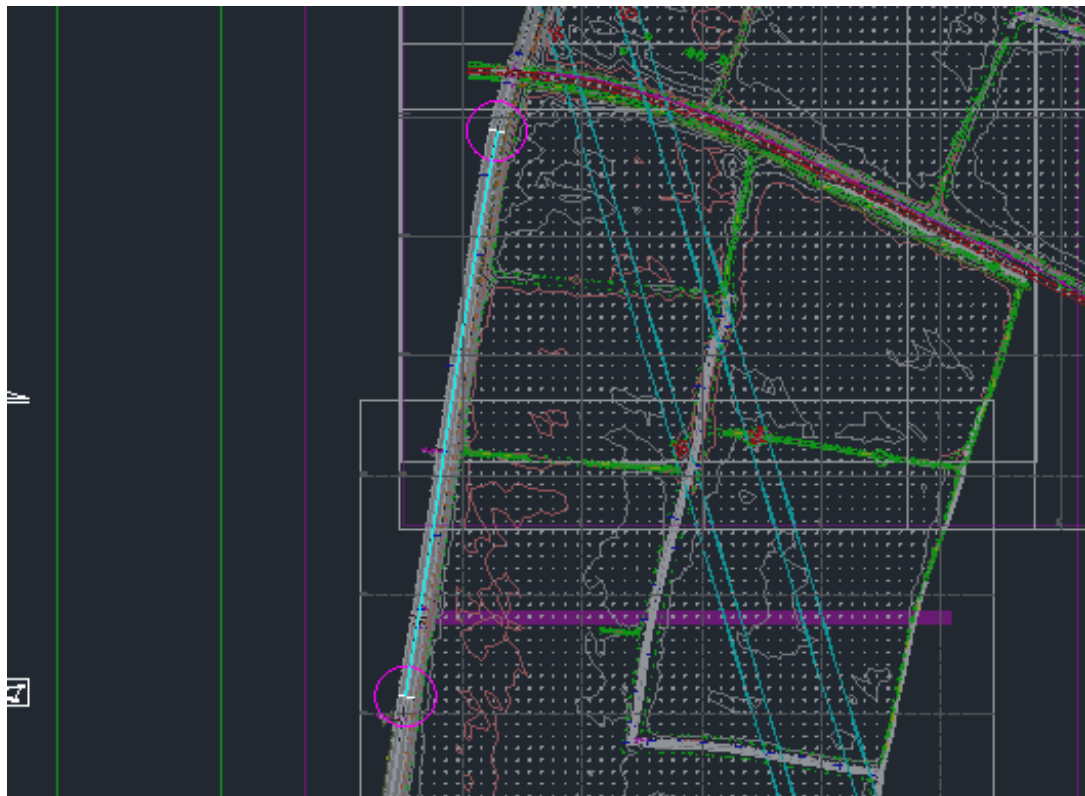
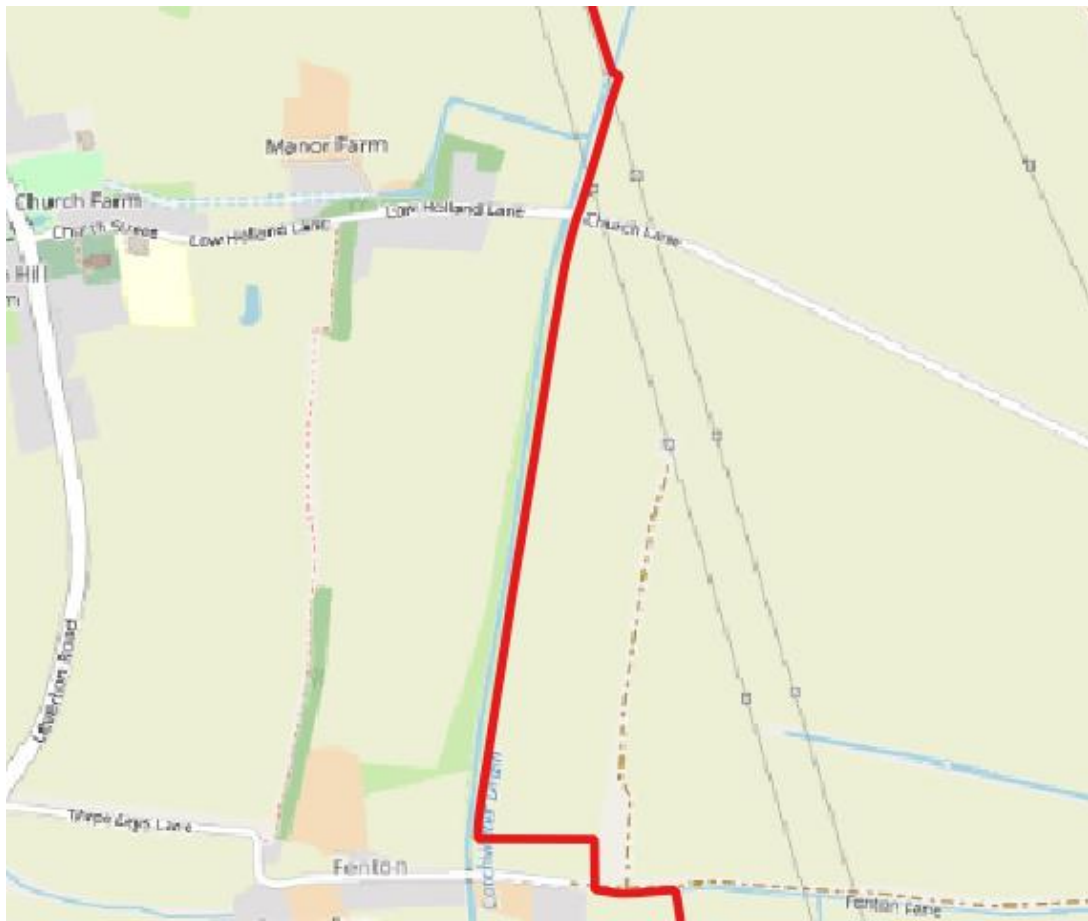
Summary of results

Rainfall - FEH22 (mm):	107.26	Total runoff (ML):	1019.95
Total Rainfall (mm):	69.48	Total flow (ML):	1868.43
Peak Rainfall (mm):	18.90	Peak flow (m³/s):	15.78

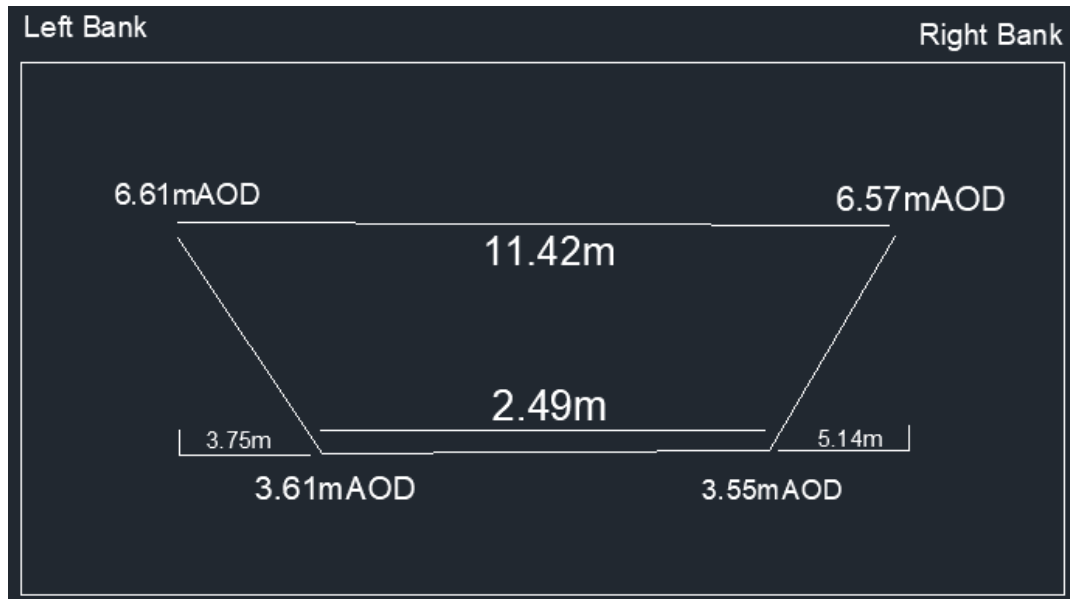
1 in 100 year + 23% cc Peak Flow = **15.78m³/s**

Channel Capacity < Q100cc Peak Flow = Flood risk

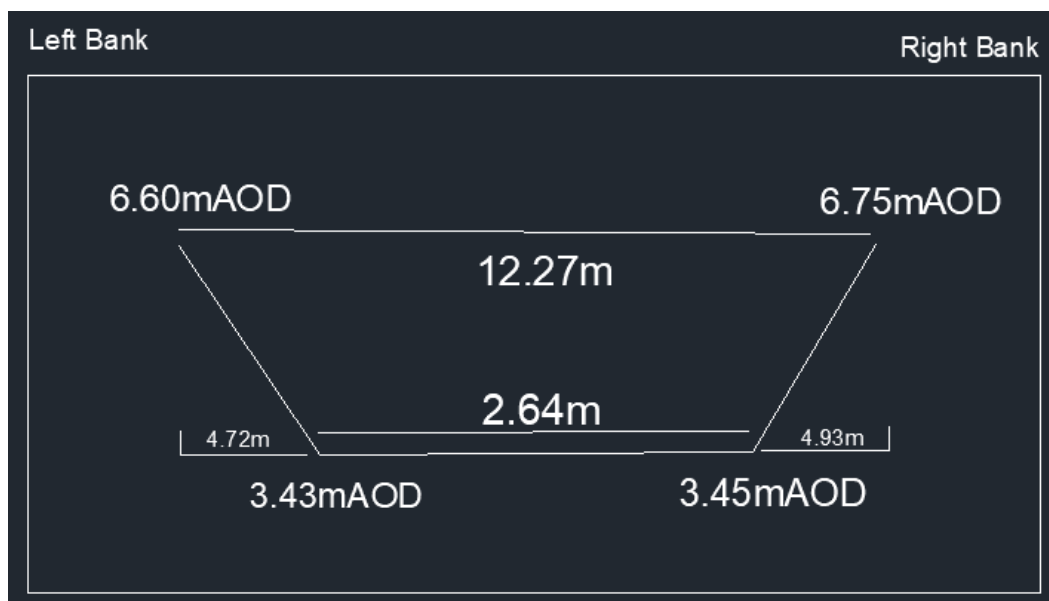
Catchwater Drain (2)



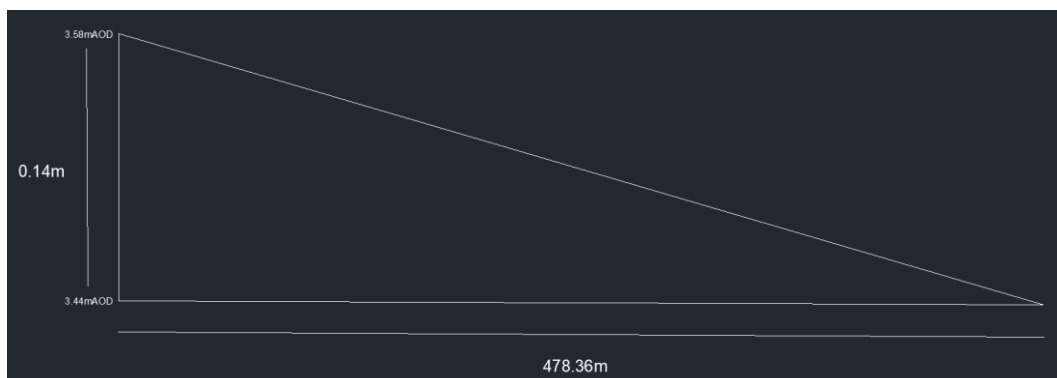
Southern Cross Section



Northern Cross Section



Channel



Inputs

Channel Slope = $dy/dx = 0.14\text{m} / 478.36\text{m} = \mathbf{0.000292}$

Max Water Depth = average of bank depths = $((6.60\text{mAOD} - 3.43\text{mAOD}) + (6.75\text{mAOD} - 3.45\text{mAOD}) + (6.61\text{mAOD} - 3.61\text{mAOD}) + (6.67\text{mAOD} - 3.55\text{mAOD})) / 4 = \mathbf{3.14\text{m}}$

Bed Width = average of north and south = $(2.49\text{m} + 2.64\text{m}) / 2 = \mathbf{2.56\text{m}}$

Left Slope (south) = $dy/dx = (6.61\text{mAOD} - 3.61\text{mAOD}) / 3.75\text{m} = 0.80$

Left Slope (north) = $dy/dx = (6.60\text{mAOD} - 3.34\text{mAOD}) / 4.72\text{m} = 0.690$

Left Slope = $(0.80 + 0.690) / 2 = \mathbf{0.745}$

Right Slope (south) = $dy/dx = (6.67\text{mAOD} - 3.55\text{mAOD}) / 5.14\text{m} = 0.607$

Right Slope (north) = $dy/dx = (6.75\text{mAOD} - 3.45\text{mAOD}) / 4.93\text{m} = 0.669$

Right Slope = $(0.607 + 0.669) / 2 = \mathbf{0.638}$

Mannings Value = $\mathbf{0.03}$

The open channel flow calculator

Select Channel Type: Trapezoid

Select unit system: Meter(m)

Channel slope: 0.000292 m/m

Water depth(y): 3.14 m

Bottom width(b): 2.56 m

Flow velocity: 0.7319 m/s

Left Slope (Z1): 0.745 z1/y

Right Slope (Z2): 0.638 z2/y

Flow discharge: 10.873 m³/s

Input n value: 0.03 or select n

Status: Calculation finished

Wetted perimeter: 10.2 m

Flow area: 14.86 m²

Top width(T): 6.9 m

Specific energy: 3.17 m

Froude number: 0.16

Flow status: Subcritical flow

Critical depth: 0.0126 m

Velocity head: 0.03 m

Channel Capacity = $\mathbf{10.87\text{m}^3/\text{s}}$

Model run: 100 year 1.23 CC

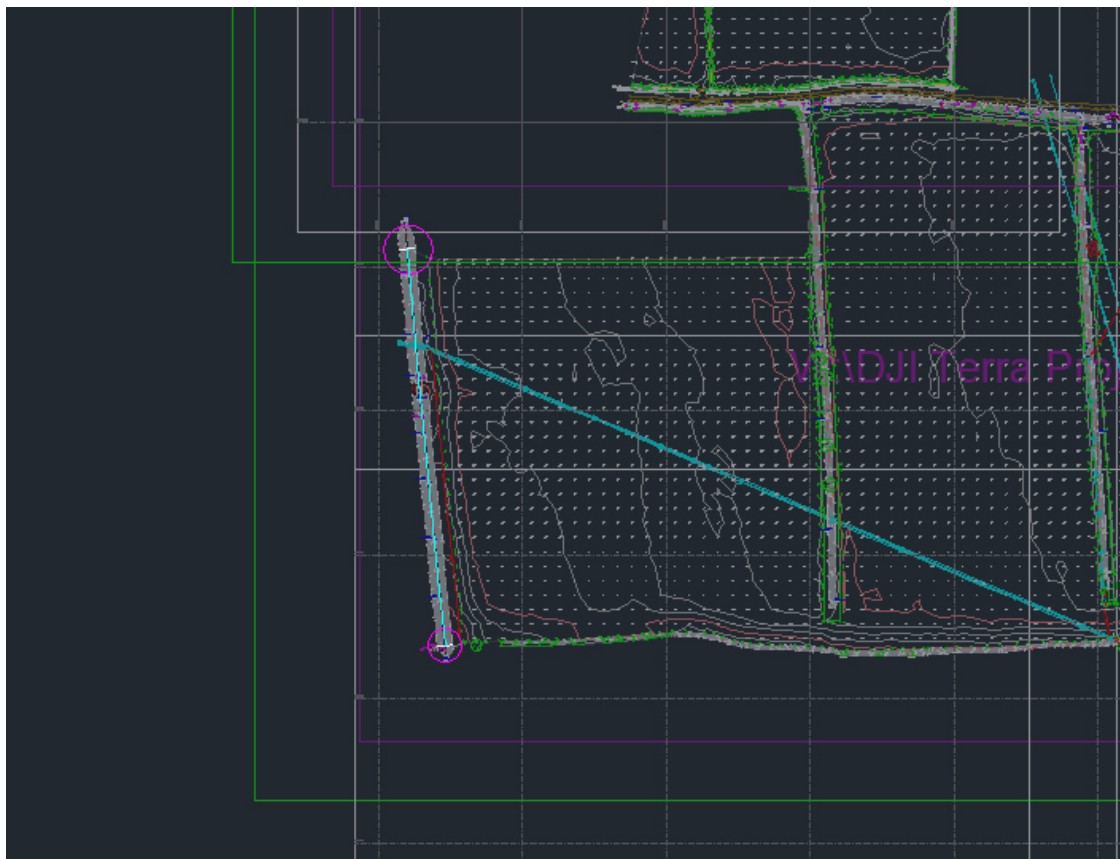
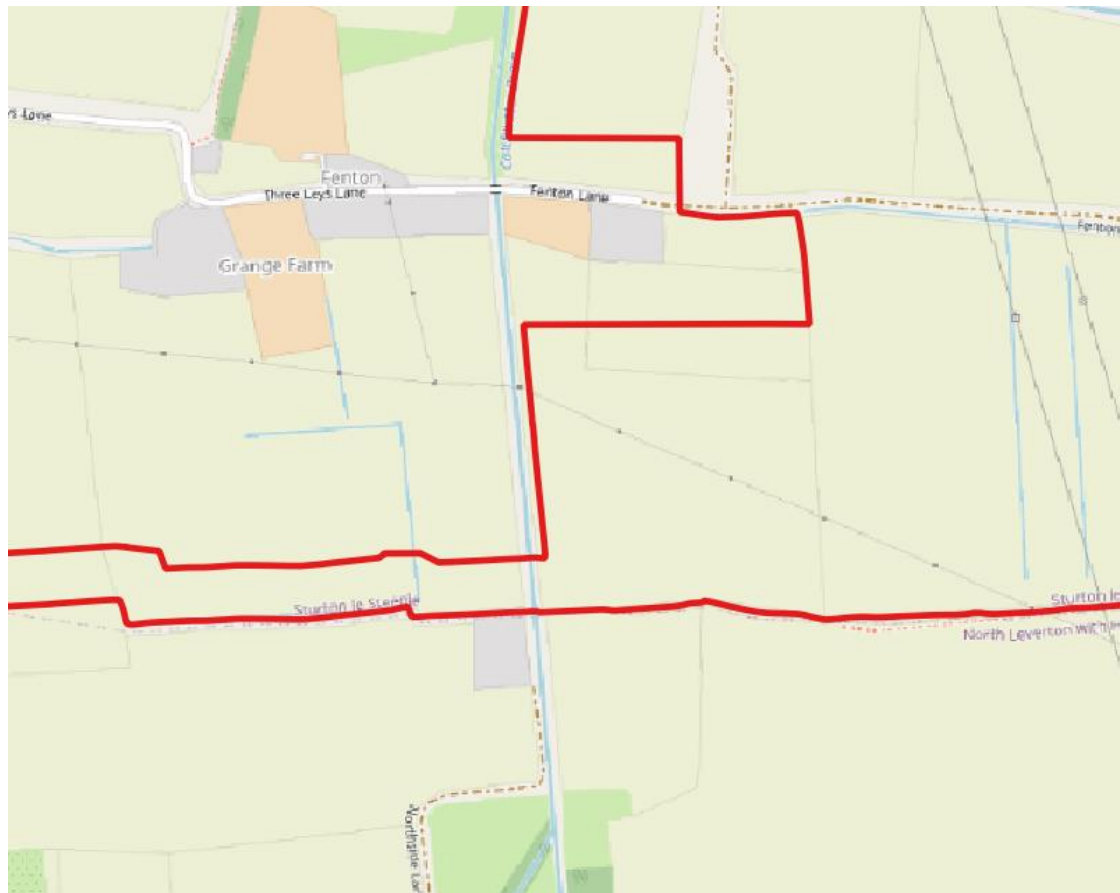
Summary of results

Rainfall - FEH22 (mm):	107.26	Total runoff (ML):	1019.95
Total Rainfall (mm):	69.48	Total flow (ML):	1868.43
Peak Rainfall (mm):	18.90	Peak flow (m³/s):	15.78

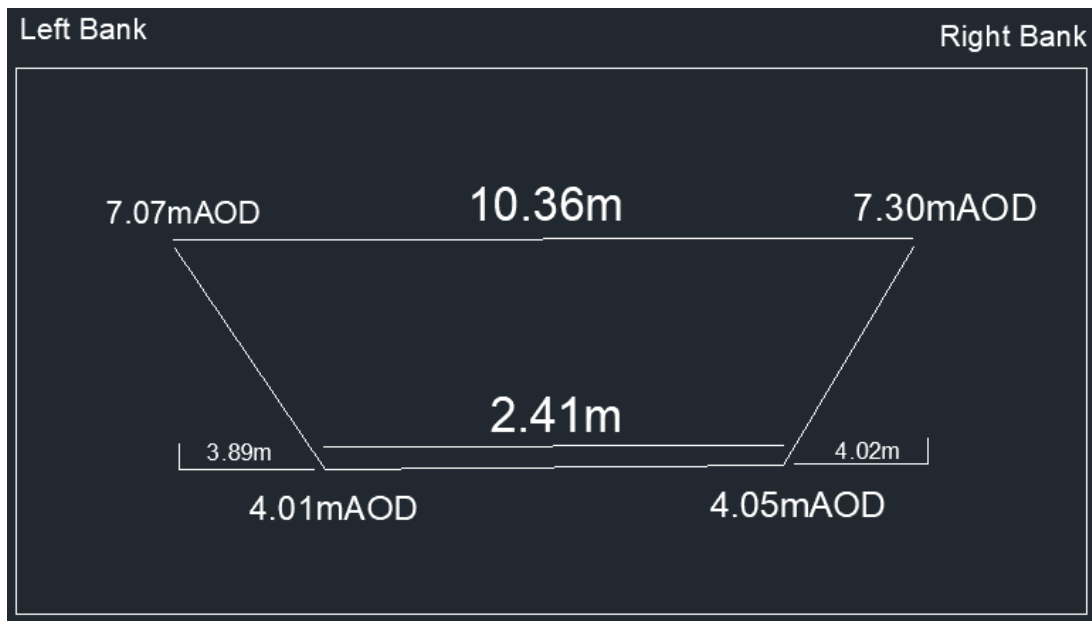
1 in 100 year + 23% cc Peak Flow = $\mathbf{15.78\text{m}^3/\text{s}}$

Channel Capacity < Q100cc Peak Flow = Flood risk

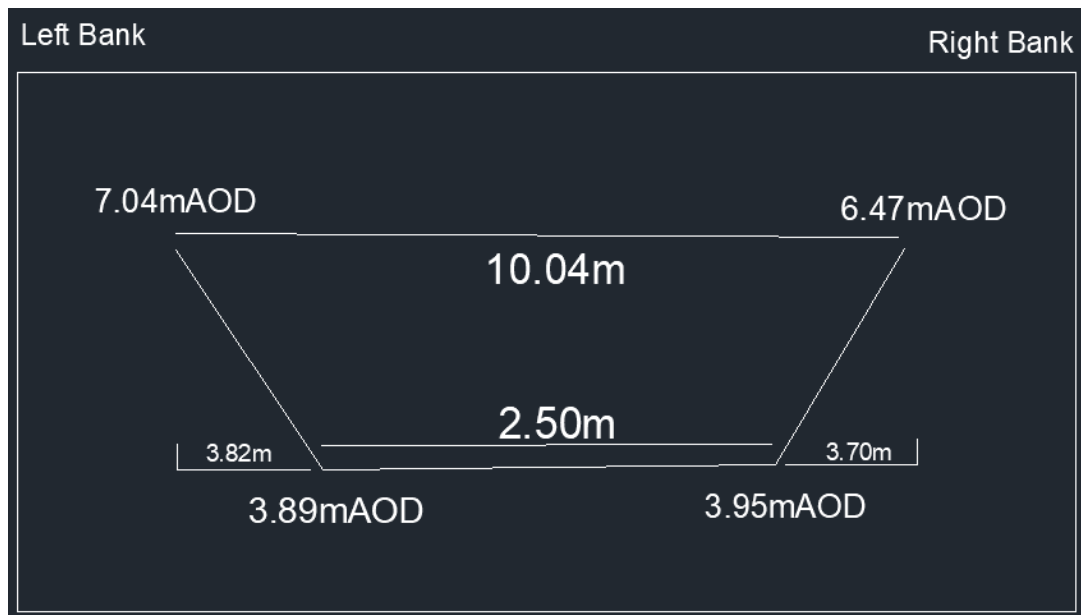
Catchwater Drain (1)



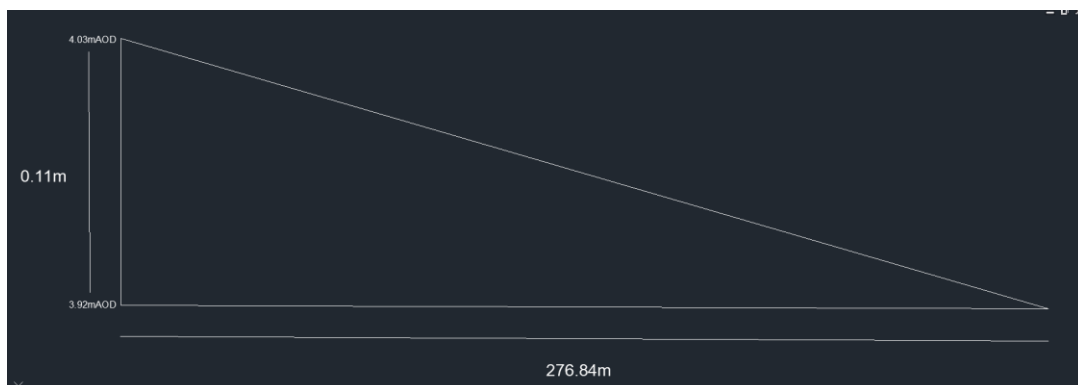
Southern Cross Section



Northern Cross Section



Channel



Inputs

Channel Slope = $dy/dx = 0.11\text{m} / 276.84\text{m} = \mathbf{0.000397}$

Max Water Depth = average of bank depths = $((7.07\text{mAOD} - 4.01\text{mAOD}) + (7.30\text{mAOD} - 4.05\text{mAOD}) + (7.04\text{mAOD} - 3.89\text{mAOD}) + (6.47\text{mAOD} - 3.95\text{mAOD})) / 4 = \mathbf{2.99\text{m}}$

Bed Width = average of north and south = $(2.41\text{m} + 2.50\text{m}) / 2 = \mathbf{2.45\text{m}}$

Left Slope (south) = $dy/dx = (7.07\text{mAOD} - 4.01\text{mAOD}) / 3.89\text{m} = 0.786$

Left Slope (north) = $dy/dx = (7.04\text{mAOD} - 3.89\text{mAOD}) / 5.14\text{m} = 0.612$

Left Slope = $(0.786 + 0.612) / 2 = \mathbf{0.699}$

Right Slope (south) = $dy/dx = (7.30\text{mAOD} - 4.05\text{mAOD}) / 4.02\text{m} = 0.808$

Right Slope (north) = $dy/dx = (6.47\text{mAOD} - 3.95\text{mAOD}) / 4.93\text{m} = 0.511$

Right Slope = $(0.808 + 0.511) / 2 = \mathbf{0.659}$

Mannings Value = **0.03**

The open channel flow calculator			
Select Channel Type: Trapezoid			
Velocity(V)&Discharge(Q)		Select unit system: Meter(m)	
Channel slope: 0.000397 m/m	Water depth(y): 2.99 m	Bottom width(b): 2.45 m	
Flow velocity: 0.8248 m/s	LeftSlope (Z1): 0.699 z1/y	RightSlope (Z2): 0.659 z2/y	
Flow discharge: 11.0494 m³/s	Input a value: 0.03 or select n	Status: Calculation finished	
Calculate!	Reset		
Wetted perimeter: 9.68 m	Flow area: 13.4 m²	Top width(T): 6.51 m	
Specific energy: 3.02 m	Froude number: 0.18	Flow status: Subcritical flow	
Critical depth: 1.14 m	Critical slope: 0.0129 m/m	Velocity head: 0.03 m	

Channel Capacity = **11.04m³/s**

Model run: 100 year 1.23 CC

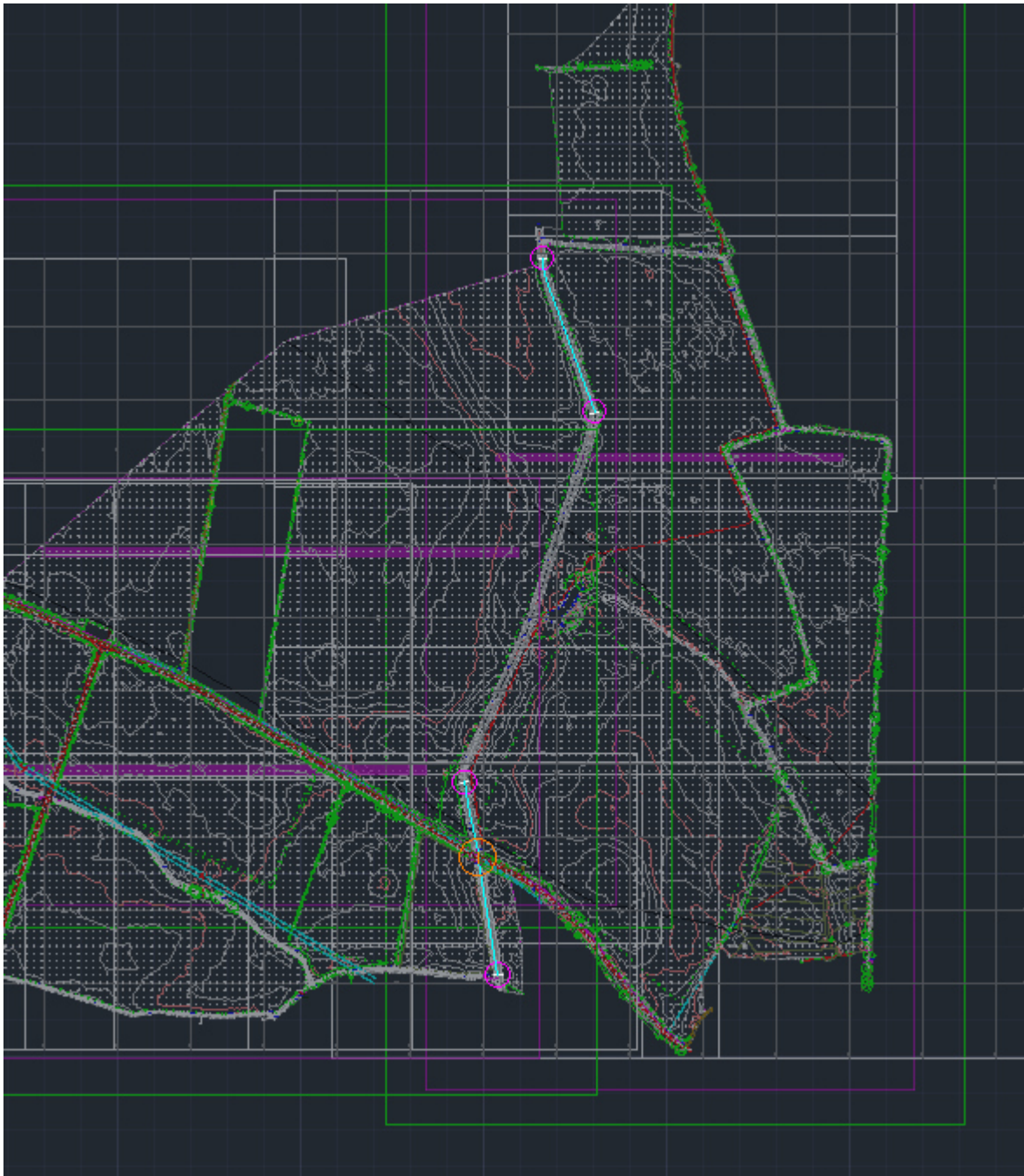
Summary of results

Rainfall - FEH22 (mm):	107.26	Total runoff (ML):	1019.95
Total Rainfall (mm):	69.48	Total flow (ML):	1868.43
Peak Rainfall (mm):	18.90	Peak flow (m³/s):	15.78

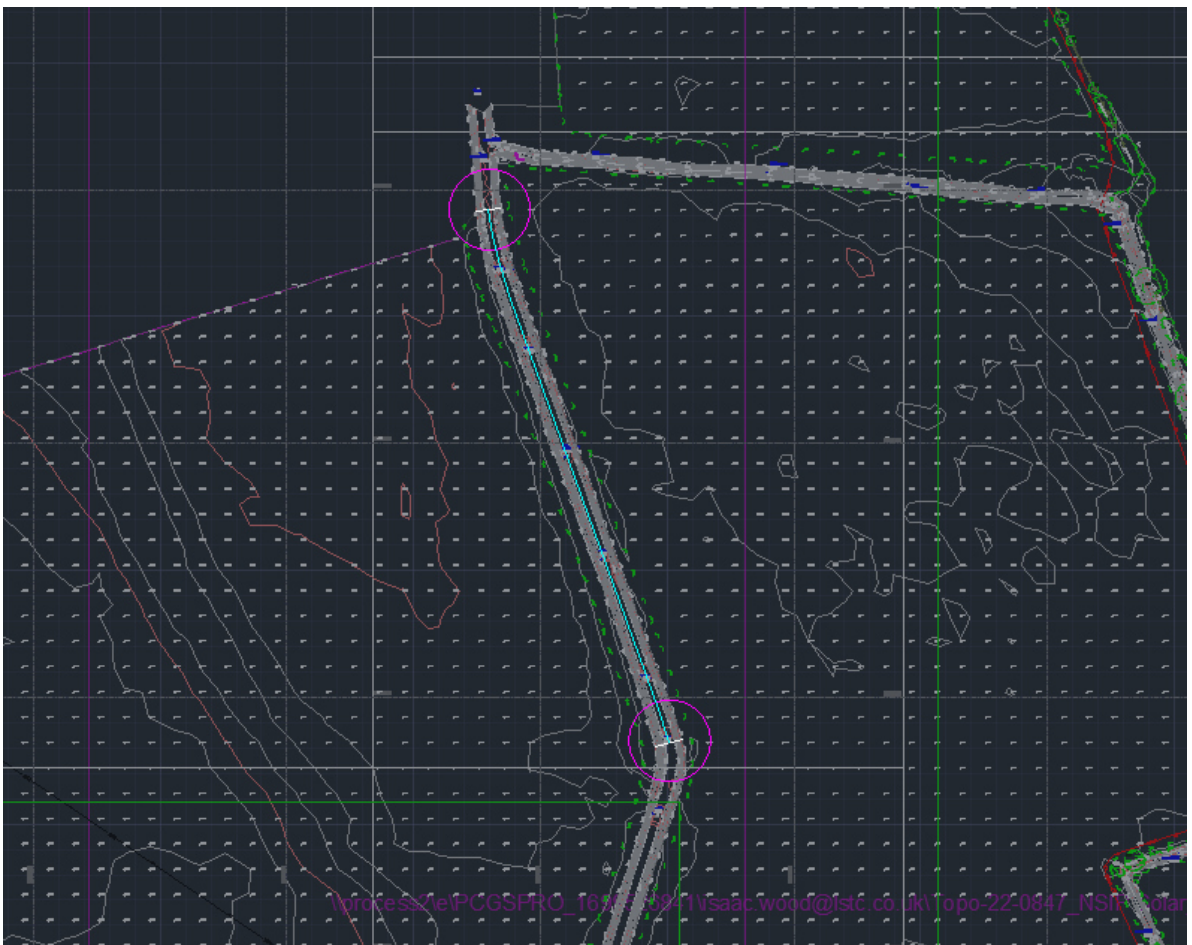
1 in 100 year + 23% cc Peak Flow = **15.78m³/s**

Channel Capacity < Q100cc Peak Flow = Flood risk

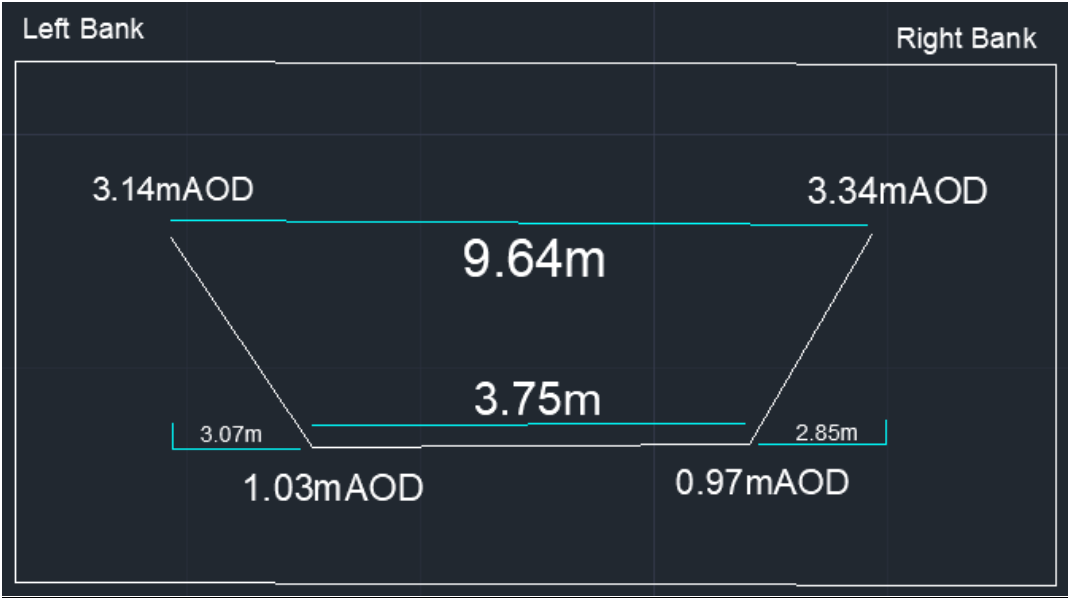
Mother Drain



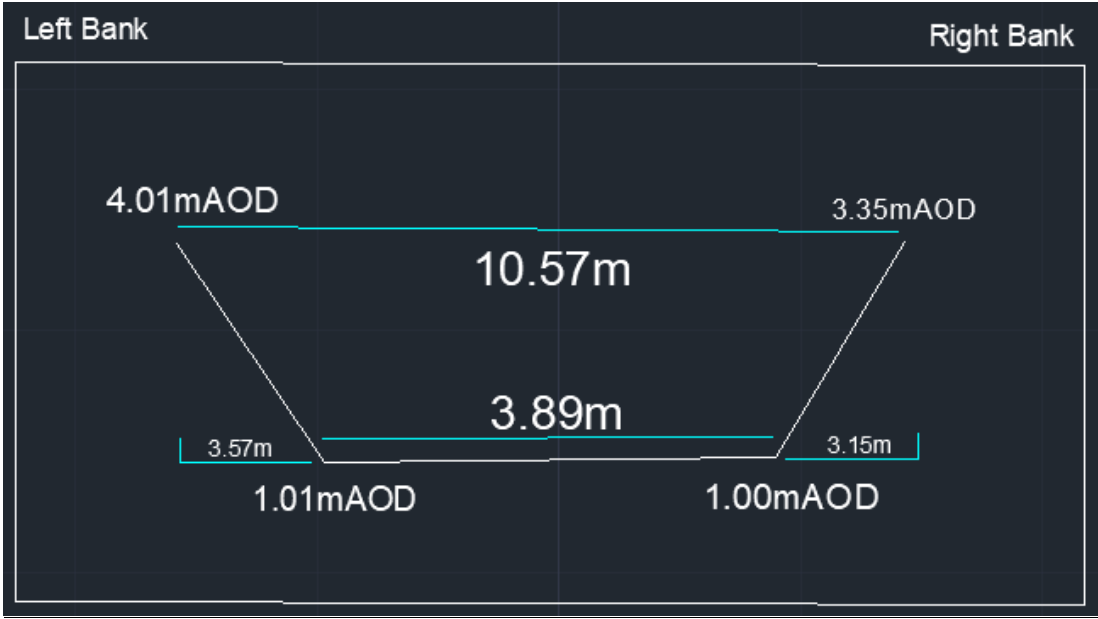
Mother Drain (2)



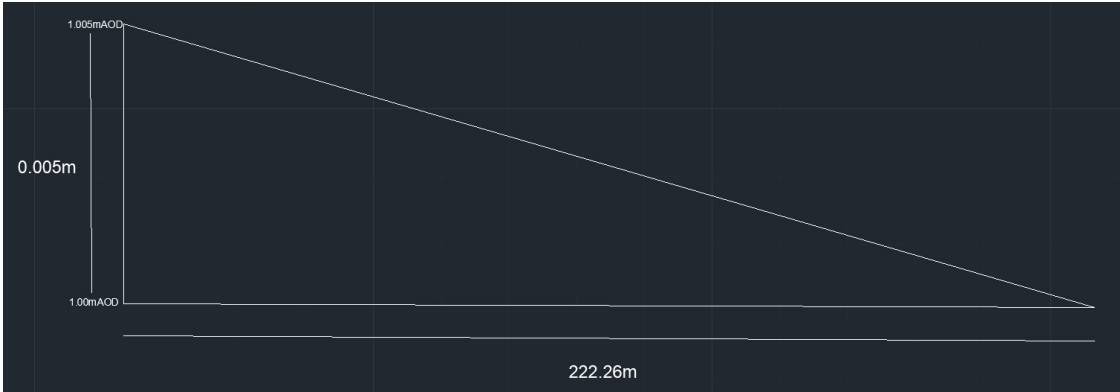
Northern Cross Section



Southern Cross Section



Channel



Inputs

Channel Slope = $dy/dx = 0.005\text{m} / 222.26\text{m} = \mathbf{0.0000224}$

Max Water Depth = average of bank depths = $((3.14\text{mAOD} - 1.03\text{mAOD}) + (3.34\text{mAOD} - 0.97\text{mAOD}) + (4.01\text{mAOD} - 1.01\text{mAOD}) + (3.35\text{mAOD} - 1.00\text{mAOD})) / 4 = \mathbf{2.45\text{m}}$

Bed Width = average of north and south = $(3.75\text{m} + 3.89\text{m}) / 2 = \mathbf{3.82\text{m}}$

Left Slope (north) = $dy/dx = (3.14\text{mAOD} - 1.03\text{mAOD}) / 3.07\text{m} = 0.687$

Left Slope (south) = $dy/dx = (4.01\text{mAOD} - 1.01\text{mAOD}) / 3.57\text{m} = 0.840$

Left Slope = $(0.80 + 0.690) / 2 = \mathbf{0.763}$

Right Slope (north) = $dy/dx = (3.34\text{mAOD} - 0.97\text{mAOD}) / 2.85\text{m} = 0.831$

Right Slope (south) = $dy/dx = (3.35\text{mAOD} - 1.00\text{mAOD}) / 3.15\text{m} = 0.746$

Right Slope = $(0.607 + 0.669) / 2 = \mathbf{0.788}$

Mannings Value = $\mathbf{0.03}$

The open channel flow calculator			
Select Channel Type: Trapezoid			
Velocity(V)&Discharge(Q)		Select unit system: Meter(m)	
Channel slope: 0.0000224 m/m	Water depth(y): 2.45 m	Bottom width(b): 3.82 m	
Flow velocity: 0.1973 m/s	LeftSlope (Z1): 0.763 z1/y	RightSlope (Z2): 0.788 z2/y	
Flow discharge: 2.7648 m³/s	Input n value: 0.03 or select n		
Calculate	Status: Calculation finished	Reset	
Wetted perimeter: 10.02 m	Flow area: 14.01 m²	Top width(T): 7.62 m	
Specific energy: 2.45 m	Froude number: 0.05	Flow status: Subcritical flow	
Critical depth: 0.37 m	Critical slope: 0.014 m/m	Velocity head: 0 m	

Channel Capacity = $\mathbf{2.76\text{m}^3/\text{s}}$

Model run: 100 year 1.23 CC

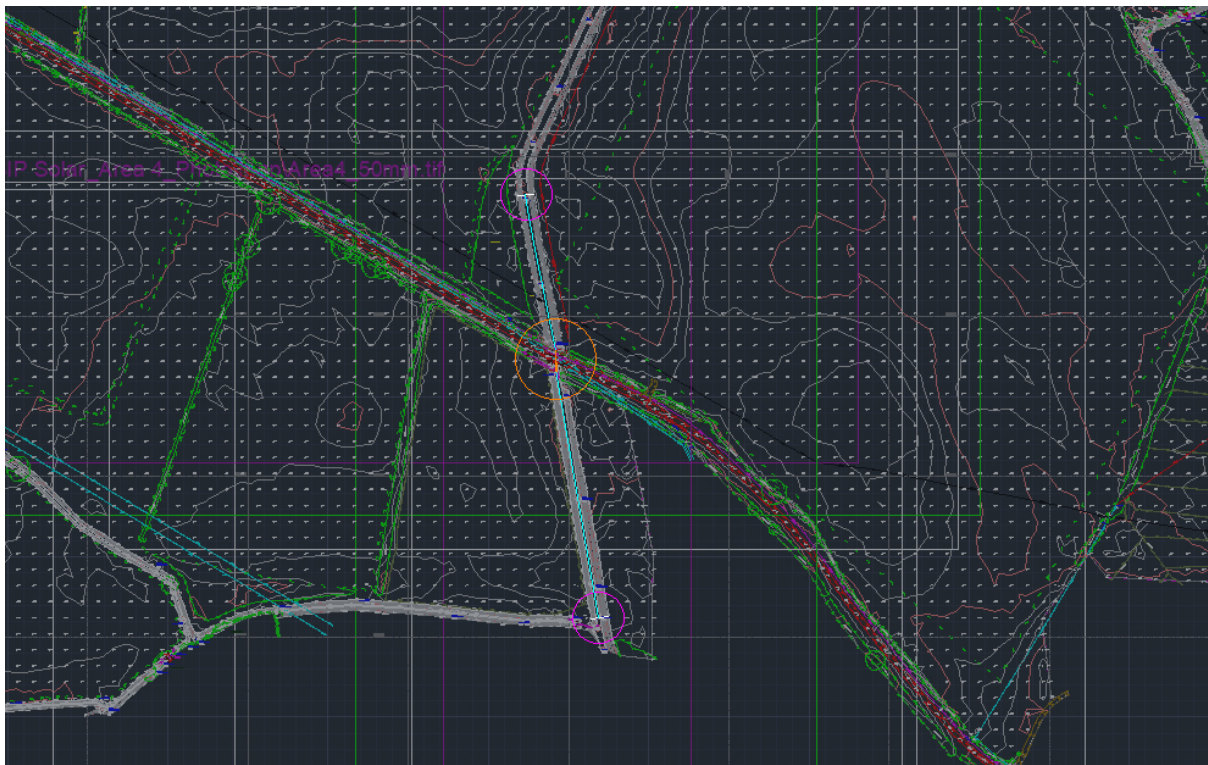
Summary of results

Rainfall - FEH22 (mm):	114.41	Total runoff (ML):	440.92
Total Rainfall (mm):	74.45	Total flow (ML):	1303.87
Peak Rainfall (mm):	20.25	Peak flow (m³/s):	5.38

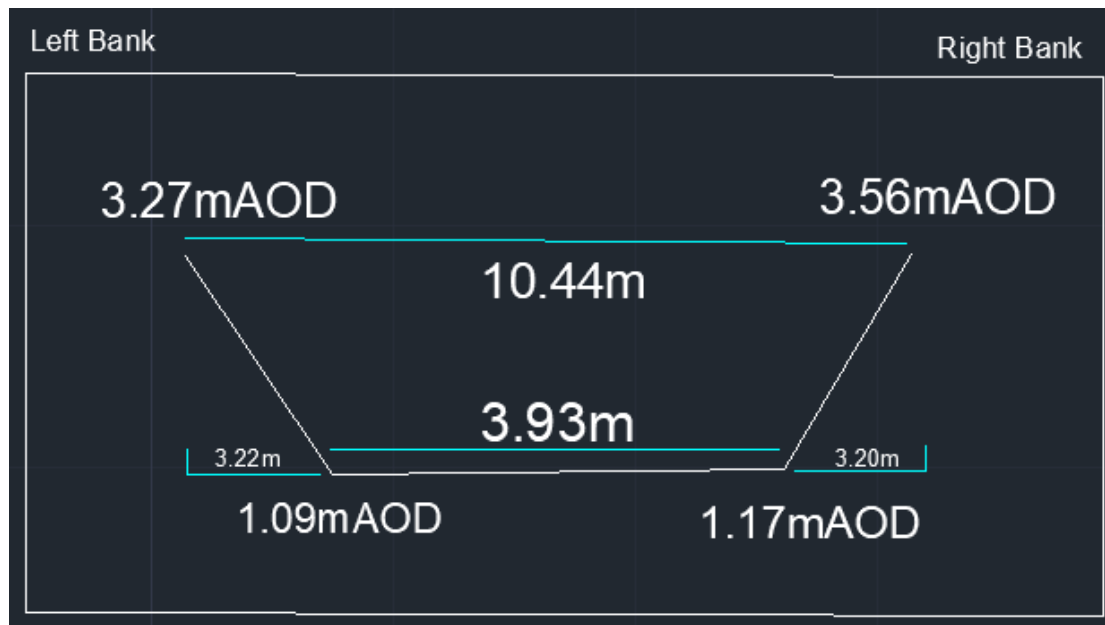
1 in 100 year + 23% cc Peak Flow = $\mathbf{5.38\text{m}^3/\text{s}}$

Channel Capacity < Q100cc Peak Flow = Flood risk

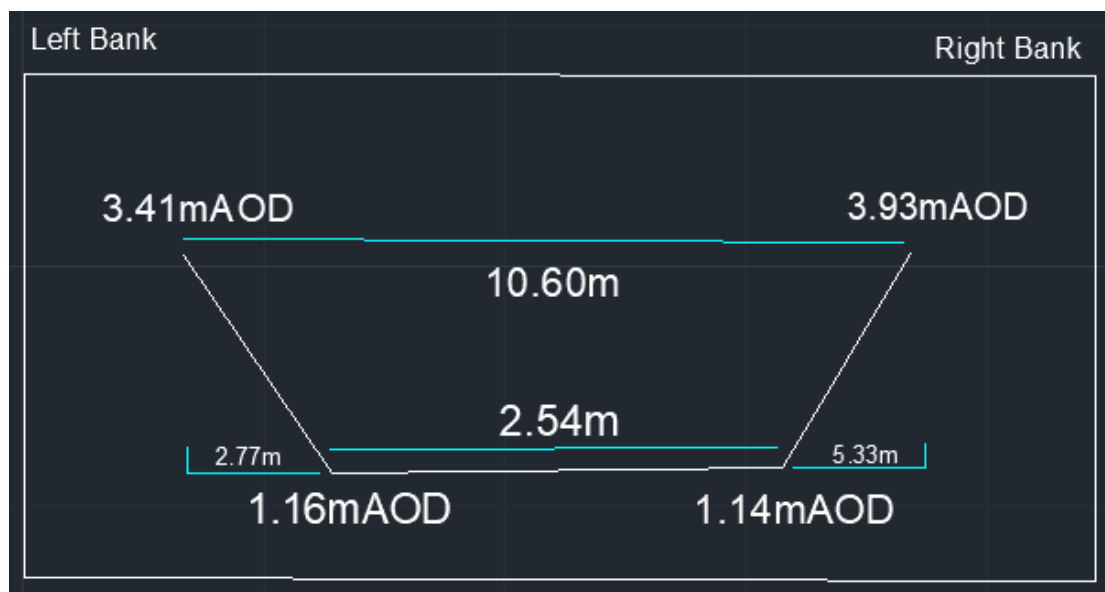
Mother Drain (1)



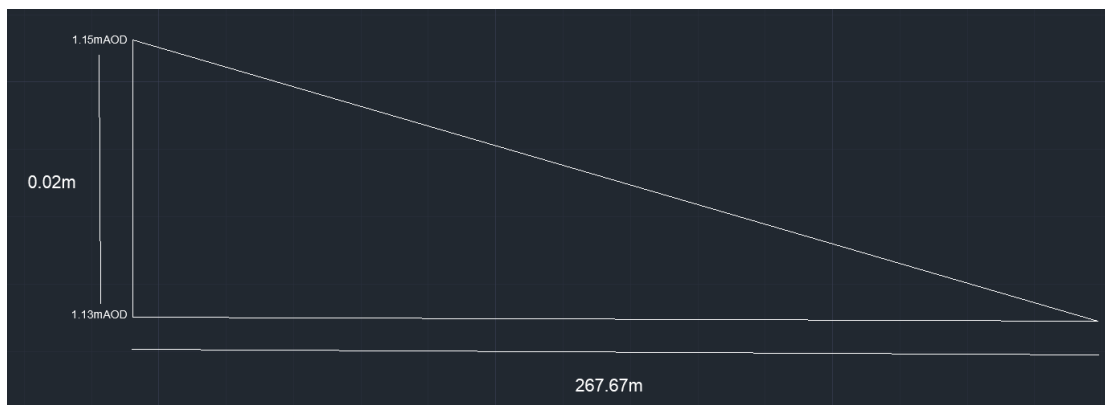
Northern Cross Section



Southern Cross Section



Channel



Inputs

Channel Slope = $dy/dx = 0.02\text{m} / 267.67\text{m} = \mathbf{0.0000747}$

Max Water Depth = average of bank depths = $((3.27\text{mAOD} - 1.09\text{mAOD}) + (3.56\text{mAOD} - 1.17\text{mAOD}) + (3.41\text{mAOD} - 1.16\text{mAOD}) + (3.93\text{mAOD} - 1.14\text{mAOD})) / 4 = \mathbf{2.40\text{m}}$

Bed Width = average of north and south = $(3.93\text{m} + 2.54\text{m}) / 2 = \mathbf{3.23\text{m}}$

Left Slope (north) = $dy/dx = (3.27\text{mAOD} - 1.09\text{mAOD}) / 3.22\text{m} = 0.677$

Left Slope (south) = $dy/dx = (3.41\text{mAOD} - 1.16\text{mAOD}) / 2.77\text{m} = 0.812$

Left Slope = $(0.80 + 0.690) / 2 = \mathbf{0.744}$

Right Slope (north) = $dy/dx = (3.56\text{mAOD} - 1.17\text{mAOD}) / 3.20\text{m} = 0.746$

Right Slope (south) = $dy/dx = (3.93\text{mAOD} - 1.14\text{mAOD}) / 5.33\text{m} = 0.523$

Right Slope = $(0.607 + 0.669) / 2 = \mathbf{0.634}$

Mannings Value = **0.03**

The open channel flow calculator			
Select Channel Type: Trapezoid			
Velocity(V)&Discharge(Q)		Select unit system: Meter(m)	
Channel slope: 0.0000747 m/m	Water depth(y): 2.40 m	Bottom width(b): 3.23 m	
Flow velocity: 0.3411 m/s	Left Slope (Z1): 0.744 z1/y	Right Slope (Z2): 0.634 z2/y	
Flow discharge: 3.965 m³/s	Input a value: 0.03 or select n	Status: Calculation finished	
Calculate	Reset		
Wetted perimeter: 9.02 m	Flow area: 11.62 m²	Top width(T): 6.46 m	
Specific energy: 2.41 m	Froude number: 0.08	Flow status: Subcritical flow	
Critical depth: 0.52 m	Critical slope: 0.0132 m/m	Velocity head: 0.01 m	

Channel Capacity = **3.96m³/s**

Model run: 100 year 1.23 CC

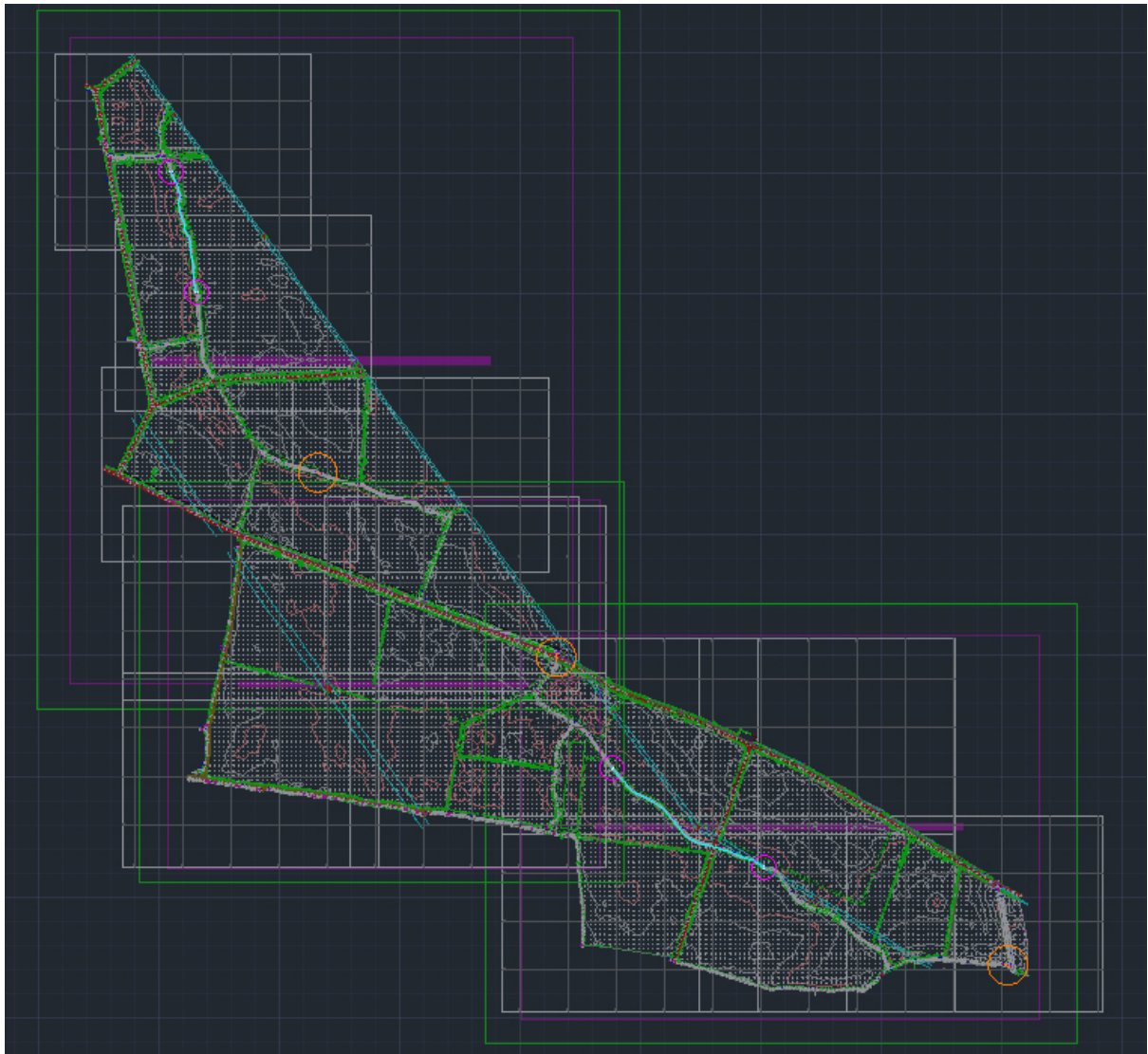
Summary of results

Rainfall - FEH22 (mm):	114.41	Total runoff (ML):	440.92
Total Rainfall (mm):	74.45	Total flow (ML):	1303.87
Peak Rainfall (mm):	20.25	Peak flow (m³/s):	5.38

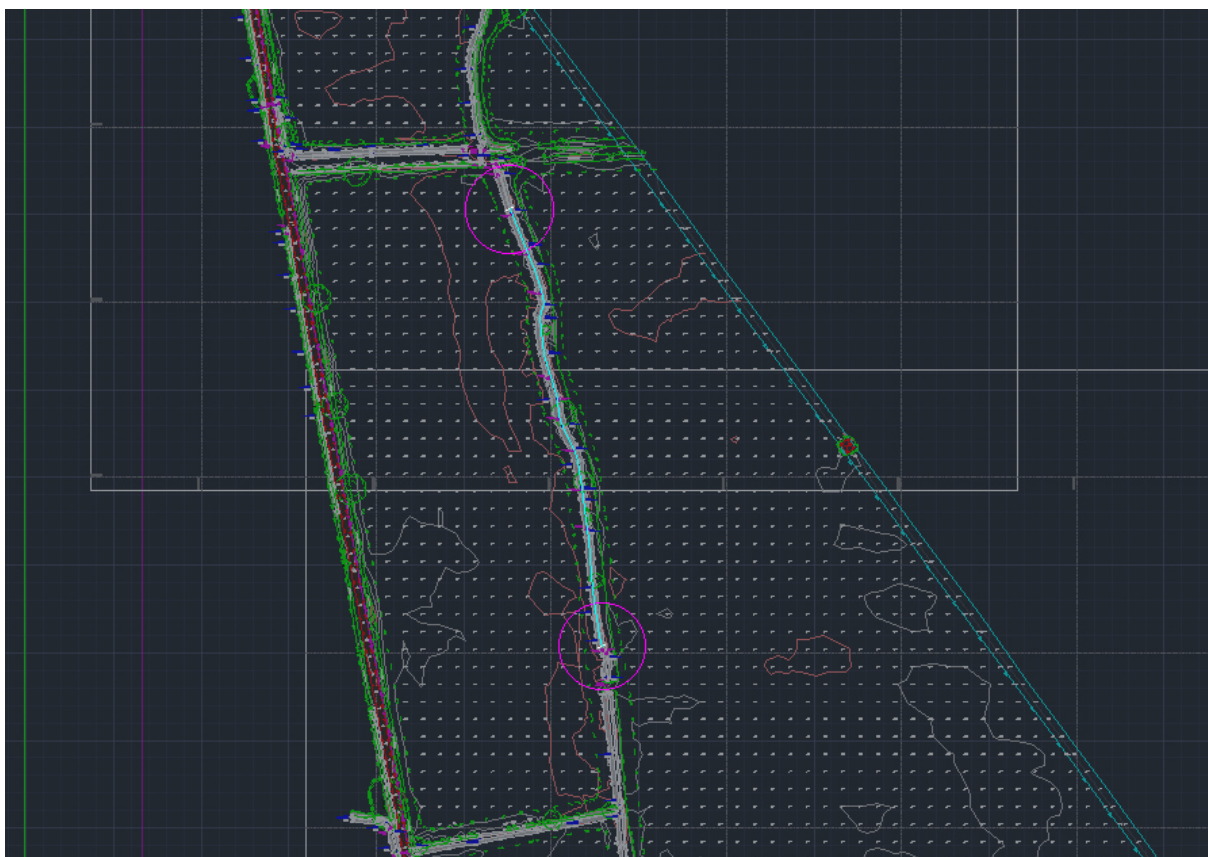
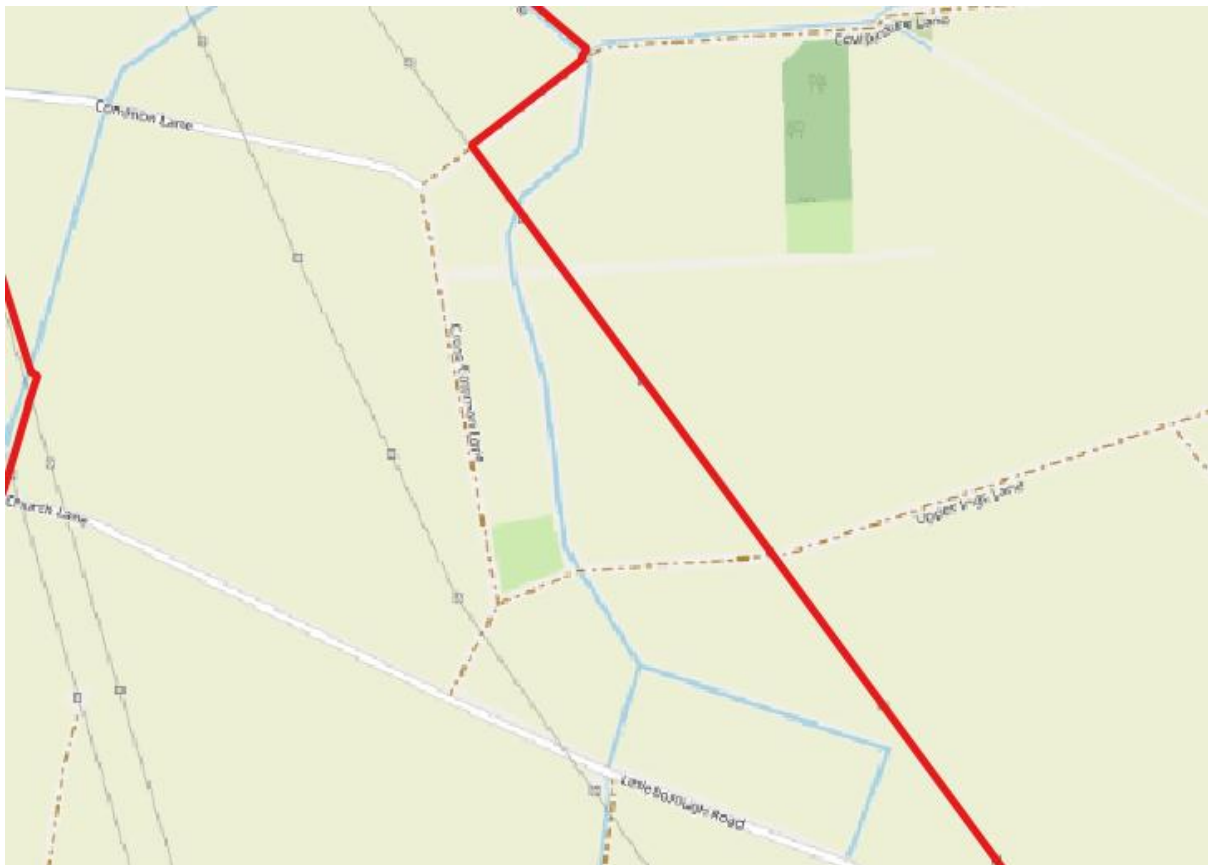
1 in 100 year + 23% cc Peak Flow = **5.38m³/s**

Channel Capacity < Q100cc Peak Flow = Flood risk

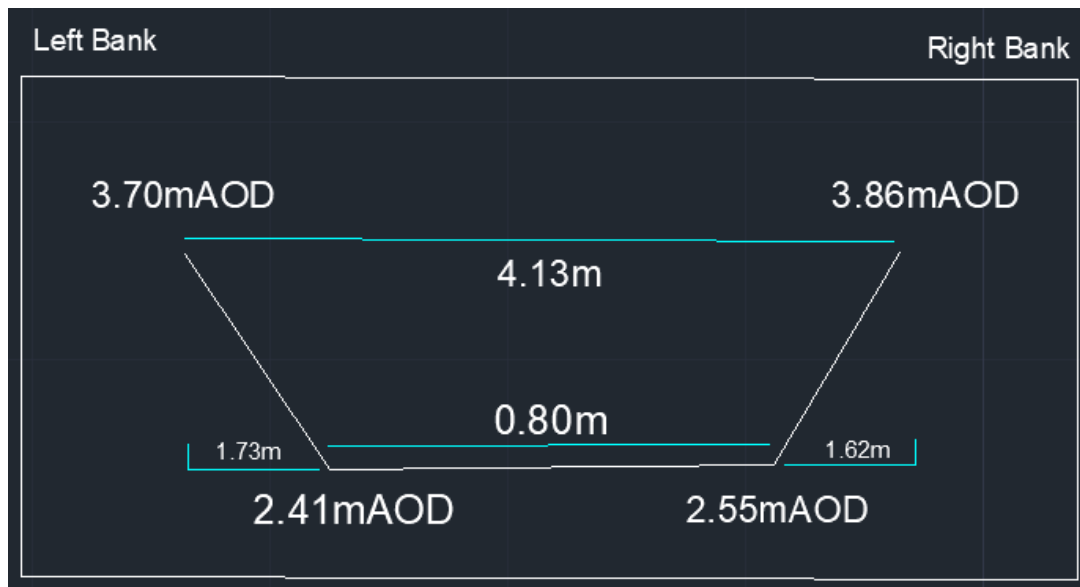
New Ings Drain



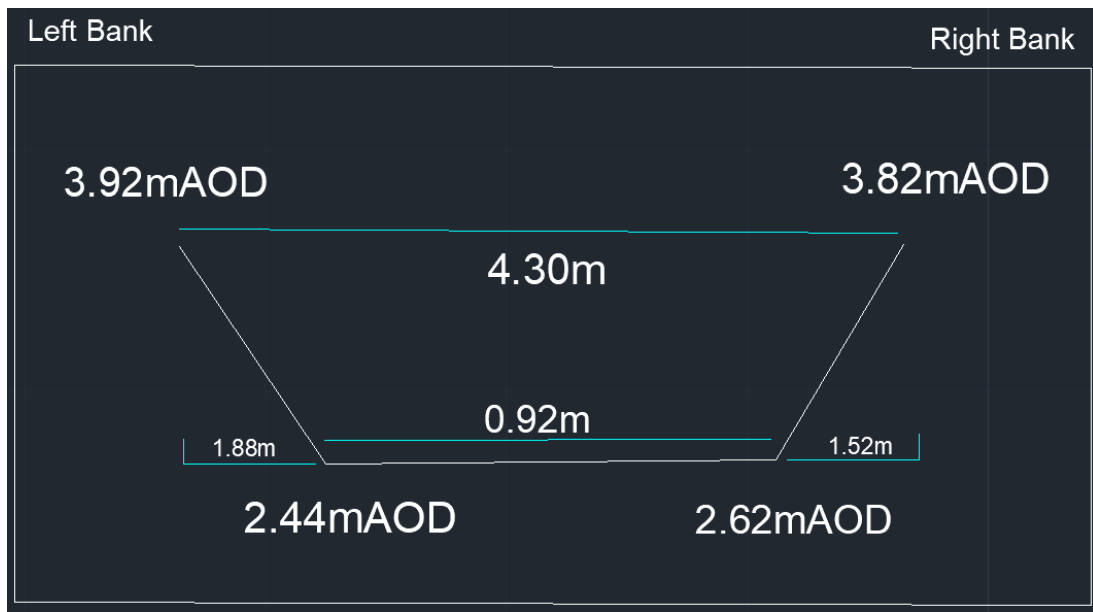
New Ings Drain (2)



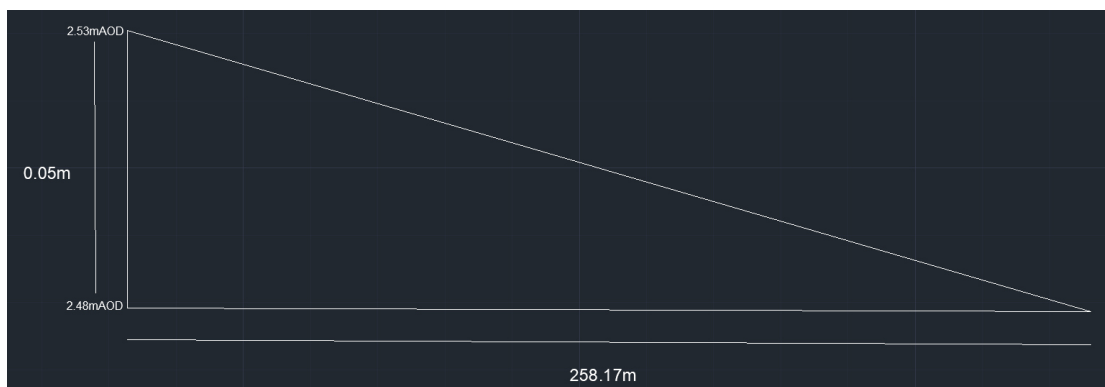
Northern Cross Section



Southern Cross Section



Channel



Inputs

Channel Slope = $dy/dx = 0.05\text{m} / 258.17\text{m} = \mathbf{0.000193}$

Max Water Depth = average of bank depths = $((3.70\text{mAOD} - 2.41\text{mAOD}) + (3.86\text{mAOD} - 2.55\text{mAOD}) + (3.92\text{mAOD} - 2.44\text{mAOD}) + (3.82\text{mAOD} - 2.62\text{mAOD})) / 4 = \mathbf{1.32\text{m}}$

Bed Width = average of north and south = $(0.80\text{m} + 0.92\text{m}) / 2 = \mathbf{0.86\text{m}}$

Left Slope (north) = $dy/dx = (3.70\text{mAOD} - 2.41\text{mAOD}) / 1.73\text{m} = 0.745$

Left Slope (south) = $dy/dx = (3.92\text{mAOD} - 2.44\text{mAOD}) / 1.88\text{m} = 0.787$

Left Slope = $(0.80 + 0.690) / 2 = \mathbf{0.766}$

Right Slope (north) = $dy/dx = (3.86\text{mAOD} - 2.55\text{mAOD}) / 1.62\text{m} = 0.808$

Right Slope (south) = $dy/dx = (3.82\text{mAOD} - 2.62\text{mAOD}) / 1.52\text{m} = 0.789$

Right Slope = $(0.607 + 0.669) / 2 = \mathbf{0.798}$

Mannings Value = $\mathbf{0.03}$

The open channel flow calculator			
Select Channel Type: Trapezoid			
Velocity (V) & Discharge (Q)		Select unit system: Meter (m)	
Channel slope: 0.000193	mm	Water depth (y): 1.32	m
Flow velocity: 0.3269	m/s	Left Slope (Z1): 0.766	z1/y
Flow discharge: 0.8165	m³/s	Input n value: 0.03	or select n
Calculator		Status: Calculation finished	Reset
Wetted perimeter: 4.21	m	Flow area: 2.5	m²
Specific energy: 1.33	m	Top width (T): 2.92	m
Critical depth: 0.4	m	Froude number: 0.11	
		Critical slope: 0.017	m/m
		Flow status: Subcritical flow	
		Velocity head: 0.01	m

Channel Capacity = $\mathbf{0.81\text{m}^3/\text{s}}$

Model run: 100 year 1.23 CC

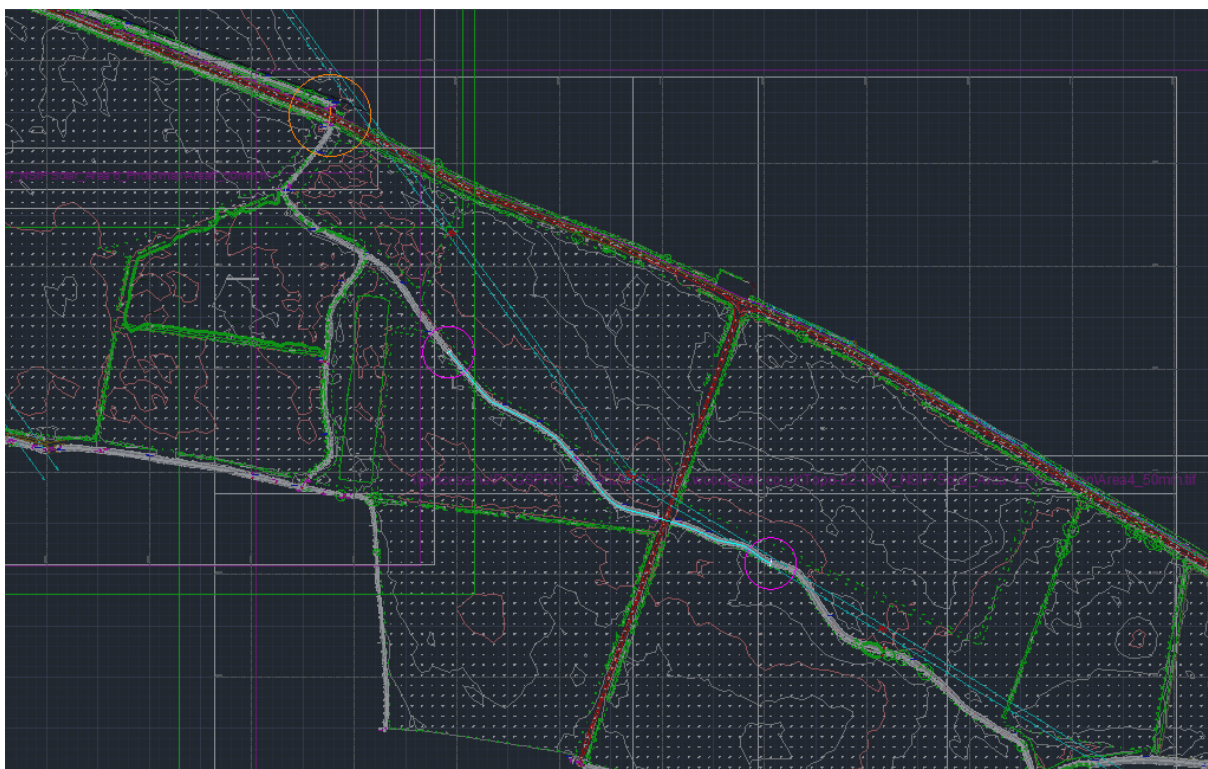
Summary of results

Rainfall - FEH22 (mm):	114.41	Total runoff (ML):	26.47
Total Rainfall (mm):	76.01	Total flow (ML):	78.32
Peak Rainfall (mm):	20.67	Peak flow (m³/s):	0.32

1 in 100 year + 23% cc Peak Flow = $\mathbf{0.32\text{m}^3/\text{s}}$

Channel Capacity > Q100cc Peak Flow = No Flood risk

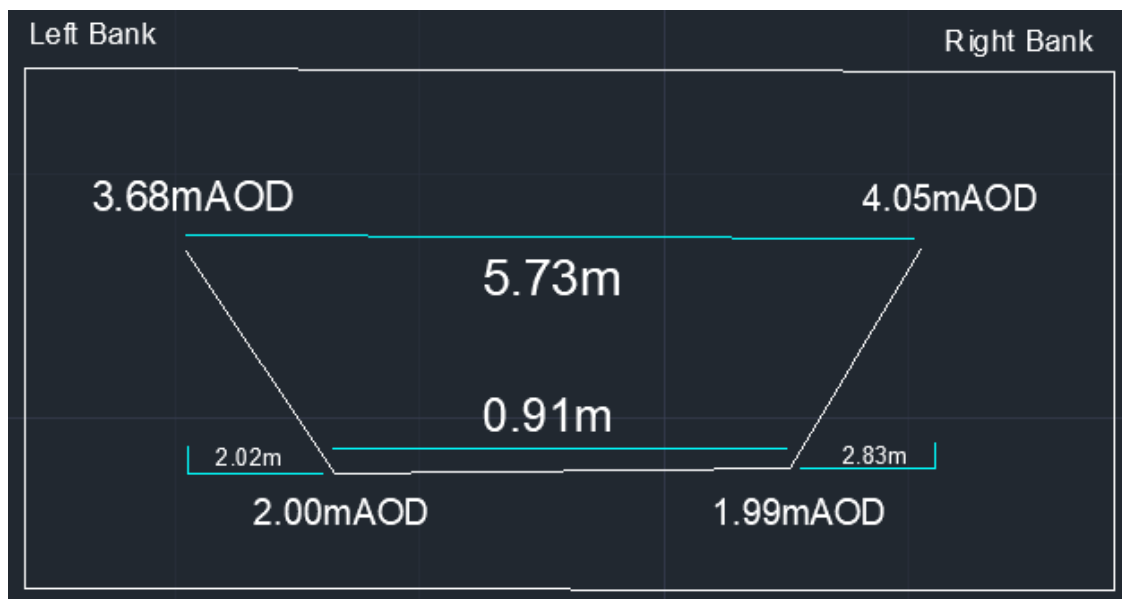
New Ings Drain (1)



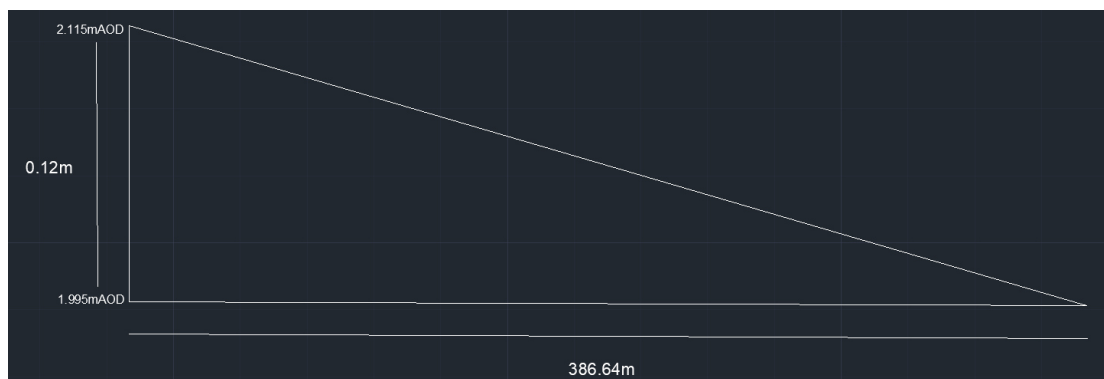
Northern Cross Section



Southern Cross Section



Channel



Inputs

Channel Slope = $dy/dx = 0.12\text{m} / 386.64\text{m} = \mathbf{0.000310}$

Max Water Depth = average of bank depths = $((3.63\text{mAOD} - 2.12\text{mAOD}) + (4.03\text{mAOD} - 2.11\text{mAOD}) + (3.68\text{mAOD} - 2.00\text{mAOD}) + (4.05\text{mAOD} - 1.99\text{mAOD})) / 4 = \mathbf{1.79\text{m}}$

Bed Width = average of north and south = $(0.76\text{m} + 0.91\text{m}) / 2 = \mathbf{0.83\text{m}}$

Left Slope (north) = $dy/dx = (3.63\text{mAOD} - 2.12\text{mAOD}) / 1.36\text{m} = 1.110$

Left Slope (south) = $dy/dx = (3.68\text{mAOD} - 2.00\text{mAOD}) / 2.02\text{m} = 0.831$

Left Slope = $(0.80 + 0.690) / 2 = \mathbf{0.970}$

Right Slope (north) = $dy/dx = (4.03\text{mAOD} - 2.11\text{mAOD}) / 2.13\text{m} = 0.901$

Right Slope (south) = $dy/dx = (4.05\text{mAOD} - 1.99\text{mAOD}) / 2.83\text{m} = 0.727$

Right Slope = $(0.607 + 0.669) / 2 = \mathbf{0.849}$

Mannings Value = $\mathbf{0.03}$

The open channel flow calculator			
Select Channel Type: Trapezoid			
Velocity(V)&Discharge(Q)		Select unit system: Meter(m)	
Channel slope: 0.000310	mm	Water depth(y): 1.79	m
Flow velocity: 0.4955	m/s	LeftSlope (Z1): 0.97	z1/y
Flow discharge: 2.1801	m³/s	Input n value: 0.03	or select n
Bottom width(b): 0.83		RightSlope (Z2): 0.849	
Bottom width(b): 0.83		RightSlope (Z2): 0.849	
Status: Calculation finished		Reset	
Wetted perimeter: 5.67	m	Flow area: 4.4	m²
Specific energy: 1.8	m	Top width(T): 4.09	m
Critical depth: 0.69	m	Froude number: 0.15	
Critical slope: 0.0157	m/m	Flow status: Subcritical flow	
		Velocity head: 0.01	m

Channel Capacity = $\mathbf{2.18\text{m}^3/\text{s}}$

Model run: 100 year 1.23 CC

Summary of results

Rainfall - FEH22 (mm):	114.41	Total runoff (ML):	28.31
Total Rainfall (mm):	75.99	Total flow (ML):	83.77
Peak Rainfall (mm):	20.67	Peak flow (m³/s):	0.35

1 in 100 year + 23% cc Peak Flow = $\mathbf{0.35\text{m}^3/\text{s}}$

Channel Capacity > Q100cc Peak Flow = No Flood risk

APPENDIX C

1D CROSS SECTION LOCATIONS



Legend

Redline Boundary

Map Contributions:
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an RSK company

Title:

Catchwater Drain 1D Cross Section Locations

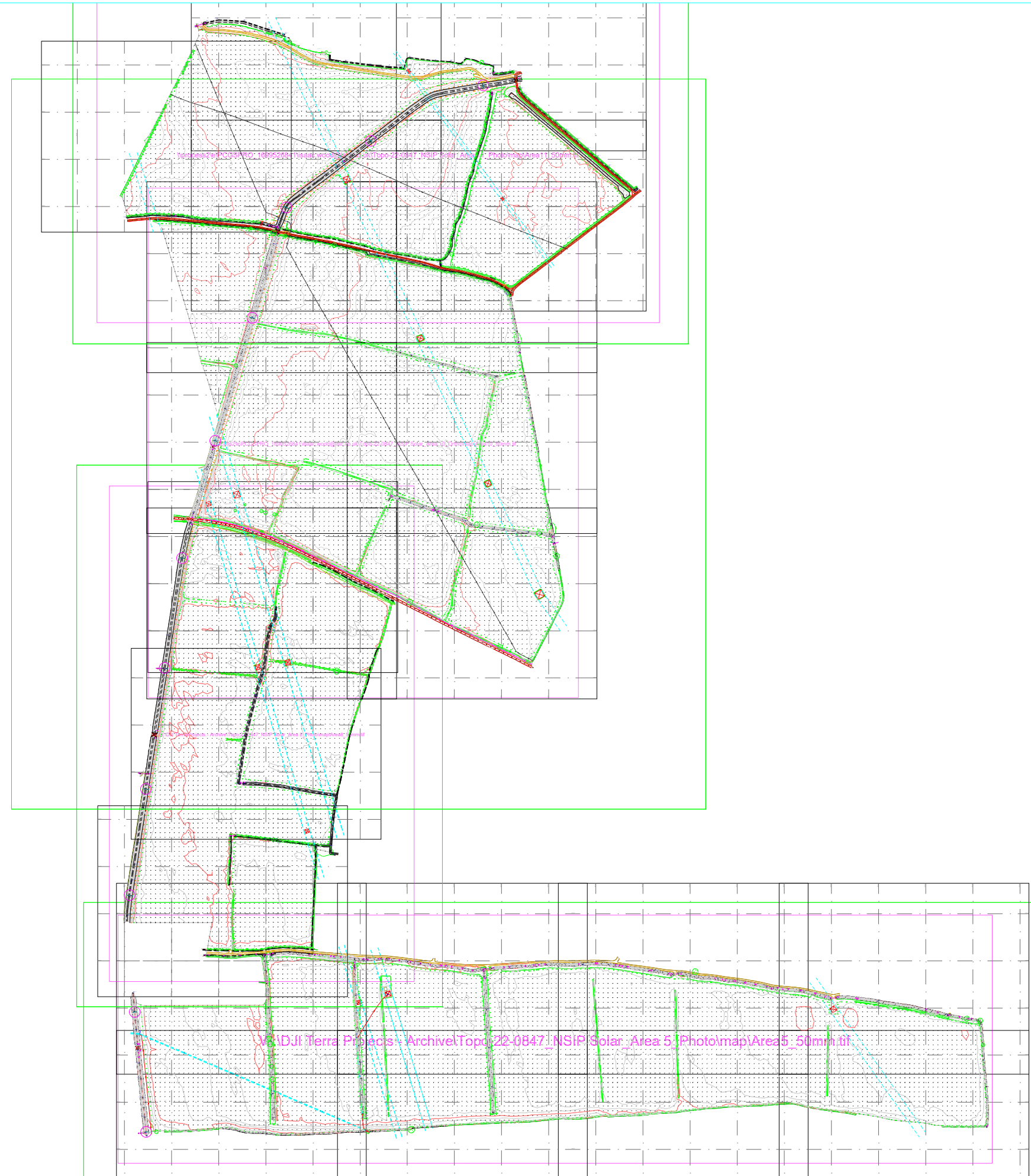
Drawn	Checked	Approved	Date
JW	CW	AC	06.05.25

Project: Steeples Renewables Project

Project No.	Originator	Number	Revision	Orig Size
680819	LDE-GIS	01	01	A3

0200400 m

Scale: 1:10,000 @A3





Legend

Redline Boundary

Map Contributions:
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Database License

LDE

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an RSK company

Title:

Mother Drain 1D Cross
Section Locations

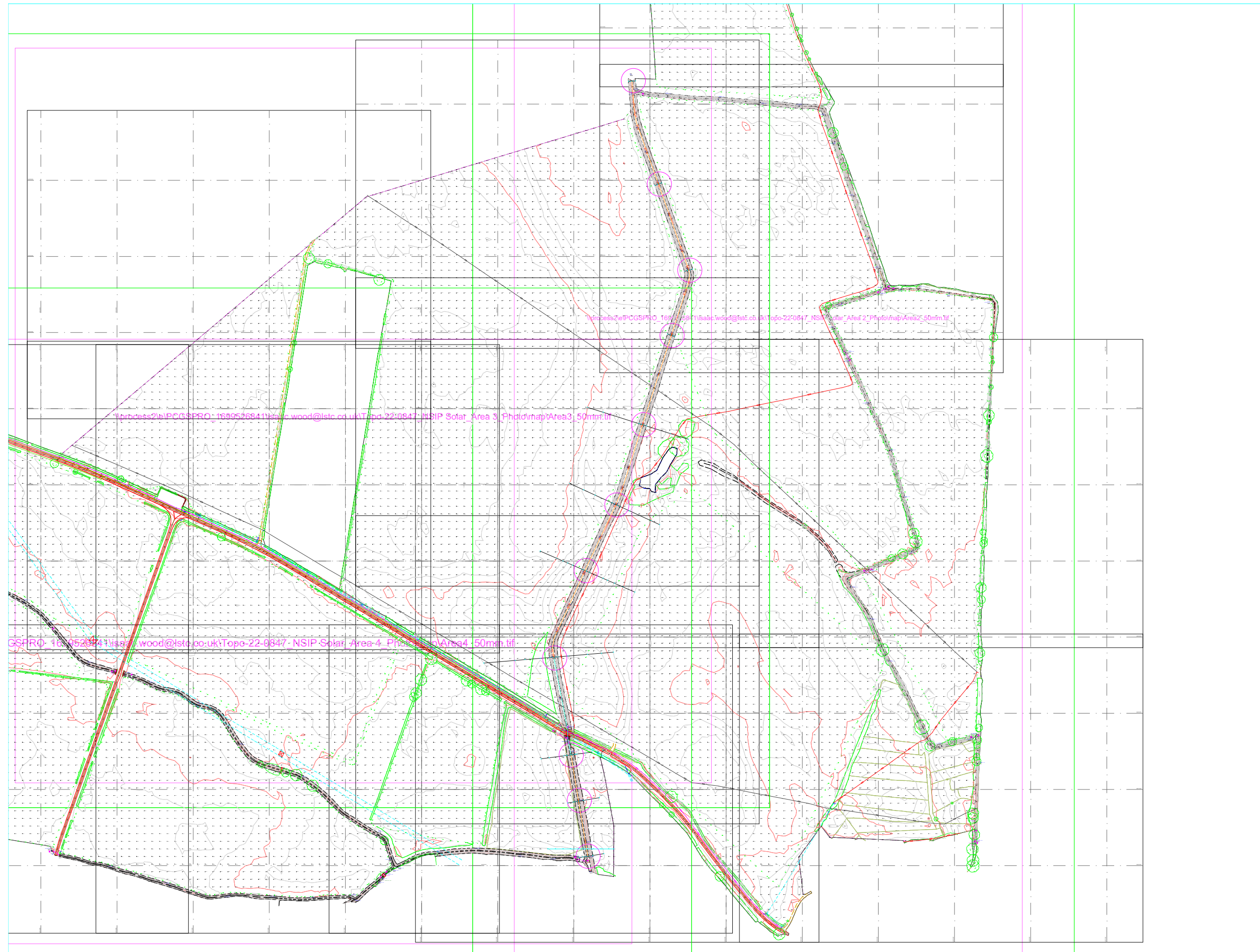
Drawn	Checked	Approved	Date
JW	CW	AC	06.05.25

Project: Steeples Renewables Project

Project No.	Originator	Number	Revision	Orig Size
680819	LDE-GIS	01	01	A3

0100200 m

Scale: 1:5000 @A3





Legend

Redline Boundary

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Title:

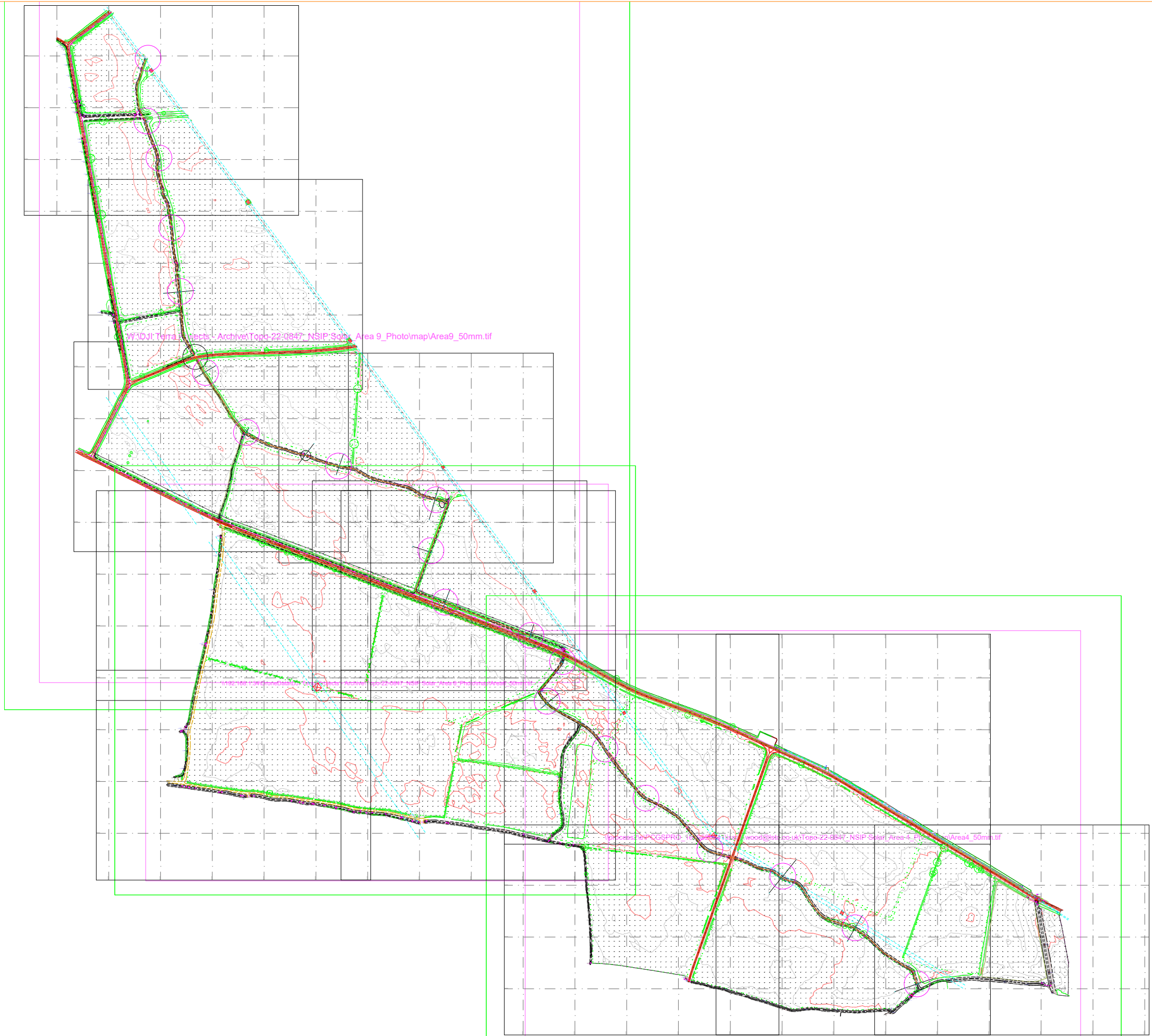
New Ings Drain 1D Cross
Section Locations

Drawn	Checked	Approved	Date
JW	CW	AC	07.05.25

Project:	Steeple's Renewables Project			
Project No.	Originator	Number	Revision	Orig Size
680819	LDE-GIS	01	01	A3

0150300 m

Scale: 1:7500 @A3



APPENDIX D

1D MODELLED CROSS SECTION DATA

CATCHWATER DRAIN CROSS SECTIONS

1		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativation	sp marker
Left Bank	0	0	7.077	0.035				479340.9713	382636.3219		
Left Bed	5.59	5.59	4.01	0.035				479344.8468	382636.7093		
Right Bed	2.4179	8.0079	4.056	0.035				479347.2539	382636.9374		
Right Bank	4.0295	12.0374	7.309	0.035				479351.2621	382637.3184		

2		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativation	sp marker
Left Bank	0	0	7.057	0.035				479316.4062	382890.8899		
Left Bed	3.8964	3.8964	3.881	0.035				479320.2898	382891.2049		
Right Bed	2.4743	6.3707	3.96	0.035				479322.7557	382891.4081		
Right Bank	3.84	10.2107	6.508	0.035				479326.5829	382891.721		

3		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativation	sp marker
Left Bank	0	0	6.837	0.035				479304.3252	383139.3745		
Left Bed	4.5011	4.5011	3.664	0.035				479308.803	383138.9175		
Right Bed	2.0626	6.5637	3.675	0.035				479310.8548	383138.7071		
Right Bank	6.0328	12.5965	6.858	0.035				479316.8565	383138.095		

4		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativation	sp marker
Left Bank	0	0	7.011	0.035				479339.3453	383364.9925		
Left Bed	4.3993	4.3993	3.493	0.035				479343.6999	383364.3666		
Right Bed	2.5146	6.9139	3.638	0.035				479346.189	383364.0093		
Right Bank	4.8934	11.8073	6.536	0.035				479351.0328	383363.3141		

5		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativation	sp marker
Left Bank	0	0	6.268	0.035				479379.437	383621.0393		
Left Bed	4.4037	4.4037	3.419	0.035				479383.826	383620.6806		
Right Bed	2.4944	6.8981	3.537	0.035				479386.3121	383620.4778		
Right Bank	5.1678	12.0659	6.683	0.035				479391.4628	383620.0578		

6		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativation	sp marker
Left Bank	0	0	6.696	0.035				479415.9	383854.9685		
Left Bed	4.9888	4.9888	3.42	0.035				479420.8364	383854.247		

Right Bed	2.6969	7.6857	3.472	0.035				479423.5051	383853.8578		
Right Bank	4.96	12.6457	6.806	0.035				479428.4129	383853.1403		

7		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativation	sp marker
Left Bank	0	0	5.955	0.035				479487.0984	384103.6757		
Left Bed	4.2896	4.2896	3.291	0.035				479491.2546	384102.6143		
Right Bed	2.388	6.6776	3.254	0.035				479493.5683	384102.0231		
Right Bank	3.8701	10.5477	6.319	0.035				479497.3182	384101.0661		

8		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativation	sp marker
Left Bank	0	0	6.116	0.035				479565.5565	384364.769		
Left Bed	3.5345	3.5345	3.142	0.035				479568.9594	384363.8137		
Right Bed	2.9262	6.4607	3.261	0.035				479571.7771	384363.0238		
Right Bank	4.7275	11.1882	6.853	0.035				479576.3287	384361.7465		

9		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativation	sp marker
Left Bank	0	0	5.772	0.035				479638.3091	384600.2822		
Left Bed	4.0368	4.0368	2.786	0.035				479641.9331	384598.5041		
Right Bed	2.2663	6.3031	2.808	0.035				479643.9679	384597.5061		
Right Bank	5.8186	12.1217	6.237	0.035				479649.1913	384594.9426		

10		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativation	sp marker
Left Bank	0	0	6.107	0.035				479818.5872	384744.0997		
Left Bed	5.4535	5.4535	2.712	0.035				479821.7462	384739.6543		
Right Bed	2.5771	8.0306	2.787	0.035				479823.2392	384737.5537		
Right Bank	3.9655	11.9961	6.056	0.035				479825.537	384734.3211		

11		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativation	sp marker
Left Bank	0	0	5.434	0.035				480059.8235	384861.7525		
Left Bed	4.4185	4.4185	2.575	0.035				480060.5282	384857.3906		
Right Bed	3.2516	7.6701	2.555	0.035				480061.048	384854.1808		
Right Bank	3.3546	11.0247	5.185	0.035				480061.5835	384850.8692		

MOTHER DRAIN CROSS SECTIONS

1		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	3.229	0.035				481965.788	382621.9402		
	10.0015	10.0015	3.403	0.035				481975.788	382621.9402		
	10	20.0015	3.397	0.035				481985.788	382621.9402		
	10.0003	30.0018	3.477	0.035				481995.788	382621.9402		
	10.0027	40.0045	3.711	0.035				482005.788	382621.9402		
	7.5194	47.5239	3.85	0.035				482012.3281	382621.9445		
Left Bed	3.1666	50.6905	1.163	0.035				482015.4946	382621.9411		
Right Bed	2.5374	53.2279	1.142	0.035				482018.032	382621.9459		
	5.3331	58.561	3.843	0.035				482023.3651	382621.9446		
	4.5075	63.0685	3.801	0.035				482025.788	382621.9402		
	10	73.0685	3.823	0.035				482035.788	382621.9402		
	10.0033	83.0718	3.505	0.035				482045.788	382621.9402		
	6.66	89.7318	3.551	0.035				482052.4477	382621.9402		

2		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left 1	-7.3374	-9.8099	3.5	0.035				481991.926	382682.1071		
Left 2	-2.4725	-2.4725	3.75	0.035				481999.1613	382683.3272		
Left Bank	0	0	3.859	0.035				482001.5994	382683.7379		
Left Bed	3.4337	3.4337	1.203	0.035				482004.9853	382684.3086		
Right Bed	2.5046	5.9383	1.229	0.035				482007.4552	382684.7245		
Right Bank	5.1649	11.1032	4.223	0.035				482012.5481	382685.5837		
Right 2	4.6598	15.763	4	0.035				482017.1453	382686.3453		
Righ 1	16.5367	32.2997	3.75	0.035				482033.4496	382689.1075		

3		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	3.25	0.035				481956.9655	382740.0877		
	10.6579	10.6579	3.5	0.035				481967.5312	382741.4868		
	19.4349	30.0928	3.763	0.035				481986.7946	382744.0613		

	3.7381	33.8309	3.75	0.035				481990.5001	382744.554		
Left Bank	0.598	34.4289	3.577	0.035				481991.0926	382744.6343		
Left Bed	3.8917	38.3206	1.234	0.035				481994.9502	382745.1486		
Right Bed	2.5306	40.8512	1.182	0.035				481997.4588	382745.4818		
Right Bank	3.4253	44.2765	3.828	0.035				482000.854	382745.9348		
	1.291	45.5675	4	0.035				482002.1333	382746.1077		
	1.9395	47.507	4.25	0.035				482004.0561	382746.3623		
	11.5539	59.0609	4.5	0.035				482015.5093	382747.8845		
	8.4793	67.5402	4.25	0.035				482023.9138	382749.0082		

4		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	3.5	0.035				481881.6148	382865.9891		
	41.301	41.301	3.25	0.035				481922.7749	382869.3983		
	13.0581	54.3591	3.099	0.035				481935.788	382870.4812		
	20.0696	74.4287	3.226	0.035				481955.789	382872.1392		
Left Bank	12.7255	87.1542	3.283	0.035				481968.4709	382873.1914		
Left Bed	3.2448	90.399	1.093	0.035				481971.7047	382873.4592		
Right Bed	3.9102	94.3092	1.174	0.035				481975.6015	382873.7824		
Right Bank	3.131	97.4402	3.587	0.035				481978.7218	382874.0414		
	13.5574	110.9976	3.25	0.035				481992.2375	382875.1051		
	25.7236	136.7212	3.5	0.035				482017.8683	382877.2875		
	18.464	155.1852	3.75	0.035				482036.2693	382878.812		
	15.8007	170.9859	4.25	0.035				482052.0158	382880.1191		

5		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	4.164	0.035				481955.788	383012.9995		
	23.4047	23.4047	4	0.035				481977.2622	383003.6914		
	9.2789	32.6836	3.75	0.035				481985.7752	383000		
	6.6371	39.3207	3.5	0.035				481991.8631	382997.3566		
	7.0141	46.3348	3.25	0.035				481998.2963	382994.5615		
Left Bank	13.4212	59.756	3.222	0.035				482010.6141	382989.2323		

Left Bed	2.7308	62.4868	1.11	0.035				482013.1197	382988.1463		
Right Bed	3.7317	66.2185	1.113	0.035				482016.5435	382986.6622		
Right Bank	4.0701	70.2886	3.287	0.035				482020.2777	382985.0431		
	19.5761	89.8647	3.25	0.035				482038.2377	382977.2543		
	6.4474	96.3121	3.5	0.035				482044.1535	382974.6907		
	9.9564	106.2685	3.75	0.035				482053.2893	382970.7325		
	12.4654	118.7339	4	0.035				482064.7246	382965.7705		
	16.7407	135.4746	4.5	0.035				482080.0859	382959.1161		

6		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	4	0.035				481994.1416	383101.9402		
	21.0174	21.0174	3.5	0.035				482012.885	383093.3137		
	16.7418	37.7592	3.5	0.035				482027.8938	383086.4736		
Left Bank	24.4972	62.2564	3.732	0.035				482050.1919	383076.3295		
Left Bed	3.4509	65.7073	1.157	0.035				482053.3308	383074.8955		
Right Bed	3.8914	69.5987	1.061	0.035				482056.8719	383073.282		
Right Bank	3.7773	73.376	3.182	0.035				482060.3084	383071.7141		
	14.0007	87.3767	3.75	0.035				482073.0436	383065.8972		
	31.2531	118.6298	4	0.035				482101.4868	383052.9455		
	12.3642	130.994	4.25	0.035				482112.7287	383047.7985		

7		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	4	0.035				482017.8752	383201.9402		
	21.5847	21.5847	3.75	0.035				482038.4461	383195.4025		
Left Bank	49.2788	70.8635	3.832	0.035				482085.4481	383180.5967		
Left Bed	3.7054	74.5689	1.105	0.035				482088.9688	383179.4416		
Right Bed	3.1237	77.6926	1.108	0.035				482091.9371	383178.4683		
Right Bank	3.459	81.1516	3.941	0.035				482095.2246	383177.3925		
	33.0979	114.2495	4	0.035				482126.7716	383167.3796		
	24.8766	139.1261	4.25	0.035				482150.4831	383159.8556		

8		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	3.699	0.035				482123.2455	383297.8842		
Left Bed	3.343	3.343	1.091	0.035				482126.4308	383296.8692		
Right Bed	3.5948	6.9378	1.146	0.035				482129.856	383295.7782		
Right Bank	2.7773	9.7151	3.656	0.035				482132.5023	383294.9353		

9		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	4.015	0.035				482145.625	383380.5435		
Left Bed	5.3213	5.3213	1.019	0.035				482149.0343	383381.4549		
Right Bed	3.8691	9.1904	1.005	0.035				482152.771	383382.4586		
Right Bank	3.1642	12.3546	3.453	0.035				482155.8282	383383.2743		

10		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	3.766	0.035				482106.3133	383493.2282		
Left Bed	3.459	3.459	1.047	0.035				482109.5761	383494.3764		
Right Bed	3.5038	6.9628	1.169	0.035				482112.8807	383495.5409		
Right Bank	2.4494	9.4122	3.264	0.035				482115.1912	383496.3541		

11		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	3.338	0.035				482071.8993	383629.9039		
Left Bed	2.687	2.687	0.996	0.035				482074.5838	383630.0173		
Right Bed	3.2884	5.9754	0.887	0.035				482077.7708	383630.1519		
Right Bank	3.1225	9.0979	3.453	0.035				482080.8905	383630.2833		

NEW INGS DRAIN SOUTH CROSS SECTIONS

1		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	3.7	0.035				481717.2246	382594.5062		
	20.6321	20.6321	3.712	0.035				481736.7474	382601.1802		
Left Bank	22.8297	43.4618	3.503	0.035				481758.3497	382608.5651		
Left Bed	1.9344	45.3962	1.815	0.035				481760.1801	382609.1908		
Right Bed	0.733	46.1292	1.806	0.035				481760.8738	382609.4275		
Right Bank	2.2677	48.3969	3.837	0.035				481763.0194	382610.1615		
	6.1922	54.5891	4	0.035				481768.8856	382612.1659		
	4.1569	58.746	4	0.035				481772.8177	382613.5143		
	19.898	78.644	4	0.035				481791.6469	382619.9481		

2		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	3.939	0.035				481626.038	382691.9402		
	12.7534	12.7534	3.75	0.035				481632.1278	382702.4304		
Left Bank	13.7854	26.5388	3.652	0.035				481639.0872	382714.3301		
Left Bed	1.9808	28.5196	1.98	0.035				481640.0635	382716.0536		
Right Bed	1.032	29.5516	1.962	0.035				481640.5701	382716.9527		
Right Bank	2.8234	32.375	3.81	0.035				481641.9625	382719.4089		
	8.9478	41.3228	4	0.035				481646.4543	382727.1476		
	16.8138	58.1366	4.101	0.035				481654.7328	382741.437		

3		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	3.75	0.035				481474.9383	382784.7955		
	20.0562	20.0562	3.678	0.035				481487.606	382800.337		
Left Bank	16.1465	36.2027	3.611	0.035				481497.503	382812.573		
Left Bed	2.4316	38.6343	1.997	0.035				481498.6525	382813.9881		
Right Bed	0.913	39.5473	2.036	0.035				481499.2269	382814.6952		
Right Bank	2.9507	42.498	4.01	0.035				481501.0874	382816.9855		
	6.613	49.111	3.963	0.035				481505.3007	382822.0825		

	35.2423	84.3533	4	0.035				481527.4601	382849.4507		
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4		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	3.67	0.035				481357.2285	382864.3821		
Left Bed	1.6669	1.6669	1.998	0.035				481358.0288	382865.8443		
Right Bed	0.7773	2.4442	2.025	0.035				481358.4031	382866.5255		
Right Bank	3.0537	5.4979	4.192	0.035				481359.8697	382869.204		

5		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	3.635	0.035				481234.9558	382965.9984		
Left Bed	1.4623	1.4623	2.174	0.035				481235.7128	382967.2495		
Right Bed	0.6897	2.152	2.146	0.035				481236.0691	382967.84		
Right Bank	2.2442	4.3962	3.968	0.035				481237.2305	382969.7604		

6		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	3.9	0.035				481156.3569	383060.9438		
Left Bed	1.8286	1.8286	2.221	0.035				481157.9137	383061.9031		
Right Bed	0.6019	2.4305	2.189	0.035				481158.4261	383062.2189		
Right Bank	2.1809	4.6114	3.958	0.035				481160.2825	383063.3635		

7		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	3.811	0.035				481034.7746	383141.49		
	7.5593	7.5593	3.75	0.035				481040.6225	383146.2802		
	1.8517	9.411	3.5	0.035				481042.0493	383147.4605		
	1.8644	11.2754	3.25	0.035				481043.4938	383148.6391		
Left Bank	1.5009	12.7763	3.046	0.035				481044.6529	383149.5927		
Left Bed	1.1076	13.8839	2.274	0.035				481045.5092	383150.2951		
Right Bed	0.7754	14.6593	2.333	0.035				481046.1087	383150.7868		
Right Bank	1.9242	16.5835	3.863	0.035				481047.5964	383152.0071		
	13.3447	29.9282	3.912	0.035				481057.9188	383160.4646		
	14.5008	44.429	4	0.035				481069.1258	383169.6667		

8		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	3.779	0.03				481073.92	383231.2645		
Left Bed	1.6054	1.6054	2.32	0.035				481075.3089	383230.4596		
Right Bed	0.7473	2.3527	2.267	0.035				481075.956	383230.0856		
Right Bank	1.5476	3.9003	3.785	0.035				481077.2946	383229.3089		

NEW INGS DRAIN NORTH CROSS SECTIONS

9		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	4.382	0.035				481011.7137	383274.1734		
	3.0157	3.0157	4.25	0.035				481012.6077	383277.0536		
Left Bank	1.8847	4.9004	4.164	0.035				481013.1647	383278.8541		
Left Bed	2.0642	6.9646	2.58	0.035				481013.7759	383280.8257		
Right Bed	0.7685	7.7331	2.644	0.035				481014.0015	383281.5603		
Right Bank	1.6791	9.4122	3.98	0.035				481014.5006	383283.1635		
	1.8586	11.2708	4	0.035				481015.0526	383284.9382		
	7.1128	18.3836	3.941	0.035				481017.1596	383291.7317		
	11.3286	29.7122	4	0.035				481020.5112	383302.5532		

10		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	4.153	0.035				480843.927	383331.354		
	6.3941	6.3941	4.25	0.035				480845.6319	383335.907		
	1.4649	7.859	4.173	0.035				480846.1577	383337.2743		
Left Bank	5.537	13.396	3.972	0.035				480848.1064	383342.475		
Left Bed	1.4736	14.8696	2.635	0.035				480848.6265	383343.8538		
Right Bed	0.8185	15.6881	2.602	0.035				480848.9145	383344.6199		
Right Bank	1.807	17.4951	3.871	0.035				480849.5517	383346.3109		
	8.7755	26.2706	3.75	0.035				480852.6483	383354.5219		
	7.9225	34.1931	3.655	0.035				480855.4358	383361.9379		
	10.4433	44.6364	3.663	0.035				480859.1208	383371.7094		

11		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	3.679	0.035				480817.4649	383443.9812		
Left Bed	2.214	2.214	2.568	0.035				480819.5817	383443.3322		
Right Bed	0.8812	3.0952	2.576	0.035				480820.4238	383443.073		
Right Bank	1.5029	4.5981	3.871	0.035				480821.8607	383442.6325		

12		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	3.75	0.035				480818.7851	383505.1234		
	27.7428	27.7428	3.801	0.035				480826.401	383531.8003		
Left Bank	11.431	39.1738	3.744	0.035				480829.5288	383542.7951		
Left Bed	1.8896	41.0634	2.576	0.035				480830.0464	383544.6125		
Right Bed	0.9727	42.0361	2.624	0.035				480830.3137	383545.5477		
Right Bank	1.6326	43.6687	4.213	0.035				480830.7615	383547.1176		
	8.253	51.9217	4.25	0.035				480833.0134	383555.0575		
	13.8219	65.7436	4	0.035				480836.8157	383568.346		

13		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	3.864	0.035				480639.1582	383591.6087		
	6.0744	6.0744	4	0.035				480641.1825	383597.3359		
Left Bank	8.5532	14.6276	4.203	0.035				480643.9973	383605.4127		
Left Bed	2.1146	16.7422	2.745	0.035				480644.6972	383607.4081		
Right Bed	0.8731	17.6153	2.696	0.035				480644.9846	383608.2326		
Right Bank	1.8133	19.4286	4.082	0.035				480645.5856	383609.9434		
	12.6965	32.1251	4.046	0.035				480649.769	383621.9309		
	10.7209	42.846	4.085	0.035				480653.3324	383632.0423		

14		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	4.201	0.035				480460.5757	383665.6855		
	1.0564	1.0564	4	0.035				480461.132	383666.583		
Left Bank	5.4228	6.4792	3.776	0.035				480463.167	383669.896		
Left Bed	1.1648	7.644	2.588	0.035				480463.7764	383670.8873		
Right Bed	1.4734	9.1174	2.757	0.035				480464.5487	383672.1421		
Right Bank	1.3361	10.4535	4.479	0.035				480465.249	383673.279		
	6.3573	16.8108	4.5	0.035				480467.6173	383677.1189		
	8.5562	25.367	4.557	0.035				480470.6469	383682.0497		

15		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
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	0	0	4	0.035				480365.788	383778.2289		
	10.926	10.926	4.047	0.035				480374.5501	383783.3865		
Left Bank	8.5408	19.4668	3.873	0.035				480381.9162	383787.7091		
Left Bed	1.5359	21.0027	2.443	0.035				480383.2398	383788.4884		
Right Bed	0.7852	21.7879	2.595	0.035				480383.9163	383788.887		
Right Bank	3.1403	24.9282	4	0.035				480386.6221	383790.4809		
	12.2971	37.2253	4.25	0.035				480397.2393	383796.6851		
	10.8095	48.0348	4.326	0.035				480405.788	383801.6902		

16		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
	0	0	3.96	0.035				480306.038	383941.9402		
	9.138	9.138	4	0.035				480314.2384	383942.6985		
	18.0646	27.2026	4.25	0.035				480332.2281	383944.3416		
Left Bank	0.7087	27.9113	4.26	0.035				480332.9341	383944.4037		
Left Bed	2.3638	30.2751	2.552	0.035				480335.288	383944.6195		
Right Bed	1.1941	31.4692	2.567	0.035				480336.4771	383944.7287		
Right Bank	1.2291	32.6983	4.014	0.035				480337.701	383944.8415		
	1.563	34.2613	4.25	0.035				480339.2595	383944.9597		
	11.6469	45.9082	4.25	0.035				480350.8559	383946.0433		
	15.5103	61.4185	4.204	0.035				480365.8968	383947.4252		

17		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	3.886	0.035				480319.1311	384065.8626		
Left Bed	1.9393	1.9393	2.346	0.035				480321.0693	384065.9281		
Right Bed	0.9539	2.8932	2.592	0.035				480322.0227	384065.9593		
Right Bank	1.2563	4.1495	3.969	0.035				480323.2783	384066.0025		

18		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	4.058	0.035				480292.8309	384199.4367		
Left Bed	2.5699	2.5699	2.439	0.035				480295.3944	384199.6179		
Right Bed	1.1313	3.7012	2.553	0.035				480296.5229	384199.6986		

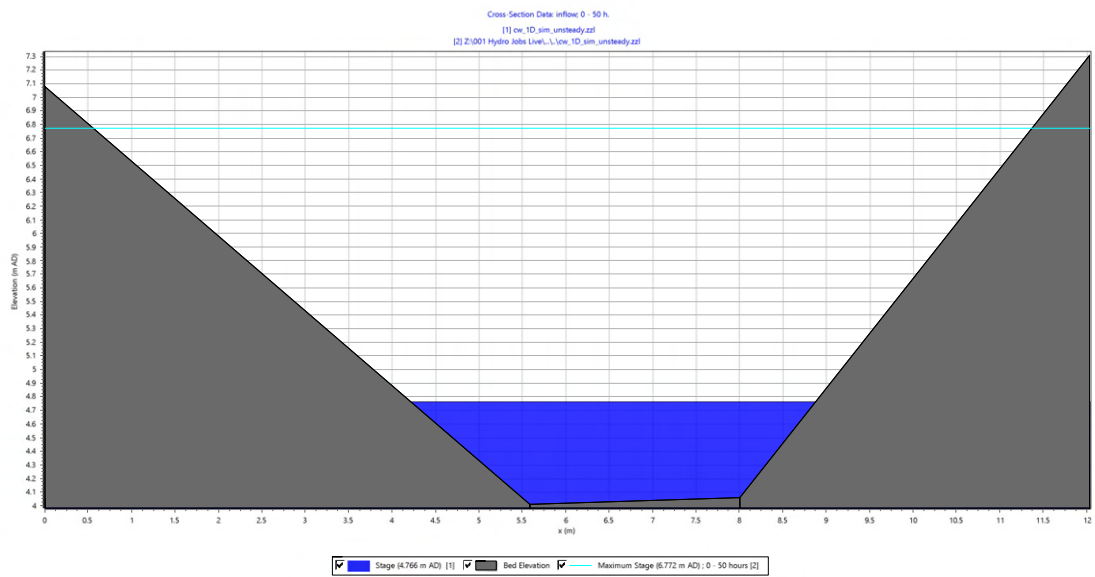
Right Bank	1.5542	5.2554	4.28	0.035				480298.0732	384199.8085		
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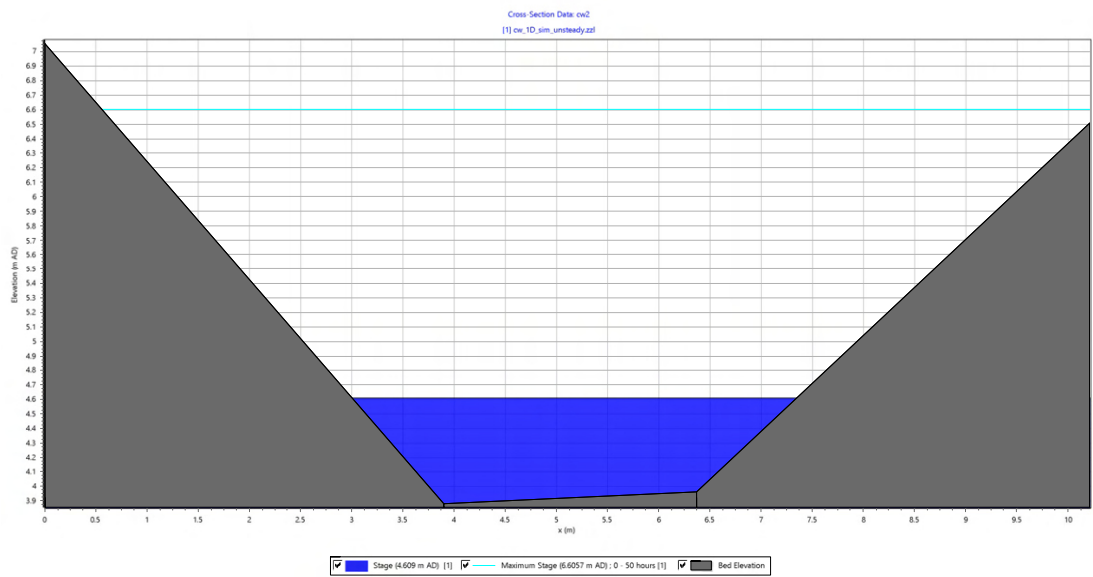
19		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	3.74	0.035				480268.2798	384271.6167		
Left Bed	2.2095	2.2095	2.372	0.035				480270.4074	384272.2126		
Right Bed	0.85	3.0595	2.554	0.035				480271.2254	384272.4439		
Right Bank	1.4239	4.4834	3.844	0.035				480272.5966	384272.8277		

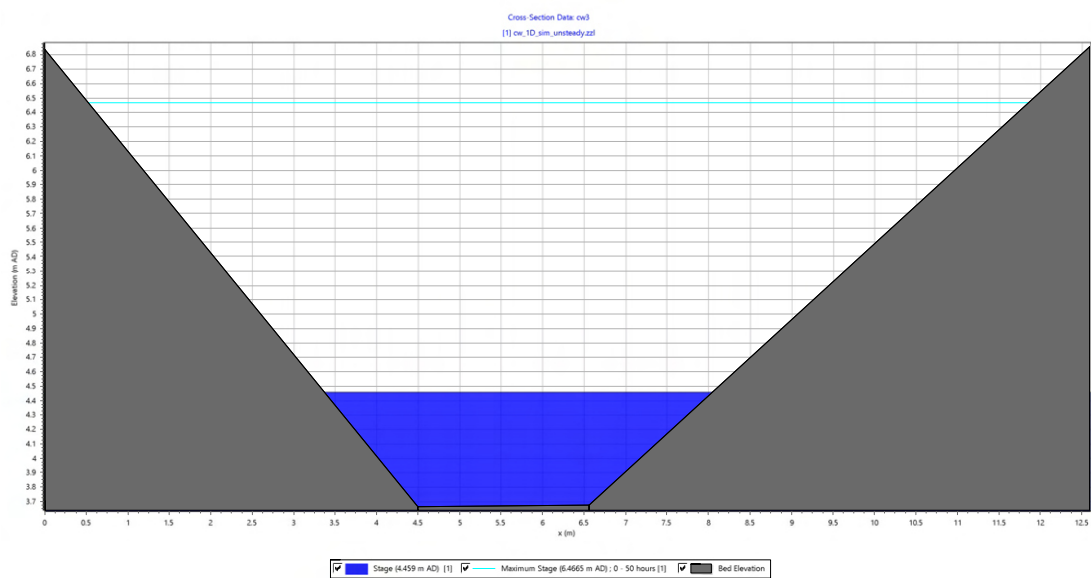
20		x(m)	y(mAOD)	mannings	pannel	RPL	Marker	Easting	Northing	Decativatio	sp marker
Left Bank	0	0	4.043	0.035				480269.182	384394.348		
Left Bed	1.8686	1.8686	2.369	0.035				480271.0184	384394		
Right Bed	1.0029	2.8715	2.495	0.035				480272.0038	384393.8129		
Right Bank	2.3014	5.1729	4.369	0.035				480274.2651	384393.3849		

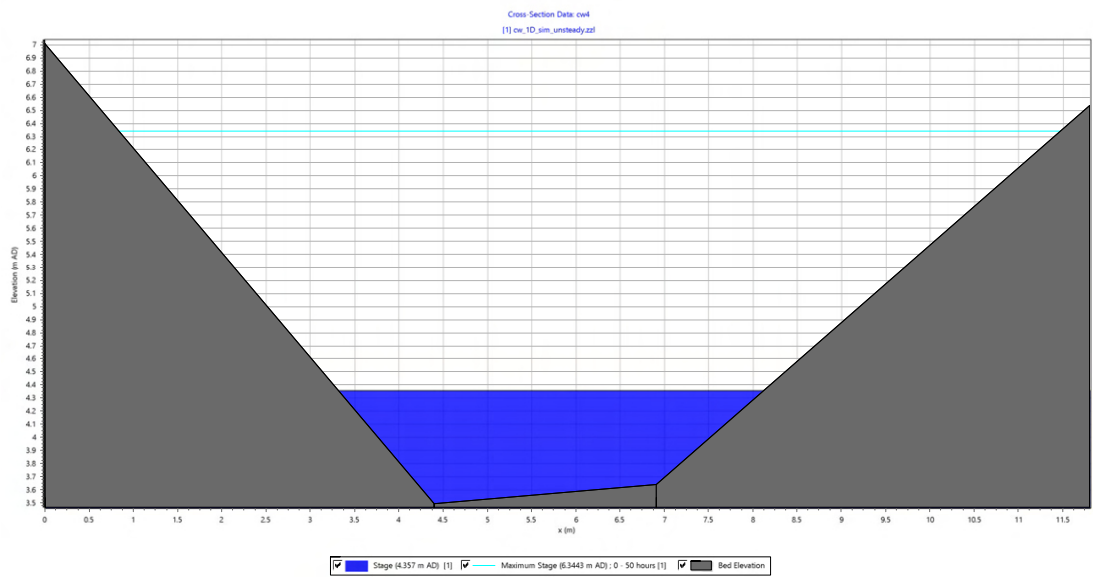
APPENDIX E

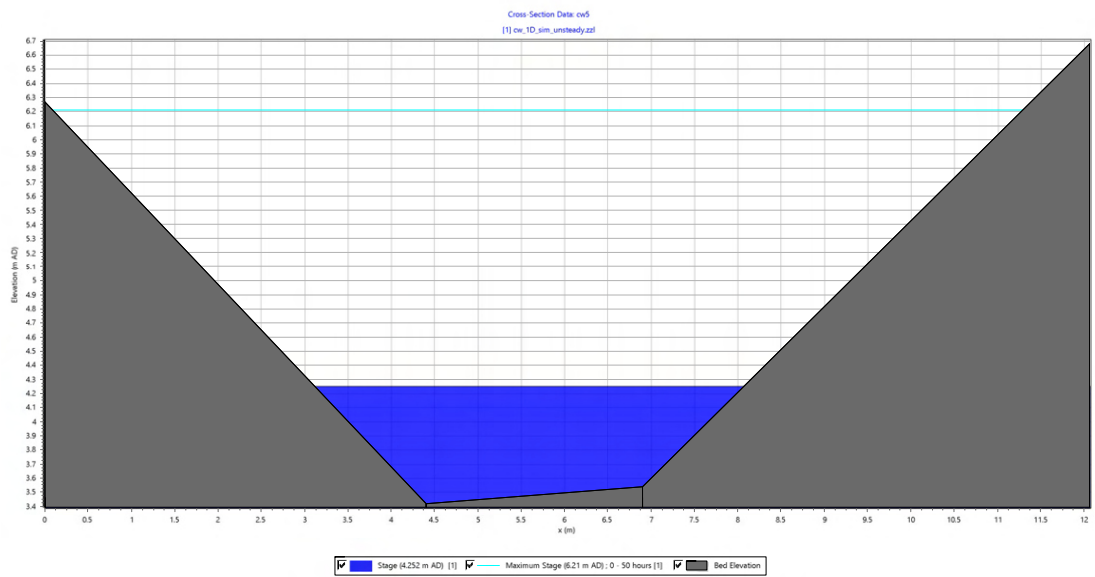
1D MODELLED CROSS SECTION WATER RESULTS

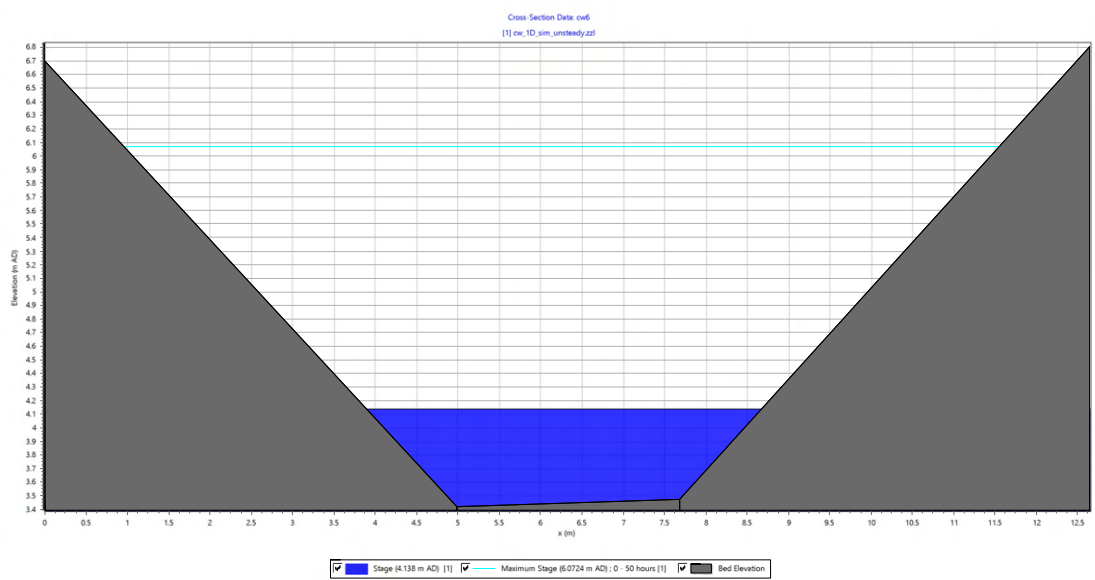


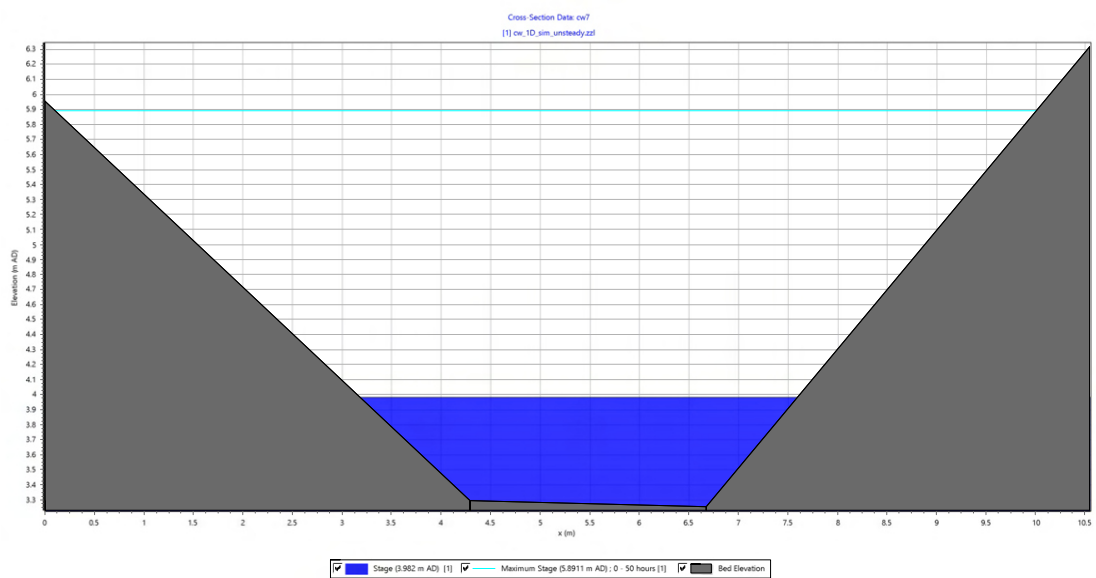


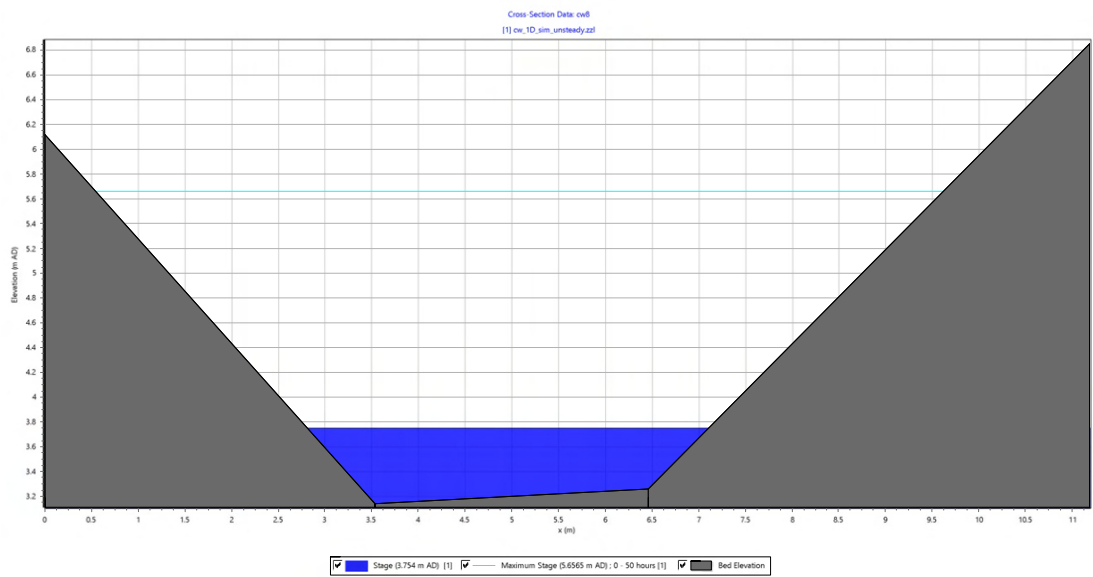


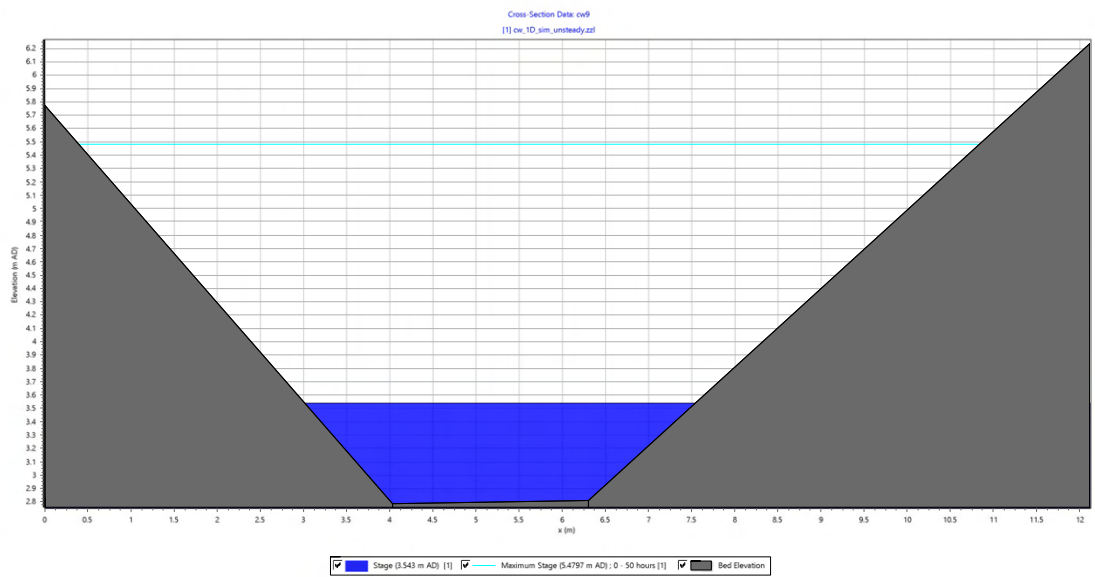


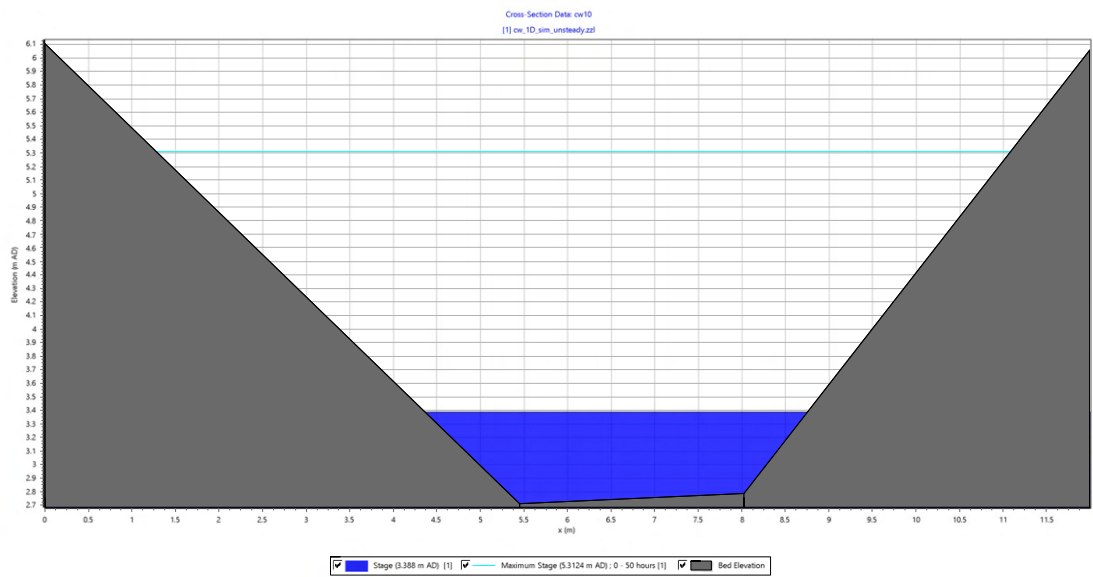


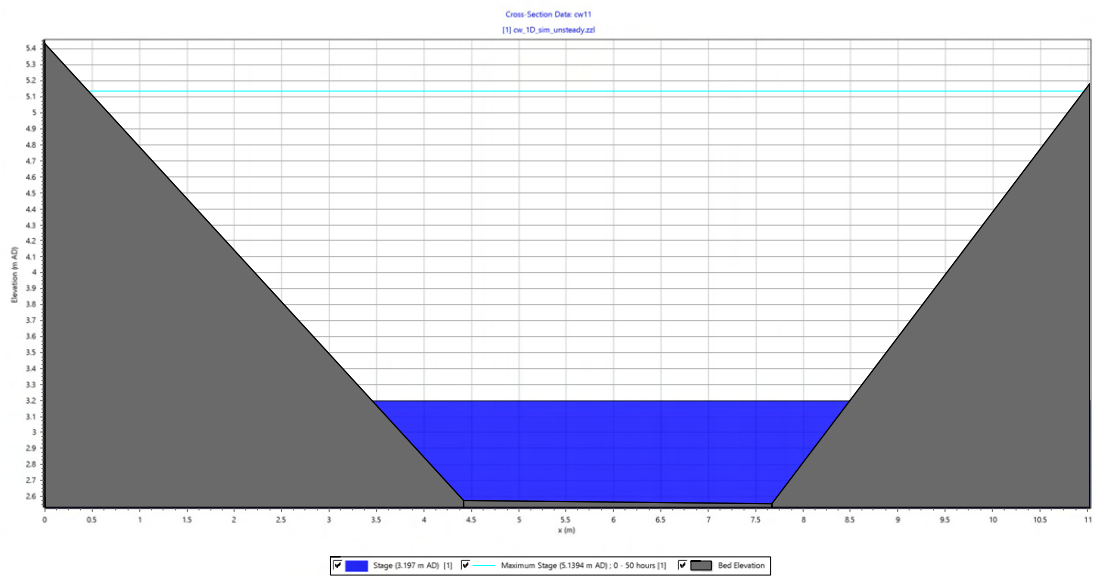


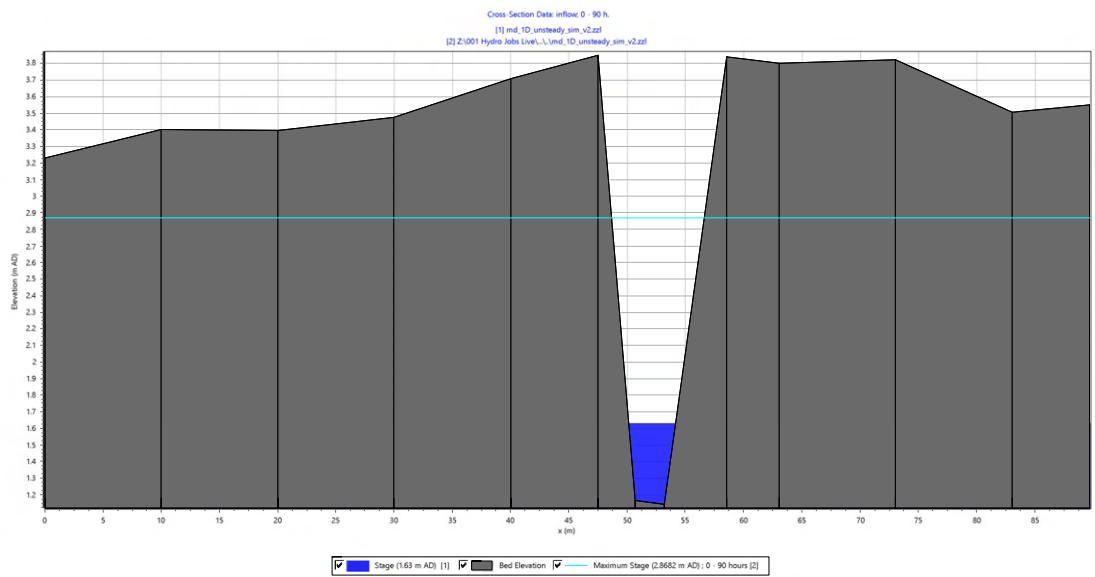


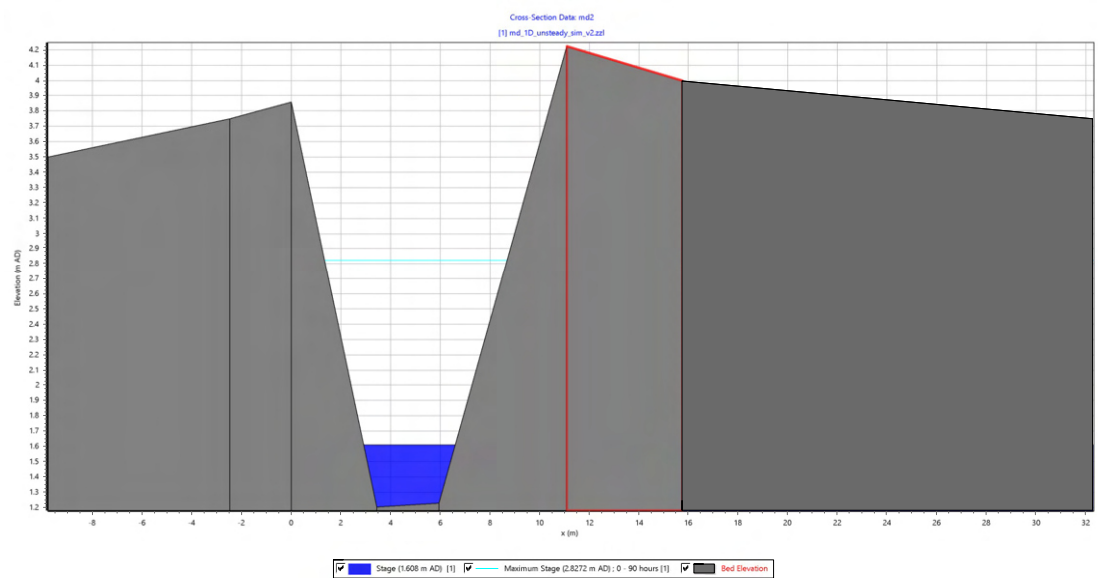


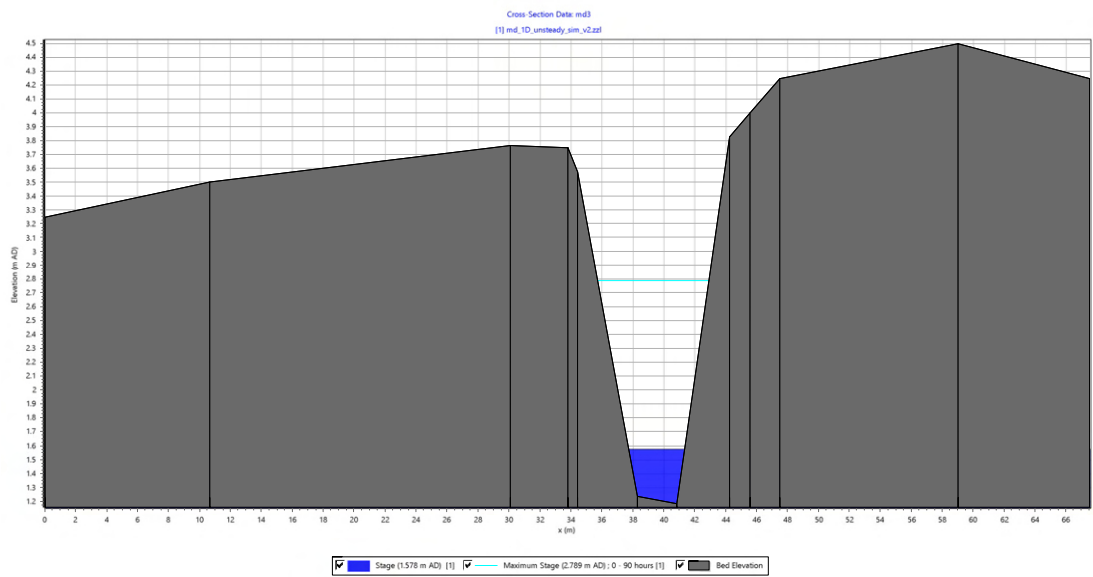


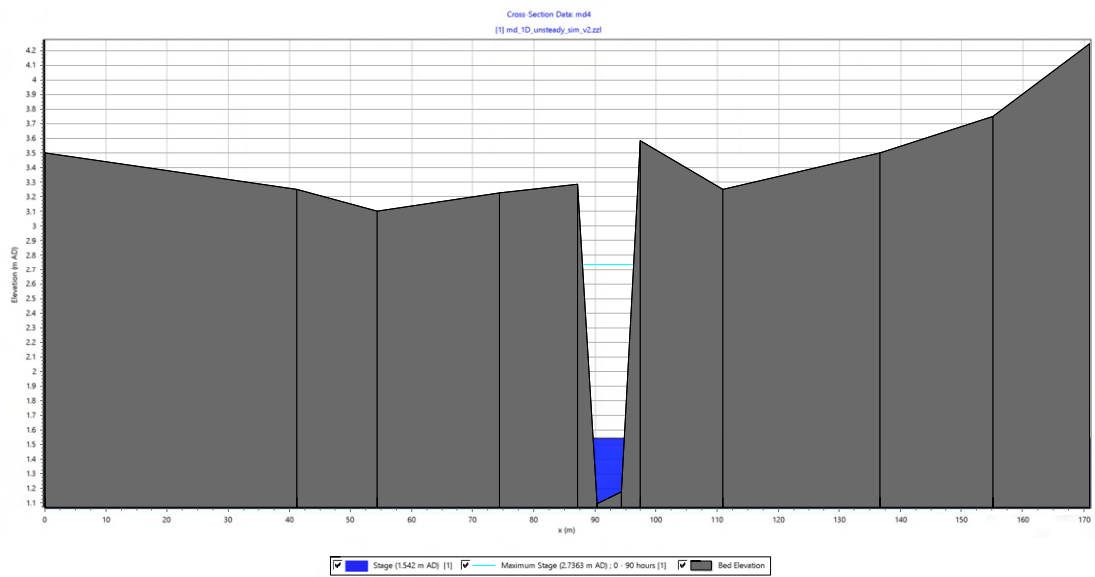


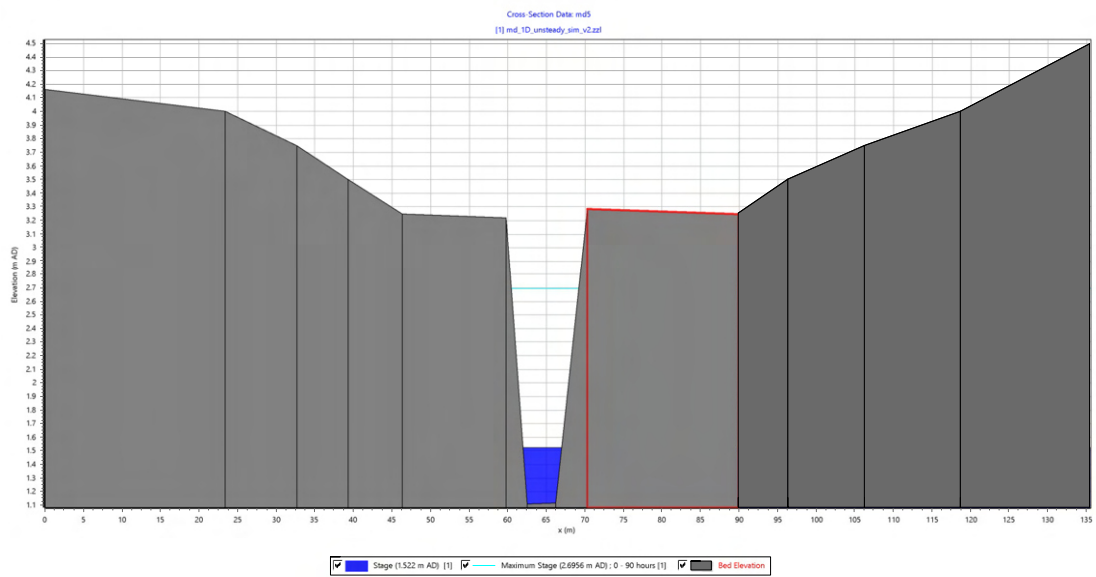


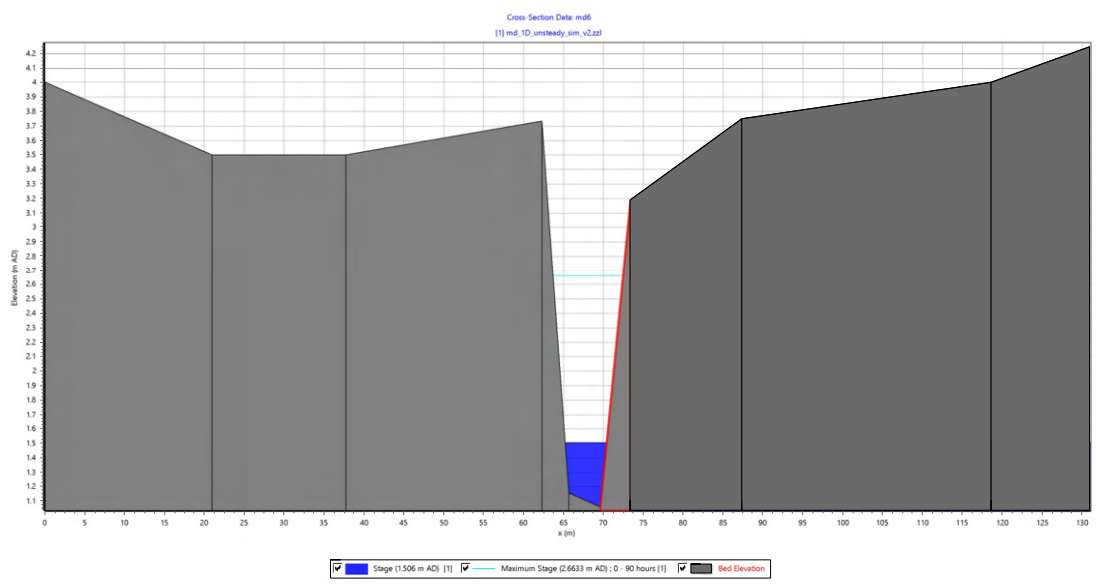


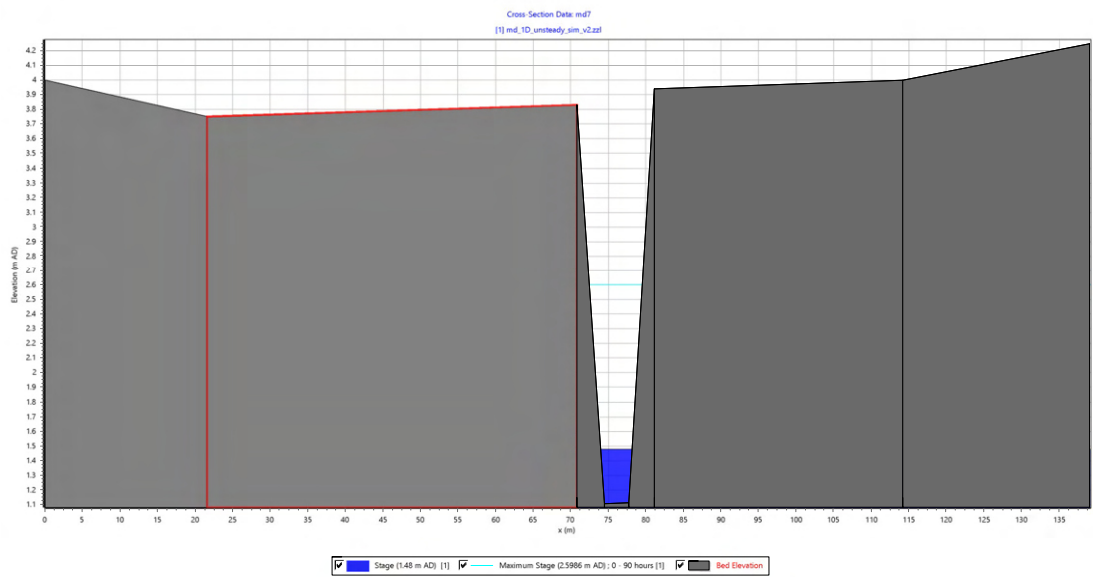


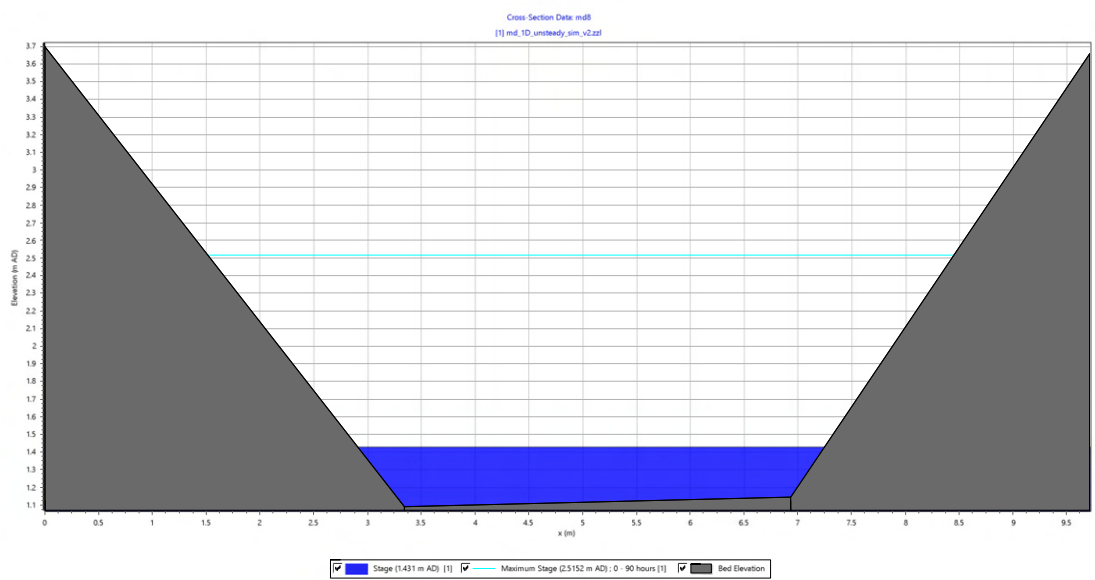


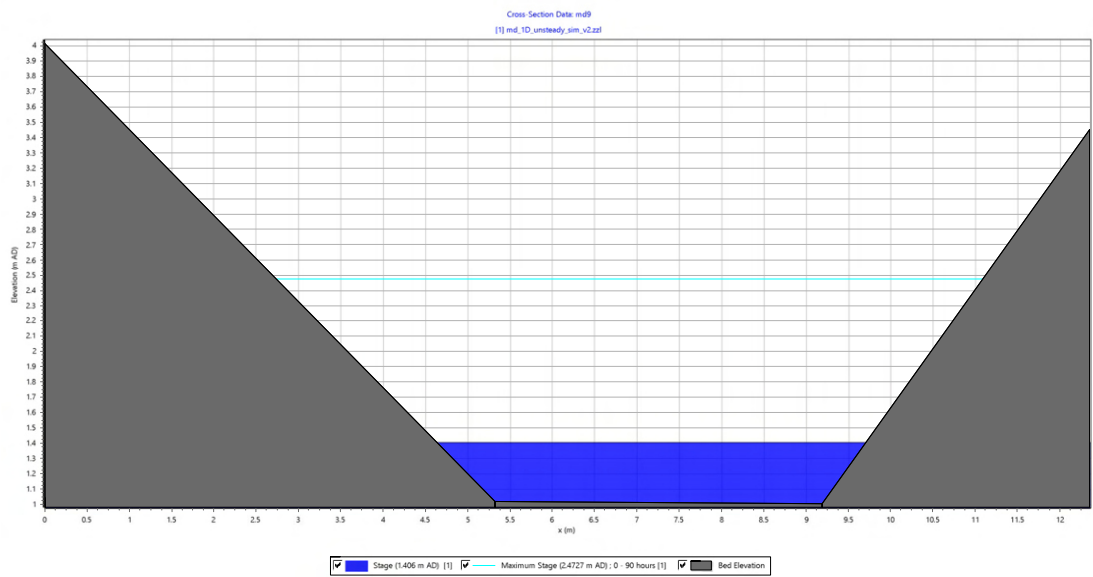


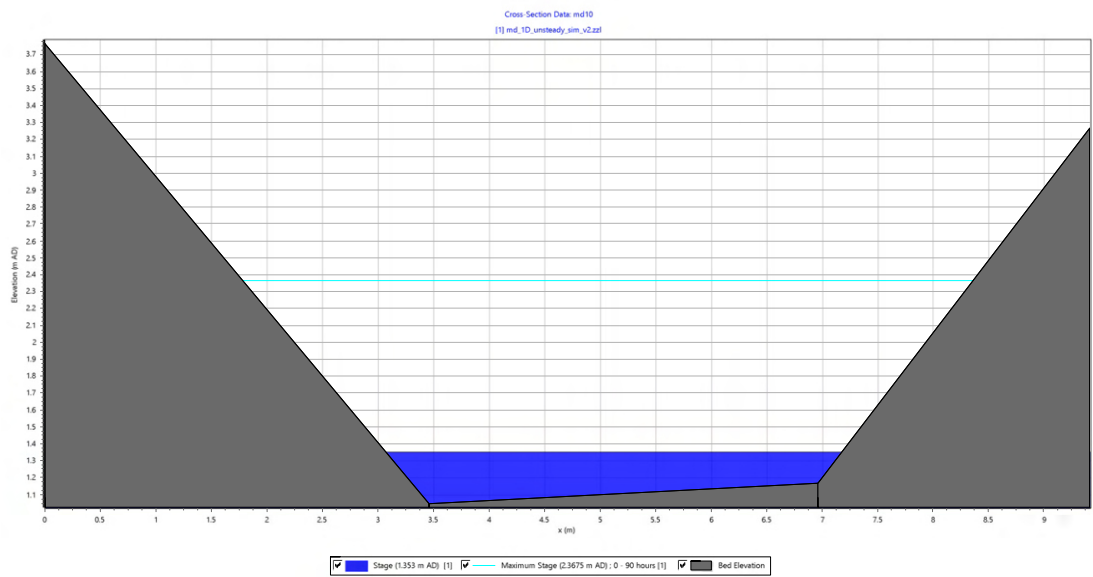


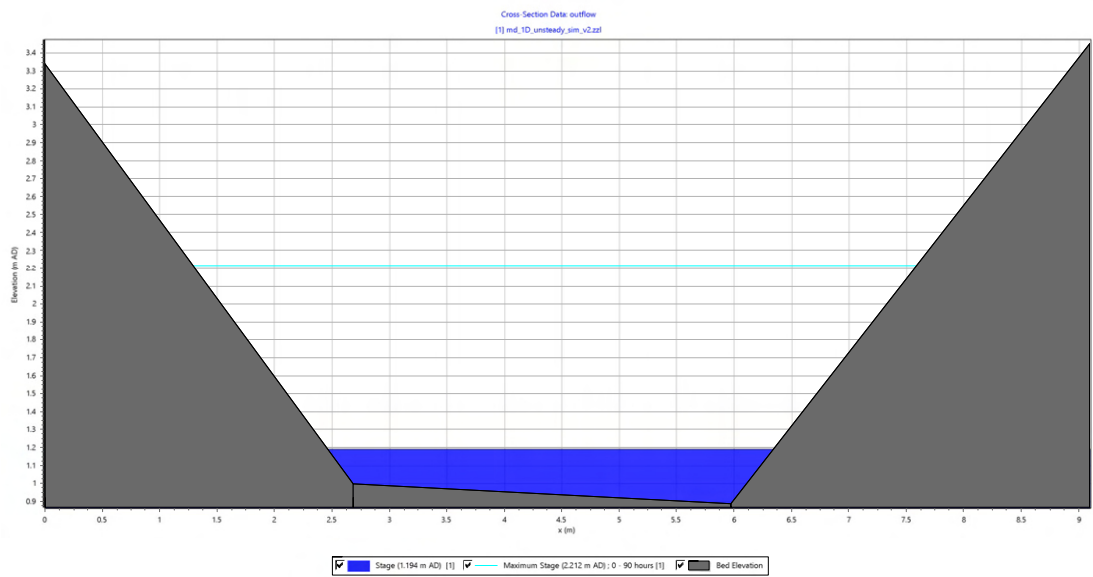


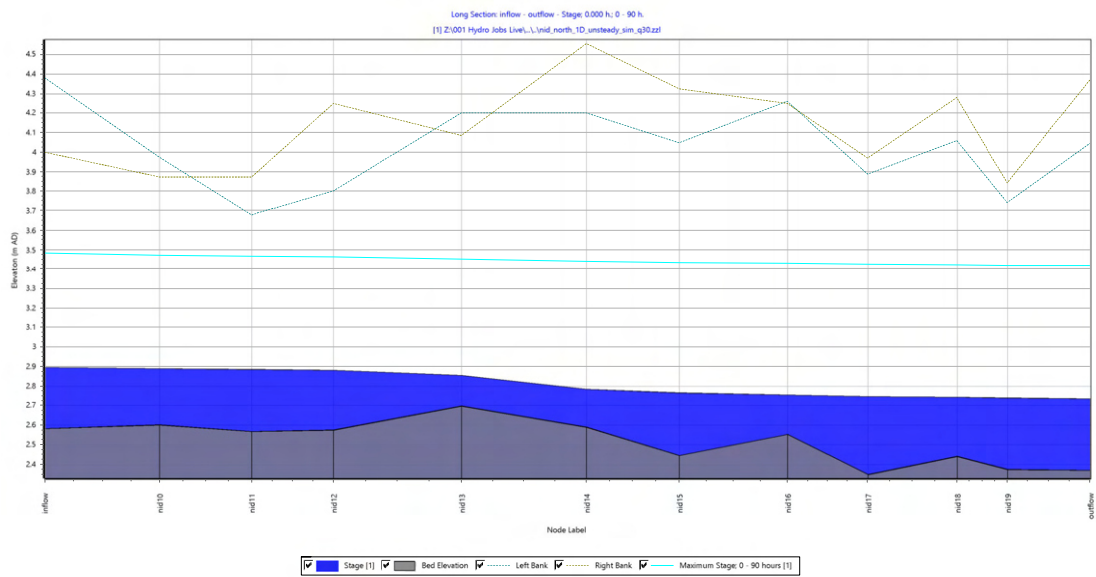


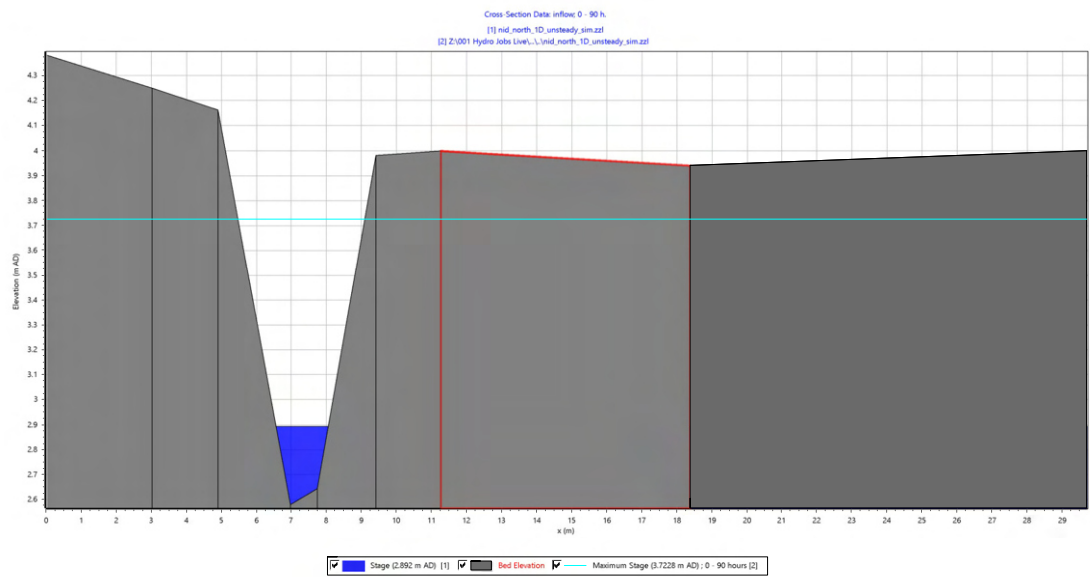


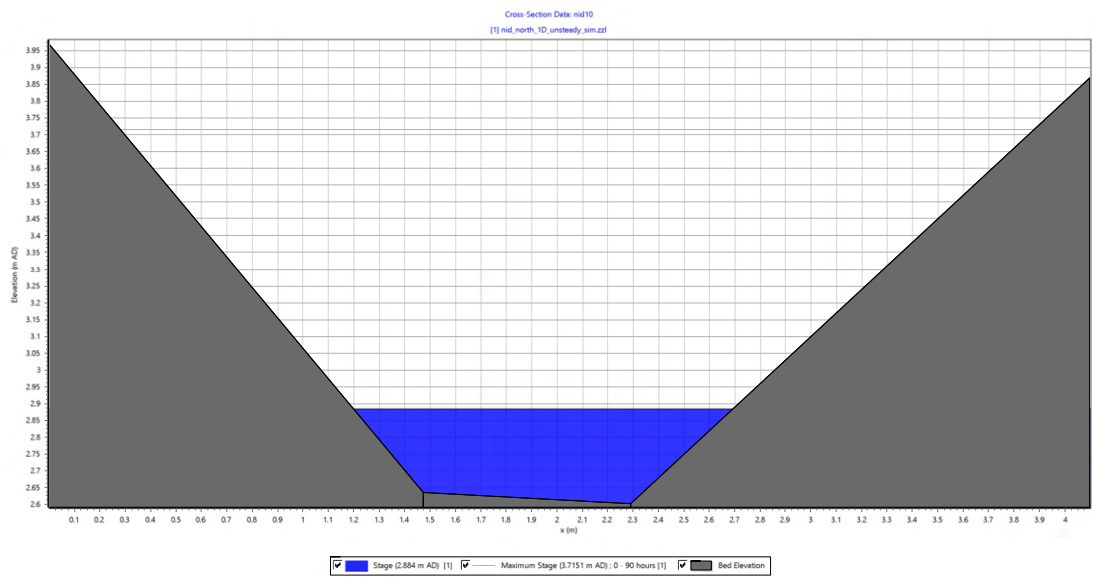


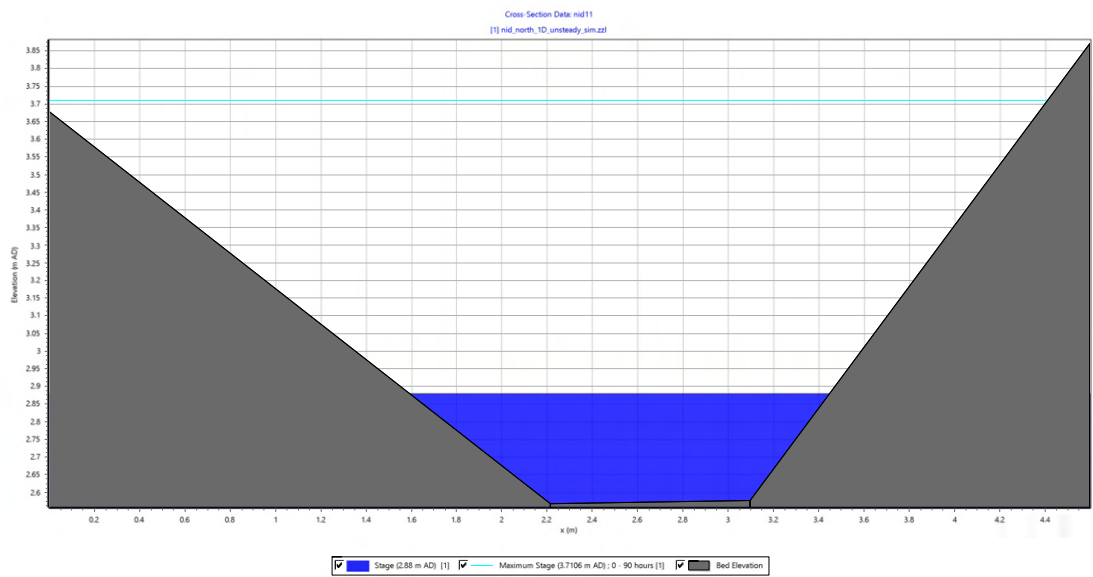


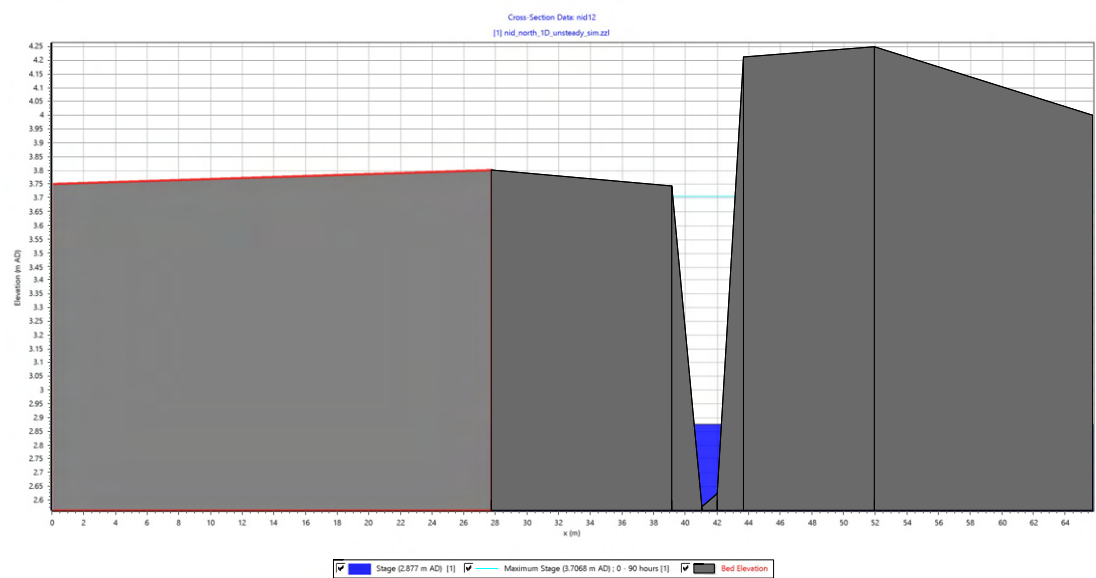


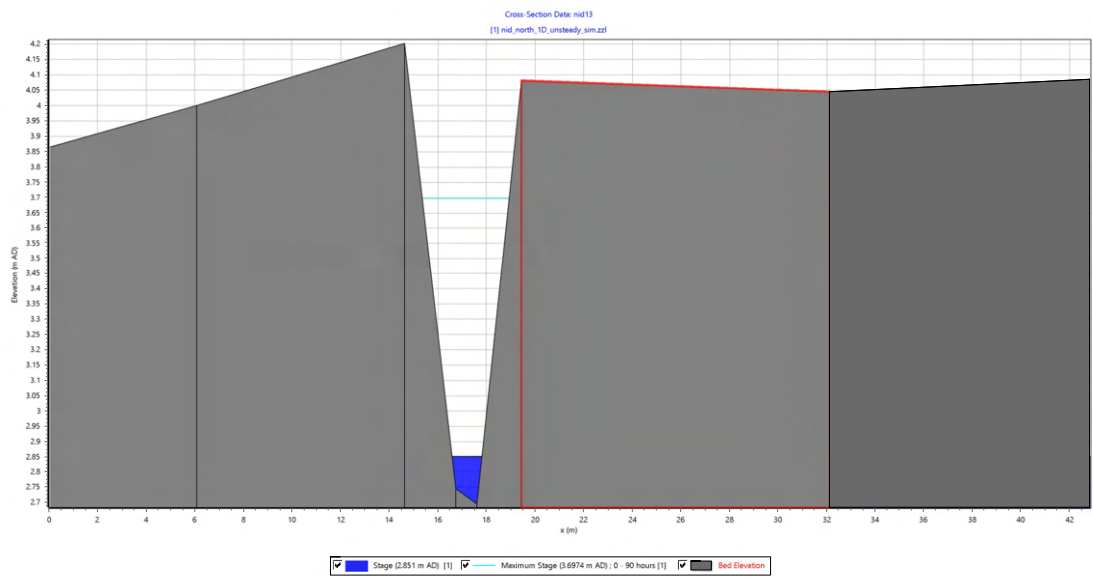


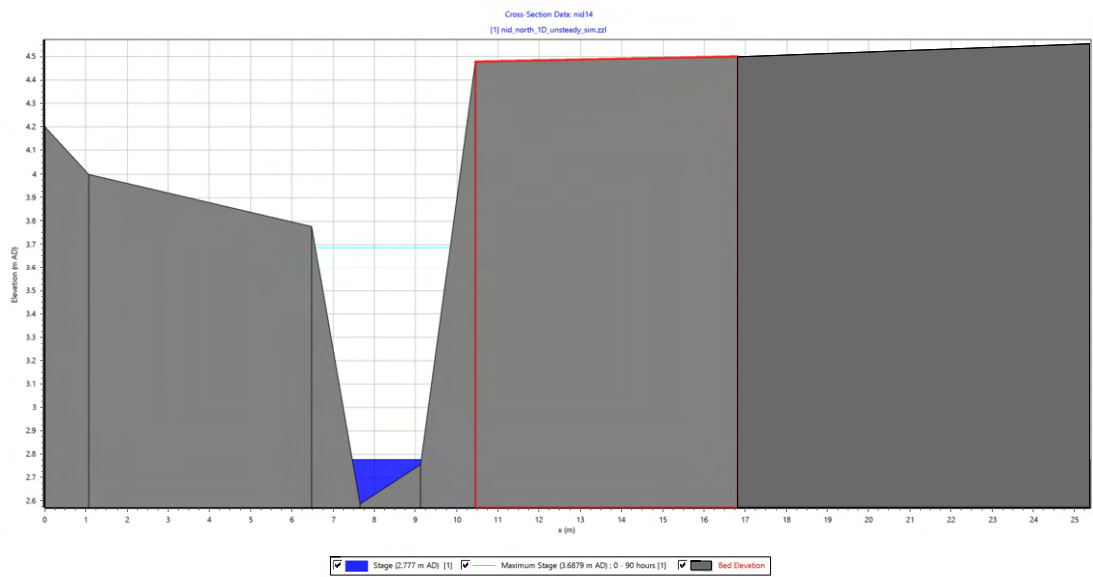


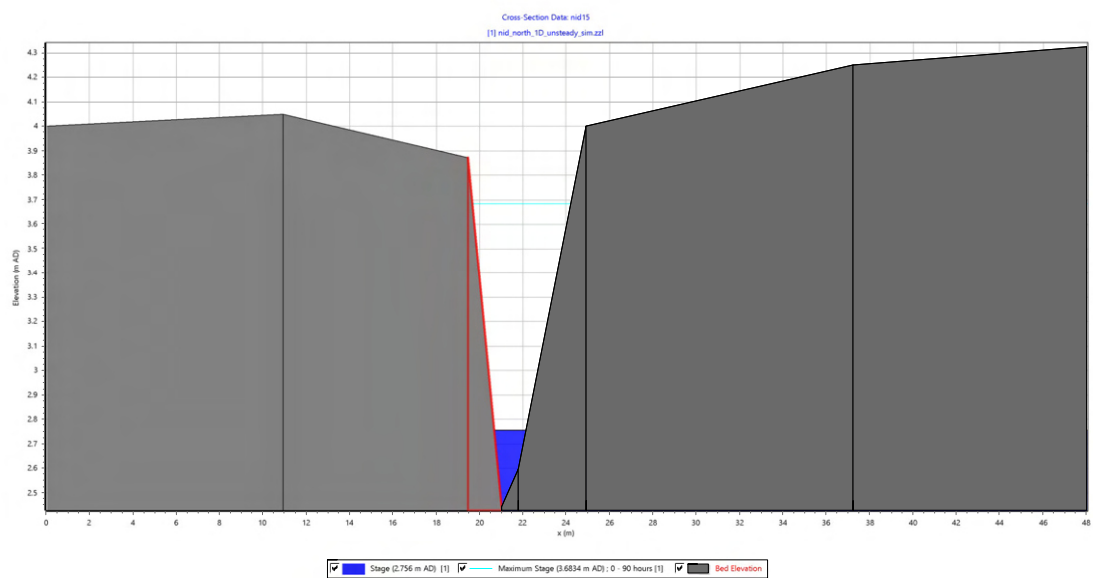


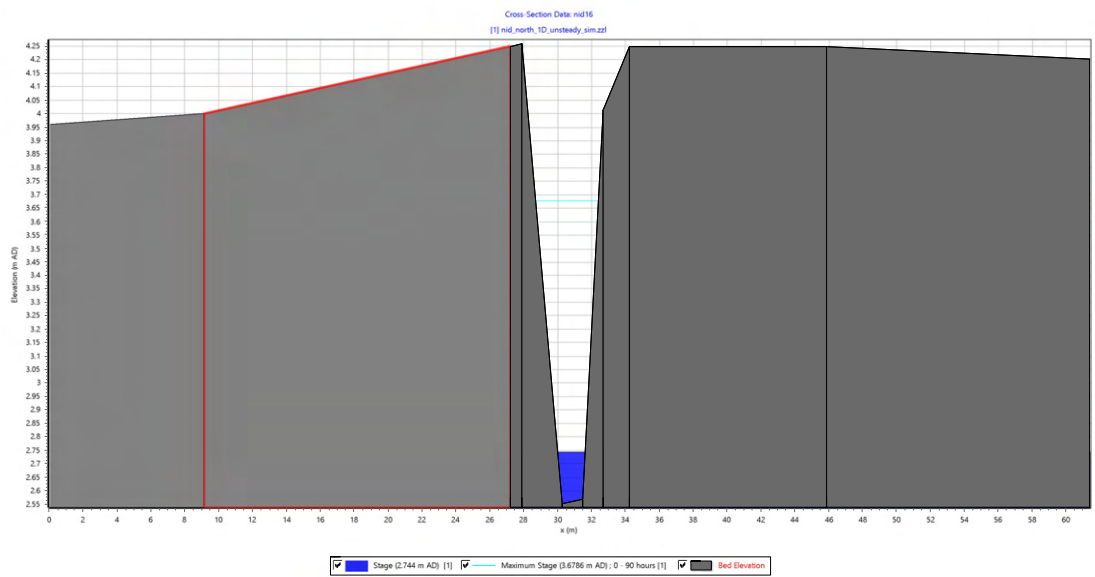


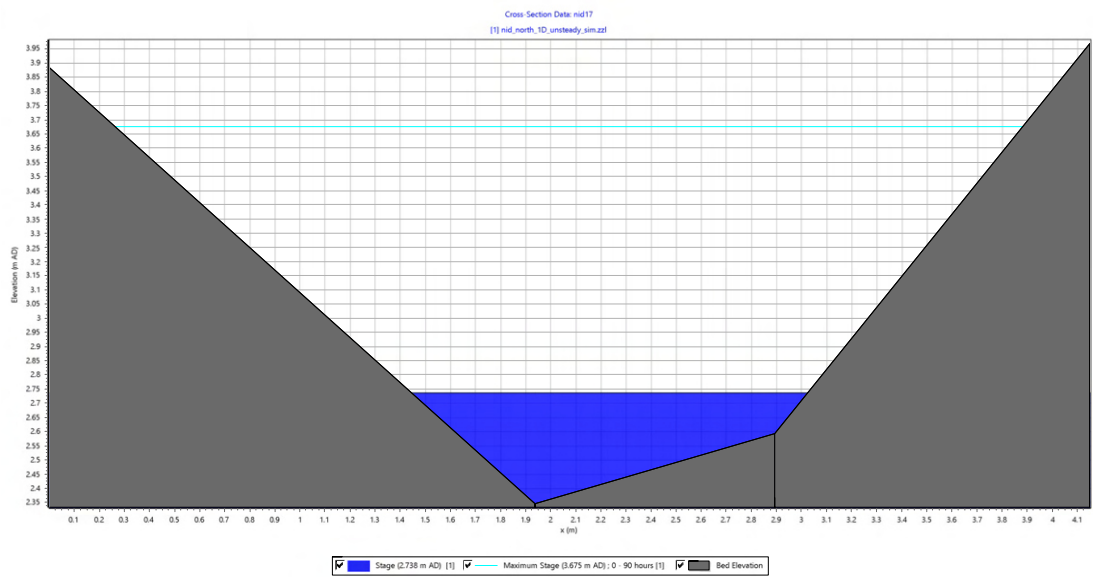


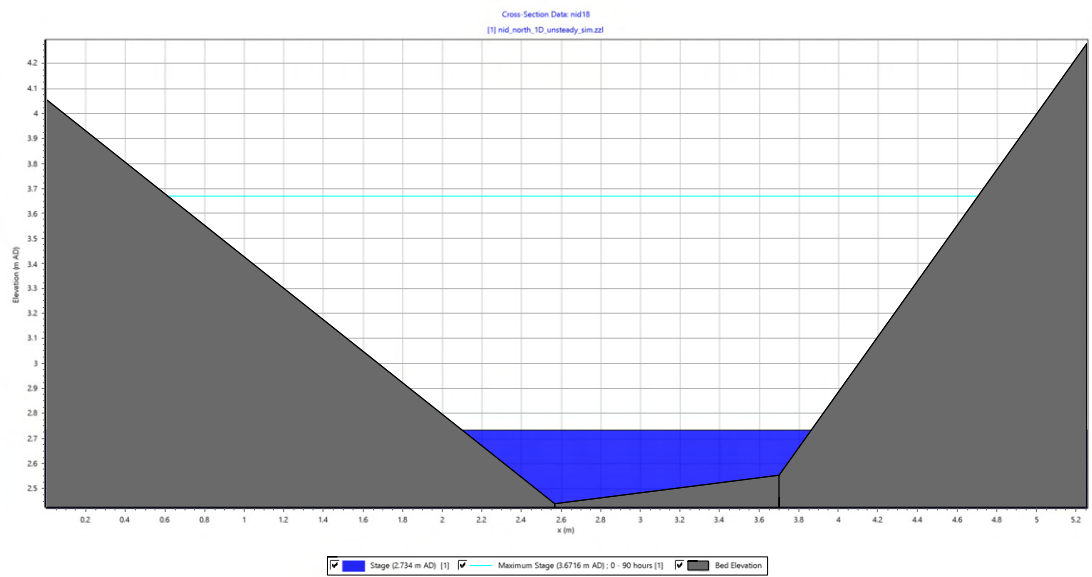


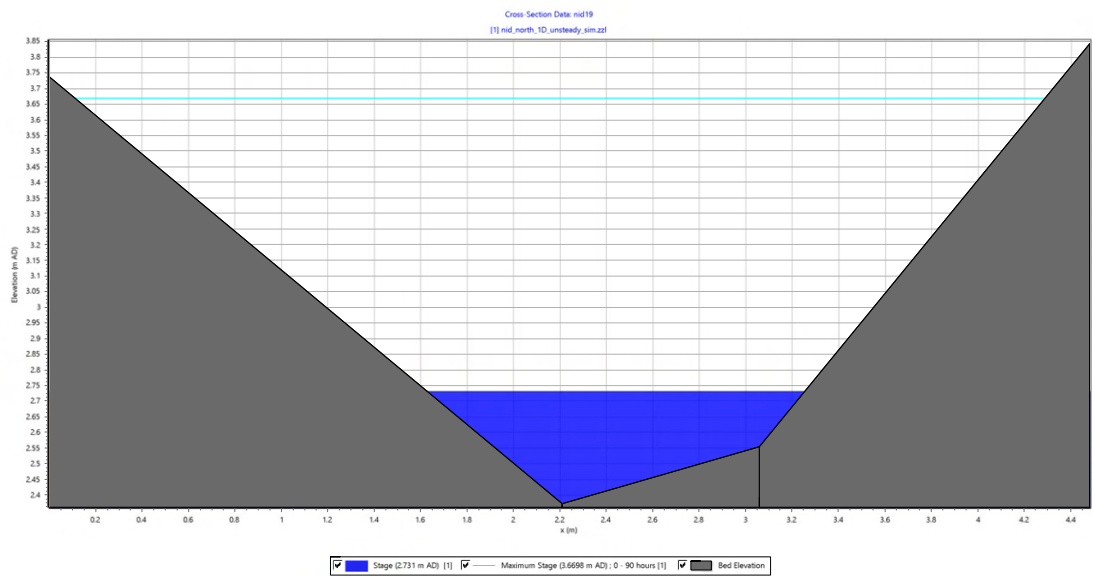


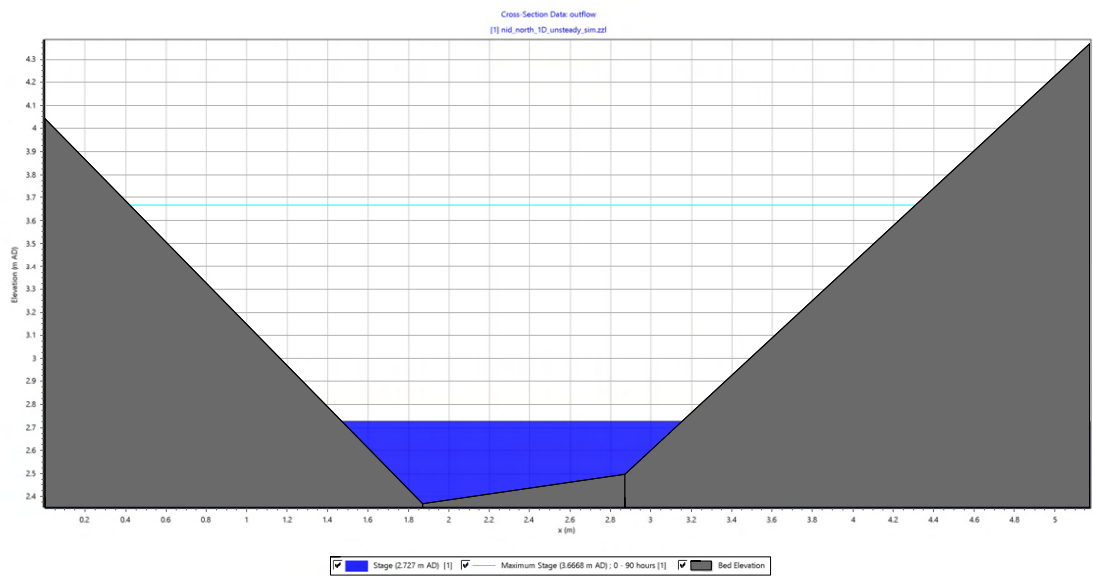


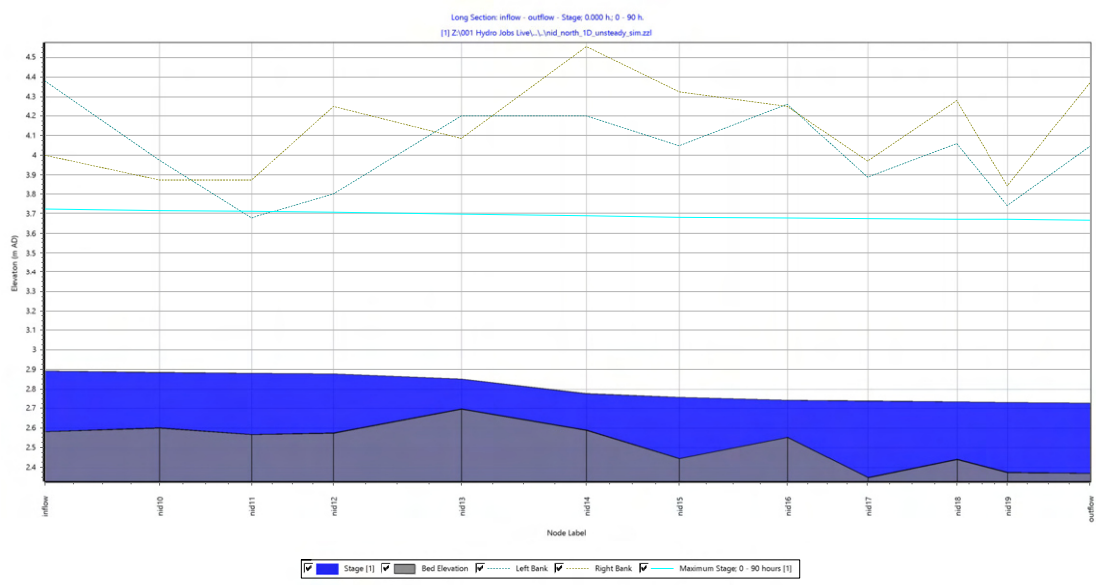


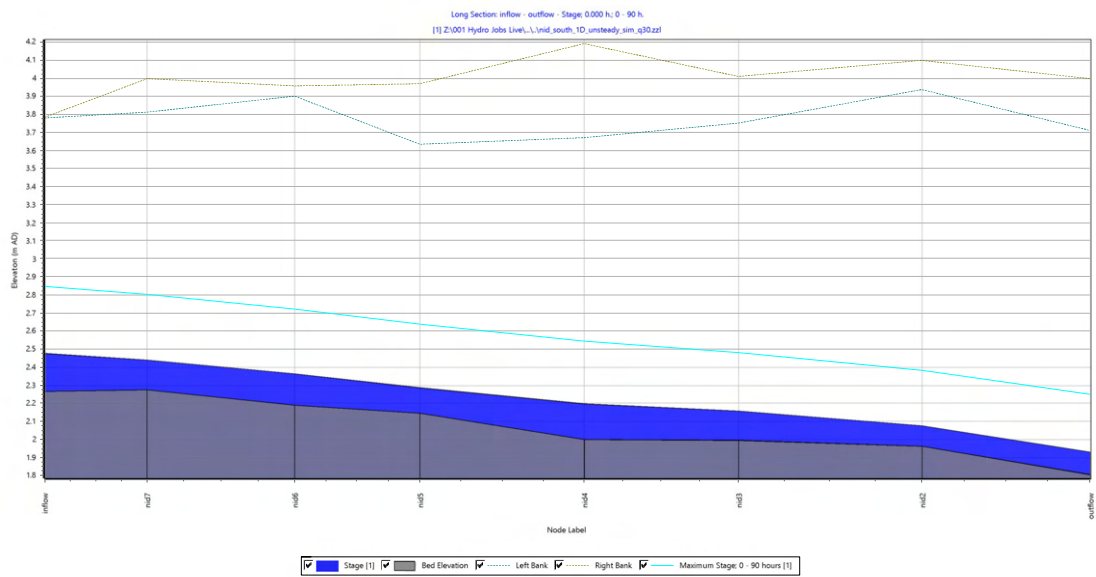


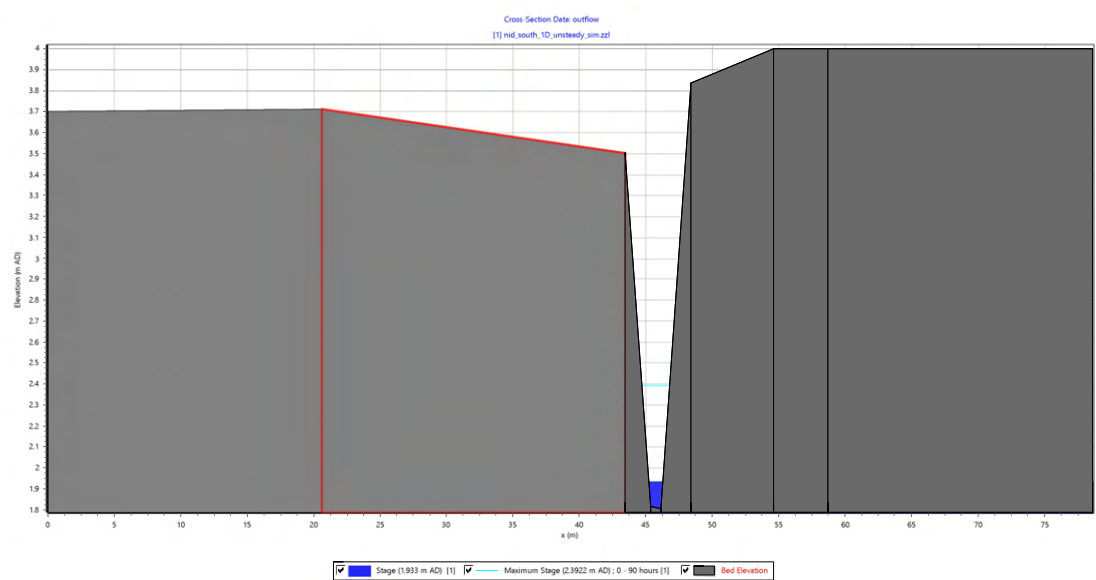


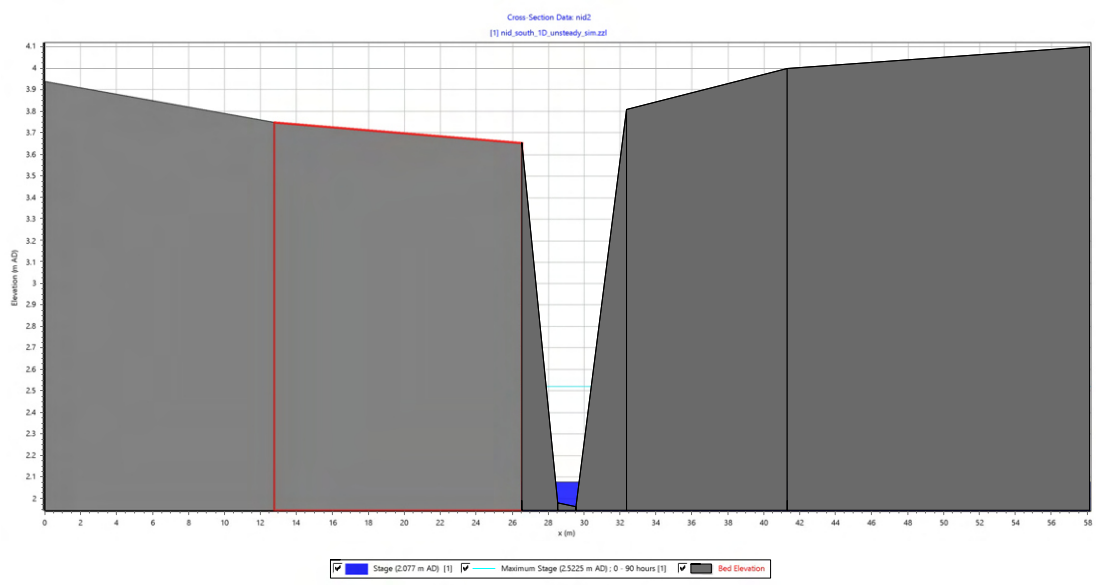


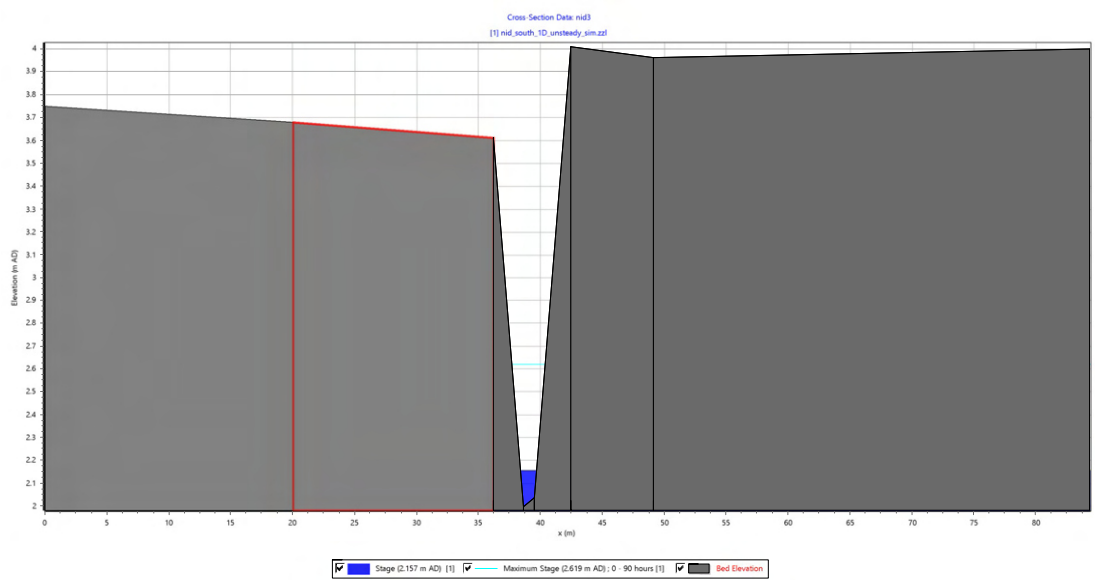


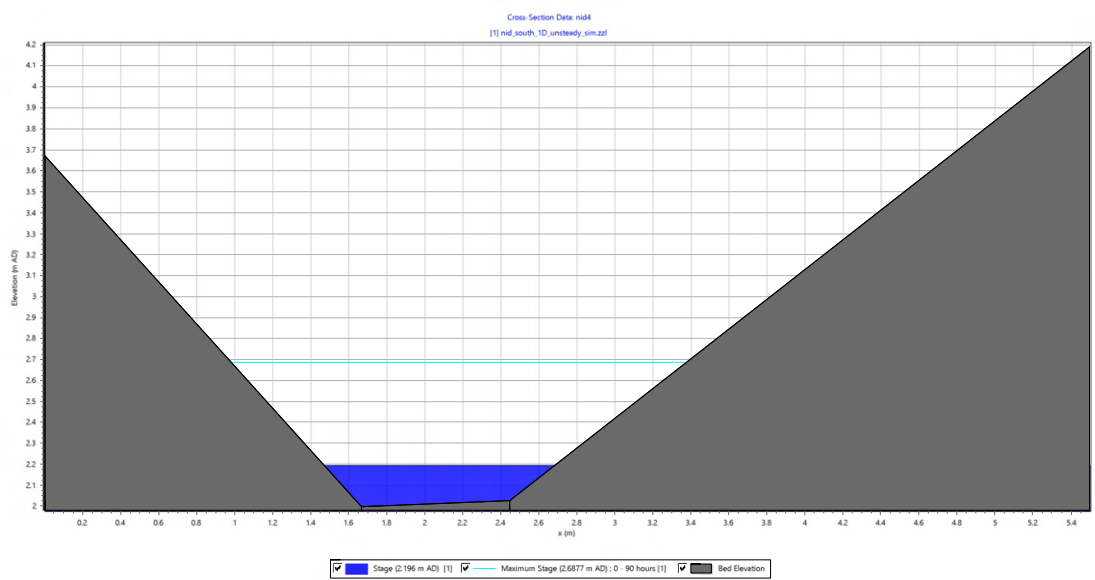


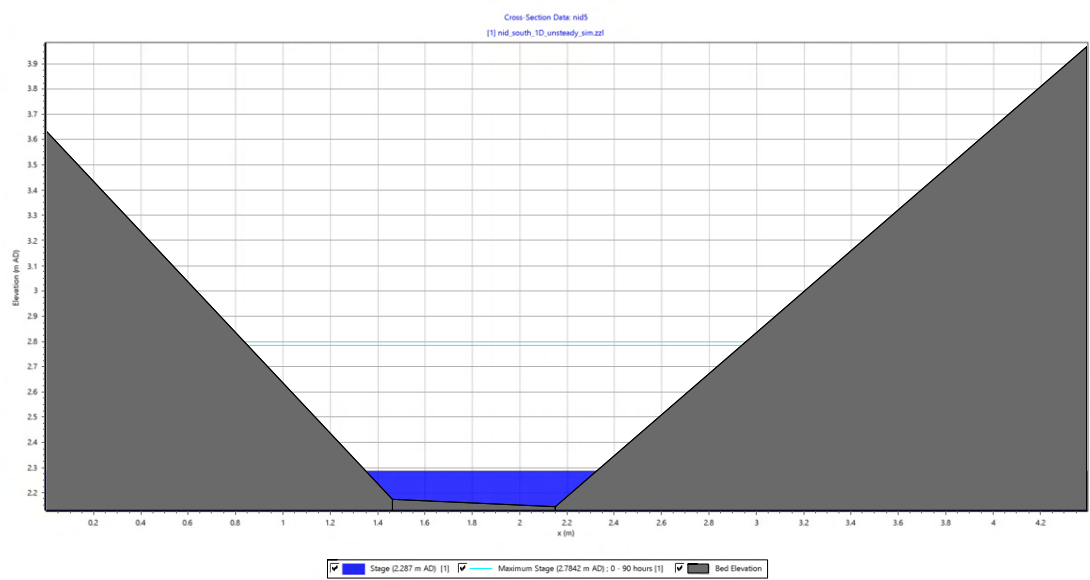


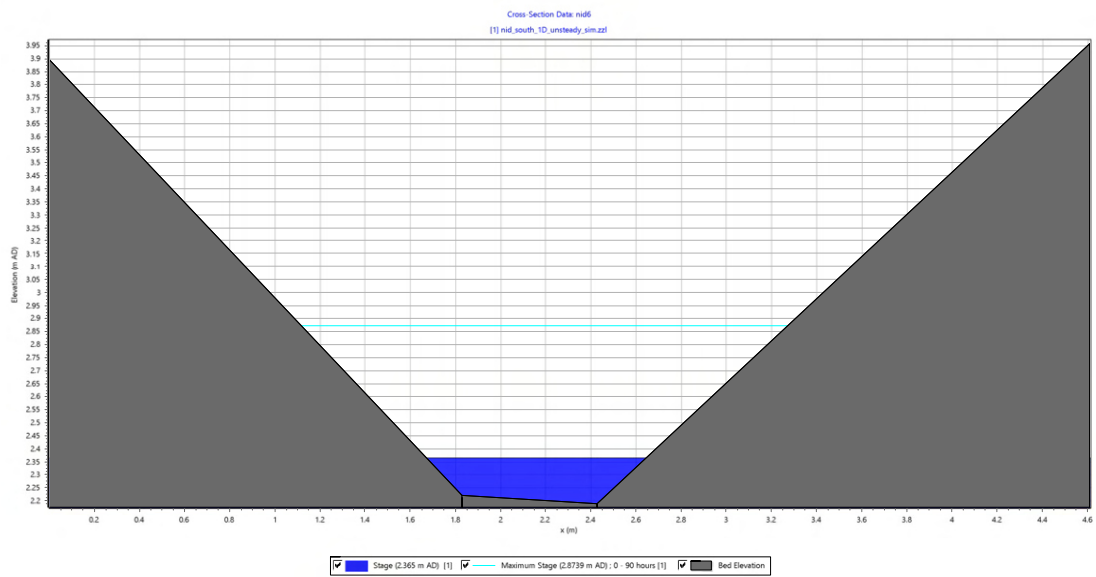


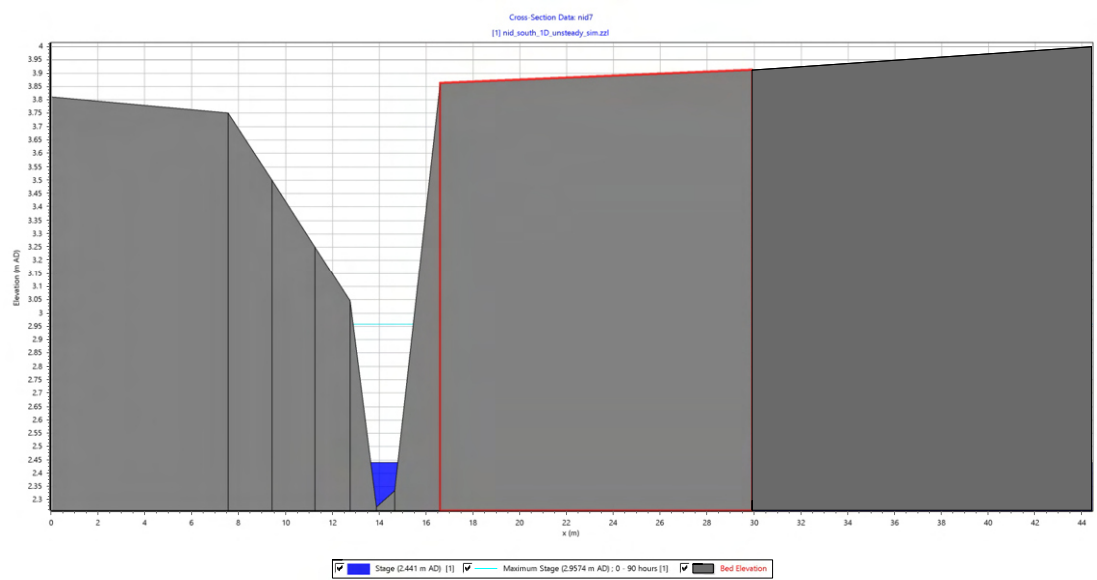


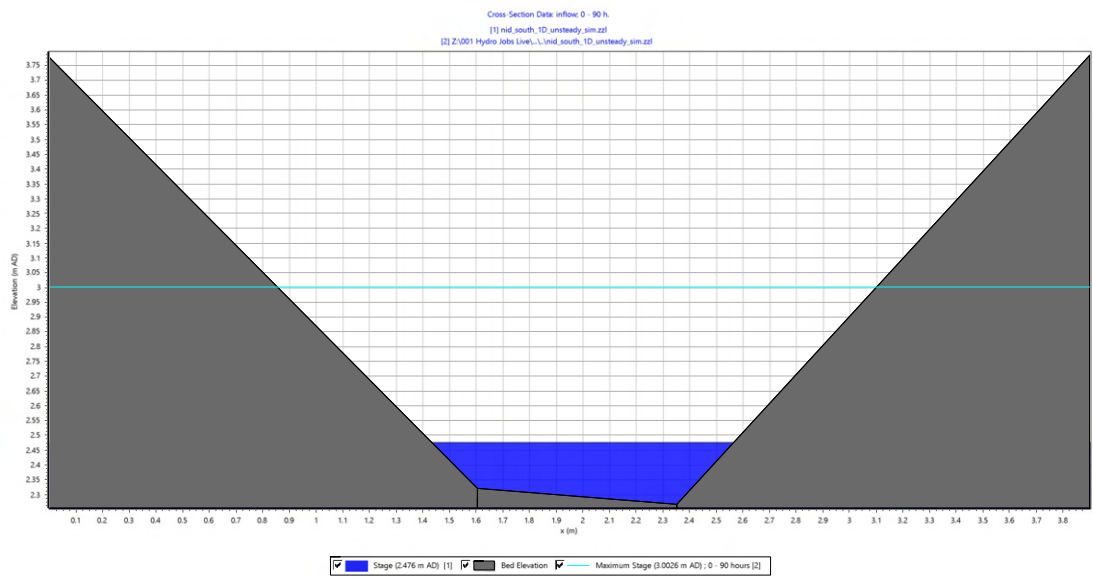


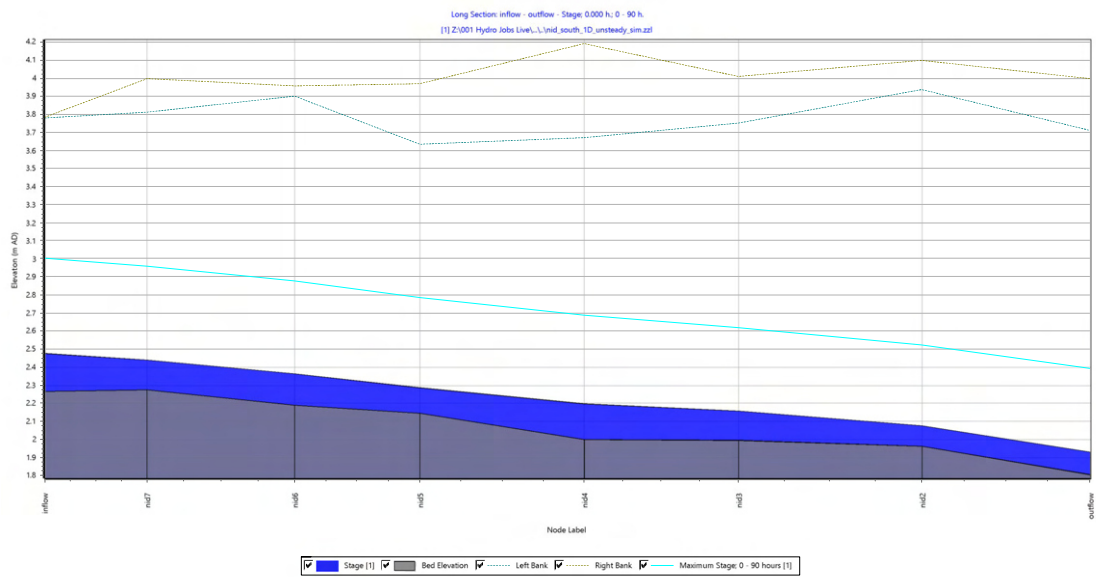












APPENDIX H

LLFA CONSULTATION RESPONSE

Alison Cadge

From: [REDACTED]
Sent: 28 February 2025 13:04
To: [REDACTED]
[REDACTED]
Subject: RE: Steeple Solar flood risk and drainage LLFA discussion

Hi [REDACTED],

Many thanks for these comments, we are in agreement with your amendments.

Kind regards,

[REDACTED]

From: [REDACTED]@nottsgov.uk>
Sent: 27 February 2025 16:28
To: [REDACTED]@rsk.co.uk>

[REDACTED]

Subject: RE: Steeple Solar flood risk and drainage LLFA discussion

CAUTION: This email originated from outside the Organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi [REDACTED]

Thanks for sending this through.

I've made some minor amends in red below, which I hope you agree reflect the discussions, just giving some further detail to this where I've felt necessary.

If you've got any queries on this please let me know.

[REDACTED]

Flood Risk Management Team, Nottinghamshire County Council,
County Hall, Loughborough Road, West Bridgford, Nottingham, NG2 7QP



[REDACTED]

Hi [REDACTED]

Many thanks for your very helpful input on our call. As mentioned, I've summarised the key points discussed below. Would you mind letting me know if there's anything you'd like to add to or amend please, or if you're happy with this summary?

[REDACTED]

General

- SS confirmed that the LLFA's jurisdiction comprises the ordinary watercourses in the centre / west of the site outside of the area managed by the IDB (eastern area close to the Trent).
- SS confirmed that a 5m development free easement **appeared** appropriate for all ordinary watercourses under LLFA control. He highlighted that the easements were largely required for access and that this should be considered, for example where existing culverts may need to be accessed for future maintenance, **to determine whether any area may need an extended easement.**
- SS confirmed that the LLFA does not hold any flood modelling for on-site watercourses.

Watercourse crossings

- SS advised that the key requirement was to maintain existing flows through any proposed crossing points. Culverts would be acceptable if this requirement is met. Land drainage consent will be required **post-planning** for any new culverts or works affecting ordinary watercourses. At this point, it will be necessary to provide high-level information to demonstrate flows are not constricted e.g. cross-sections up stream and downstream of the proposed pipe and dimensions of the new pipe, or demonstration that any extension to sizes of culverts matches the existing. Modelling should not be required.
- There are no specific restrictions on having two crossings located in close proximity to each other but ecological impacts should be considered.
- There are no specific restrictions in relation to HDD / open cut crossings for cables. Temporary consent may be required.

Ecological enhancement

- EM explained the rotational management (cutting of vegetation) of ditches on a 10 year rotation - currently seem to be cut annually. Longer rotation, defined in the Defra sustainable farming incentive guidance, would allow vegetation to get more structure and fruit/seeds. EM asked SS if any concerns on allowing vegetation to develop
- SS mentioned that it may locally increase flood risk by preventing water flow, which may be a concern
- Sturton has had some flooding events recently - there is a local awareness about ditch maintenance
- SS noted 10 years is a long time - would need to understand how ditches are inspected to avoid flooding issues
- However, some natural flood management has been undertaken to the west - intended to hold back water in the right places - so it can be done
- SS would need to see more detail on how the ditches are maintained and monitored
- EM mentioned that an outline monitoring and maintained plan will be submitted with the application, and could include an outline of the ditch maintenance
- EM asked if another option to only have the long rotation on one bank, so inspections could still take place from the other bank to make sure no blockages - SS said might be more palatable
- SS mentioned the use of the side scrapes/channels as being acceptable, as it would allow the vegetation to develop **out of the main cross sectional area of the watercourse.**

Surface water flood risk

- AC shared the EA's latest surface water flood risk mapping – extents and depths – noting that the peripheral areas of the proposed BESS and substation locations are within surface water flood risk areas but primarily with a 'low' risk and with a 'very low chance of up to 20cm depth' of flooding.
- AC noted that all sensitive equipment would be raised above the potential surface water flood depths, albeit these are expected to be minimal.
- SS noted that any infrastructure within the surface water risk areas would push flows around these features and that this was not a concern unless there were sensitive receptors nearby that could be impacted by these diverted flows. He suggested discussing this within the flood risk assessment.

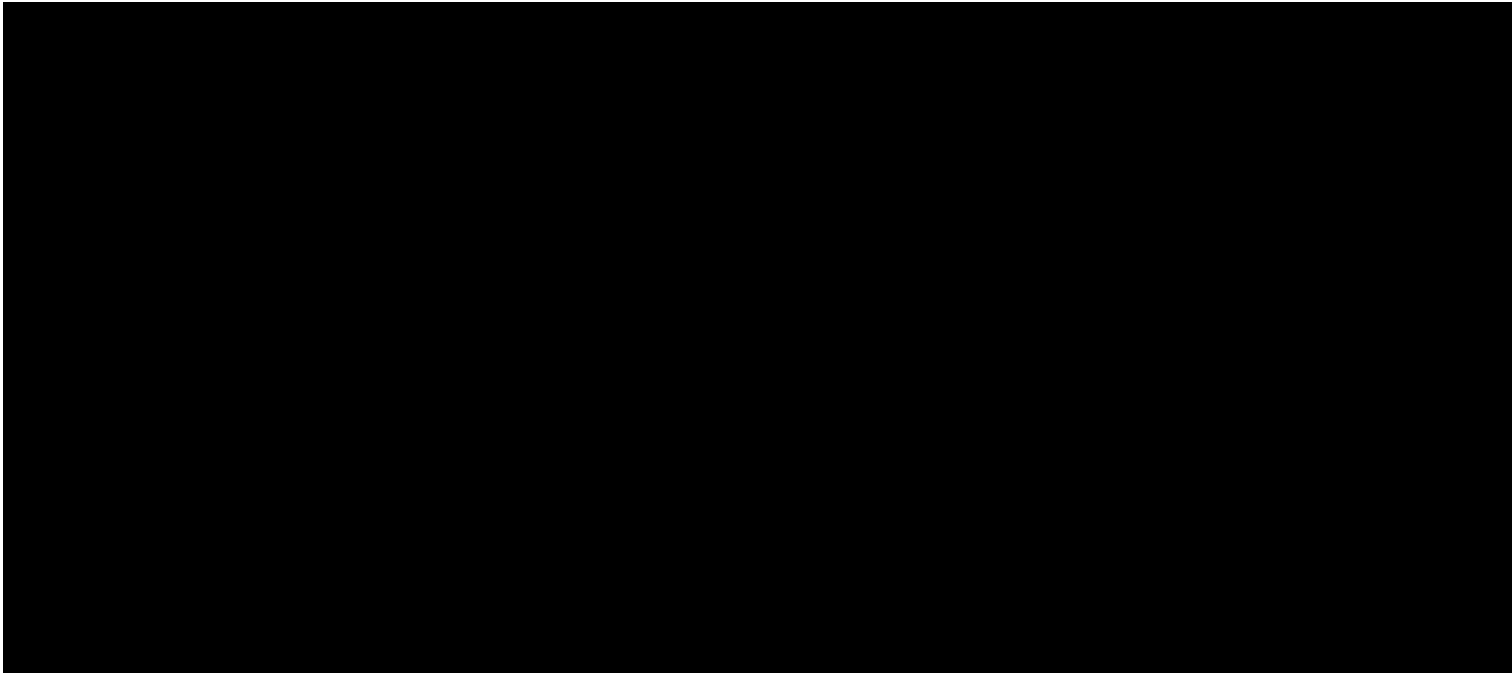
Surface water drainage proposals

- AS introduced the proposed drainage arrangements for the BESS and substation areas which include a basin for each area and storage within the subgrade for the BESS. The substation area will discharge to an LLFA watercourse (which subsequently drains to an IDB watercourse) and the BESS area will discharge to the Catchwater Drain (IDB watercourse). AS explained that additional storage volume had been provided for the BESS area to accommodate spent fire water.
- SS was generally in agreement with proposals for the substation and BESS area. He suggested that the IDB should also review the proposals.
- SS was happy with a proposed QBar greenfield discharge rate, and with the use of 2l/s as a practical minimum discharge rate where appropriate to prevent blockages.
- SS requested that swales or shallow ditches were considered at the lower edge of fields within the solar area, particularly given local perception of increased risk. No modelling or calculations would be

needed to support their design but they should **be based broadly on the nature of that area of solar panels (i.e number of panels, site gradient) and** consider potential ecological benefits.

- SS requested that linear drainage features (e.g. swales / cut off drains) were considered for the proposed access tracks (although the surfacing will largely be permeable) particularly where the tracks are close to residential receptors.
- SS noted that headwalls for surface water outfalls should **ideally** be designed to be outside the cross-section of the receiving watercourse.
- SS confirmed that the proposed 25% climate change allowance was appropriate for the design of storage features.

Many thanks,



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APPENDIX I

IDB CONSULTATION RESPONSE

Hi [REDACTED],

Many thanks for your time on the call yesterday and for sending through the shapefile of IDB assets. As promised, please see below a record of our discussion. If there's anything you'd like to amend or clarify, please let me know. There are some actions in **bold** including some for yourself.

Drainage strategy

- BG outlined the proposed drainage strategy for the site as a whole, and in detail for the BESS and substation areas. The drainage for the substation area would have an outfall to an LLFA Ordinary Watercourse just upstream of an IDB asset and would discharge at 2l/s (a rate agreed with the LLFA). The BESS area would discharge to the Catchwater Drain (IDB asset) at a rate of 1.4l/s/ha (based on IDB guidance) which equates to 2.4l/s.
- DC was in agreement with the proposed strategy including the proposed discharge rates. IDB consent will be required for the proposed discharges from the BESS and substation, and for the creation of the outfall to the Catchwater Drain.

Road crossings

- DC confirmed that IDB consent will be required for crossings over IDB assets. Existing flows should be maintained through any new or extended culverts / bridges.
- DC noted that any temporary structures used for access would need to be removed after the temporary period, otherwise a commuted maintenance fee will apply.
- For the DCO application, a commitment should be made to maintain flows and to remove / remediate temporary structures after use. Greater detail would be required at the consenting stage, at which point designs should be specific to individual circumstances.

Cable crossings

- DC stated that Board policy is for all cable crossings to be via HDD. Cables should be at least 2m below bed level plus a cable safety allowance.
- DC stated that any open cut methods would require a strong justification.
- DC stated that any cable crossings beneath IDB assets will require IDB consent. He noted that cable laying should not impact the Board's ability to maintain watercourses.

Easements

- DC confirmed that required easements are 9m from each bank of IDB assets. It may be possible to reduce this, with agreement, for individual situations.

Biodiversity enhancements

- EM provided background on biodiversity of ditches and noted that the proposed development is seeking to enhance where possible, but not seeking to change any of the channel or morphology - so enhancement it mainly to do with the plant diversity
- EM outlined proposals to change the cutting regime, as ditches appear to be cut along the entire length annually. Defra sustainable Farming incentive pilot scheme provides guidance on introducing 10year cutting rotation - though we understand this may have interactions with the drainage function and monitoring, so we invite comment on a 3-6 year rotation of 10-20 sections, or cutting one bank at a time.
- Trent area management is usually flail every 1-3 years. Typically cut annually.
- [REDACTED] was introduced to the call, and provided links to IDB guidance([Environment - Association of Drainage Authorities](#)). [REDACTED] will follow up with him directly ***EM to liaise with Iain Turner regarding cutting regimes***
- EM introduced the Local Wildlife Site Drains (Mother Drain and Thornhill Drain, notified for their aquatic invertebrates) and queried whether scrapes on the bank top (50cm depth within 10m of bank top) would require consent. DC confirmed that would need consent, considered on their own merit, but that the riparian watercourses would have more.
- EM asked if the IDB would have comment or require consent for application to create new ditches that are isolated from existing ditches. DC confirmed that there is no problem with creating new ditches 'orphaned riparian watercourses'. The only concern would be if it was created for the purpose of conveying water or to discharge into a IDB managed feature.
- EM queried about possible plug planting every 10m or so (on the bankside and possible sub-aquatically), which may require use of hessian matting and pegs, and whether this would be acceptable. DC suggested that it would need to be considered as part of the management, to make sure the plants were not damaged.

Abstractions

- AC queried whether it might be possible to abstract water from IDB watercourses. DC considered this may be possible but he understood there was a restriction on the amount of water in the watercourse at the time of abstraction (600mm? ***DC to confirm***). Abstractions of more than 20m3 per day would require EA consent.
- AC queried whether the IDB held records of local abstractions. DC noted that the EA records would be best for larger abstractions but that the IDB may hold records of smaller abstractions. These may not be current. ***DC to request abstraction data and provide to AC***.

Flood data

- DC advised that it was unlikely the IDB would be able to provide flood data. ***DC to investigate and confirm***

Protective Provisions

- DC noted that the IDB have a solicitor who deals with SoCG and Protective Provisions. ***DC to speak to solicitor to obtain any draft PP and provide to AC***

Kind regards,

