STEEPLE SOLAR FARM LIMITED

STEEPLE RENEWABLES PROJECT

IDB Watercourse Hydraulic Analysis

680819-R7(1) – Technical Note
January 2026

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RSK GENERAL NOTES

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Author	J Winfield	**Technical reviewer**	C Whittingham
Signature	[redacted]	Signature	[redacted]
Date:	08.01.2026	Date:	08.01.2026
Project manager	A Cadge	**Approved by**	A Cadge
Signature	[redacted]	Signature	[redacted]
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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 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, straight, 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 this report, together with a description of the modelling outcomes in the context of the Proposed Development.

2 ENVIRONMENT AGENCY COMMENTS

On 19th August 2025, the Environment Agency sent a letter to the Planning Inspectorate providing their Relevant Representations on project issues that fall within their remit. Their comments with respect to the hydraulic modelling exercise, following review of an earlier revision of this report (Report Ref: 680819-R7(0), **Appendix G of Flood Risk Assessment [App-117 to 119 and APP-178]**), are as follows:

Comment	Issue	Impact	Solution
FR05	It is unclear what scenario the maximum water level results presented on the cross sections in Appendix E relate to	Flood Risk could be misinterpreted	Please make it clear on the cross sections in Appendix E what scenario the maximum water levels represent. It is presumed that this is the design flood event.
FR06	The available freeboard shown in the 1d modelling for some cross sections of the Catchwater Drain is limited and it is not clear whether structures have been included in the modelling	Flood risk to critical elements such as the BESS and BESS attenuation pond on the left bank floodplain of the Catchwater Drain could be underestimated.	Please consider the sensitivity of model results to changes in roughness, design flows, and missing structures on the Catchwater Drain. It is important that the uncertainties of model results in the vicinity of the BESS and BESS attenuation pond are presented so that the implications for the development design and resilience can be properly understood. Please see the additional narrative section below for further information.
	Additional narrative: 1D modelling has been developed to assess flood risk from the Ordinary Watercourses which cross the site. This is welcomed, but		

	it is unclear whether any structures been included within this modelling. An area of key interest is the Catchwater Drain in the vicinity of the BESS and associated attenuation pond (Catchwater drain cross sections 7 to 11). In some locations, for example at Catchwater Drain Cross section 7, 8, and 9 there is limited freeboard in the design flood event between the maximum water level and the left bank elevation. How sensitive are the model results in these locations to changes in design flows and the adopted Mannings roughness values? This is particularly important to consider as the In the Risk of Flooding from Rivers and Sea dataset the BESS attenuation basin appears to be within an area of medium to high fluvial flood risk and the BESS itself is just outside of the area of medium to high risk. If the BESS attenuation basin floods from fluvial flood risk sources this could limit the available storage from surface water runoff from the BESS area

The above comments from the EA have been addressed below in this updated version of the report.

3 MANNINGS ASSESMENT

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).

3.1 Methodology

This analysis of the capacity of the IDB watercourses has been completed using FEH catchment data and Manning’s 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 conservate 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 (m^3/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 $1.43km^2$, whilst the southern section was $1.54km^2$. 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 3.1: New Ings Drain Northern Catchment

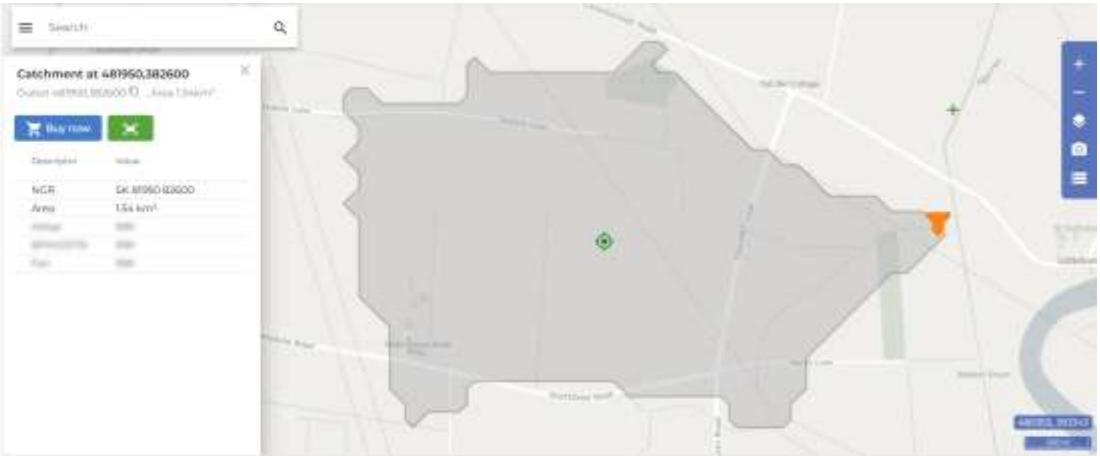

Figure 3.2: New Ings Drain Southern Catchment

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 Manning’s 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 Manning’s equation for a trapezoid-shaped channel to calculate channel velocity (m/s) and channel discharge (m^3/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 give a percentage.

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 distance^2 = channel length^2 – 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 Manning's open channel flow calculator, with a Manning's value of 0.03 (as this is considered an appropriate 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 3.3: Location of channels assessed

3.2 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.

3.2.1 Catchwater Drain

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

Channel Capacity < Q100cc Peak Flow = Flood risk

3.2.2 Mother Drain

- Mother Drain (1) Channel Capacity = **3.96m^3/s**
- Mother Drain (2) Channel Capacity = **2.76m^3/s**
- 1 in 100 year + 23% cc Peak Flow = **5.38m^3/s**

Channel Capacity < Q100cc Peak Flow = Flood risk

3.2.3 New Ings Drain

- New Ings Drain (1) Channel Capacity = **2.18m^3/s**

New Ings Drain (1) 1 in 100 year + 23% cc Peak Flow = **0.35m^3/s**

Channel Capacity > Q100cc Peak Flow = No Flood risk

- New Ings Drain (2) Channel Capacity = **0.81m^3/s**
- New Ings Drain (2) 1 in 100 year + 23% cc Peak Flow = **0.32m^3/s**

Channel Capacity > Q100cc Peak Flow = No Flood risk

3.2.4 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, the initial mannings assessment has shown that channel capacity exceedance would not 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.

4 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. The hydraulic modelling has been undertaken using Flood Modeller (v7.3).

4.1 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 1D model schematisation and the node locations selected are shown in **Figure 4.1, Figure 4.2, Figure 4.3** and **Figure 4.4** below, with the survey locations and raw data for the associated cross sections included as **Appendix C.** Cross sections are drawn from left to right bank facing the direction of flow (generally northwards). The topographic survey indicates 5 bridge features along the channel of the Catchwater Drain. These bridges have been included within the 1D river network using as ‘Arch Bridge’ nodes, with the sofit and springing levels taken from the topographic survey, with additional channel cross sections included upstream and/or downstream of the bridges where required.

Starting at the upstream end, a flow 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 to ensure no glass walling within the model.

All data points were given a Mannings value of 0.035 which is a value similar to a straight, clear, vegetated channel, as witnessed during a site inspection. 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.

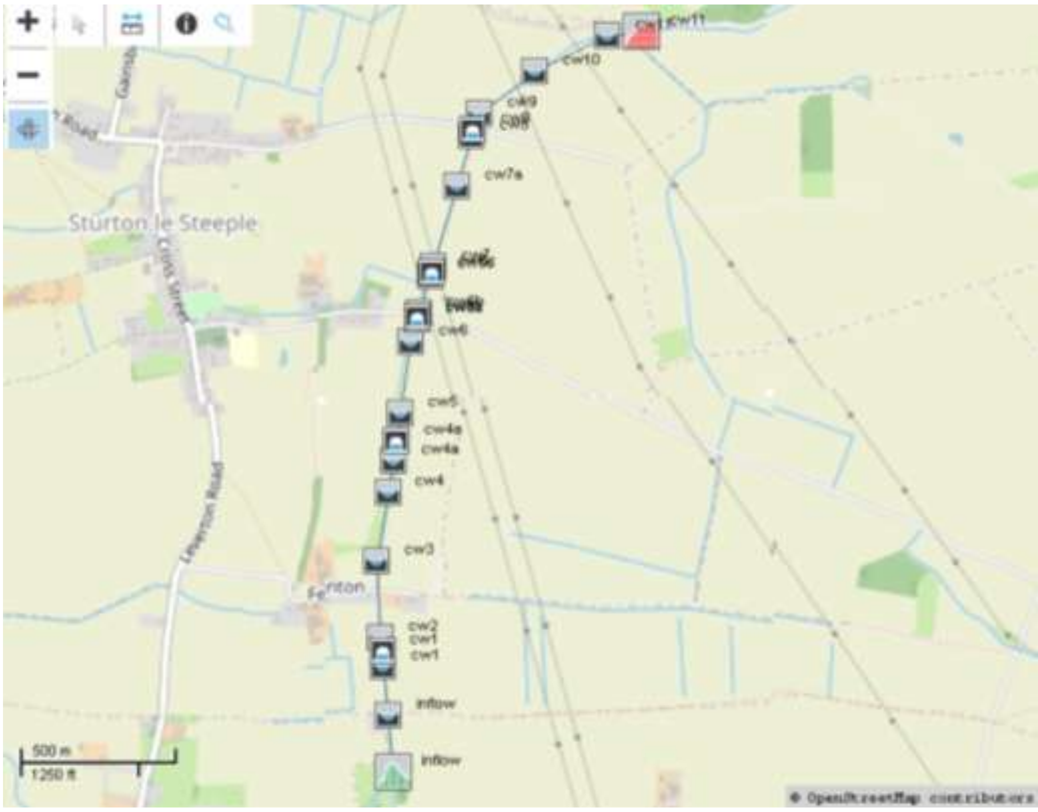

Figure 4.1: Catchwater Drain 1D Node Locations

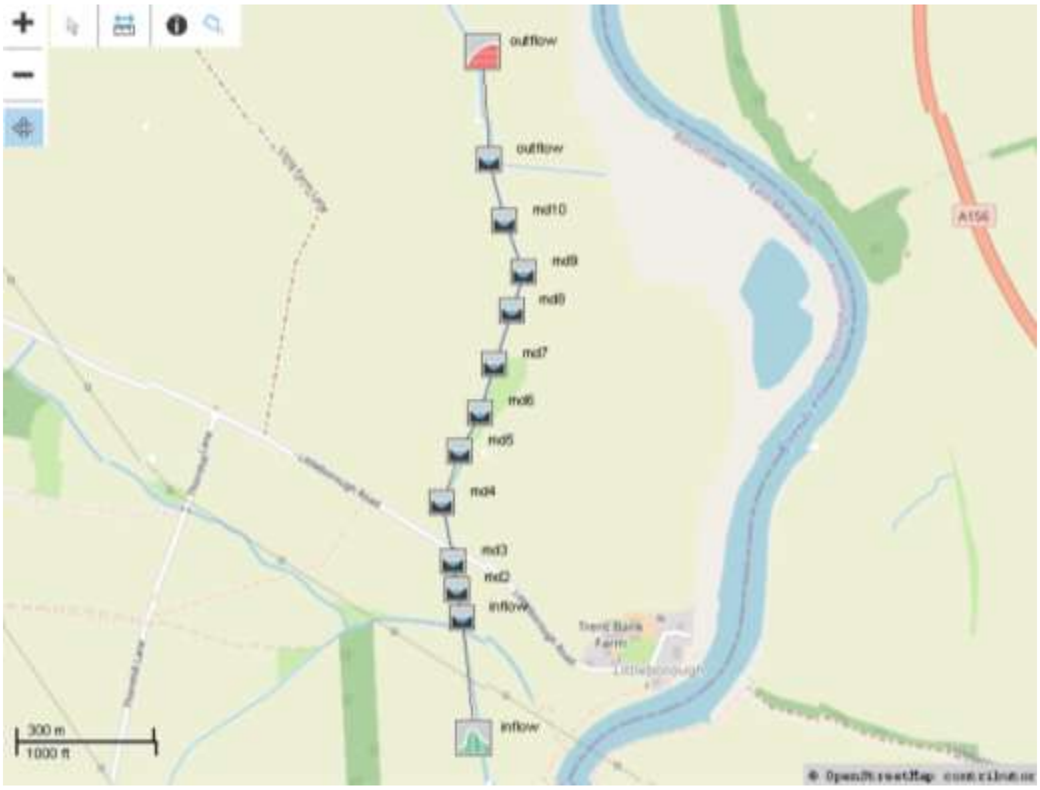

Figure 4.2: Mother Drain 1D Node Locations

Figure 4.3: New Ings Drain (South) 1D Node Location

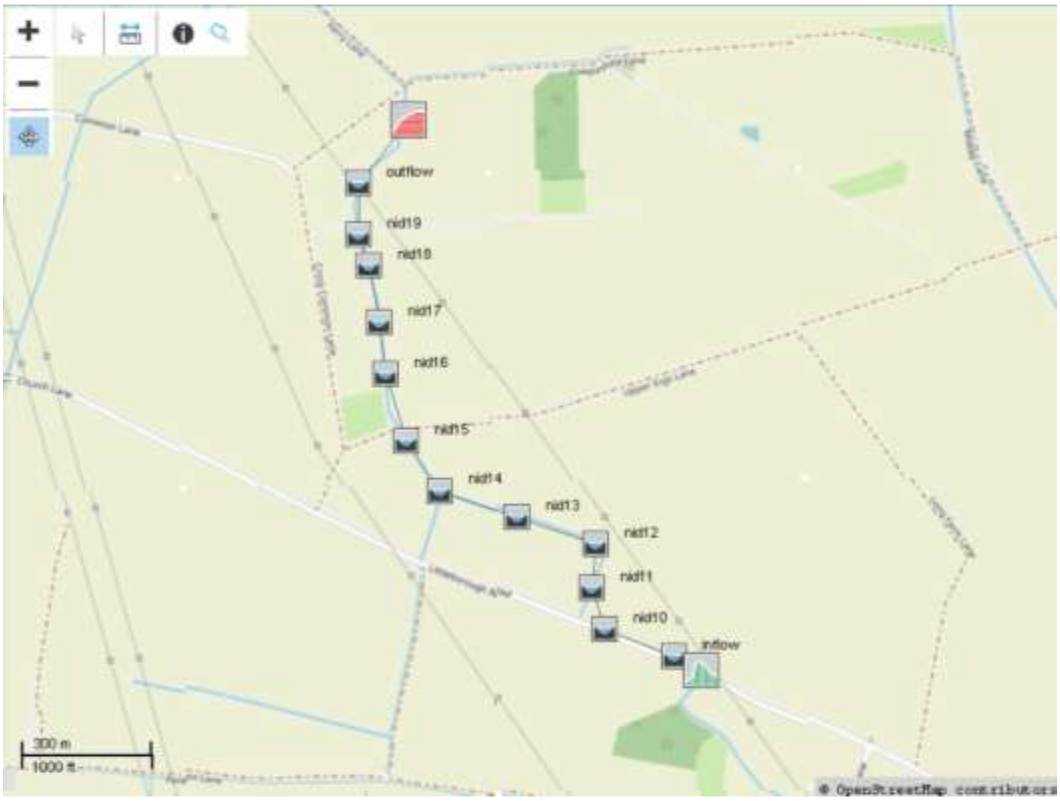

Figure 4.4: New Ings Drain (North) 1D Node Location

4.2 Steady and Unsteady Simulations

To represent the full hydrograph for each of the selected watercourses, a steady simulation was first run to create initial conditions within the watercourse channels. Unsteady (adaptive timestep) simulation run type were then selected using the initial conditions created from the steady simulations, with the finish times set to 90 hours for Catchwater Drain, Mother Drain and New Ings Drain. An initial timestep of 20 seconds was selected with a minimum timestep of 0.5 seconds applied if a smaller timestep was required by the 'Adaptive Timestep' solver. Unsteady simulations were run for both the design event (1 in 100 year plus 23% climate change) and the 1 in 30 year scenario.

4.3 Results

4.3.1 Catchwater Drain

The long section results from the 1 in 100 year plus 23% climate change storm have been included below as **Figure 4.5.** 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 6.508mAOD, with the modelled maximum water level indicated as 6.5465mAOD. The cross section of node 2 has been included as **Figure 4.6** and indicates that only 38mm 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 E.**

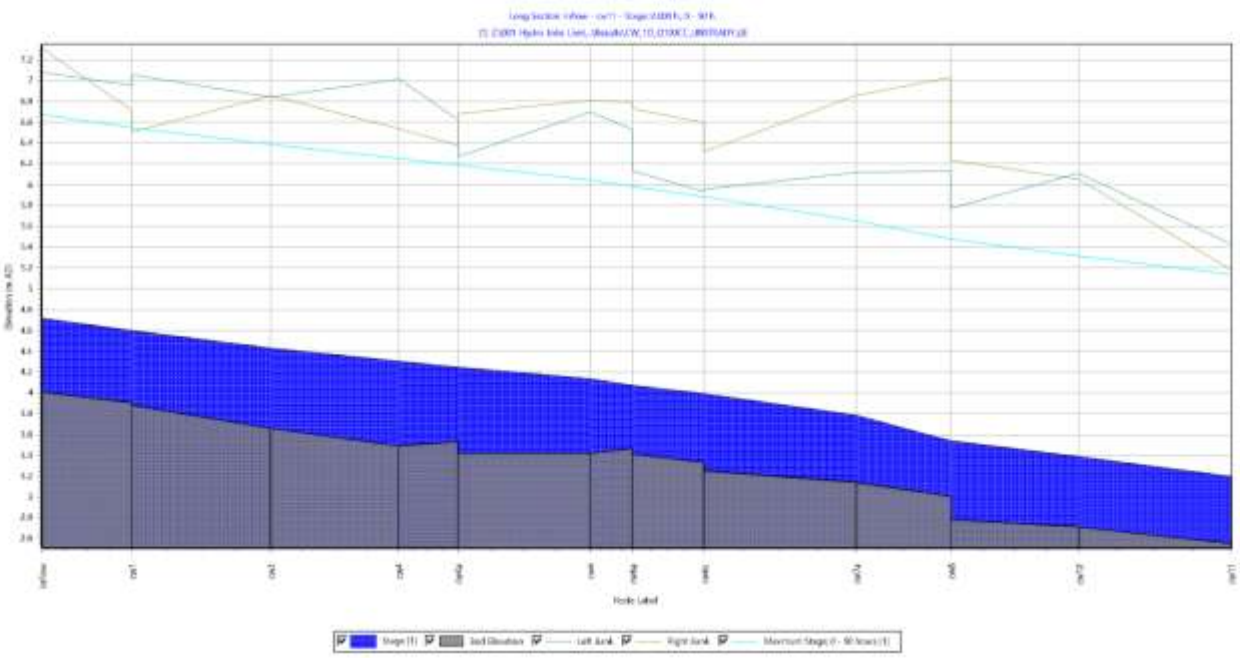

Figure 4.5: Catchwater Drain 1 in 100 year + 23% Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

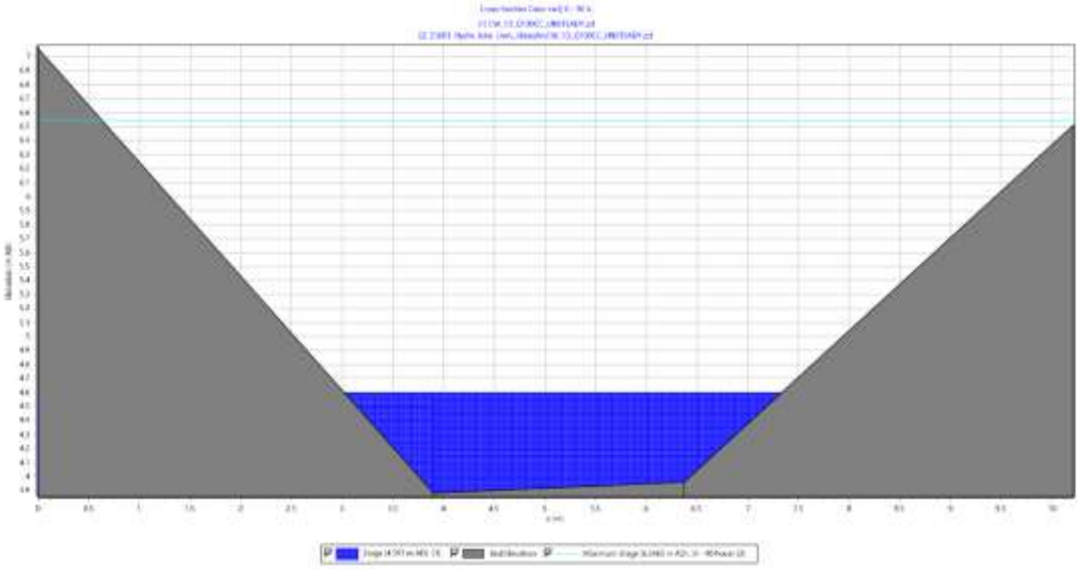

Figure 4.6: Catchwater Drain 1 in 100 + 23% Node 2 Cross Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

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 4.7.** 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) which remain unimpacted by flooding from this source.

Figure 4.7: Catchwater Drain node location for single overtopping location

Figure 4.8 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.

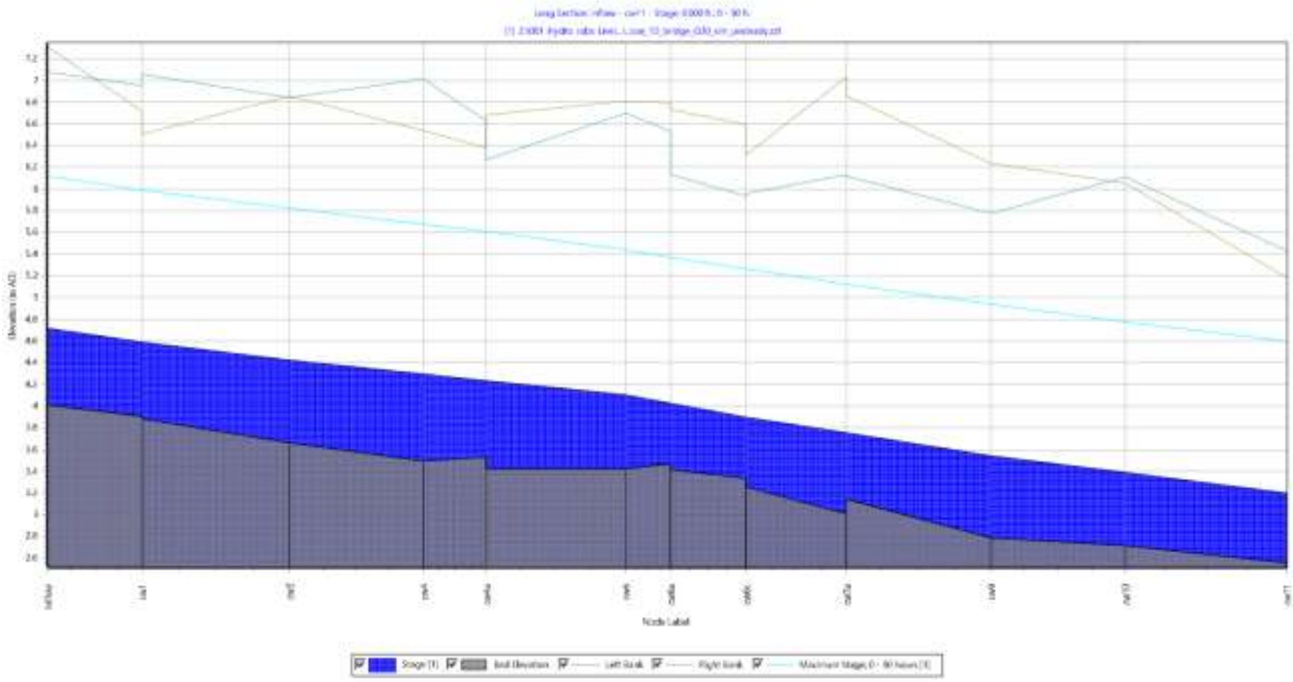

Figure 4.8: Catchwater Drain 1 in 30 year Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

Within their relevant representations response to the previous version of this hydraulic modelling report, the EA expressed concerns that there was limited freeboard between the top of bank levels and the maximum modelled water levels for the Catchwater Drain, and that the models may be sensitive to Mannings roughness values and design flows. As such sensitivity analysis was undertaken to assess the impacts of changes in roughness and design flows within the Catchwater Drain. Four models were run in total based on the 1 in 100 year + 23% climate change event: a +20% design flow, a -20% design flow, a +20% roughness and a -20% roughness. The resultant long sections for each of the model runs are included below as **Figure 4.9, Figure 4.10, Figure 4.11** and **Figure 4.12.** The associated cross sections for each of the model runs are included **Appendix E.**

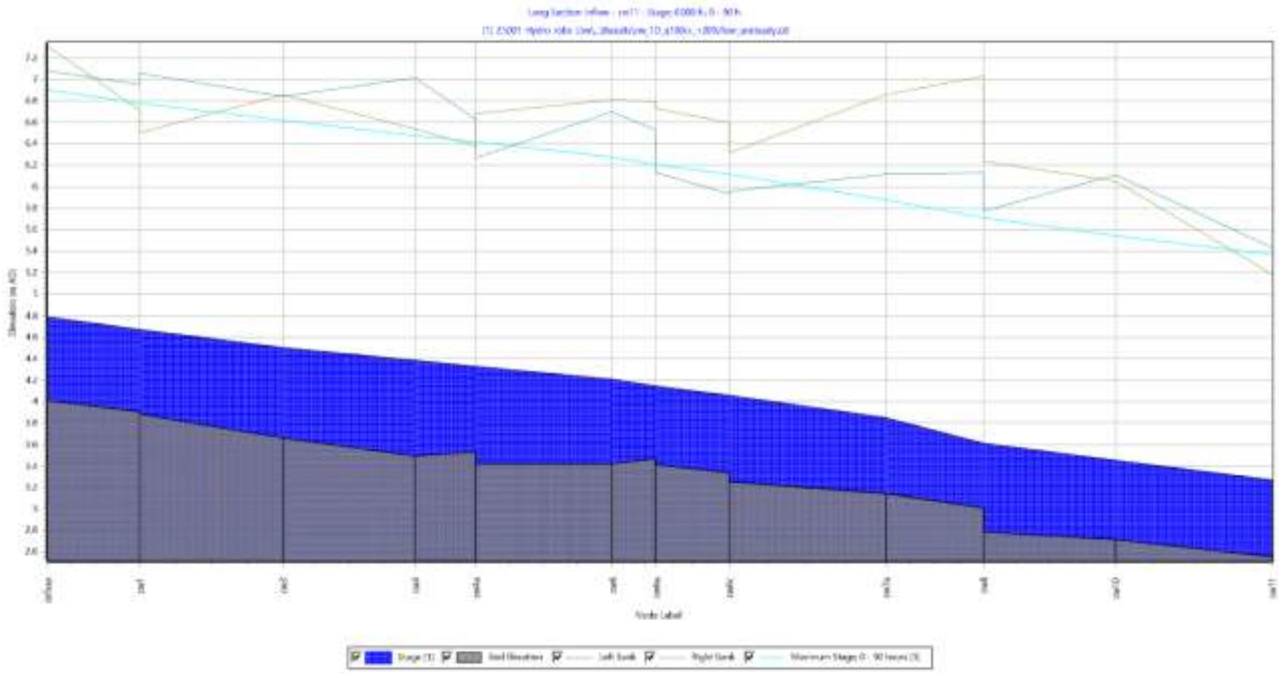

Figure 4.9: Catchwater Drain 1 in 100 year + 23% (+ 20% flows) Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

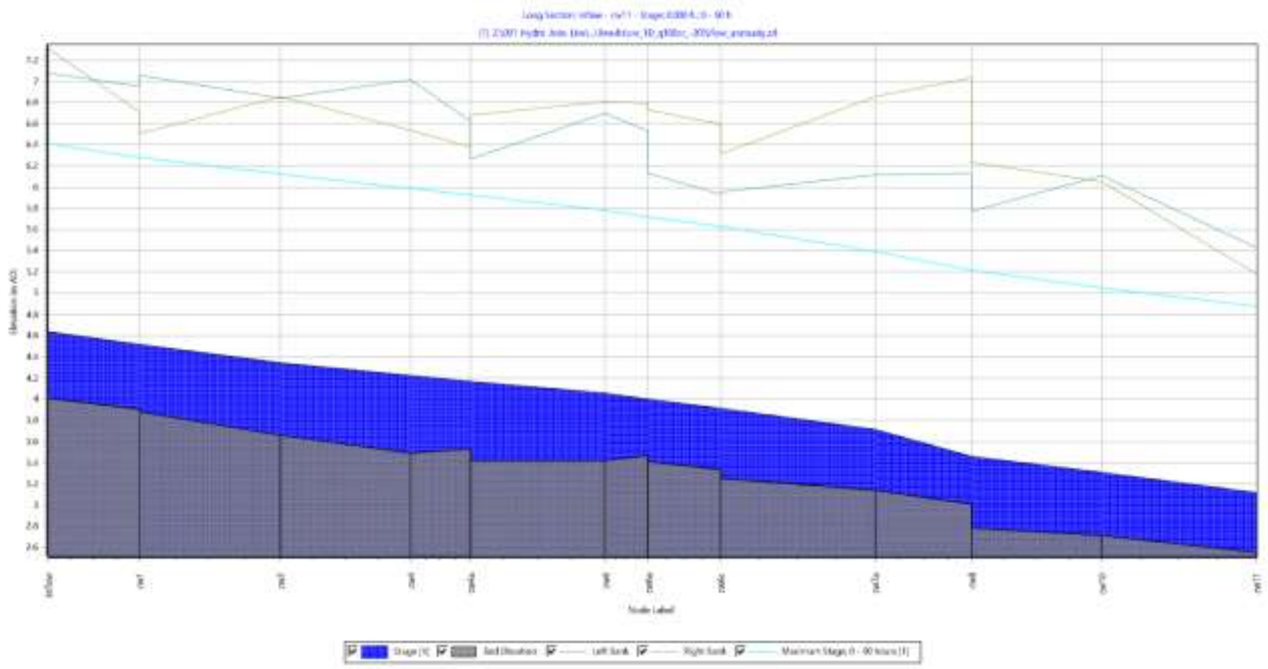

Figure 4.10: Catchwater Drain 1 in 100 year + 23% (- 20% flows) Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

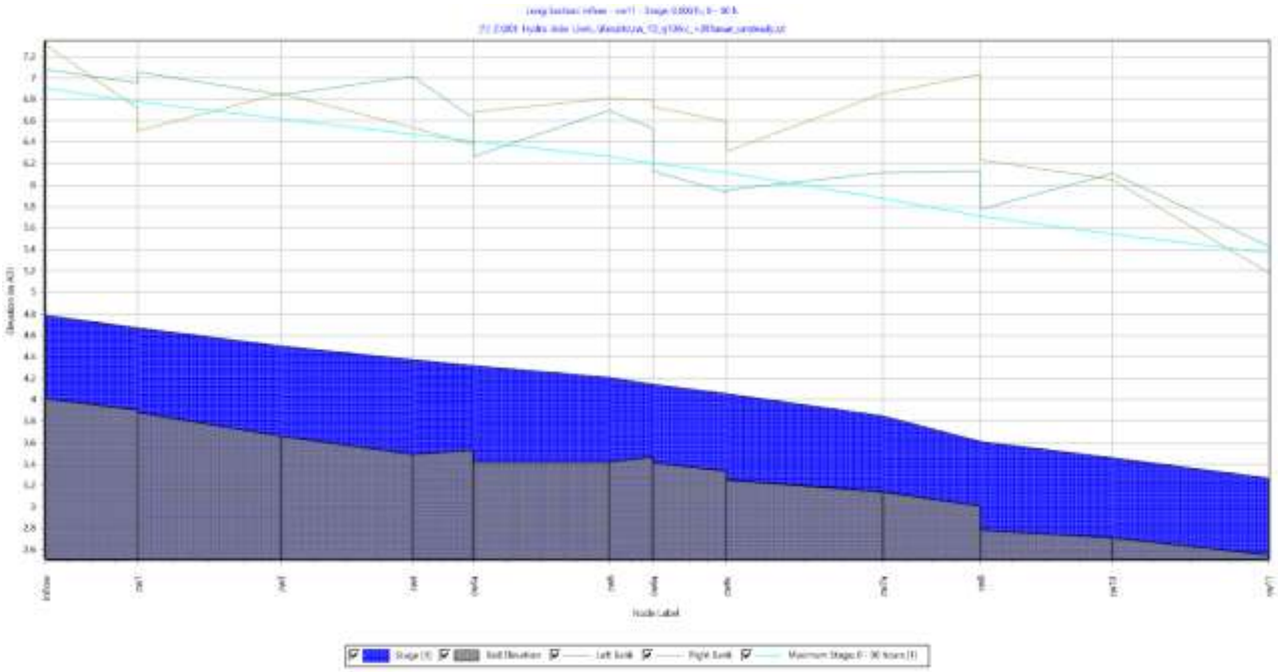

Figure 4.11: Catchwater Drain 1 in 100 year + 23% (+ 20% Mannings) Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

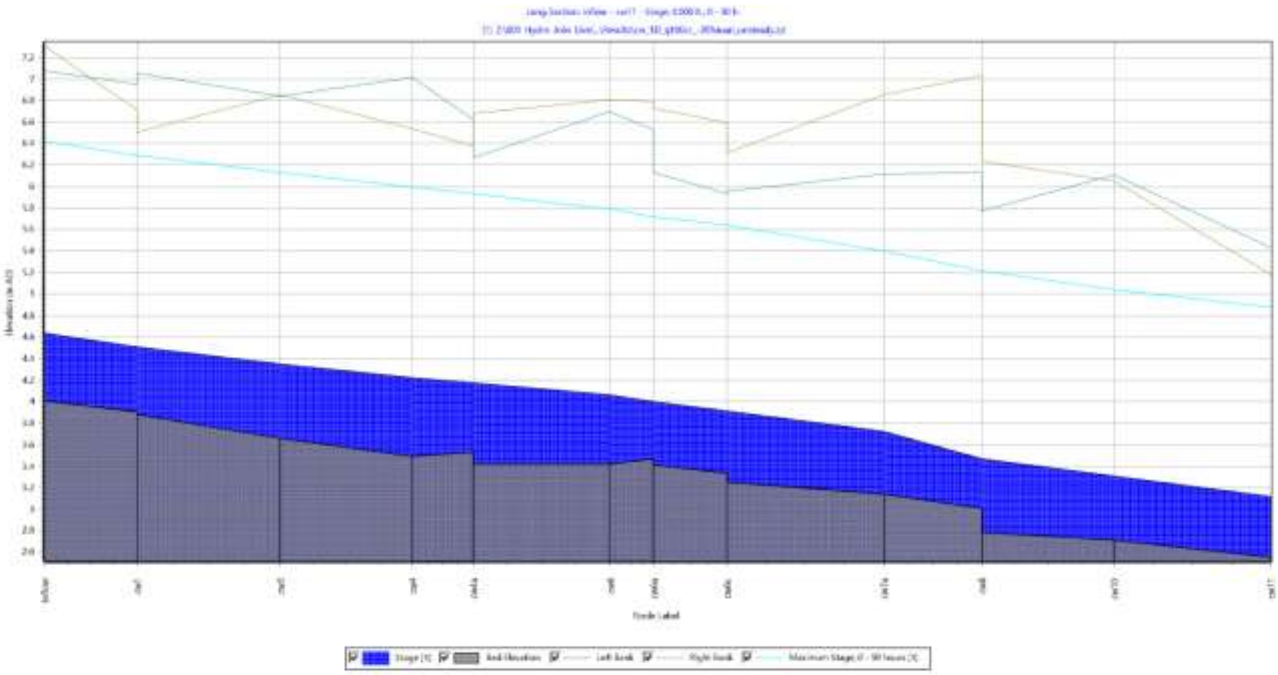

Figure 4.12: Catchwater Drain 1 in 100 year + 23% (- 20% Mannings) Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

Figure 4.9 indicates that when flows are increased by 20% during the 1 in 100 year plus 23% climate change scenario there would be overtopping at 3 'right bank' nodes (CW2, CW4a and CW11) and 4 'left bank' nodes (CW5, CW6b, CW6c, CW7). **Figure 4.10** indicates that when flows are decreased by 20% during the 1 in 100 year plus 23% climate change scenario there would be no overtopping.

Figure 4.11 indicates that when flows are increased by 20% during the 1 in 100 year plus 23% climate change scenario there would be overtopping at 4 'right bank' nodes (CW1, CW2, CW4a and CW11) and 4 'left bank' nodes (CW5, CW6b, CW6c, CW7). **Figure 4.12** indicates that when flows are decreased by 20% during the 1 in 100 year plus 23% climate change scenario there would be no overtopping.

These results suggest that whilst the increases / decreases in modelled flows and Mannings value have the potential to impact the peak water levels within the Catchwater Drain, the peak water level values are generally within an anticipated range for the increases / decreases to flows and Mannings values.

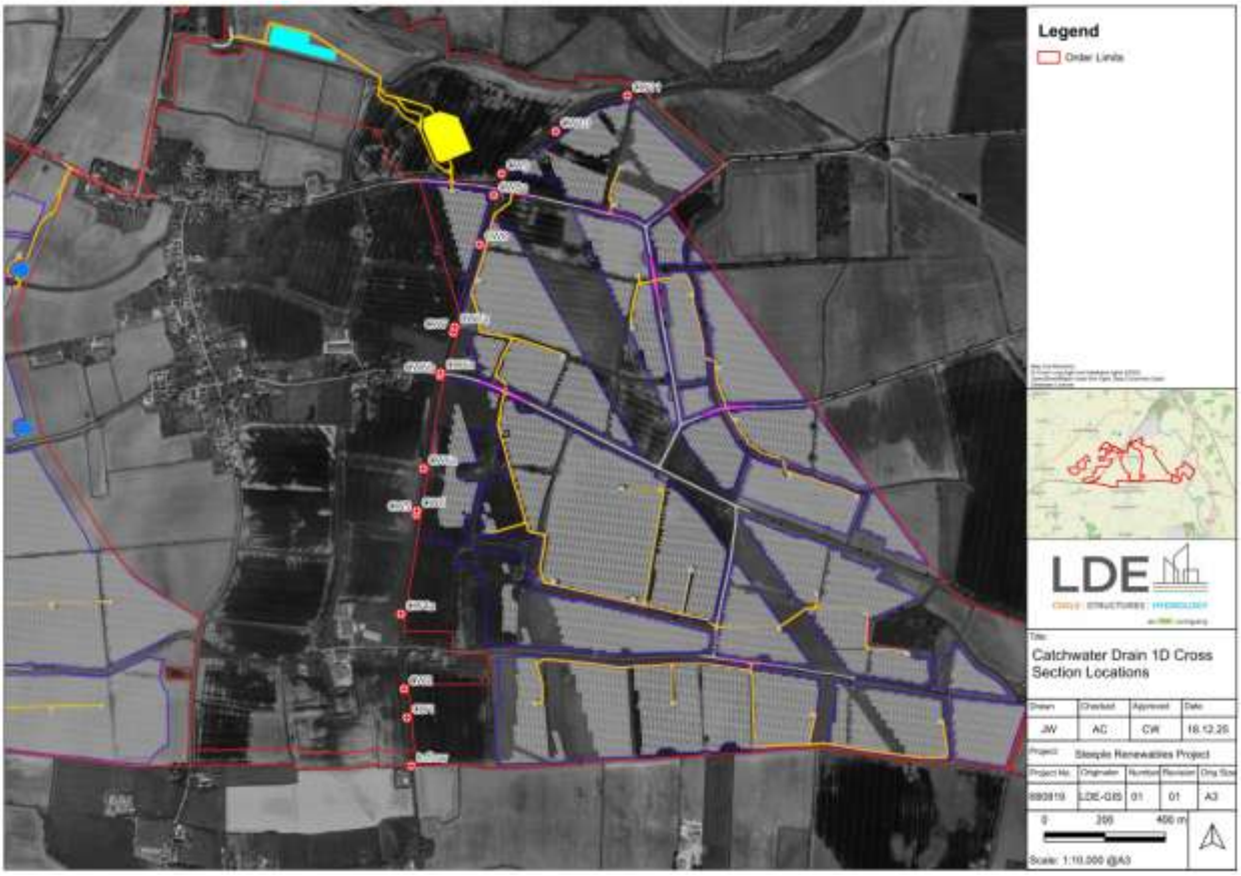

Figure 4.13: Catchwater Drain 1D Cross Section Locations Development Overlay

During both the +20% flow and +20% roughness simulations the cross sections with 'right bank' overtopping were CW1, CW2, CW4a and CW11. Based on the locations of these cross sections in relation to the proposed development layout, cross sections CW1, CW2 and CW4a are all within the southern area of the site and have no sensitive infrastructure within the vicinity, with the closest Solar PV panels being 350m east. CW11 is located at the northern end of the site and is the last node in the modelled reach. The nearest sensitive piece of infrastructure to this node is an inverter located approximately 250m south. Based on the level of overtopping (maximum of 267mm bank exceedance), topography of the site, and anticipated direction of flow over the right floodplain, it is considered unlikely that significant inundation would occur with the site boundary during these scenarios.

During both the +20% flow and +20% roughness simulations the cross sections with 'left bank' overtopping were CW5, CW6b, CW6c and CW7. Based on the locations of these cross sections in relation to the proposed development layout, cross sections CW5, CW6b, CW6C and CW7 are all located within the central area of the site. The 'left bank' of these cross sections is outside of the site boundary and hence there is no development located within the immediate vicinity of these areas of potential overtopping. The nearest sensitive infrastructure to any of the nodes with 'left bank' overtopping is the proposed Substation and BESS area located in the northern area of the site. The closest node with potential overtopping to this area is CW7, which is approximately 550m south. The 1 in 100 year plus 23% climate change water level was shown to be approximately 163mm above the left bank level in this location. Whilst the likely direction of flow across the 'left' floodplain of the Catchwater Drain is northward, the significant distance of travel, increased level of topography heading northward, and presence of two drainage channels between the overtopping location and substation / BESS location mean that flows from the 'left bank' of the CW7 would not result in flood waters reaching the Substation / BESS area.

4.3.2 Mother Drain

The long section results from the 1 in 100 year plus 23% climate change storm have been included below as **Figure 4.16.** 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 E**, with the long section of the 1 in 30 year storm shown in **Figure 4.17.** 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.

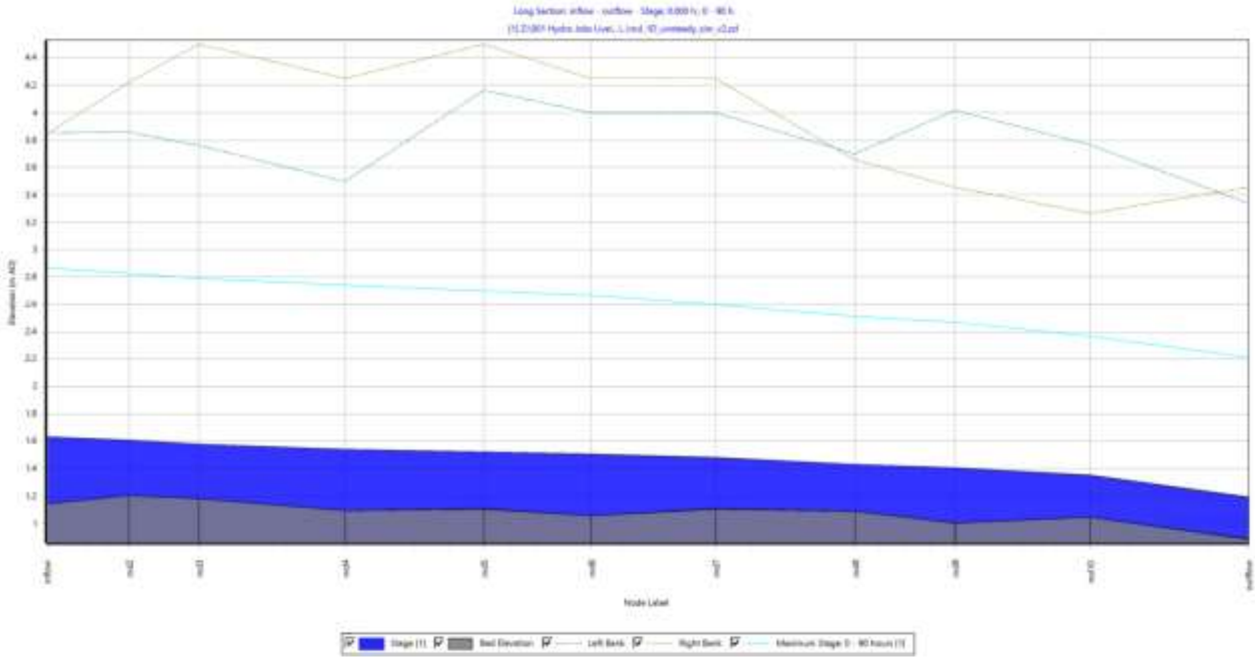

Figure 4.14: Mother Drain 1 in 100 year + 23% Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

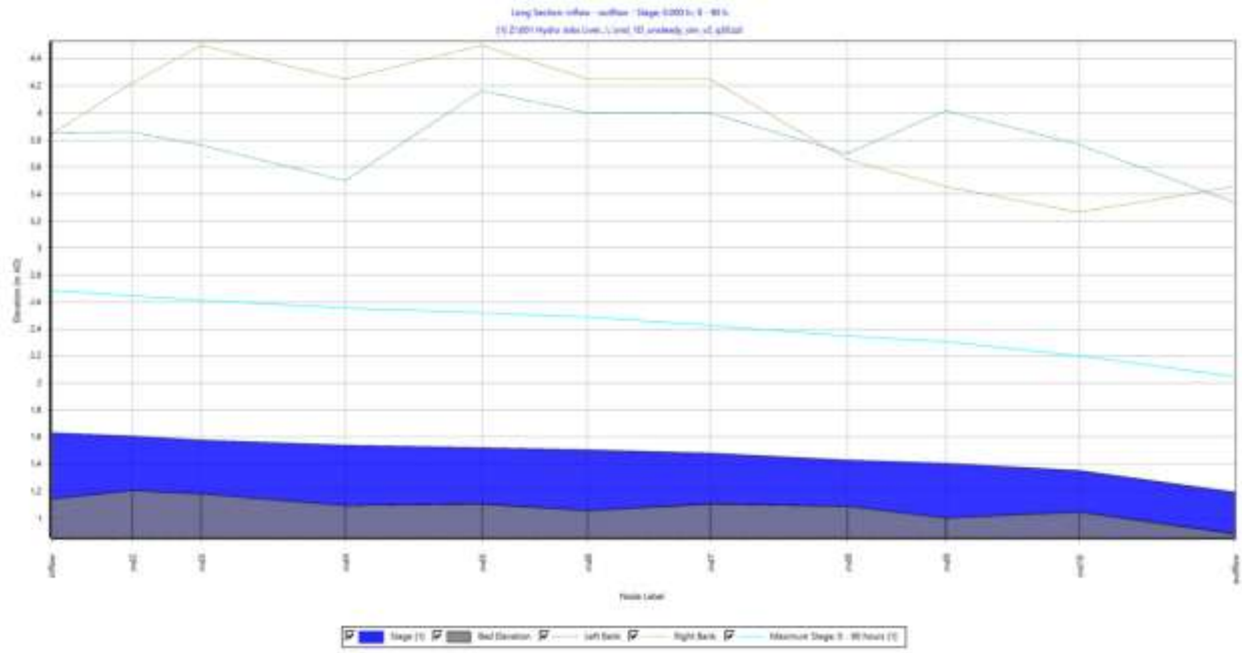

Figure 4.15: Mother Drain 1 in 30 year Unsteady Simulation Long Section (solid blue hatching represents the baseflow, light blue line represents the top water level)

4.3.3 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 4.18.** These results indicate that during this storm event the maximum water level in northern section of New Ings Drain would be approximately 3.72mAOD. 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 4.19** and indicates that the left bank of the channel would be overtopped by approximately 30mm. This small amount of exceedance will not 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 comprises solar arrays only. The flood risk to the proposed infrastructure is considered to be low. The 1 in 30 year results **(Figure 4.20)** indicate that there would be no out of bank flow during this event, with the maximum water level during this scenario at approximately 2.9mAOD. The cross sections for the 1 in 100 year plus 23% climate change storm have been included in **Appendix E.**

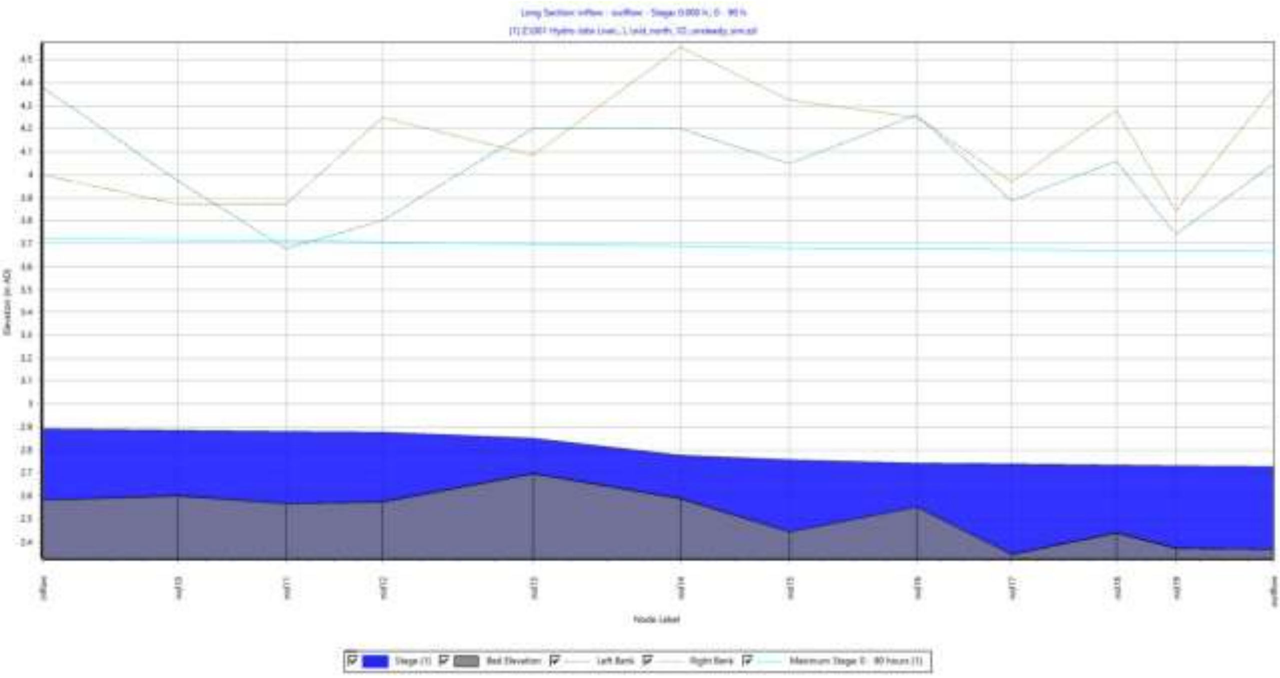

Figure 4.16: New Ings Drain (North) in 100 year + 23% Unsteady Simulation Long Section

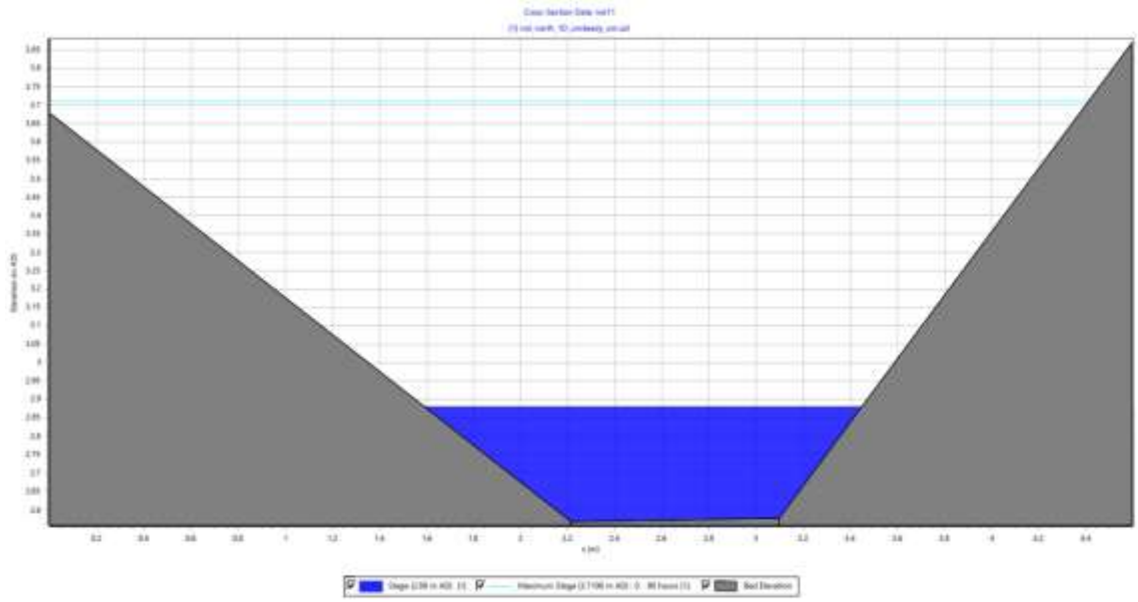

Figure 4.17 New Ings Drain (North) Node 11 in 100 year + 23% Unsteady Simulation Cross Section

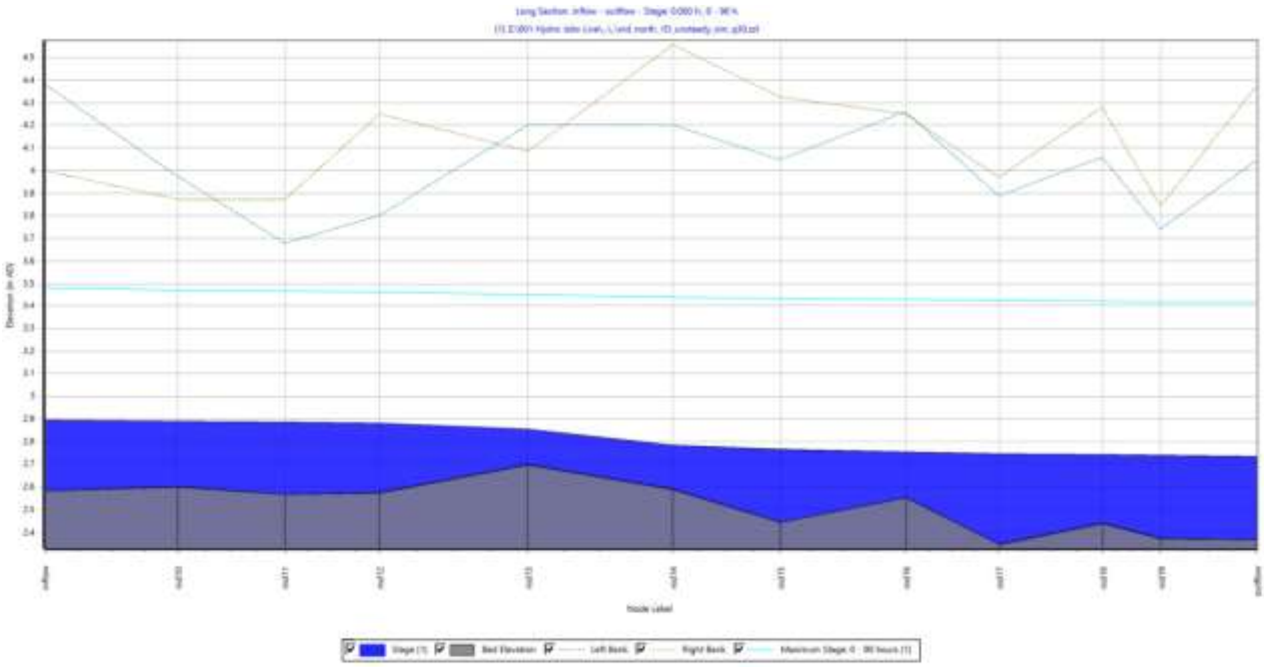

Figure 4.18: New Ings Drain 1 in 30 year Unsteady Simulation Long Section

4.3.4 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 4.21.** 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 E**, with the long section of the 1 in 30 year storm shown in **Figure 4.22.** There is no out of bank flooding for the 1 in 30 year event.

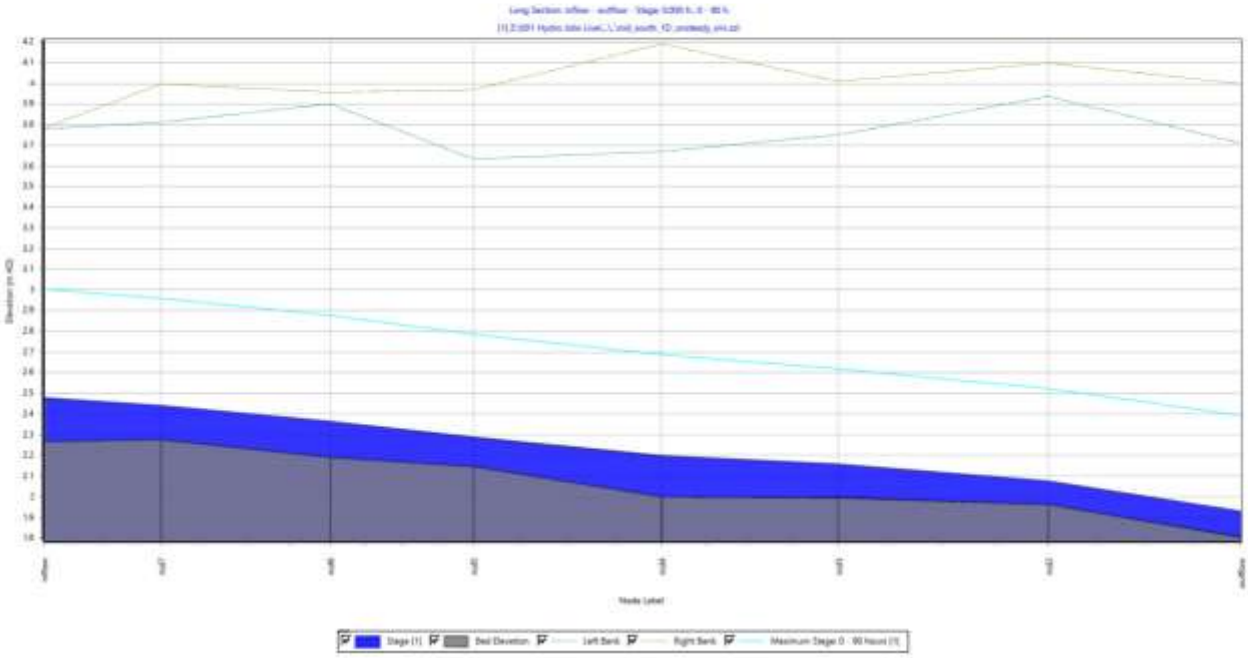

Figure 4.19: New Ings Drain (South) in 100 year + 23% Unsteady Simulation Long Section

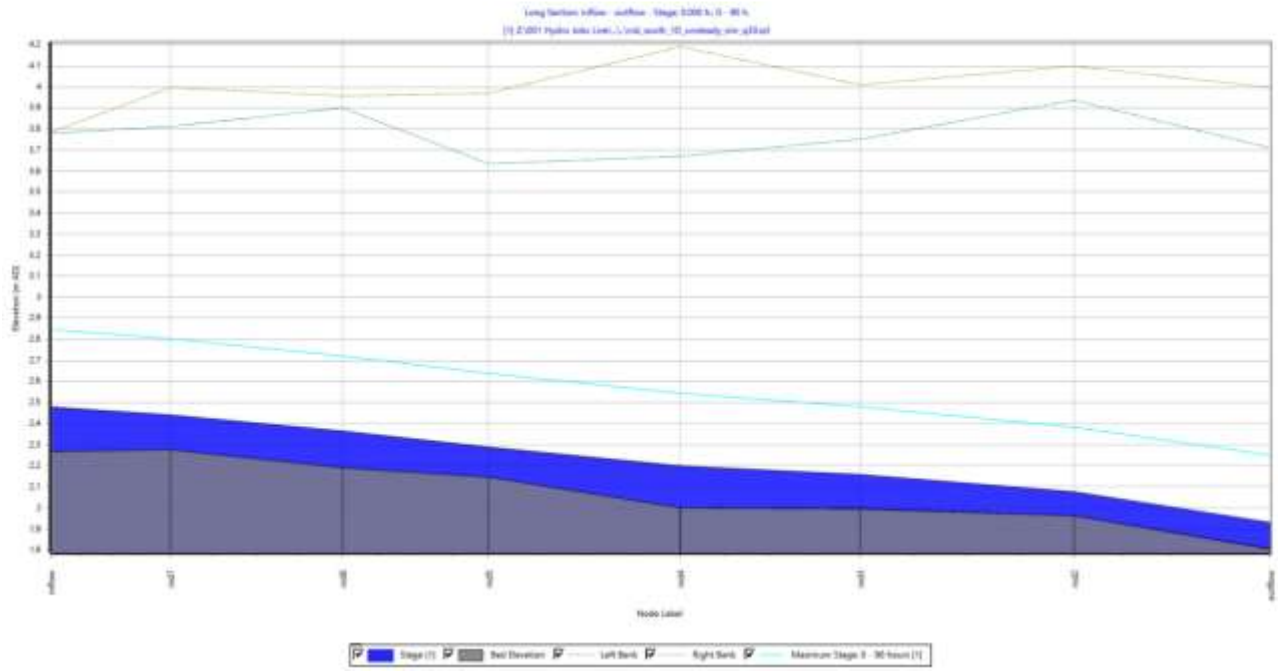

Figure 4.20: New Ings Drain (South) in 30 year Unsteady Simulation Long Section

4.4 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.

The EA expressed concerns in their Relevant Representations response to the previous version of this hydraulic modelling report that structures had not been included in the Catchwater Drain model and that there was limited freeboard between the top of bank levels for the Catchwater Drain and the maximum modelled water levels. The EA noted that the models may be sensitive to Mannings roughness values and design flows. Five bridges have been added to the Catchwater Drain model, this exercise does not result in any additional overtopping of the Catchwater Drain, with a single location showing overtopping to very shallow depths as previously. Sensitivity testing was conducted on the Catchwater Drain 1D models to assess the impacts of different flow and roughness inputs. The results concluded that increases in flows and roughness values resulted in channel capacity exceedance at multiple cross sections during these scenarios. Upon further review of these areas where overtopping could potentially occur, it has been assessed that even in this unlikely scenario, the overall risk to the proposed infrastructure would be 'very low' due to the limited expected magnitude of overtopping and the overtopping locations being a significant distance from the nearest proposed infrastructure. 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.

5 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 (amended model including bridge structures), 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.38mm. 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.

Sensitivity testing of the Catchwater Drain channel as per the request of the EA concluded that there was potential for bank overtopping to occur during the +20% channel flows and +20% Mannings roughness scenarios. Further analysis of the locations of overtopping was undertaken and it was assessed that the majority of the ‘right bank’ overtopping occurred within the southern area of the site where the nearest proposed development is located at least 350m away. The majority of the ‘left bank’ overtopping occurred within the central areas of the site where the left side of the watercourse is located outside of the application boundary, with the nearest sensitive infrastructure approximately 550m north and upgradient of the model nodes. Overall, this watercourse is therefore considered to represent a low risk to the Proposed Development.

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

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