

Developer Services Hydraulic Modelling Report

156 – N164 Tan Y Bont, Wrexham – Five Fords WwTW – 00675

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Executive Summary

- This Hydraulic Modelling Assessment (HMA) has assessed proposed residential flows connecting to Tan Y Bont, Wrexham. The proposed development consists of 189 properties. The topography of the site will allow all 189 properties to drain by gravity to Connection Point 1 (manhole SJ33533001) at the north east of the development. The assessment consists of two phases, Phase 1 with 38 properties connected to the network and Phase 2 consisting of the total development of 189 dwellings.
- The proposed development at Tan Y Bont consists of one connection point:
 - Connection Point 1: The proposed connection point for the residential properties is manhole SJ33533001 located off Plas Acton Road to the north east of the proposed development site.
- The proposed development is located within the Five Fords WwTW catchment. The existing model for Five Fords, which was recently upgraded in 2018 for a separate study within the catchment, was used as the basis for this HMA. The model required further modifications before being deemed suitable for the purpose of this HMA. Following these updates, the model was considered suitable for assessing the impact of the proposed development.
- The developer has been advised that surface water runoff is to be separated from foul flows and it will not be discharged into the existing foul/combined system. The scope of this HMA is limited to the impact on the existing combined system, hence surface water systems within the separated areas have not been considered.
- The hydraulic assessment does not indicate any significant increases in flooding. The CSO assessment indicates both phases of the development are predicted to cause detriment to the spills at Wrexham CSO (2502) and Pandy PS EO (72658) located downstream of the proposed connection point. The detriment is significant, and it is predicted to increase to 2350m³ over the total development across both of the overflows. The potential detriment at the overflows would be caused by a hydraulic incapacity in the downstream network. The detriment is not considered acceptable and solutions would be required.
- Solution development has identified 1 solution to resolve the predicted detriment. This solution is:
 - Solution 1 – Utilising existing network storage. This solution requires an RTC which sets the penstock at the connection point (SJ33533001) to close before the spill level of 72.480 mAOD is reached at Pandy PS EO (72658). In addition, a decrease in the penstock opening height to 0.120 m is required at Wrexham CSO (2502).
- This solution can be delivered internally by DCWW. Therefore, there is no cost attributed to the developer.

Introduction

1.1 Appointment

WSP was appointed by Dŵr Cymru Welsh Water (DCWW) in August 2019 to assess the development impact in Tan Y Bont, Wrexham.

The development is entirely residential and will include 189 properties. Due to the topography of the site, it is proposed that all 189 residential dwellings will drain under gravity to the public sewer located in the north east of the catchment. A potential connection point of manhole SJ33533001 located off Plas Acton Road has been identified. Downstream of the connection point, the following assets could be possibly impacted on by the development: Wrexham CSO (2502) and Pandy SPS (1258).

DCWW has advised that a HMA should be undertaken to establish whether points of adequacy exist within the network. The purpose of this HMA is to quantify the effects that the development would have on the existing combined sewer network performance and identify notional solutions to resolve any potential detriment and consider further recommendations.

This report presents the findings of the HMA for the proposed development at Tan Y Bont, Wrexham.

1.2 Development Sites

- Size: Approximately 6.3 ha.
- Location: The site is located in the east of Tan Y Bont, Wrexham bounded by New Road (B5425) at the west and the A483 at the south of the site.
- Topography: The development site ranges from approximately 84.9 mAOD to the east, climbing to 97.2 mAOD in the south west of the catchment by New Road.
- Previous/ Current Usage: Greenfield site – currently open grassland.
- Proposed Usage: Entirely residential
- Sewerage Details: It is proposed that 189 residential properties will drain by gravity to the public sewer at the north east of the site.
- Connection Type: Separate gravity connections for 189 properties which will drain by gravity to the public sewer.
- Phasing: A first phase of 38 residential dwellings will be assessed and a second and final phase of 151 dwellings for the total development.

1.3 Background Information

The proposed development is within the Five Fords Waste Water Treatment Works (WwTW) catchment.

An existing model for this catchment exists. The model was updated during AMP5 as part of a Sustainable Drainage Plan (SDP) study in the catchment. Following a model review further update and verification was deemed necessary in the vicinity of the development. A flow survey and verification, as well as targeted manhole survey, impermeable area survey, and connectivity surveys were undertaken to update the area in the model where the development assessment would be undertaken. For further information on amendments made to the model see section 3.

2 Land Usage

The developer is proposing a development consisting of 189 residential units. The current land use for the site is greenfield. 38 dwellings will be delivered during the initial phase and the remaining 151 dwellings will be delivered during Phase 2.

Initial Phase		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Housing	10	4 (3.2 Occupancy)	32
Housing	21	3 (2.6 Occupancy)	55
Housing	7	2 (1.9 Occupancy)	13
Total			100

Table 2-1 - Proposed Domestic Development Contribution – Phase 1 (Initial)

Note: Population dwelling density based on Household characteristics (household size by type of accommodation and by number of bedrooms 2001-04. Sourced by Survey of English Housing). Household size is estimated as 1.3 for one bedroom; 1.9 for two bedrooms; 2.6 for three bedrooms and 3.2 for four or more bedrooms.

Total Development		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Housing	51	4 (3.2 Occupancy)	163
Housing	104	3 (2.6 Occupancy)	270
Housing	34	2 (1.9 Occupancy)	65
Total			498

Table 2-2 - Proposed Domestic Development Contribution – Phase 2 (Total)

Note: Population dwelling density based on Household characteristics (household size by type of accommodation and by number of bedrooms 2001-04. Sourced by Survey of English Housing). Household size is estimated as 1.3 for one bedroom; 1.9 for two bedrooms; 2.6 for three bedrooms and 3.2 for four or more bedrooms.

3 Developed System Modelling

3.1 Model Build / Enhancement

The proposed development is within the Five Fords WwTW catchment. The existing model for Five Fords was used as the basis for this HMA and required modifications before being deemed suitable for the purpose of this HMA.

Data to assist the model build/enhancement was obtained from the following sources:

- Existing DCWW Geographical Information Systems (GIS)
- Historic Survey Data
- DCWW Telemetry Data
- Manhole Survey
- Connectivity Survey
- Impermeable Area Survey (IAS)
- Flow Survey

The following sections detail the infill data used to build/enhance the hydraulic model and the other model build activities undertaken to ensure the model was suitable to undertake the HMA assessment.

3.1.1 STC25 Manhole Survey

As part of this study, a manhole survey consisting of 14 manholes was commissioned to supplement the existing DCWW GIS data. From the 14 manholes that were scheduled for survey, 13 were successfully completed with 1 manhole (SJ33536201) unable to locate (UTL).

This survey data was identified with the InfoWorks flag “SA” and notes included within the model.

3.1.2 Connectivity Survey

A connectivity survey covering the vicinity of Rhosddu Industrial Estate was completed. This area was shown to have a separate drainage system which has been replicated in the model. The survey identified some contributing paved and roof area from the industrial estate. In addition, Rhosddu Industrial Estate has been updated in the area take off and the trade flows generated by this area was modelled in accordance with the DCWW Wastewater Modelling Specification.

This survey data was identified with the InfoWorks flag “SI” and detailed notes included within the model.

3.1.3 Impermeable Area Survey (IAS)

Impermeable Area Survey covering the vicinity of Gresford Industrial Estate was undertaken to confirm runoff from this area. This survey indicated that all runoff from the roofs discharged to a surface water system. In addition, all the roads were shown to discharge to the surface water system, except for the access road to the industrial estate which has a separate soakaway.

This survey data was identified with the Infoworks flag “SI” and notes included within the model.

3.1.4 Summary of Model Build / Enhancement Activities

The existing model for Five Fords was updated before undertaking the HMA. These updates included the verification of flows in the area by means of a short-term flow survey. The representation of the subcatchments, impermeable areas, manholes and ancillaries have all been reviewed and updated as per the surveys detailed in Section 3.1 of this report.

3.2 Verification

A short term flow survey was carried out, comprising of 3 flow-monitors (FMs) and 2 rain-gauges (RGs) located within the Five Fords catchment.

FM01 was situated upstream of the incoming sewer located to the south of Wrexham CSO (2502). FM01 measured flows from Rhosddu Industrial Estate and areas within Old Rhosrobin.

FM02 was installed on a branch sewer located to the south of Wrexham CSO (2502) to measure flows covering areas upstream of Garden Village.

FM03 was situated upstream of the incoming sewer at the east of Wrexham CSO to help determine flows entering the CSO.

The flow survey was installed on 07/01/2020 and was terminated on 06/03/2020, a total duration of 59 days. The performance of the system was initially verified for dry weather flows using diurnally varying profiles. The model was then simulated using 3 storm events observed during the flow survey that achieved the specific requirements as stipulated in the WaPUG Code of Practice.

The resulting model predictions of the flow, depth, and velocity were compared to those observed during the flow survey. Where significant differences were found between predicted and observed data, justifiable amendments to the model were made, especially where previously interpolated levels had been used. The model was then refined by a process of continuing iteration until reasonable verification plots were obtained.

Flow/Depth Monitor	Manhole Ref.	Model Conduit Ref.	Pipe Size (mm)	Date Installed	Date Removed
FM01	SJ33530001	SJ33520902.1	220	07/01/2020	06/03/2020
FM02	SJ33523901	SJ33523801.1	600	07/01/2020	06/03/2020
FM03	SJ33533101	SJ33533106.1	300	07/01/2020	06/03/2020

Table 3-1 - Flow & Depth Monitor Location Details

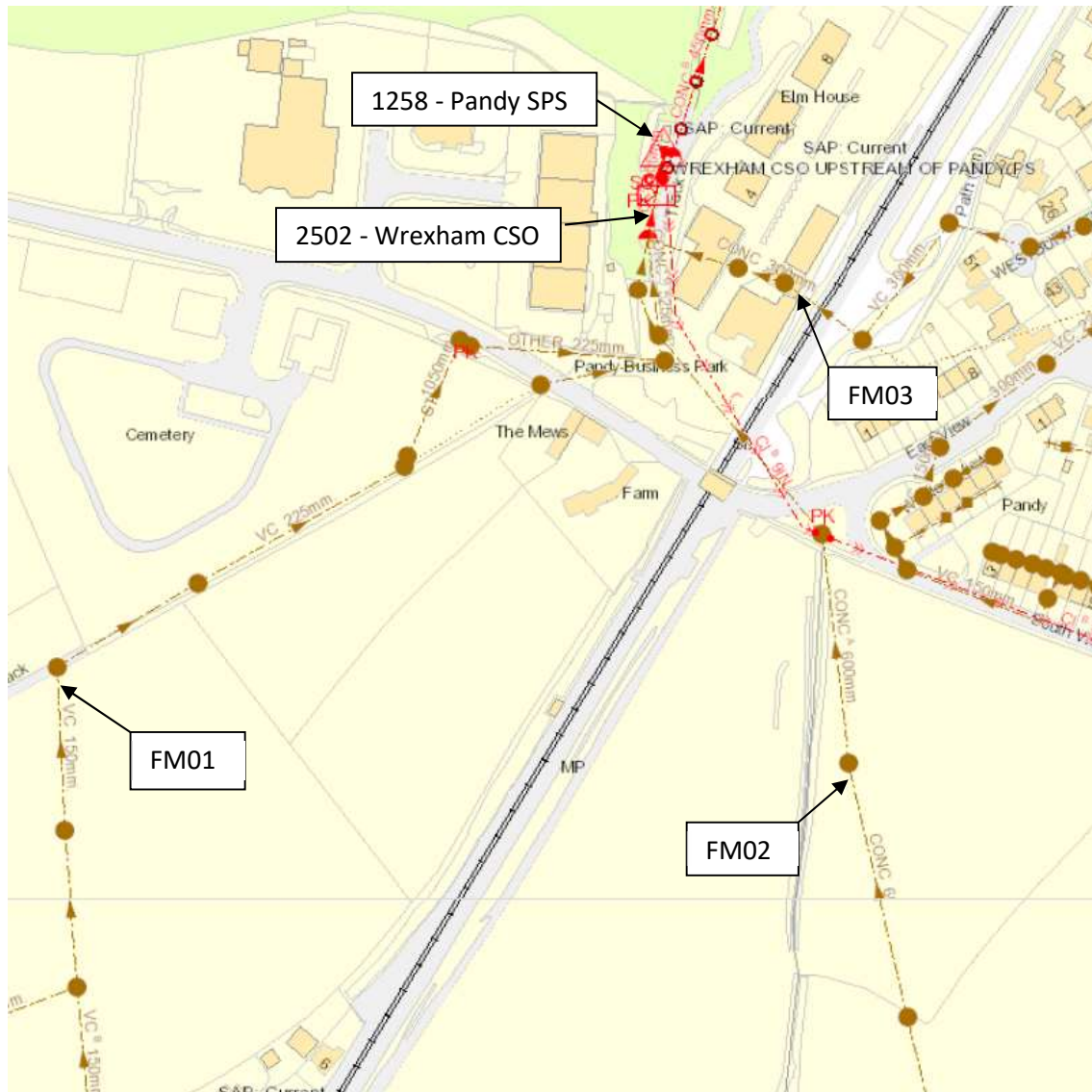


Figure 3-1 - Flow Monitor Location Plan

3.2.1 Dry Weather Flow Verification

Two dry days were selected for the dry weather flow (DWF) verification.

- DD1; 22/01/2020 (Wednesday)
- DD2; 25/01/2020 (Saturday)

FM01

The flow monitor recorded poor data for both dry days which indicated low depths and flows.

Initial verification plots showed that the model was over-predicting flow volumes and the observed diurnal profile was not similar to the modelled profile. To achieve verification, trade flows modelled upstream of the flow monitor at Rhosddu Industrial Estate were recalculated and modelled. As a result, there was a better match with the observed velocity. However, the model-predicted flows and volumes were still significantly greater than the observed. No changes have been made to the modelled depths as they are within the WaPUG criteria.

The verification of this flow monitor is considered acceptable given the low velocities recorded.

FM02

The flow monitor recorded good data for both dry days and diurnal profiles are visible.

The initial verification plots showed a good match between the observed depths and the modelled depths. However, the model under-predicted flow volumes. The subcatchments upstream of FM02 were updated with a new wastewater profile (14) at a consumption rate of 180l/day, which gave a better match to the observed flows and diurnal profile. A connectivity plan indicated four residential properties located upstream on Ffordd Estyn contribute to the foul system. Therefore, a new subcatchment was modelled in this area which led to a slight increase in modelled flow volume. In addition, the population in the subcatchments upstream of FM02 was updated using available census data and estimation, which gave a slight increase in the total population from 931 to 945. Overall, the model-predicted depths and flow volumes are within the required criteria.

A good level of verification was achieved at this monitor with nearly all predicted levels within criteria.

FM03

The flow monitor recorded good data for both dry days and the observed diurnal profile was similar to the standard Ciria profile.

Initial verification plots showed that the model was over-predicting volume and the shape was not represented by the standard Ciria profile. The modelled diurnal profiles did not match the observed, therefore the subcatchments upstream of FM03 were updated with a new wastewater profile (15). The new wastewater profile has a lower consumption rate of 140l/day and it uses the standard Ciria profile. This led to a better fit overall as the model-predicted volumes reduced. The modelled depths are within the required criteria; however, the model still over-predicts flow volumes.

The verification of this flow monitor is considered acceptable.

3.2.2 Storm Flow Verification

Three storm events were selected for storm flow verification. These are detailed in Table 3-2 below.

Event	Date	Weekday	Start Time	End Time	Duration (hrs.)	Peak Intensity (mm/hr.)
A	09/02/2020	Sunday	04:50	22:00	17	24
B	10/02/2020	Monday	11:00	19:00	8	6
C	15/02/2020- 17/02/2020	Saturday	04:00	13:00	57	12

Table 3-2 - Flow Survey Storm Events

FM01

The observed data recorded at this flow monitor was reasonable across all selected storm events. There was some velocity drop out during Storm A and Storm C, which affected the recorded flow volume. The velocity data was below the accuracy threshold for the monitor.

The initial verification plots showed an over-prediction of peak flows for Storm A and an under-prediction of peak flow for Storm B. An over-prediction of runoff contribution and an under-prediction of slow-response was also shown. However, a good correlation was indicated between the observed depths and the modelled depths.

A connectivity survey was conducted at Rhosddu Industrial Estate which is located upstream of FM01. The survey data indicated that the estate is connected to the network and some mis-connections were identified which have been replicated in the model. Three buildings located to the north of the industrial estate appeared to have a separate drainage. Additionally, residential properties located upstream of FM01 on Rhosrobin Road, Briarswood and Churchlea also appeared to have a separate surface water system using street view. These properties have been updated in the area take off to produce a more accurate peak flow and storm response by the model. The observed data showed evidence of slow response that was not predicted by the model. Therefore, a ground infiltration module has been created in the model with a percolation percentage infiltrating coefficient of 20%.

The verification of this monitor is acceptable considering the quality of the data and velocity drop outs observed. The model gives an acceptable match to the full period observed data.

FM02

The observed data recorded at FM02 was of reasonable quality, with occasional drop outs in velocity data. The initial verification plots indicated the model was under-predicting peak flow and flow volumes. However, the observed depth levels and the modelled depth levels were similar.

All the roofs within the subcatchments upstream of this flow monitor were previously allocated to the foul system and the paved areas were allocated to soakaway. Therefore, to increase storm response in the model, 0.56ha of paved area which was previously assumed to be soakaway has been allocated to the foul sewer. This resulted in an increase in modelled flows and there was a better match of peak



flows across the storm events. However, it was difficult to match the peak flow for Storm A and Storm C due to spikes in velocity caused by an upstream SPS. In addition, slow response was calibrated in the subcatchments upstream of the flow monitor. A subcatchment was created at a field for rainfall induced infiltration, and a ground infiltration module has been created in the model with a percolation percentage infiltrating coefficient of 96%. Overall, the model-predicted flow volumes and depth levels are within criteria.

The has model achieved a good level of verification at this location.

FM03

The observed data for FM03 shows good data for the selected storm events. The flow monitor showed a good response to rainfall.

The initial verification plots showed an under-prediction of depths across all the storm events. In addition, the observed data indicated there was slow response which was not predicted by the model.

An IAS covering the vicinity of Gresford Industrial Estate which is located upstream of FM03 was conducted. The survey showed that all runoff from the roofs and the majority of runoff from the roads discharged to a surface water system. A good match to the observed peak flows was shown after updating the area take off. Also, a ground infiltration module was added in the model for the subcatchments upstream of FM03 using a percolation percentage infiltrating coefficient of 22%. A better fit overall was obtained after updating the model. It is worth noting that the downstream CSO and SPS have been recently surveyed during the SDP and all surveyed data is unchanged in the model.

A good level of verification was achieved at this monitor with nearly all model-predicted levels within criteria.

3.3 Historical Verification

A review of DCWWs flooding incident databases has been undertaken to determine where historical reports of flooding have been recorded within the catchment.

Design storms based on a 2, 5, 10, 20 and 30 year return periods were simulated using the verified model to determine where the model predicts flooding.

There are numerous reported flooding locations identified on the DFL, which were used as part of the historical verification process. The results for each reported flooding cluster are explained below.

Rhosrobin (Churchlea) OF (1:10)

The model does not predict flooding during a 1 in 10 year design storm at the reported location. One incident has been reported at this location and it was at a road/foot path. The incident has been listed as 'OF' (Other Flooding), therefore it is unlikely to be linked to the existing foul sewer. Model confidence is low here as the majority of the asset data is flagged 'OM' (Old Model). It is worth noting that the model does predict higher surcharge levels in the foul sewer near the reported location.

Wrexham (Chester Road) OF (1:20+)

The model does not predict flooding at the reported location for a 1 in 30 year design storm. The model does predict surcharge in the main sewer. The incident at this location was previously reported as 'other

flooding' and it is also marked as 'private' which suggests it is not related to the foul sewer near the location. The model downstream is medium confidence as the manhole which the properties drain to has been surveyed. However, the surrounding manholes are flagged as 'OM' (Old Model).

Wrexham (Ffordd Estyn) DG5 (1:10)

The model predicts large flooding volumes at the reported flooding location during a 1 in 10 year design storm. The flooding is predicted at two manholes near the location of the incident and it is caused by a hydraulic incapacity. Model confidence is medium here as the downstream manhole has been surveyed as part of this HMA, however, the cover level at the manhole where the flooding is predicted is based on inferred data.

Little Acton, Wrexham DG5 (2:10)

A number of incidents have been reported within the vicinity of Smithy Close and Smithy Lane. The model predicts large flooding volumes at the reported flooding location during a 1 in 10 year design storm. The mechanism for flooding is due to the low spot manholes. Model confidence is high as the majority of the manholes within the reported location have been surveyed and the surcharge levels reach the cover level.

The historical verification has been considered acceptable.

3.4 Verification Summary

The model has been verified and is considered acceptable for assessing the impact of the proposed residential developments on the existing foul sewer network. Verification graphs and the reported compliance with WaPUG criteria are presented in Appendix C.

3.5 Model Assumptions & Limitations

A number of assumptions have been made during the model build and verification, these include:

- The datasets supplied are correct.

The hydraulic model utilised for this HMA study is considered to have the following limitations:

- The verification has been focused for the purpose of this HMA only.
- Detailed modelling of the surface water system was not included as part of the study. The impact of the proposed development is limited to the impact of the foul/combined system which is deemed acceptable for the purpose of this HMA.

4 Development System Analysis

4.1 Dry Weather Flow

The DWF for the residential properties has been calculated as below for the total development and the initial phase.

Parameter	Value	Comment
Population - P	100	38 properties with population as outlined in Table 2-1
Per Capita Return to Sewer Flow Rate – G	180 l/hd/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 180 l/hd/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration	0.0208 l/s	10% DWF (PG) assumed
Total DWF Calculations		
P * G	0.208 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	0.229 l/s	
DWF Peak Hydraulic Assessment Multiplier	1 and 2	DWF Peaking factor for CSO (1) and flooding (2) level of performance investigation.

Table 4-1 - HMA - DWF Parameters – Phase 1 (Initial)

Parameter	Value	Comment
Population - P	498	189 properties with population as outlined in Table 2-2
Per Capita Return to Sewer Flow Rate – G	180 l/hd/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 180 l/hd/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration	0.1038l/s	10% DWF (PG) assumed
Total DWF Calculations		
P * G	1.04 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	1.14 l/s	
DWF Peak Hydraulic Assessment Multiplier	1 and 2	DWF Peaking factor for CSO (1) and flooding (2) level of performance investigation.

Table 4-2 - HMA - DWF Parameters – Phase 2 (Total)

4.2 Surface Water Run-off

The developer has been advised that surface water runoff is to be separated from foul flows and it will not be discharged into the existing foul/combined system. The scope of this HMA is limited to the impact on the existing combined system, hence surface water systems within the separated areas have not been considered.

Whilst the surface water network of the proposed development has not been modelled, a nominal allowance of 2% for residential and 1% for commercial of the total contributing area has been allocated to represent possible future misconconnections between the foul and storm systems and the impact of urban creep. This has been applied to each of the road and roof runoff surfaces within the foul sub-catchment.

Detailed layout plans of this development are not available. A location plan of the development site was provided which did not contain enough detail to complete an area take off procedure. Therefore, the impermeable area for this site has been determined based on estimated values. An even distribution between road (2%) and roof (2%) surfaces was applied (i.e. 2% of total contributing area). As no details have been provided, it is assumed that the housing density will be medium (60%).



Figure 4-1 - Location plan of the development site

Total Impermeable Area (ha)	Total Road Area (ha)	2% Road Area (ha)	Total Roof Area (ha)	2% Roof Area (ha)
0.76	0.38	0.0076	0.38	0.0076

Table 4-3 - Development Impermeable Areas – Phase 1 (Initial)

Total Impermeable Area (ha)	Total Road Area (ha)	2% Road Area (ha)	Total Roof Area (ha)	2% Roof Area (ha)
3.79	1.89	0.0379	1.89	0.0379

Table 4-4 - Development Impermeable Areas – Phase 2 (Total)

5 Existing / Developed Comparison

5.1 Hydraulic Assessment

Design storms based on a 30 year return period were used to determine the potential flood volumes in the existing and development scenarios.

Winter and summer design storms with durations of 15, 30, 60, 90, 120, 240, 360, 480, 720, 960 and 1440 minutes were applied to the existing and developed models. Summer events were considered the 'worst case' scenario. It has been found that most flooding incidents occur during the 120 minute Summer storm duration. However, model predicted flood volumes vary with the duration of the event and therefore all storm durations have been assessed to highlight the worst case scenario.

Existing flooding is predicted at a number of locations downstream of connection point SJ33533001. The flooding is caused by a localised hydraulic incapacity and is not affected by the development flows. The flooding reported in the table below focuses on the locations where the model predicts detriment greater than 1m³ or new flooding. See Table 5-1.

5.1.1 Scenario 1 – Phase 1 (Initial)

This scenario assesses the impact of the development connecting to SJ33533001 for the initial phase of 38 units. The hydraulic analysis shows the model does not predict flooding detriment for Phase 1 of the development.

5.1.2 Scenario 2 – Phase 2 (Total)

This scenario assesses the impact of the development connecting to SJ33533001 for the total development of 189 units.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m ³)		Flooding Detriment	
			Existing	Developed	Absolute (m ³)	Percentage (%)
SJ35513604	SJ35513604	120 (Summer)	140.4	141.6	1.2	0.85

Table 5-1 - Hydraulic Assessment Results – Scenario 2 Phase 2 (Total)

The model predicts zero flooding detriment for Phase 1 and approximately 1m³ of flooding detriment is predicted for Phase 2 of the development. The increase in flooding is predicted at a manhole further downstream of Pandy SPS (1258) at a distance of around 2.2km.

5.2 CSO Assessment

Spill volume analysis of the overflow was carried out using a 'typical year' TSR series. A summary of the analysis is shown in Table 5-2 and 5-3.

CSO Name	Spill Frequency							
	Existing		Developed		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m ³)	Spills (No.)	Total Spill Vol. (m ³)	Absolute (No.)	Percentage (%)	Absolute (m ³)	Percentage (%)
Wrexham CSO (2502)	51	12372	51	12507	0	0	135	1.09
Pandy PS EO (72658)	134	43870	138	44219	4	2.99	349	0.80

Table 5-2 - CSO Assessment – Phase 1 Initial Development

CSO Name	Spill Frequency							
	Existing		Developed		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m ³)	Spills (No.)	Total Spill Vol. (m ³)	Absolute (No.)	Percentage (%)	Absolute (m ³)	Percentage (%)
Wrexham CSO (2502)	51	12372	52	13117	1	1.96	745	6.02
Pandy PS EO (72658)	134	43870	138	45475	4	2.99	1605	3.66

Table 5-3 - CSO Assessment – Phase 2 Total Development

The CSO assessment for spill count and spill volume indicates no increase in spill count at Wrexham CSO for Phase 1, but a slight increase in spill count is indicated at Pandy PS EO. The spill count is predicted to increase at both the CSO and EO during Phase 2. The spill volumes are predicted to significantly increase over the typical year during both phases. The increase in spill volume over the typical year equates to 1.09% at Wrexham CSO (2502) for Phase 1, increasing to 6.02% over the total development. The increase in spill volume over the typical year equates to 0.80% at Pandy PS EO for Phase 1 increasing to 3.66% over the total development. The reason for the increase in spill volume is likely due to the CSO and EO being located directly downstream of the point of connection and within close vicinity to the development site (0.14km).

5.3 Formula 'A' Assessment

The value of Formula 'A' has been determined at each CSO considered to be impacted on by the development. The Formula 'A' flow is a measure of the continuation flow required at a CSO prior to spill occurring. The calculated Formula 'A' figures are presented in Table 5-4.

Model	Pass Forward Flow (l/s)	Formula A (l/s)	DWF (l/s)	Passes Formula A
Existing	91	43.6	5.7	Yes
Phase 1 (Initial)	91	45.3	5.9	Yes
Phase 2 (Total)	93	52.5	6.7	Yes

Table 5-4 - Formula 'A' Assessment – Wrexham CSO (2502)

The model has been assessed to ensure that the CSO meets the requirements to pass forward Formula 'A' flows and that this requirement is not unduly affected by the addition of the development. The CSO setting has been determined by assessing the flow at first spill for a range of low return period events (such as the verification events and 1 in 1 year return period design events).

The model shows that Wrexham CSO (2502) is passing forward a much higher value than Formula A in the existing system and the development is not predicted to cause significant detriment to this. The consent value for Wrexham CSO (2502) is 56l/s which, based on model predictions, is being met in the existing system.

5.4 SPS Assessment

The impact of development flows has also been assessed at Pandy SPS (1258) in relation to operational performance including number of pump starts, pump runtimes and pump volumes. The assessment also determines the impact on emergency storage requirements.

The normal requirements for emergency storage are for 2 hours of storage at 3DWF.

Storage calculations are presented in Table 5-5.

	3DWF	Pump Rate	Storage (2hrs @ 3DWF)	Pump Rate Acceptable	Storage Acceptable
Existing	16.64 l/s	35l/s	119.81m ³	Yes	No
Phase 1 (Initial)	17.29 l/s	35l/s	124.49m ³	Yes	No
Phase 2 (Total)	19.85 l/s	35l/s	142.92m ³	Yes	No

Table 5-5 – Pandy SPS (1258) Assessment – Emergency Storage

The theoretical emergency storage requirement for the existing system is 119.8m³, rising to 142.9m³ with the inclusion of the total development.

The development causes significant detriment at the pumping station, with storage required at 2hrs x 3DWF increasing by 23.1m³ over the total development. The analysis also suggests that the pumping station does not have acceptable emergency storage at present.

Pump performance results for a 24 hour period are presented in Table 5-6 and Table 5-7.

SPS Name	Existing		Developed		Run Time Difference		Run Volume Difference	
	Run Time (minutes)	Run Volume (m ³)	Run Time (minutes)	Run Volume (m ³)	Absolute (minutes)	Percentage (%)	Absolute (m ³)	Percentage (%)
Pandy SPS (1258)	260	409.9	323	508.6	63	24.2	98.7	24.1

Table 5-6 – Pandy SPS (1258) Assessment – Runtime & Volume

The table above shows that over a dry weather day, the pump will run for 63 minutes longer and pump an additional volume of 98.7m³ for the total development scenario.

In accordance with Sewers for Adoption, all pumping stations should operate with a maximum of 15 starts per hour. Table 5-7 gives the maximum number of dry weather starts per hour for all pumps, on a weekday 22/01/2020 and weekend 25/01/2020.

The assessment compares the predicted number of starts per hour for the existing system with the number for the developed system.

SPS Name	Existing Pump Starts		Developed Pump Starts	
	Dry Day 1	Dry Day 2	Dry Day 1	Dry Day 2
Pandy SPS (1258)	3	2	3	3

Table 5-7 – Pandy SPS (1258) Assessment – Number of Pump Starts

As shown above, there are on average 3 starts per hour in the existing system during Dry Day 1 and 2 starts per hour during Dry Day 2. Over the course of a 24hr period, there is an increase of one additional PS start in the total development scenario.

5.5 Flows Arriving at Five Fords WwTW

Using the annual time series 'typical year', it was calculated that 11,503,710.2 m³ of flow arrives at Five Fords WwTW. With the new development, this figure increases to 11,538,155.1 m³. This corresponds to an increase of 34,444.9 m³ or 0.3%.

5.6 Network Performance Assessment Summary

Flooding summary

The flooding detriment assessment undertaken predicts no detriment for Phase 1 of the development. The model predicts that the initial phase of 38 dwellings can be accommodated in the sewers by the model. The model predicts a detriment of 1.2m³ of flooding at manhole SJ35513604 located further downstream of the point of connection (around 2.5km) with the addition of Phase 2. The model predicts flows to back up and the flooding is due to the low spot of the manhole. The model shows there is hydraulic incapacity in the sewer network downstream.



CSO summary

The CSO detriment assessment undertaken predicts an increase in both the spill volume and spill frequency at Wrexham CSO (2502) and Pandy PS EO (72658). The flows calculated from the development have a detrimental effect on the CSO and EO. The development scenario indicates the additional flow has a greater detriment on the overflows in comparison to the manholes. Therefore, a solution is required to mitigate the detriment at the overflows.

SPS summary

The results of the SPS assessment indicate the proposed development has a significant detriment on Pandy SPS (1258).

6 Solution Development

The hydraulic assessment has indicated that the addition of development flows has caused detriment with regards to network performance. Therefore, solutions have been investigated to resolve this detriment caused by the development flows.

The notional solutions described in the following sections show conceptual arrangements only and are presented to illustrate the adequacy of the solutions in terms of gross parameters (e.g. pipe capacities); their inclusion does not infer buildability and they are not to be considered as detailed design proposals.

6.1 Discounted Solutions

A number of solutions were considered but discounted because they did not resolve the predicted detriment and/or were not considered feasible:

1. Restricting downstream flows by reducing penstock opening height
The opening height of the penstock at the connection point was reduced to restrict the downstream flows and resolve the detriment at the CSO and EO. Reducing the opening height of the penstock decreased the spill volume at the overflows but not to acceptable levels as there was significant betterment. The penstock was replaced with an orifice with a limiting discharge of what the flow rate was prior to the development (121l/s). This did not lessen the spill volumes at the CSO/EO to acceptable levels and therefore the solution was discounted.
2. Storage pipe located immediately upstream Wrexham CSO 2502
A 15m, 1200mm diameter storage pipe was modelled to bifurcate flows at the manhole upstream of the CSO and mitigate the detriment at both of the overflows downstream. The excess flow would enter the storage pipe via a weir and return using an orifice with a limiting discharge of 5l/s. The solution was discounted as it resolved the detriment at the CSO but not the detriment at the EO downstream. This suggested that a storage may be required at the EO in addition to the storage at the CSO. The solution was also discounted as it would likely result in an increase in flooding detriment upstream.

6.2 Solution 1; Utilising existing network storage

6.2.1 Description

This solution addresses the total development flows utilising Connection Point 1. The solution proposes an RTC at the penstock located at the connection point (SJ33533001). The RTC rule is the penstock will be closed before the spill level is reached at Pandy PS EO (SJ33532204). This results in the utilisation of the network storage upstream of the connection point. The RTC at the penstock will mitigate the detriment at the CSO and majority of the EO detriment. In order to fully mitigate all detriment at the overflows, the penstock at the CSO (SJ33532202) needs to be reduced to 0.120 m.

The penstock at the connection point was surveyed as part of the Five Fords SDP, the photos indicate there is a kiosk at the chamber which suggests new equipment is not required for the penstock automation. The invert level and width of the penstock at the CSO was previously surveyed; however, the opening height has not been surveyed. The current opening height of the CSO penstock (0.150 m) was estimated based on a photograph.

The solution elements are as follows:

- An RTC is required which sets the penstock at the connection point (SJ33533001) to close before the spill level of 72.480 mAOD has been reached at Pandy PS EO (72658).
- A decrease in the penstock opening height at Wrexham CSO (2502) to 0.120m.

6.2.2 Notional Design Solution

There is model predicted detriment at the overflows downstream of the connection point. The solution proposes to utilise the existing network storage upstream of the connection point when there is insufficient storage downstream. Survey information suggests new equipment is not required as part of the solution. There is a weir located at the point of connection which diverts excess flows if there is insufficient capacity.

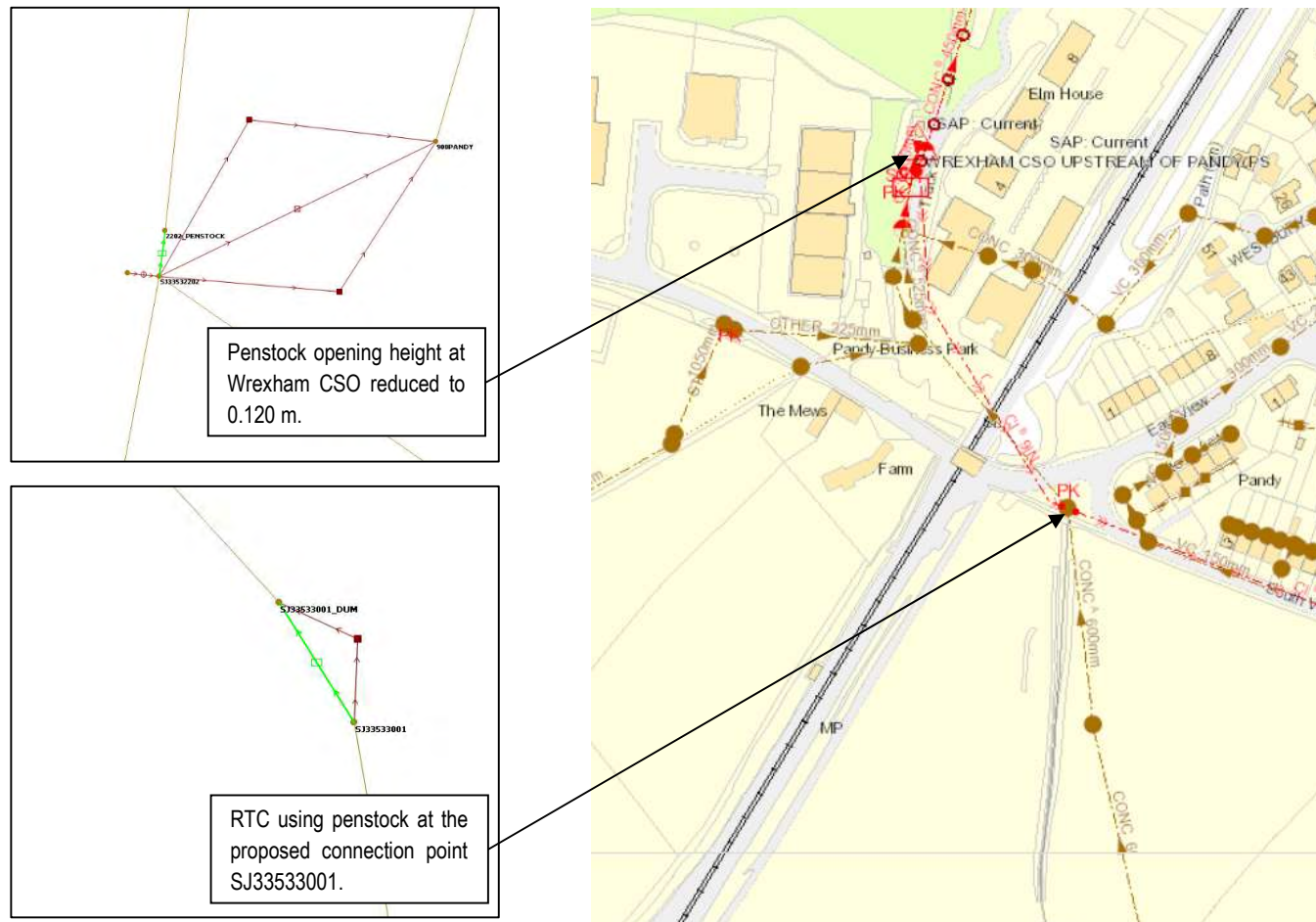


Figure 6-1 - Solution 1



Figure 6-2 – Solution 1 (MH SJ33533001)

6.2.3 Solution Assessment

Comparison Analysis

CSO Name	Spill Frequency							
	Existing		Developed		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m ³)	Spills (No.)	Total Spill Vol. (m ³)	Absolute (No.)	Percentage (%)	Absolute (m ³)	Percentage (%)
Wrexham CSO (2502)	51	12372	45	12066	-6	-11.76	-306	-2.47
Pandy PS EO (72658)	134	43870	136	43668	2	1.49	-202	-0.46

Table 6-1 - Solution 1 CSO Analysis

Solution 1 leads to a betterment in total spill volume at the CSO and EO. The model predicts a betterment in the CSO spill count but a slight detriment in the EO spill count. It should be noted that the spill count increase is not significant as the total spill volume is less than the existing spill volume. Reducing the betterment in the spill frequency at the CSO would lead to a further increase in the detriment at the EO.

6.2.4 Option Considerations

Model simulations indicate a similar RTC using an existing penstock (SJ33531104) upstream the CSO would also mitigate the detriment caused by the development. However, this would result in more betterment at the CSO. It is more suitable to use an RTC based on the penstock located at the connection point.

7 Solution Costs

The solution costs provided are based on the DCWW Solution Target Pricing Tool (STPT). This cost model predicts costs based on final costs of completed schemes. These are intended to be high level cost estimates and are for option comparison only. It is recommended that a detailed cost estimate is undertaken during the detailed design phase.

Solution	Description	Cost
1	Utilising existing network storage	0

Table 7-1 - Solution Costs

8 Conclusions & Recommendations

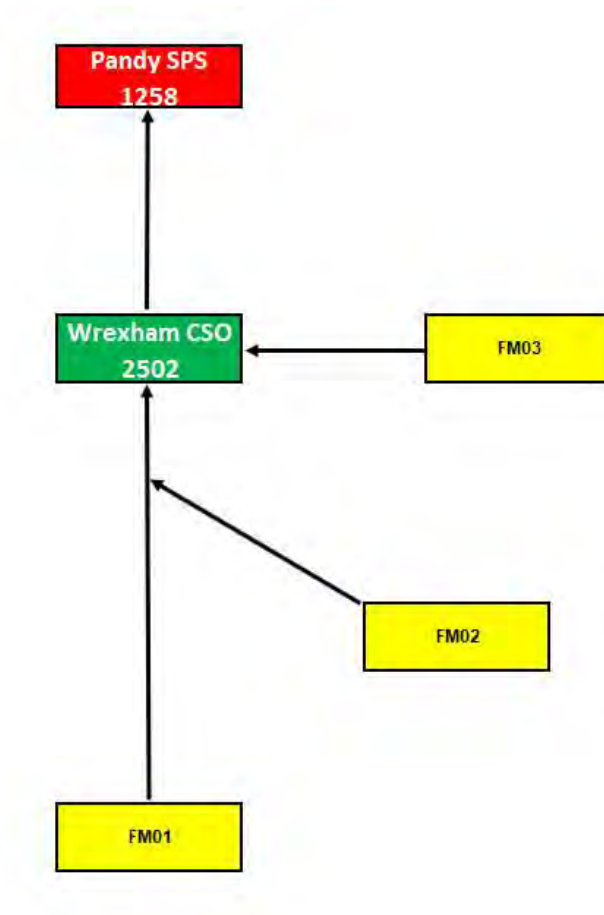
- This Hydraulic Modelling Assessment (HMA) has assessed proposed residential flows connecting to Tan Y Bont, Wrexham. The proposed development consists of 189 properties. Due to the topography of the site, all 189 properties will drain by gravity to Connection Point 1 (manhole SJ33533001) at the north east of the development. The assessment consists of two phases, Phase 1 with 38 properties connected to the network and Phase 2 consisting of the total development of 189 dwellings.
- The proposed developments at Tan Y Bont consists of one connection point:
 - Connection Point 1: The proposed connection point for the residential properties is manhole SJ33533001 located off Plas Acton Road to the north east of the proposed development site.
- The proposed development is located within the Five Fords WwTW catchment. The existing model for Five Fords, which was recently upgraded in 2018 for a separate study within the catchment, was used as the basis for this HMA. The model required further modifications before being deemed suitable for the purpose of this HMA. Following these updates, the model was considered suitable for assessing the impact of the proposed development.
- The developer has been advised that surface water runoff is to be separated from foul flows and it will not be discharged into the existing foul/combined system. The scope of this HMA is limited to the impact on the existing combined system, hence surface water systems within the separated areas have not been considered.
- The hydraulic assessment does not indicate any significant increases in flooding. The CSO assessment indicates both phases of the development are predicted to cause detriment to the spills at Wrexham CSO (2502) and Pandy PS EO (72658) located downstream of the proposed connection point. The detriment is significant, and it is predicted to increase to 2350m³ over the total development across both of the overflows. The potential detriment at the overflows would be caused by a hydraulic incapacity in the downstream network. The detriment is not considered acceptable and solutions would be required.
- Solution development has identified 1 solution to resolve the predicted detriment. This solution is:
 - Solution 1 – Utilising existing network storage. This solution requires an RTC which sets the penstock at the connection point (SJ33533001) to close before the spill level of 72.480 mAOD has been reached at Pandy PS EO (72658). In addition, a decrease in the penstock opening height to 0.120 m is required at Wrexham CSO (2502).
- This solution can be delivered internally by DCWW. Therefore, there is no cost attributed to the developer.

Appendix A – Drawings & Plans



Location plan of the development site

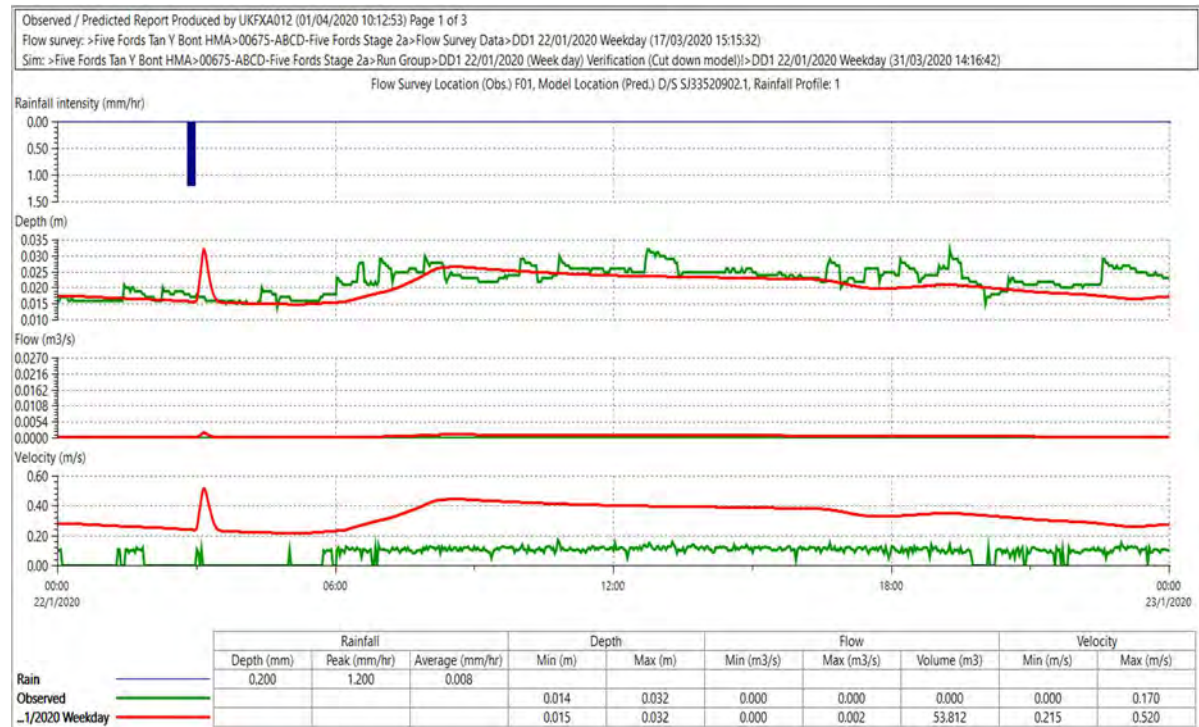
Appendix B – Verification Plots & Comparative Analysis



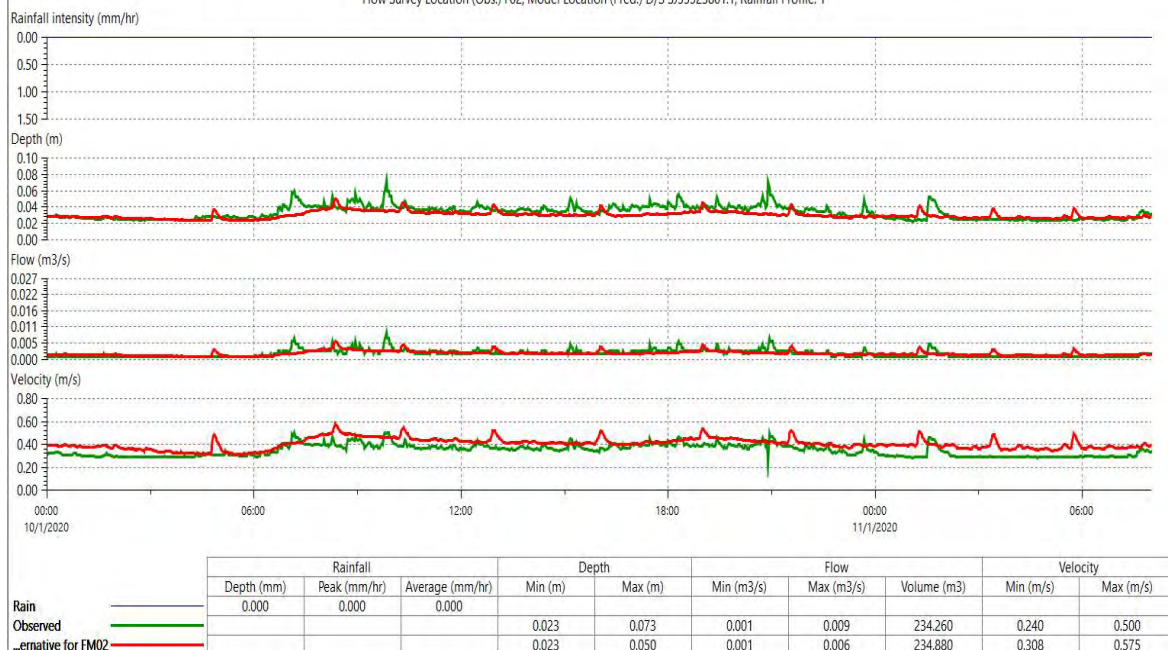
Flow Monitor Schematic

DRY WEATHER FLOW VERIFICATION

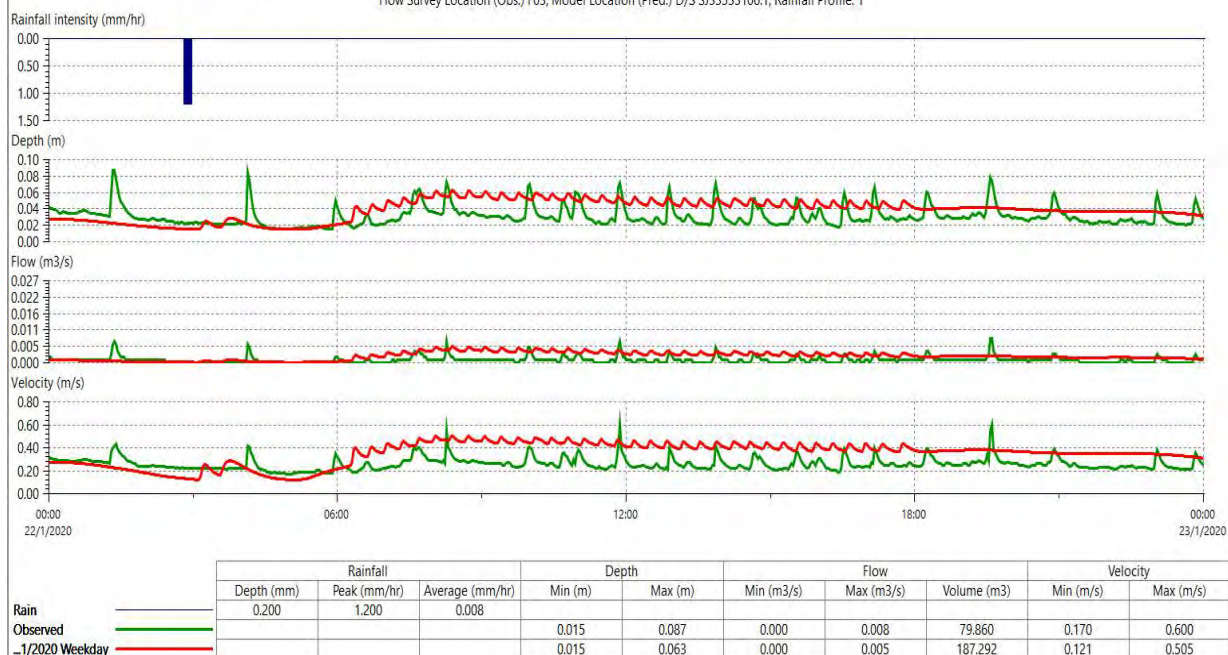
Dry Day 1



Flow Survey Location (Obs) F02, Model Location (Pred.) D/S SJ33523801.1, Rainfall Profile: 1



Flow Survey Location (Obs) F03, Model Location (Pred.) D/S SJ33533106.1, Rainfall Profile: 1



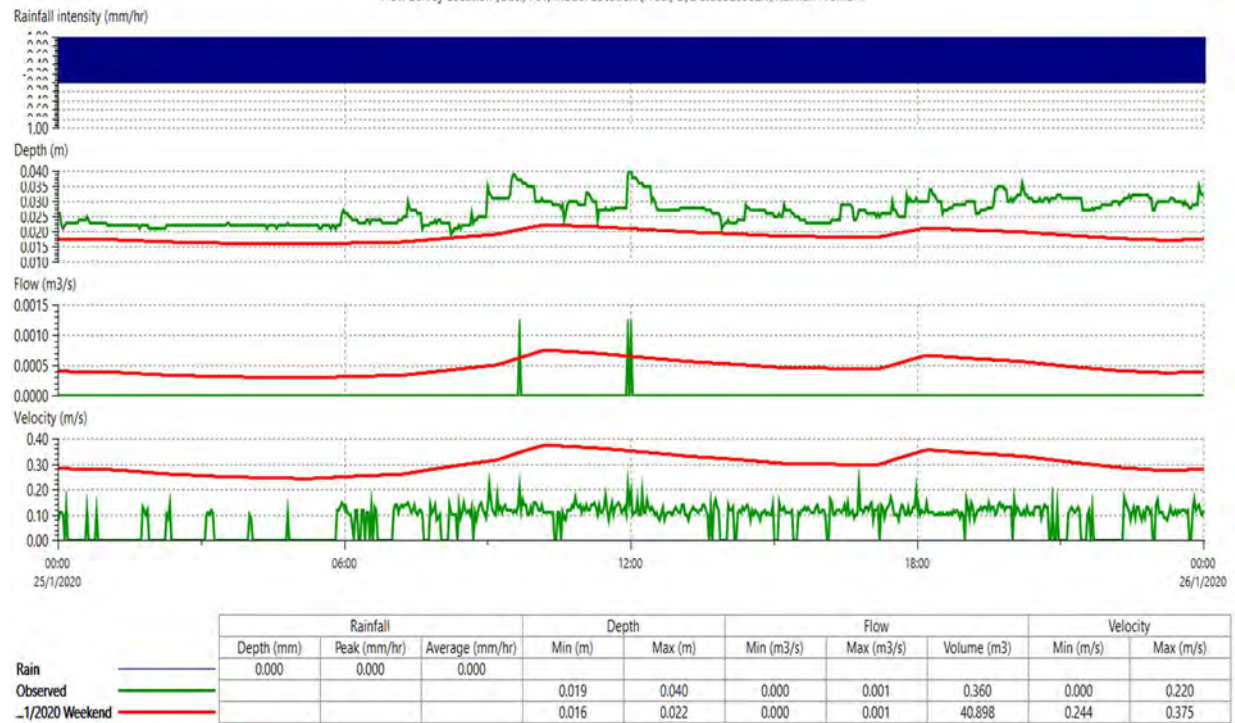
Dry Day 2

Observed / Predicted Report Produced by UKFXA012 (01/04/2020 10:13:06) Page 1 of 3

Flow survey: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Flow Survey Data>DD2 25/01/2020 Weekend (17/03/2020 15:15:32)

Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Run Group>DD2 25/01/2020 (Weekend) Verification (Cut down model)>DD2 25/01/2020 Weekend (31/03/2020 14:16:49)

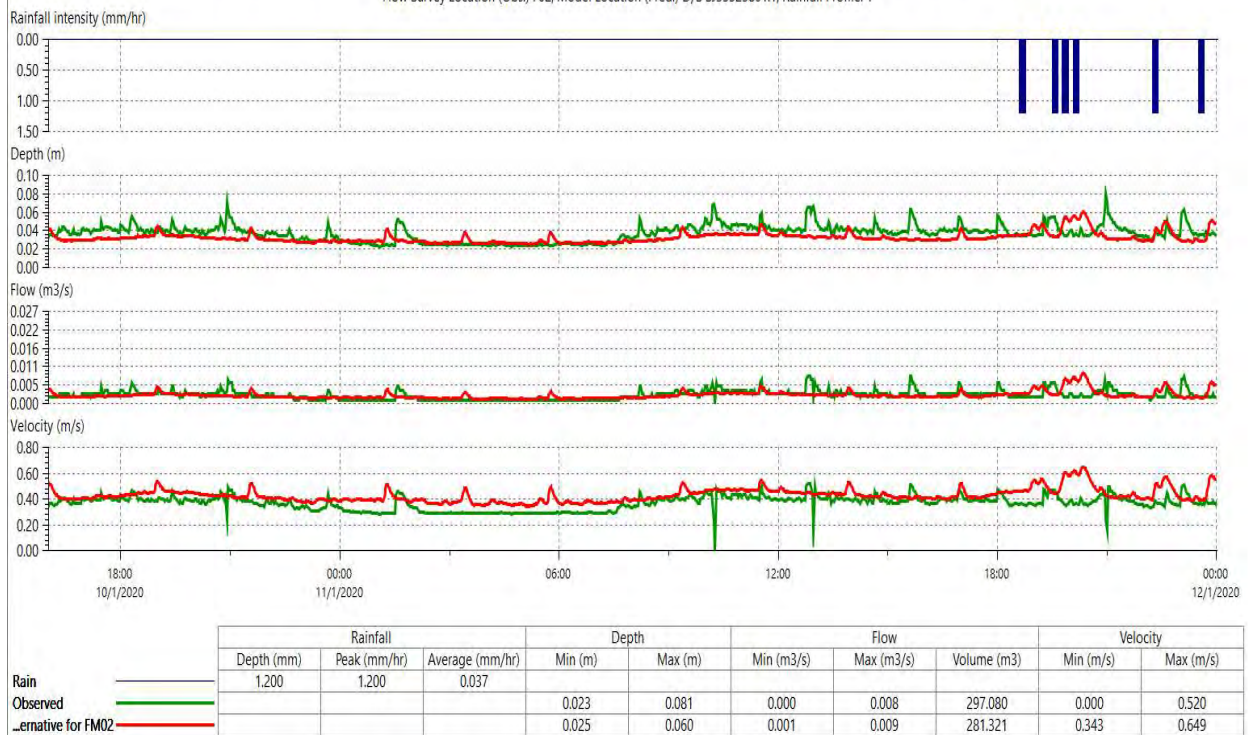
Flow Survey Location (Obs.) F01, Model Location (Pred.) D/S S133520902.1, Rainfall Profile: 1



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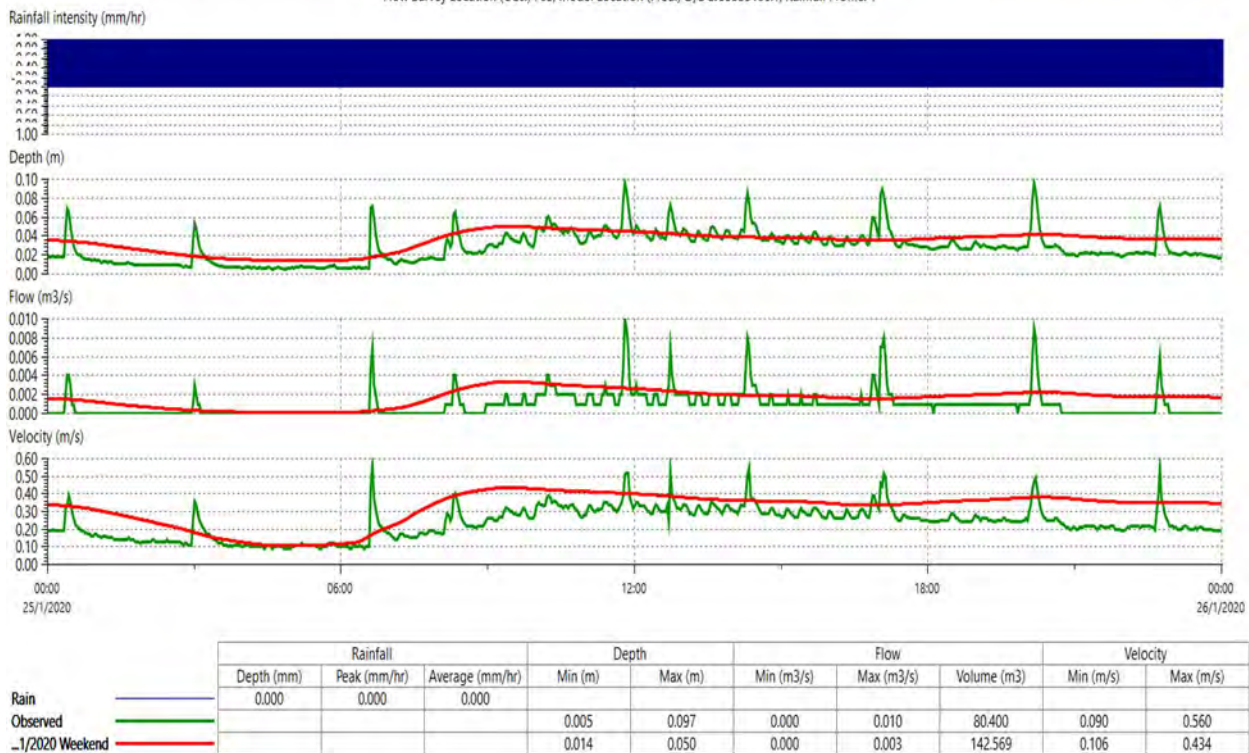
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Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Run Group>DD2 25/01/2020 (Weekend) Verification (Cut down model)>DD2 25/01/2020 Weekend (31/03/2020 14:16:49)

Flow Survey Location (Obs.) F03, Model Location (Pred.) D/S SJ33533106.1, Rainfall Profile: 1



STORM VERIFICATION

Storm A

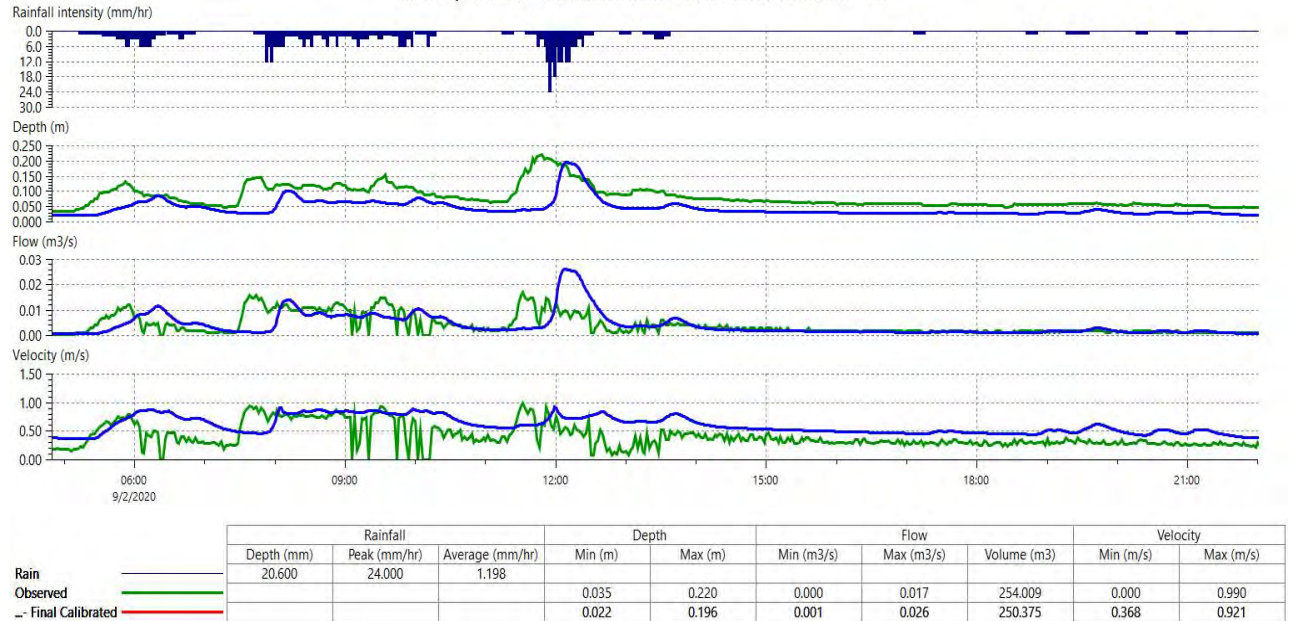
Observed / Predicted Report Produced by UKFXA012 (17/04/2020 15:07:44) Page 1 of 3

Flow survey: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Flow Survey Data>Full Period Data - Final Calibrated (17/03/2020 15:15:32)

Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Verification Run Group>Full Period Verification Storm Verification_v9>Full Period Data - Final Calibrated (14/04/2020 13:03:04)

Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Verification Run Group>Full Period Verification Storm Verification_v9>Full Period Data - Final Calibrated (14/04/2020 13:03:04)

Flow Survey Location (Obs.) F01, Model Location (Pred.) D/S SJ33520902.1, Rainfall Profile: 1



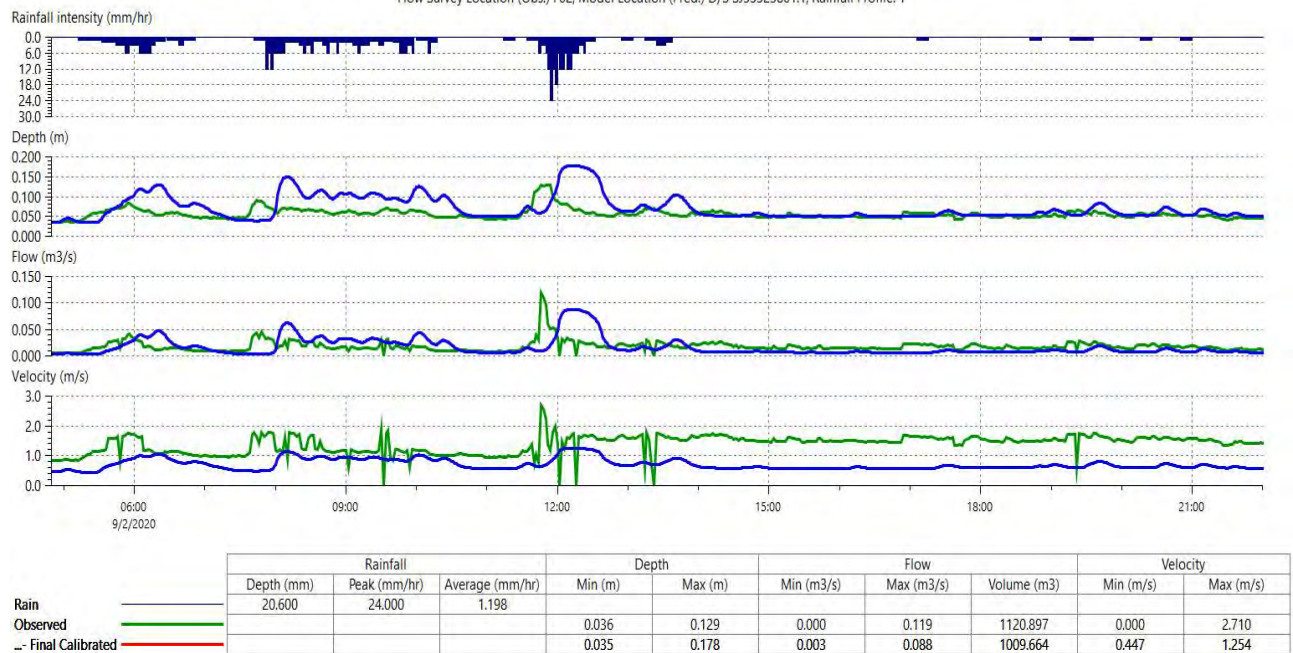
Observed / Predicted Report Produced by UKFXA012 (17/04/2020 15:07:44) Page 2 of 3

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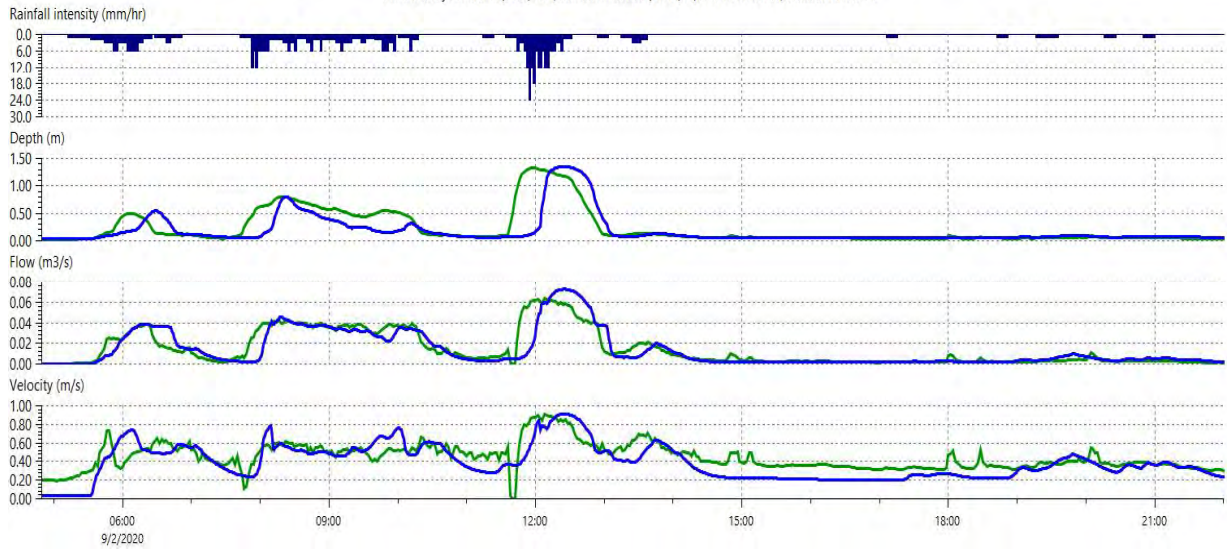
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Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Verification Run Group>Full Period Verification Storm Verification_v9>Full Period Data - Final Calibrated (14/04/2020 13:03:04)

Flow Survey Location (Obs.) F02, Model Location (Pred.) D/S SJ33523801.1, Rainfall Profile: 1



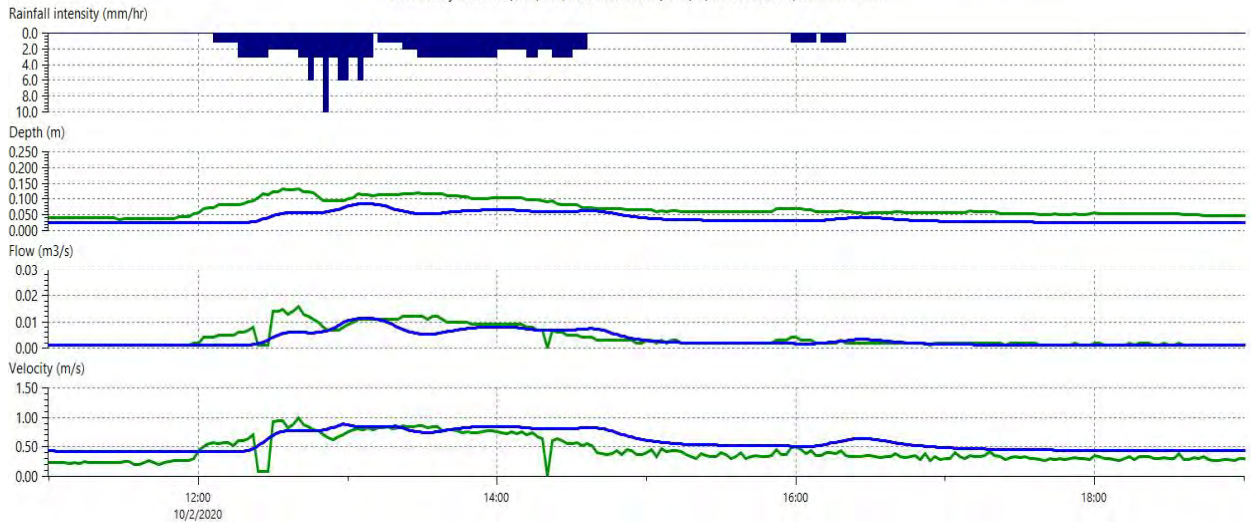
Flow Survey Location (Obs.) F03, Model Location (Pred.) D/S SJ33533106.1, Rainfall Profile: 1



	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m³/s)	Max (m³/s)	Volume (m³)	Min (m/s)	Max (m/s)
Rain	20.600	24.000	1.198							
Observed				0.018	1.328	0.000	0.064	874.169	0.000	0.910
Final Calibrated				0.033	1.355	0.000	0.072	842.565	0.030	0.912

Storm B

Flow Survey Location (Obs.) F01, Model Location (Pred.) D/S SJ33520902.1, Rainfall Profile: 1



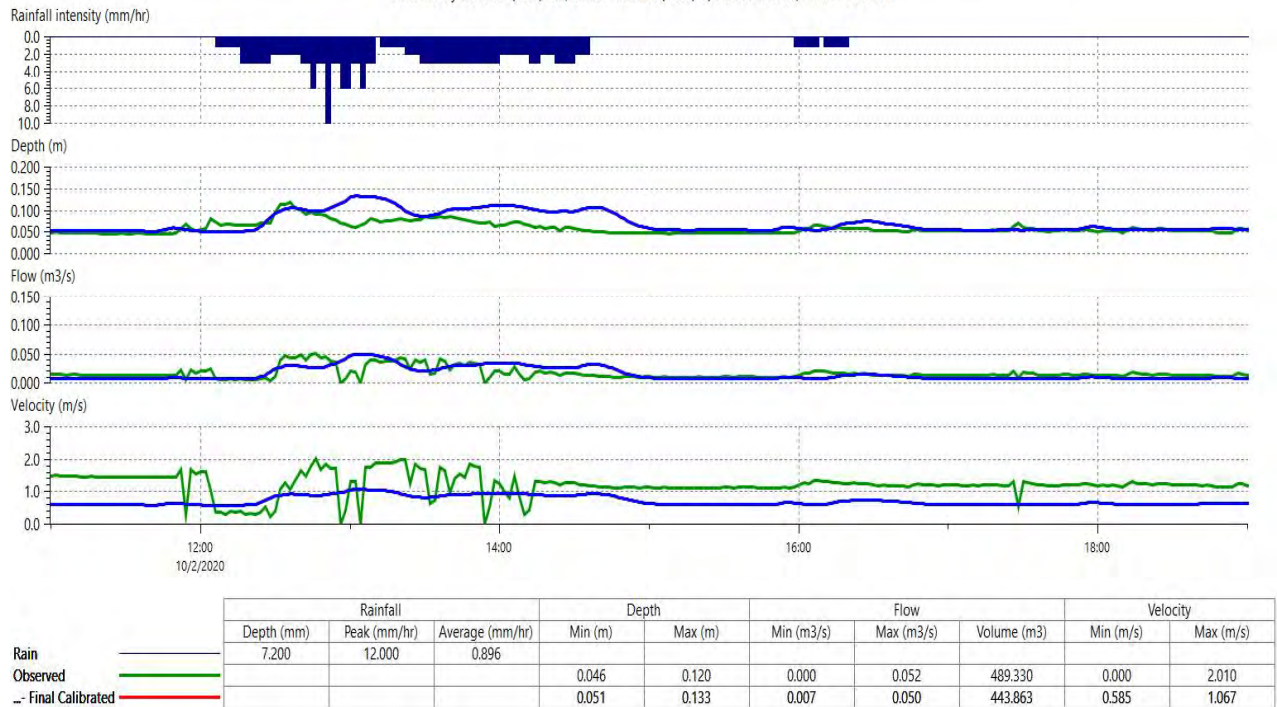
	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m³/s)	Max (m³/s)	Volume (m³)	Min (m/s)	Max (m/s)
Rain	7.200	12.000	0.896							
Observed				0.036	0.133	0.000	0.016	115.618	0.000	0.990
Final Calibrated				0.025	0.085	0.001	0.011	93.993	0.415	0.891

Flow survey: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Flow Survey Data>Full Period Data - Final Calibrated (17/03/2020 15:15:32)

Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Verification Run Group>Full Period Verification Storm Verification_y9>Full Period Data - Final Calibrated (14/04/2020 13:03:04)

Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Verification Run Group>Full Period Verification Storm Verification_y9>Full Period Data - Final Calibrated (14/04/2020 13:03:04)

Flow Survey Location (Obs.) F02, Model Location (Pred.) D/S SJ33523801.1, Rainfall Profile: 1

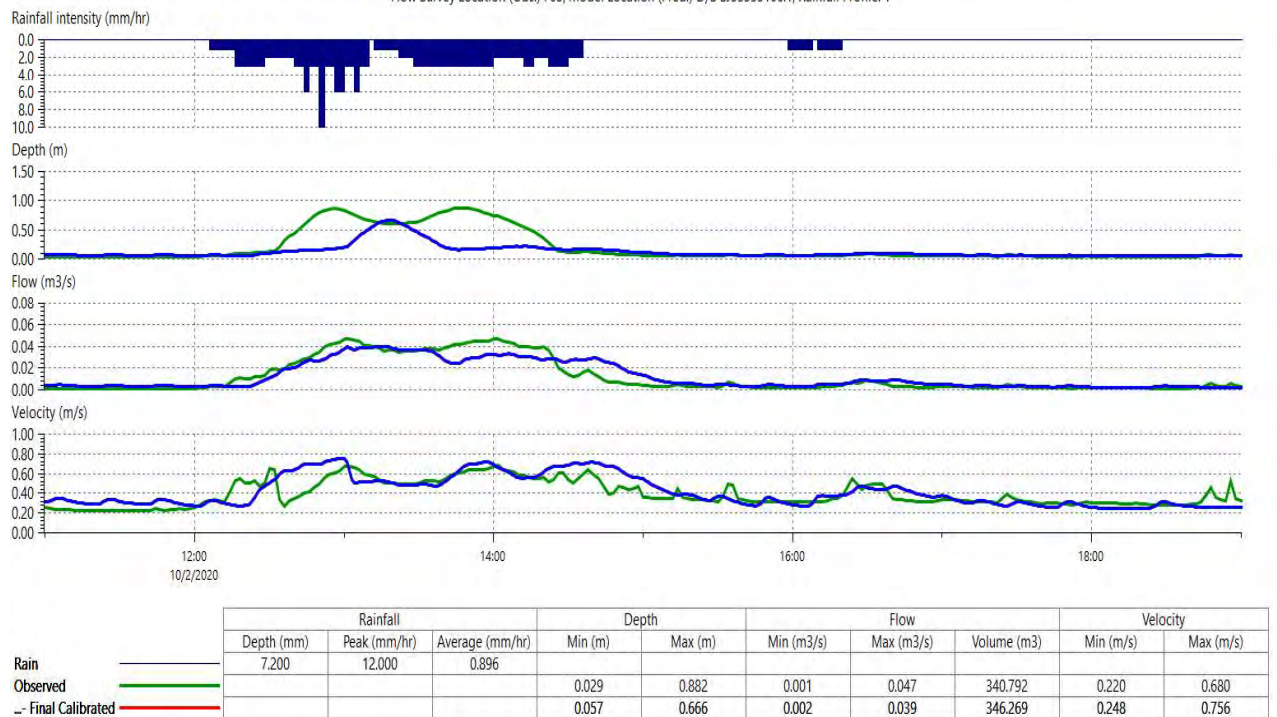


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Flow Survey Location (Obs.) F03, Model Location (Pred.) D/S SJ33533106.1, Rainfall Profile: 1



Storm C

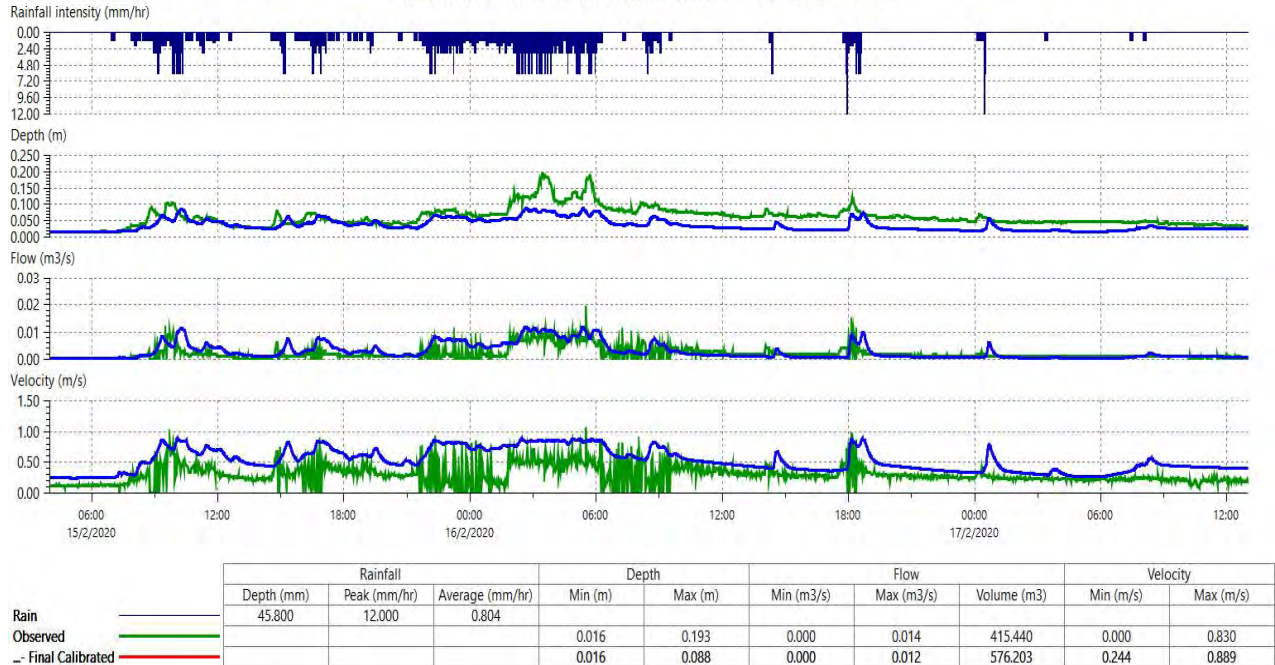
Observed / Predicted Report Produced by UKFXA012 (17/04/2020 15:07:22) Page 1 of 3

Flow survey: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Flow Survey Data>Full Period Data - Final Calibrated (17/03/2020 15:15:32)

Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Verification Run Group>Full Period Verification Storm Verification_v9>Full Period Data - Final Calibrated (14/04/2020 13:03:04)

Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Verification Run Group>Full Period Verification Storm Verification_v9>Full Period Data - Final Calibrated (14/04/2020 13:03:04)

Flow Survey Location (Obs.) F01, Model Location (Pred.) D/S SJ33520902.1, Rainfall Profile: 1



Observed / Predicted Report Produced by UKFXA012 (17/04/2020 15:07:22) Page 2 of 3

Flow survey: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Flow Survey Data>Full Period Data - Final Calibrated (17/03/2020 15:15:32)

Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Verification Run Group>Full Period Verification Storm Verification_v9>Full Period Data - Final Calibrated (14/04/2020 13:03:04)

Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Verification Run Group>Full Period Verification Storm Verification_v9>Full Period Data - Final Calibrated (14/04/2020 13:03:04)

Flow Survey Location (Obs.) F02, Model Location (Pred.) D/S SJ33523801.1, Rainfall Profile: 1

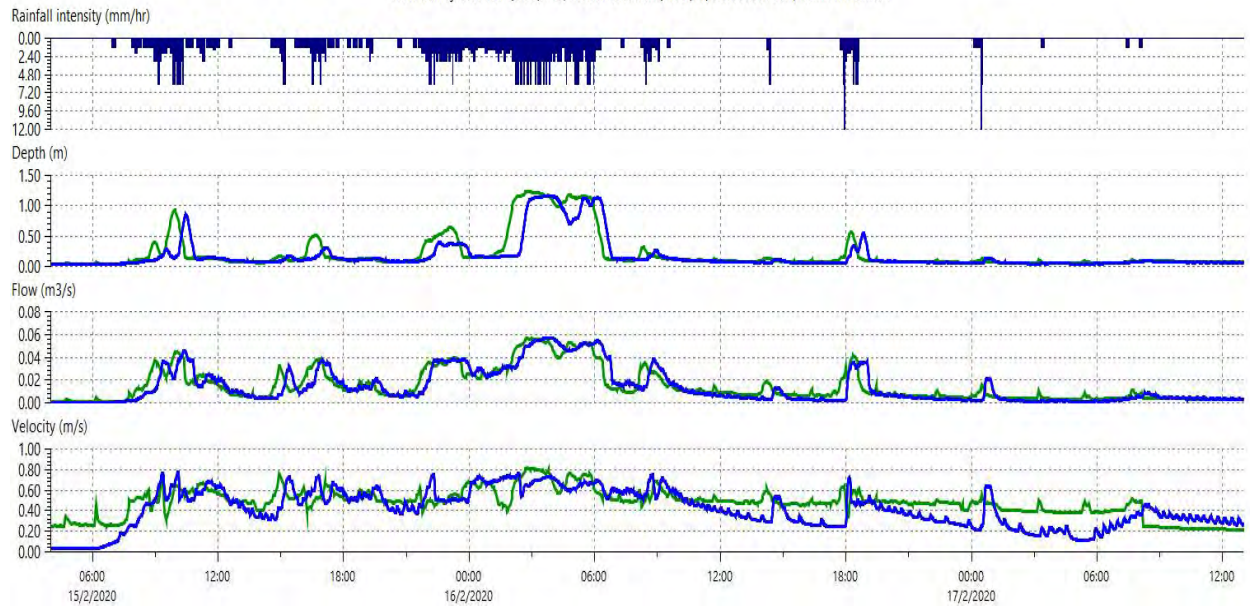


Flow survey: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Flow Survey Data>Full Period Data - Final Calibrated (17/03/2020 15:15:32)

Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Verification Run Group>Full Period Verification Storm Verification_v9>Full Period Data - Final Calibrated (14/04/2020 13:03:04)

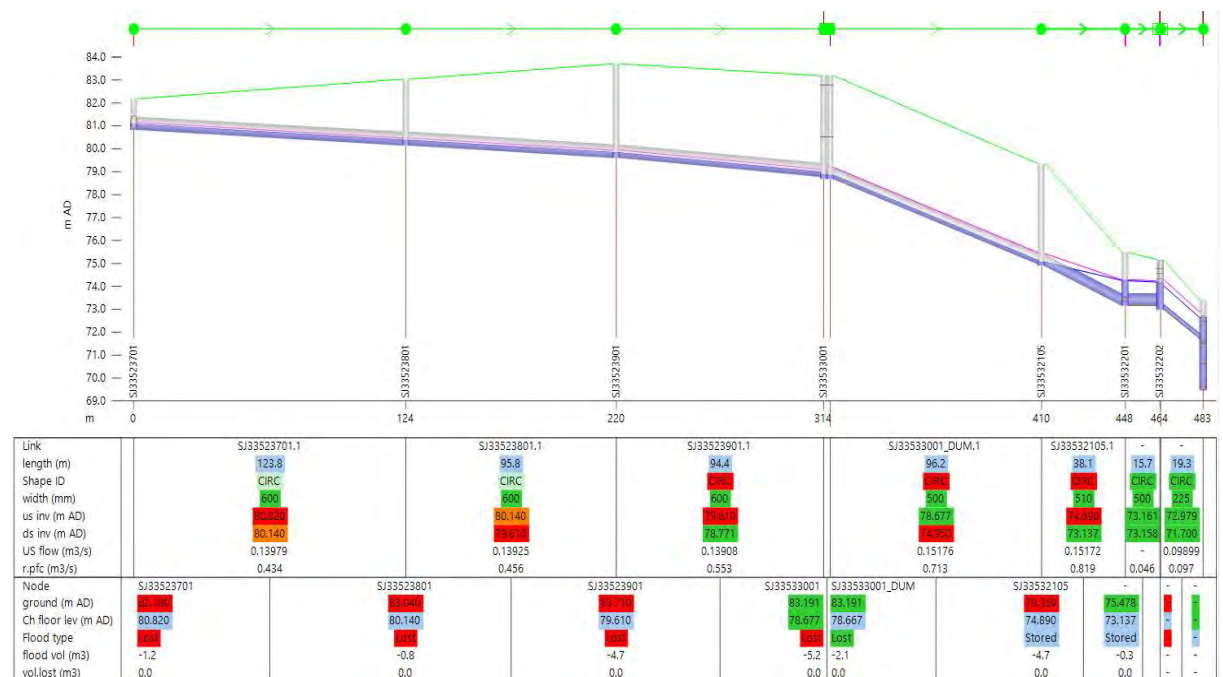
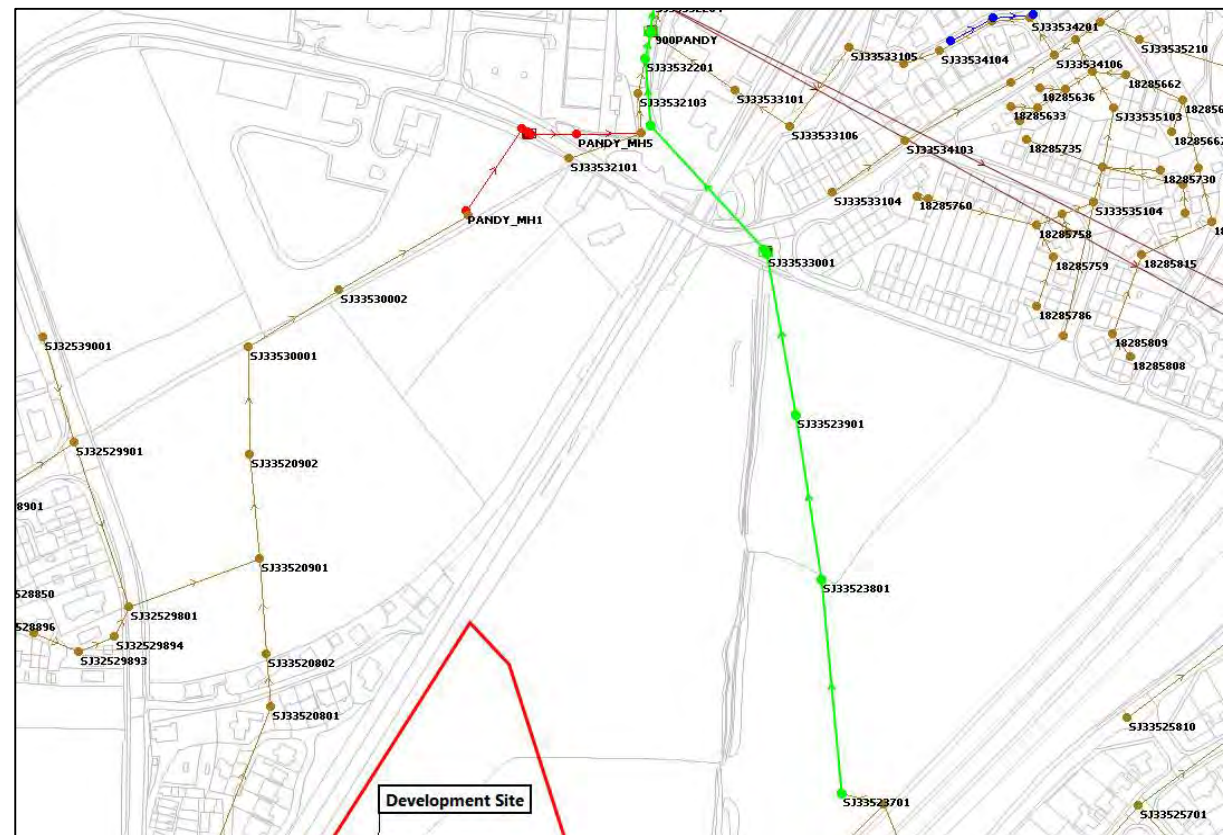
Sim: >Five Fords Tan Y Bont HMA>00675-ABCD-Five Fords Stage 2a>Verification Run Group>Full Period Verification Storm Verification_v9>Full Period Data - Final Calibrated (14/04/2020 13:03:04)

Flow Survey Location (Obs.) F03, Model Location (Pred.) D/S SJ33533106.1, Rainfall Profile: 1

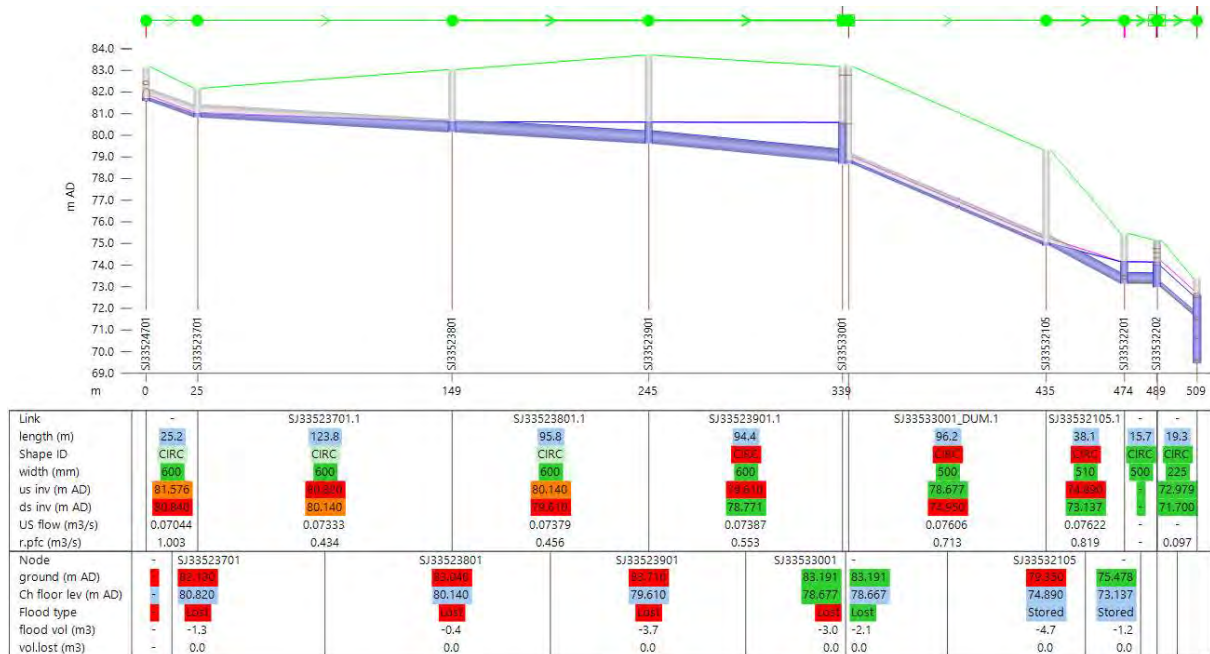


	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Rain	45.800	12.000	0.804							
Observed				0.036	1.239	0.001	0.057	3009.898	0.210	0.820
- Final Calibrated				0.033	1.158	0.000	0.057	2866.407	0.030	0.773





Solution 1



Appendix D – Formula A Calculation Spreadsheet

Five Fords (Tan Y Bont) Hydraulic Modelling Assessment

INTERMITTENT DISCHARGE LOCATIONS										FORMULA A DETERMINATION PRE-DEVELOPMENT VALUES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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