



Developer Services Hydraulic Modelling Report

199-2066 W Gatewen Road – Hydraulic Modelling Assessment

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Executive Summary

RPS were appointed in October 2021 to undertake a Hydraulic Modelling Assessment (HMA) for a proposed development of 112 residential units located on land off Gatewen Road, New Broughton, within the Five Fords (Wrexham) Wastewater Treatment Works (WwTW) catchment.

Dŵr Cymru Welsh Water (DCWW) has advised in order for the increase in flow and volume to be permitted a Hydraulic Modelling Assessment (HMA) must be carried out on the sewer network to identify what effect this development may have on the existing network.

The development will consist of 112 residential dwellings. No occupancy details or characteristics of the dwellings were provided by the developer. The number of residents was calculated using an assumed occupancy rate of 2.5 people per property. The standard flow per capita design figure adopted by DCWW for new developments of 180 l/hd/day was used. Details of phasing have been provided, stating that there are two phases of the development, 24 units in phase 1. However, the development has only been assessed in totality (Phase 2).

Prior to carrying out the hydraulic modelling assessment, the AMP7 DWMP model underwent several upgrades to the model build, and to its match with the latest DCWW specification. Following the model upgrade performance checks on the existing 2014 verification, and historical verification, were undertaken. This indicated the upgraded model was suitable to be used for hydraulic assessments.

Some limitations in the models assessment capabilities were identified as described in section 3.5. It is recommended these are investigated and addressed as required by future model users.

Using the upgraded base model in a 'Clean' operational state, hydraulic assessments were undertaken to determine the impact of the development upon the existing network. The hydraulic assessments revealed that the development does not cause flooding detriment on the downstream line to the WwTW. The CSO assessment identified marginal spill volume detriment at Five Fords (Wrexham) works CSO. However, there are significant uncertainties in the predicted hydraulic performance of the WwTW.

No options have been developed as there is no predicted flooding detriment for Phase 2 (all 112 units) on the downstream line to the WwTW. The only detriment observed is in regard to total spill volume at Five Fords (Wrexham) Works CSO, where a marginal 0.6% of additional spill volume is predicted.

1 Introduction

1.1 Appointment

Dŵr Cymru Welsh Water (DCWW) has appointed RPS to undertake a Hydraulic Modelling Assessment (HMA) for a proposed development of 112 residential units to be located on Gatewen Road, New Broughton, within the Five Fords (Wrexham) Wastewater Treatment Works (WwTW) catchment.



Dŵr Cymru Welsh Water (DCWW) has advised in order for the increase in flow and volume to be permitted it has been deemed that a Hydraulic Modelling Assessment (HMA) must be carried out on the sewer network to identify what effect this development may have on the existing network, to identify notional hydraulic options to resolve any potential detriment and consider any further recommendations.

This report presents the findings of the HMA for the proposed Gatewen Road Development.

1.2 Development Site

- Size – 112 residential units covering 5.1 hectares. During the kick-off meeting the developers informed us that the development will take place in two phases. The first phase will consist of 24 apartments (two blocks) and the second phase will consist of 88 private properties.
- Location – On the north side of Gatewen Road, New Broughton. This is located to the north-West of the catchment.
- Topography – The site slopes from the north to south direction. The highest point is approximately at 120mAD in the north, and the lowest in the south being approximately 115mAD where the site meets Gatewen Road.
- Previous/ Current Usage – The land to be developed is greenfield. According to satellite imaging, the existing site appears to be farmland.
- Proposed Usage – Residential.
- Sewerage Details – The site will drain via gravity sewers. There is no current contribution from this site to the existing sewerage system.
- Connection Type – All units will connect to the existing network via a new gravity sewer, and connect to existing manhole SJ31511401.
- Phasing – Two phases, two blocks of 24 units in first stage. However, the development is assessed only in totality.
- Surface Water - The developer has advised that surface water runoff is to be separated from foul flows and it will not be discharged into the public sewer system. Due to lack of plans, the outfall location of the surface water drain is unknown.

1.3 Background Information

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

A hydraulic model of the Five Fords WwTW catchment already exists, the model was last fully verified in AMP5 (2014) for the catchment Sustainable Drainage Plan (SDP). Since then, the model has been updated by another consultant in AMP6 SDP although there is no supporting information about the



upgrades undertaken. There were other upgrades also undertaken throughout AMP6 in the form of HMAs and capital schemes.

The model was built in Infoworks ICM 8.0 and upgraded to InfoWorks ICM 9.5 for the DWMP. Following the upgrade to the newer version of the Infoworks ICM 9.5.5 a series of model upgrades were performed as part of the DWMP. The main updates to the model included the addition of new network around the New Broughton which comprised of two pumping stations.

2 Land Usage

The HMA proposal assumes the development will be built in one phase. According to information provided by the developer in the kick-off meeting regarding the details of phasing it was confirmed that the development will be built in two phases. However, the development has only been assessed in totality (Phase 2).

All units will connect to the existing network via gravity. The number of residents was calculated using an assumed occupancy rate of 2.5 people per property due to lack of information on dwelling density from the developer.

Initial Phase		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Apartments	24	-	60
Total	24	-	60

Table 1. Proposed Domestic Contribution (Phase 1).

Initial Phase		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
House	88	-	220
Apartments	24	-	60
Total	112	-	280

Table 2. Proposed Domestic Development Contribution (Phase 2).

2.1 Proposed Connection Details

The following connection point has been proposed by DCWW:

Connection Point 1: Manhole reference SJ31511401. This manhole is located on Coronation Road to the south of the development.

See Figure 1 for a plan of the development site and the proposed connection point. Based on the development details provided from the developer and a desktop assessment, the topography of the catchment should enable flows to gravitate from the development to the connection point.

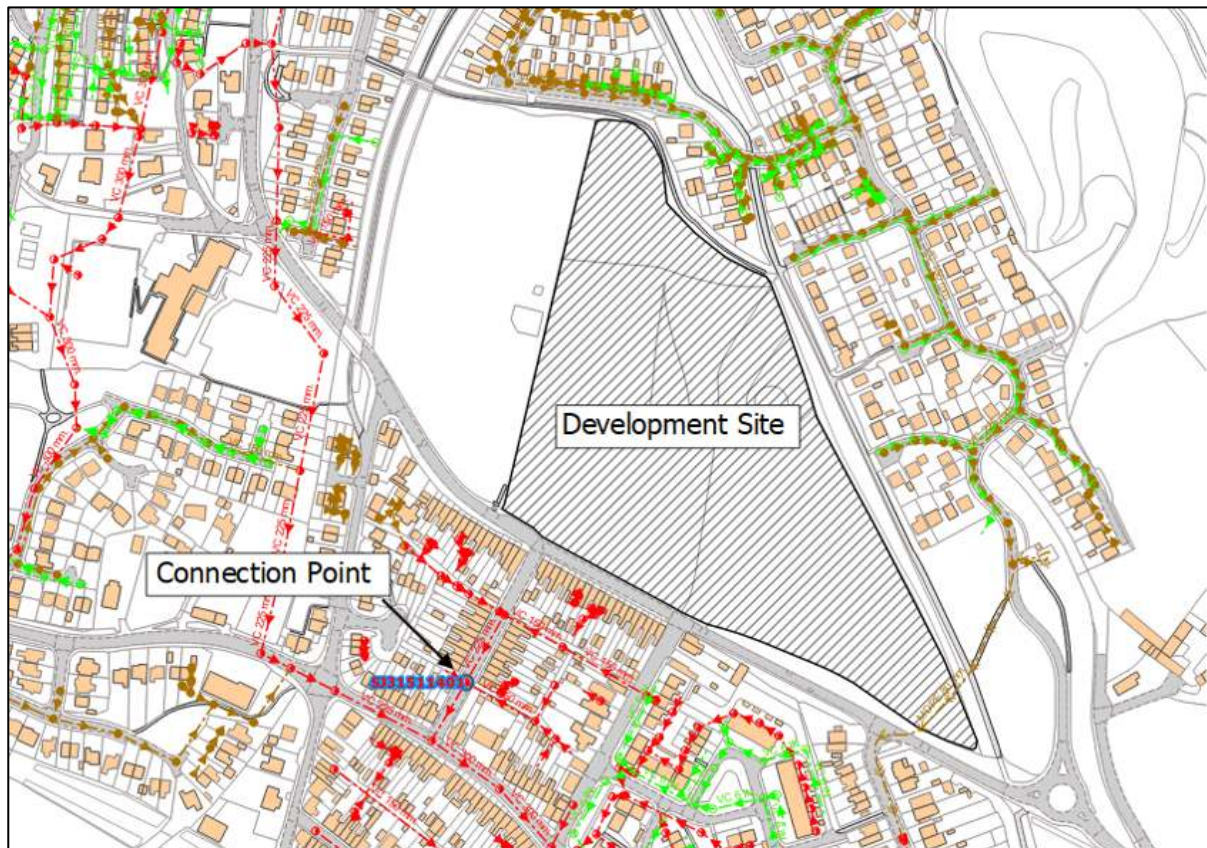


Figure 1. Development Site and Proposed Connection Point.

3 Developed System Modelling

3.1 Model Build / Enhancement

The base model used as part of this HMA underwent model upgrades as part of the AMP7 DWMP. As a result of recent updates implemented during the AMP7 DWMP (see Section 1.3), limited model updates were required as part of this HMA to improve confidence in model predicted flooding and spills. Data to assist the model build / enhancement was obtained from the following sources:

- Existing DCWW Geographical Information Systems (GIS)
 - Manhole Survey
-



- CCTV Survey
- Impermeable Area Survey (IAS)

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 ten manholes was commissioned to supplement the existing DCWW GIS data and existing model survey data, to improve model accuracy around the study drivers. The justification of these manhole surveys was to improve model confidence around the connection point and the DFL properties downstream of the development. Ten manholes were chosen for survey with an extra manhole chosen as a reserve, in case another one could not be surveyed.

The ten manholes surveyed included:

- SJ31511402
- SJ31510402
- SJ31511401
- SJ31511301
- SJ30519601
- SJ31510502
- SJ30519401
- SJ31510403
- SJ31511210
- SJ34498102 (UTGA)
- SJ31512201 (Reserve)

The locations of these manholes can be seen in **Error! Reference source not found.** and 3 below.

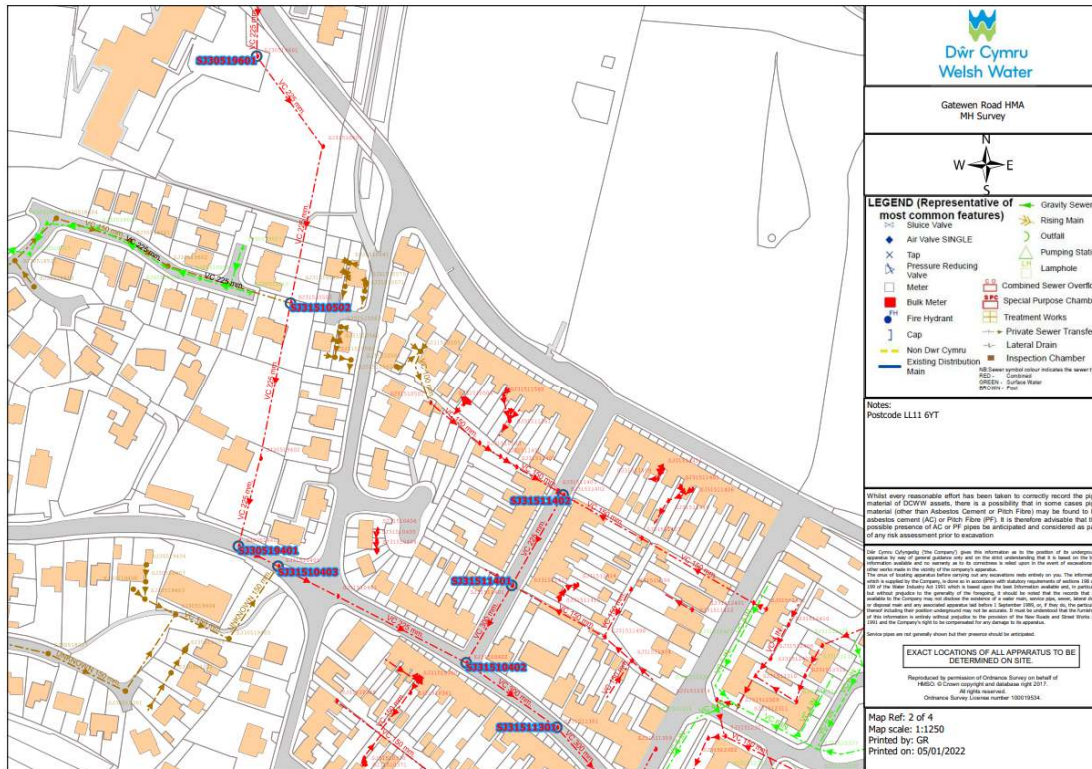


Figure 2: Manhole Survey Plan 1.

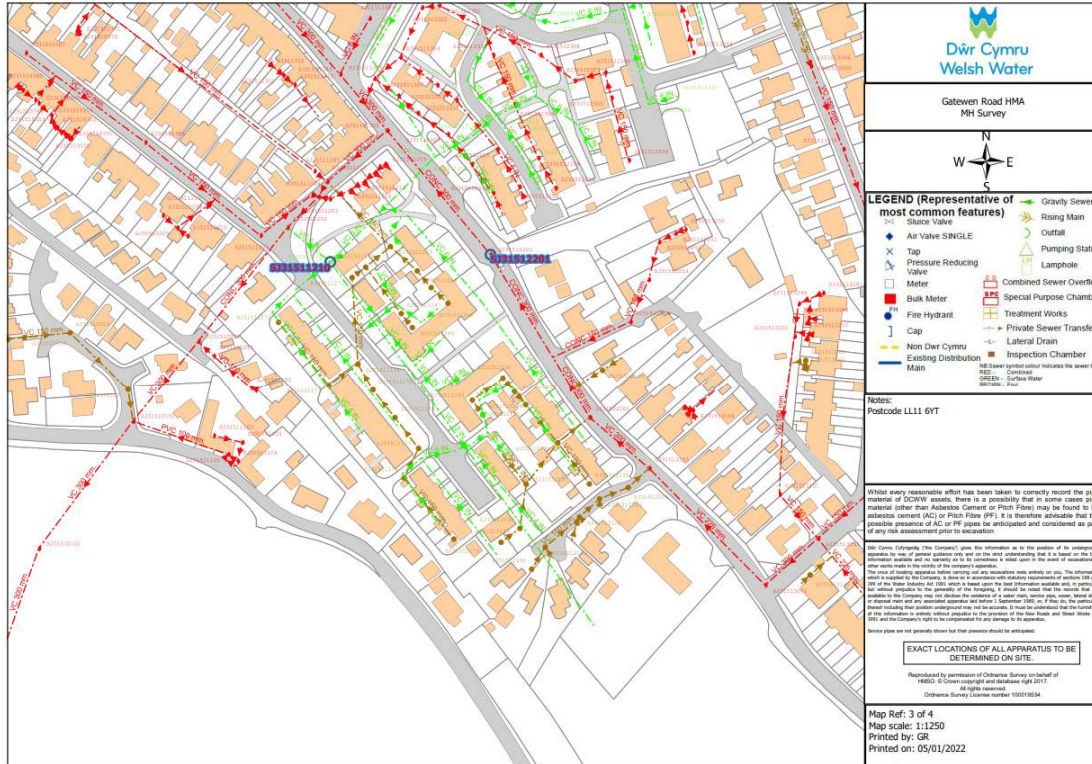


Figure 3: Manhole Survey Plan 2.

The manhole surveys were carried out on 27/01/2022 and 11/01/2022. The reserve manhole (SJ31512201) was surveyed because manhole SJ34498102 was unable to be accessed. The surveyed data was identified with the InfoWorks flag “SA” and notes were included in the model.

3.1.2 CCTV Survey

A CCTV survey covering 1050m of pipe length was commissioned to supplement the existing DCWW GIS data. The CCTV survey began at manhole SJ31510502 and went downstream to manhole SJ31510101. Network from manhole SJ31511402 to SJ31510402, covering the proposed connection point, was also surveyed. The incoming and outgoing pipes of the proposed connection point were both silted (10-15% cross-sectional area loss). According to the CCTV Inspection Report, the survey had to be abandoned due to “camera unable to pass silt build up”.

Part of the CCTV survey covered the surface water system in order to confirm network connectivity in the vicinity of SJ31511210. The CCTV Inspection Report suggests that along this stretch of pipe, the two systems remained separate. Figures 4 and 5 below indicate the areas where the CCTV surveys were undertaken.

The surveyed data was identified with the InfoWorks flag “SC” and notes were included in the model.

CCTV surveys were completed on 10/01/2022 and 26/01/2022.

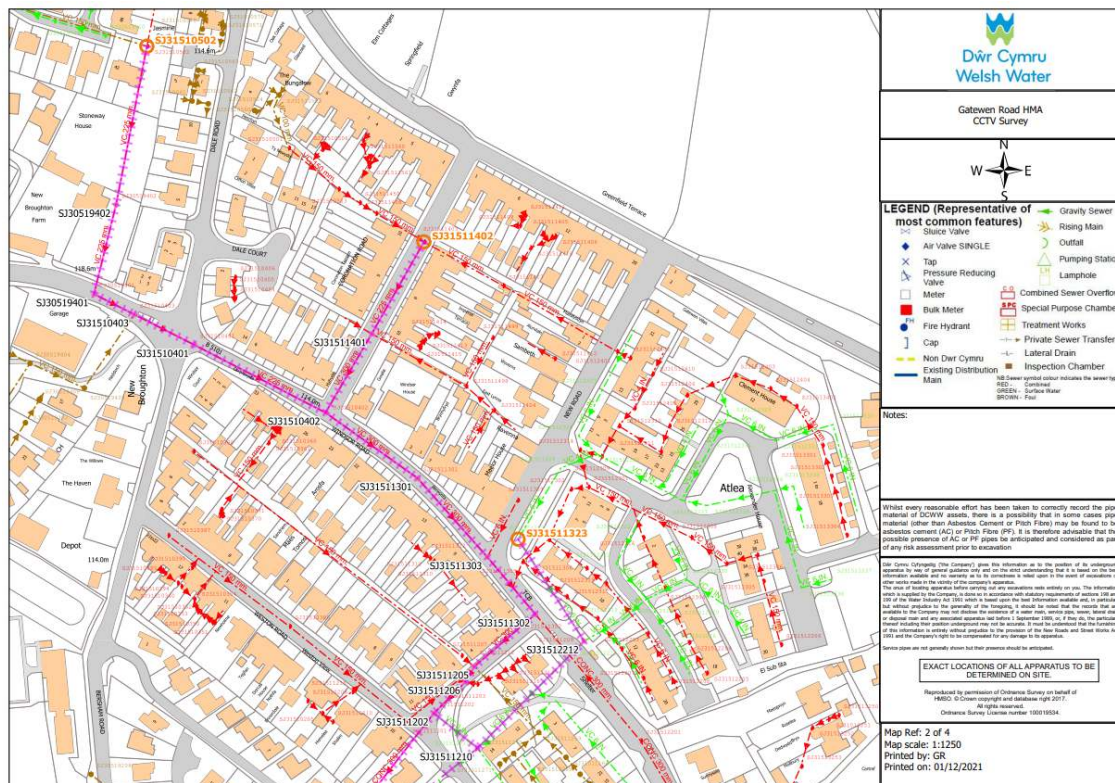


Figure 4. CCTV survey plan 1.

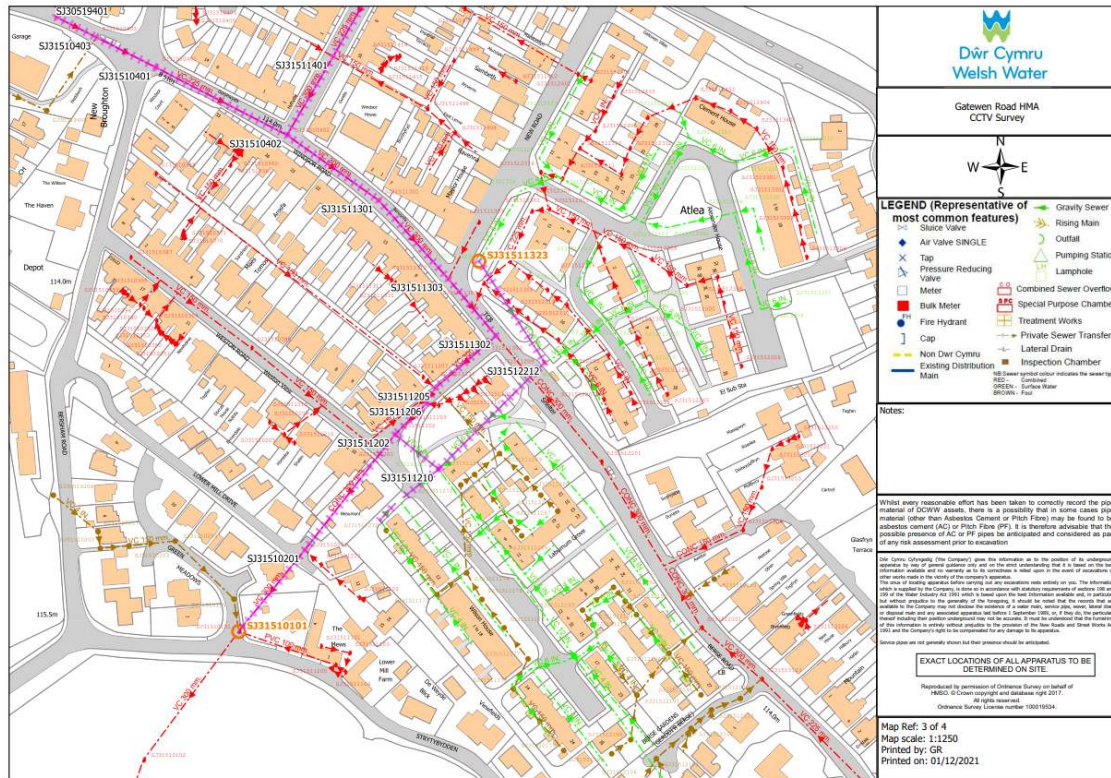


Figure 5. CCTV survey plan 2.

3.1.3 Impermeable Area Survey (IAS)

15 hectares of IAS were proposed to supplement previous surveys. The aim was to improve model flow predictions by increasing the confidence of contributing impermeable areas to the network. This information can also be used to find opportunities for surface water removal to offset the development flows if hydraulic options were required. The survey was spread out over numerous areas throughout the catchment. Most of the survey was carried out upstream of the proposed development to gain a better understanding of flows arriving at the junction just downstream of the proposed development connection point.

The impermeable area survey was carried out between the 7th and 11th February 2021, in dry weather. This survey data was identified in InfoWorks with the flag "SA". The location of the IAS surveys can be seen in Figure 6 below.

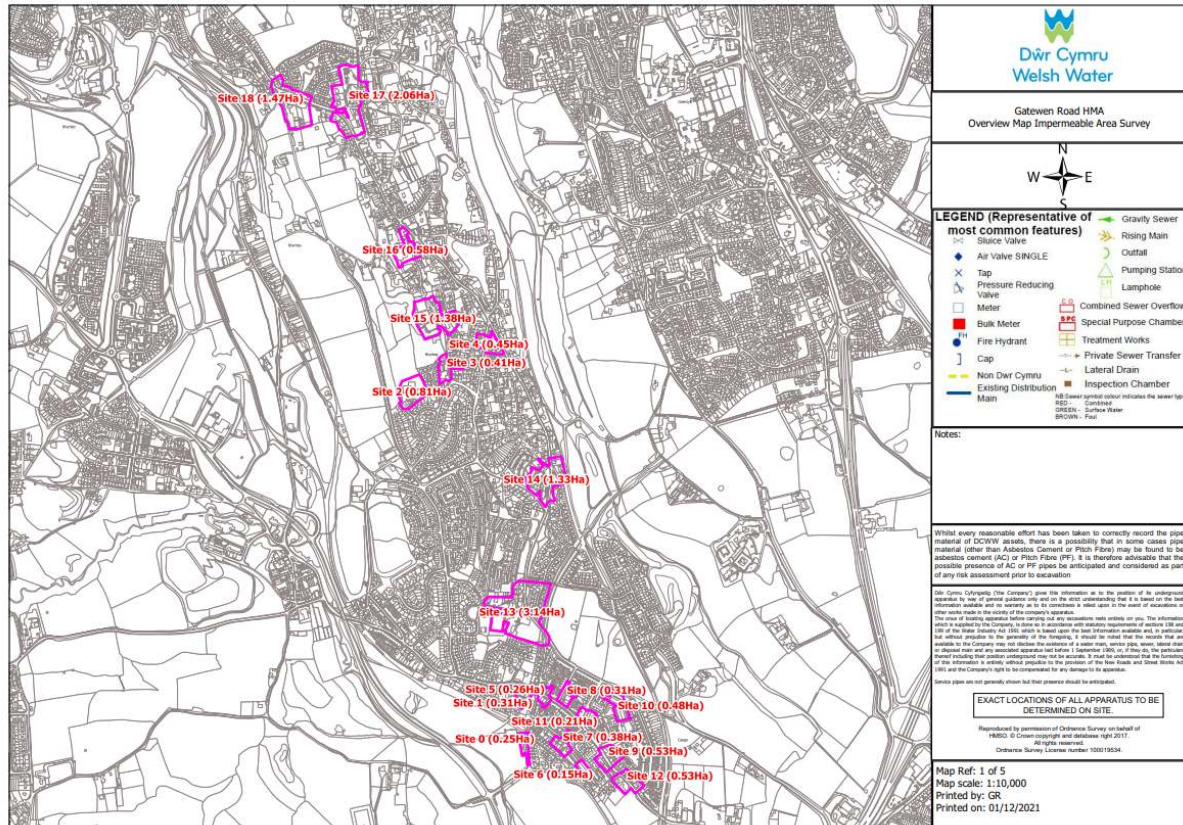


Figure 6. Impermeable area survey overview.

3.1.4 Additional Network Imports

The manhole and CCTV surveys suggested there was drainage network missing from the model within the study area. When comparing the model to the sewer records, it became apparent this was the case and the missing network was then added to the model. Subcatchment draining nodes were reviewed after importing new network to improve predicted flows within the study area. Figure 7 below indicates where the missing network was added into the model.

CCTV surveys also shows that the layout of the storm network in the DWMP model was incorrectly modelled near Chapel Road. Originally the outfall discharged to the middle of a residential area, which manhole surveys and CCTV confirmed not to be the case. The outfall location was then changed in line with the sewer records as seen in Figure 8 below. The CCTV surveys also confirmed there was no interaction between the storm and foul/combined systems in this region of the drainage network.

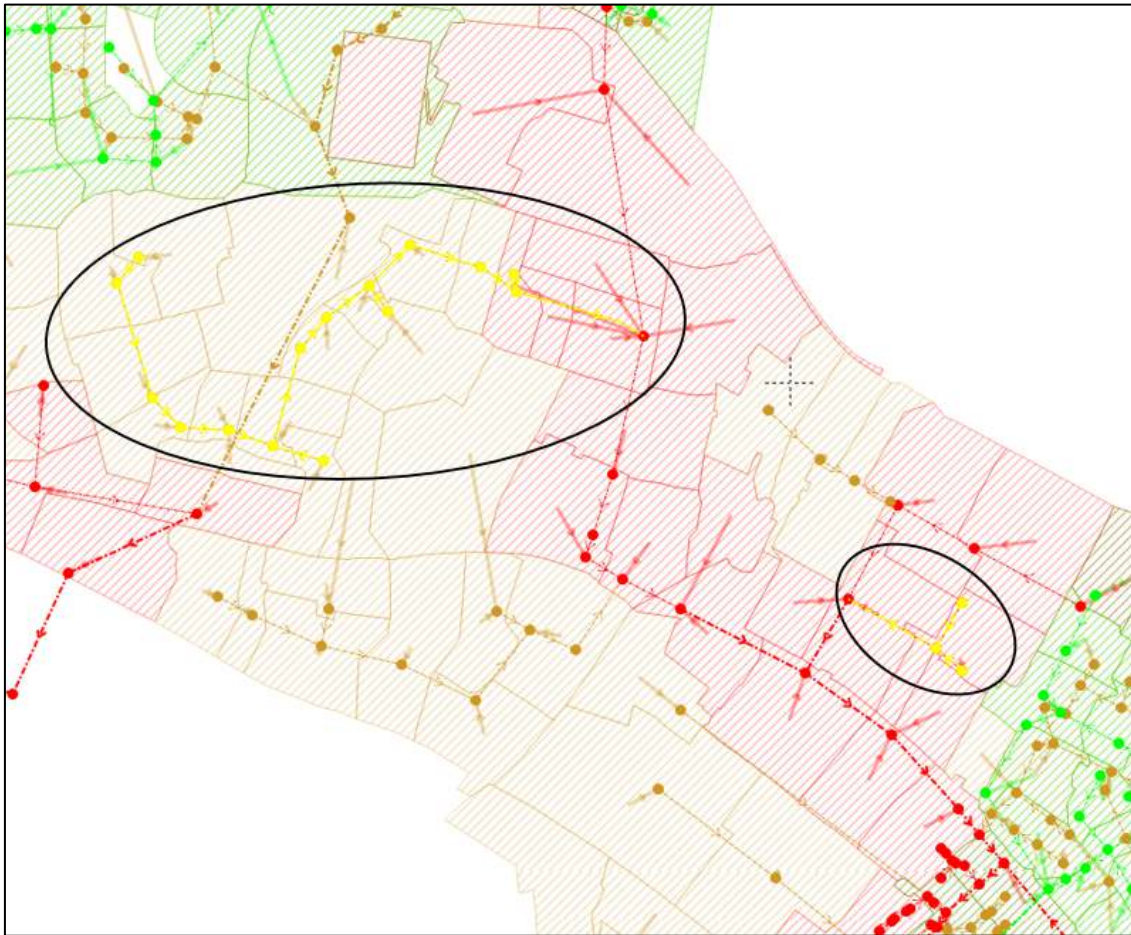


Figure 7. Network Added in Study Area (yellow).

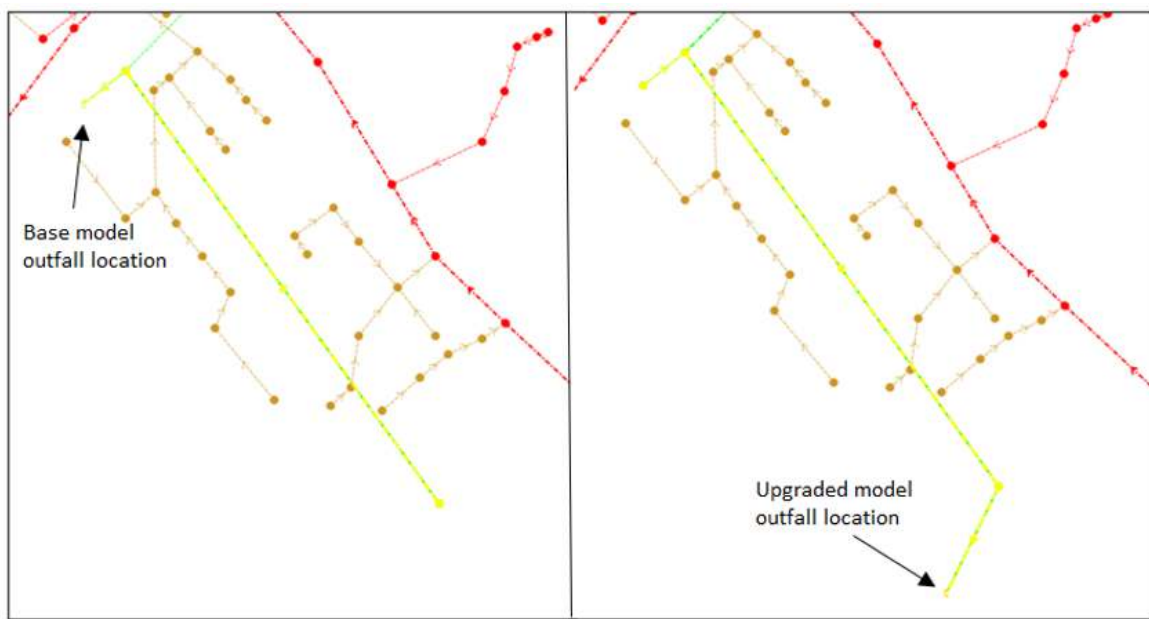


Figure 8. Storm network layout adjustment.

3.1.5 Summary of Model Build / Enhancement Activities

Model build activities were undertaken in consideration of the surveys and the addition of the development. This included:

- Addition of ten Manhole surveys, 1050m of CCTV survey and 15 hectares IAS in the study area.

The model was reviewed against the latest DCWW model build and verification specification to identify any necessary updates. As a result, the following updates have been made to the model.

- The long sections have been reviewed and updated where new survey data and additional sewer network have been added to the model.
- Updating subcatchments with the new impermeable areas (IA) derived from the IAS survey. Updates to impermeable areas were made using the Area Take Off (ATO) tool.
- Pipe headloss which were #D were updated with the InfoWorks headloss tool and all updated values over 8.0 were reviewed to ensure they were sensible.
- Various pipe roughness values flagged as #D were updated in accordance with the spec. Storm conduit roughnesses were updated where applicable, and roughnesses updated where pipe material was known.
- Manhole additional storage was calculated for those which had not gone through the process. Storage compensation and numerical correction values added. New values were checked for sensibility.
- Manhole flood types were reviewed to ensure they matched the requirements from the DCWW specification. All editable floodable areas below 0.1 increased to 0.1 where necessary.
- Engineering validation was completed on the fully upgraded model a final check to identify any potential issues within the model.

3.2 Verification

No new flow survey was commissioned as part of the study. An eight- week flow survey was carried out across the Five Fords WwTW catchment between February 2014 and April 2014, comprising of 21 flow monitors (FMs), and 8 rain-gauges (RGs). The existing model verification was reviewed where model upgrade carried out through the study could impact on the existing verification. Only the monitors which were in the vicinity of the proposed development (FM02 and FM03) have been assessed as no further detailed verification was proposed as part of this HMA. Plots between the DWMP model and upgraded model were compared, and no significant changes were observed in depth, velocity, and flow. Therefore, the level of verification was deemed suitable for the study.

Flow/Depth Monitor	Manhole Ref.	Model Conduit Ref.	Pipe Size (mm)
FM02	SJ31500801	DUM_0105.1	400
FM03	SJ31500801	SJ30509801.1	525

Table 3. Flow Monitor Location Details.

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.

3.3.1 Predicted Flooding

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

Overall, 3253 model nodes are predicted to flood in a 30-year design storm with 690 model nodes predicting flood volumes of 25m³ or more. Much of this flooding does not correlate to any reported incidents. Areas directly relevant to the proposed development have been investigated in more detail. Out of the 94 nodes located on the downstream network from the development's proposed connection point to the WwTW, no nodes are predicted to flood during a 30-year event.

3.3.2 Historical Location Flooding

There are only five properties on the Definitive Flooding List (DFL) located downstream of the development and likely to be impacted by the development flows and as a result historical verification was focused on these locations. Table 4 **Error! Reference source not found.** compares the five historical flooding locations against model predicted flooding in the vicinity.

DFL Property Name	Flooding Manhole Node ID	Flood Type	First Model Predicted Flooding
Abenbury Road, Wrexham (1)	-	OF (1:20)	No flooding predicted
Abenbury Road, Wrexham (2)	-	ARR (2:10)	No flooding predicted
Chapel Road, New Broughton (1)	-	DG5 (1:20+)	No flooding predicted
Chapel Road, New Broughton (2)	-	DG5 (1:20+)	No flooding predicted
Windsor Road, New Broughton	-	DG5 (1:20+)	No flooding predicted

Table 4. Historical flooding compared to predicted flooding.

To assess the historical verification, the following design rainfall was ran through the upgraded model:

- 2 year return period (all durations, summer and winter)
- 5 year return period (all durations, summer and winter)
- 10 year return period (all durations, summer and winter)
- 20 year return period (all durations, summer and winter)
- 30 year return period (all durations, summer and winter)

The simulation results showed that none of the manholes near the DFL properties flooded in any of the design rainfalls listed above. The Five Fords SDP Model Build and Verification (MBV) Report from April 2015 suggests that flooding mechanism may be 'other cause' and not due to hydraulic issues. A further check of an 'other cause' flooding register revealed there has been a history of 'other cause' related flooding incidents in this region of the catchment. The 2015 MBV report also suggests there is a high

likelihood of blockages in these regions of the model. The CCTV surveys undertaken as part of this study support this information, as it was found that settled deposits were present in several pipes within the study area. Furthermore, the CCTV Inspection Report noted that there were instances where the CCTV surveys had to be abandoned as the camera could not pass through the silt. Model confidence in the local network around the DFLs was relatively high in the DWMP model and has been further improved upon with the surveys commissioned as part of this study. The way silt is modelled is based off the most recent survey data and may not be representative of network conditions at the time of flooding. Furthermore, private connections have not been represented within the model.

CSO Name	Consent Ref.	Model Predicted Spills	Total duration of spill (mins)	Total Volume (m3)	Telemetry Spill Count
Five Fords (Wrexham) works	CM0005702	2	294.6	2521.8	31

Table 5. TSR predicted spills compared to EDM.

3.4 Verification Summary

No flow survey was undertaken as part of this study. The model was verified with two monitors during the AMP5 SDP (FM002 & FM003). The model verification in AMP5 SDP was considered acceptable and there was sufficient confidence in the contributing flows in the vicinity. However, predicted flows from the upgraded model were reviewed against flow survey data during dry weather and storm event flows, telemetry data and historically verified against known flooding locations. Flows predicted at FM02 and FM03 when using the upgraded model were compared to the DWMP model and the observed data. The plots showed little change in flow, velocity, and depth. Therefore, the verification was deemed suitable for this study. Historical verification results show that no flooding is predicted around the DFL locations listed in Table 4. Evidence suggests that “other cause” flooding could pose a risk in the DFLs area. However, it should be noted that private connections have not been represented in the model.

The upgraded model spill predictions were also compared against EDM spill count data at the works CSO. There was a large difference between model predicted spill count and EDM spill count. Further investigations are required to ascertain the storm pumps regime at the WwTW, as they are likely to have a significant impact on the number of spills predicted in the upgraded model.

As the MBV report corresponding to the AMP6 SDP model was not available, there are uncertainties about the impact of model upgrades undertaken during the AMP6 SDP.

3.5 Model Assumptions & Limitations

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

- No storm return has been modelled at the treatment works, and the treatment works causes some model instability, causing run times to be high.
- No flow survey was undertaken as part of the SDP for AMP6 and so the base model was last fully verified to a flow survey undertaken in AMP5. No supporting information available for the AMP6 SDP model.

- Not all assets in the Five Fords wastewater catchment have been surveyed and there are some pumping stations which have been modelled using a generic procedure for unsurveyed pumping stations. However, none of these are within the HMA study area.
- Private connections have not been represented within the model.

4 Development System Analysis

4.1 Dry Weather Flow

The DWF for the residential properties has been calculated for the first phase (**Error! Reference source not found.**), and the total development (**Error! Reference source not found.**).

Parameter	Value	Comment
Population - P	280	112 properties with population as outlined in Error! Reference source not found.
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	0.0583 l/s	10% DWF (PG) assumed
Total DWF Calculations		
P * G	0.583 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	0.6413 l/s	
DWF Peak Hydraulic Assessment Multiplier	1 and 2	DWF Peaking factor for CSO (1) and flooding (2) level of performance investigation.

Table 6. HMA - DWF Parameters – Phase 2 (Total).

4.2 Surface Water Run-off

The developer has 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% of the total contributing area has been allocated to represent possible future misconnections 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,

Impermeable areas of the development were assumed due to lack of development plans. The development area is approximately 5.1 ha, so it was assumed that when the development is complete (after Phase 2), half the area would be paved area and half would be buildings.



The table below outline the contributing areas included in the modelled development, based on these assumptions.

Total Impermeable Area (ha)	Total Road Area (ha)	2% Road Area (ha)	Total Roof Area (ha)	2% Roof Area (ha)
5.1	2.55	0.051	2.55	0.051

Table 7. 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. These were run on a version of the upgraded model set to a 'Clean' operational state. This was the removal of all blockages, and all sediment and related pipe roughness increases.

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. Flooding is predicted for both summer and winter durations within the model. It has been found that most flooding incidents occur during the 90-minute Summer duration. However, model predicted flood volumes vary with the duration of event and therefore all storm durations have been assessed to highlight the worst-case scenario.

In the upgraded base model, flooding is not predicted between the development connection point, SJ31511401 and the WwTW. Flooding is also not predicted around the five DFL properties listed in Table 3.

For the total development (Phase 2), the model predicted flooding detriment of greater than 1 m³ occurred in 34 manholes across the catchment. However, the manholes where this level of detriment was predicted were in areas of the catchment that could not be influenced by the development. The detriment at many of the manholes was slightly above 1 m³ and due to model instability issues.

Detailed reasoning as to why the model did not predict any flooding detriment around the DFL properties or on the downstream line to the WwTW is included in section 3.3.2.

5.1.1 Flooding Detriment

There was no predicted flooding detriment for the total development (all 112 units) around the DFL properties listed in Table 4, or on the downstream line to the WwTW. Therefore, there was no requirement to investigate flooding detriment any further.

5.2 CSO Assessment

Spill volume analysis of the overflow(s) on the downstream line was carried out using a typical year rainfall dataset. Five Fords (Wrexham) works is the only CSO required to be included in this assessment. There are significant uncertainties in the predicted hydraulic performance of the WwTW as outlined in section 3.3.2 so the confidence of this assessment is low.

A summary of the spill detriment analysis is shown in Table 9 below.

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 (%)
Five Fords (Wrexham) works	2	2527	2	2543	0	0	16	0.63

Table 8. CSO Assessment - Phase 2 Development.

The model predicts no increase in spill counts in a typical year rainfall at Five Fords (Wrexham) Works CSO. The only detriment observed is in regard to total spill volume, where a marginal 0.6% of additional spill volume is predicted. This increase in spill volume would likely be masked by model instabilities. As well as this, there is low confidence in hydraulic performance at the treatment works as outlined in section 3.3.2. For these reasons, there is no requirement to develop hydraulic options to minimise the impact of the proposed development on Five Fords (Wrexham) works CSO.

5.3 SPS Assessment

There are no pumping stations on the downstream path of the development site and therefore the SPS assessment is not required.

5.4 Flows Arriving at Five Fords WwTW

Using the annual time series 'typical year', it was calculated that 10,764,340m³ of flow arrives at Five Fords WwTW. With the new development, this figure increases to 10,784,863m³. This corresponds to an increase of 20,523m³ or 0.2%.

5.5 Network Performance Assessment Summary

- The hydraulic assessment did not identify detriment at any of the manholes downstream of the development. This was assessed in Phase 2 representing the total development.
- The CSO assessment identified marginal detriment at Five Fords (Wrexham) Works CSO, where although no additional spills were predicted, additional spill volume increased by 0.6%.
- The only CSO downstream of the development connection point fail Formula A. However, Formula A is predicted to fail in the existing, pre-development scenario also.

6 Hydraulic options Development

The hydraulic assessment has indicated that the addition of development flows does not cause detriment with regards to network performance. Therefore, there was no requirement to investigate hydraulic options to resolve detriment caused by the development flows.

7 Conclusion & Recommendations

The hydraulic assessment indicates that there is no flooding detriment around the four DFL properties downstream, or on the downstream line to the wastewater treatment works.

- No requirement to develop hydraulic options to solve flooding detriment.
- The hydraulic assessment indicates that there is negligible spills detriment at Five Fords (Wrexham) Works CSO downstream.
 - No requirement to develop hydraulic options to solve spills detriment at downstream CSO.