

Developer Services Hydraulic Modelling Report

CLE10801 Lower Berse Farm, Ruthin Road, Wrexham – Hydraulic Modelling Assessment

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Contents

Executive Summary	3
1 Development System Analysis	4
1.1 Dry Weather Flow	4
1.2 Surface Water Run-off	5
2 Existing / Developed Comparison	6
2.1 Hydraulic Assessment	6
2.2 DWF Assessment	7
2.3 Formula 'A' Assessment	7
2.4 SPS Assessment	7
2.5 Flows Arriving at Five Fords WwTW	7
2.6 Changes From the Previous Assessment	7
2.7 Network Performance Assessment Summary	8
3 Solution Development	9
3.1 Discounted Solutions	9
3.2 Solution 1- Connect to SJ32491406 and IA removal	13
3.3 Solution 2- Connect to SJ32491406	18
3.4 Solution 3- Online storage bifurcation	21
3.5 Solution Summary	23
4 Solution Costs	24
5 Conclusion & Recommendations	25

Figures

Figure 1. Discounted solution for lateral online storage	10
Figure 2. Discounted solution for online storage.....	11
Figure 3. Discounted solution for a new SPS	12
Figure 4. Location of new connection point	14
Figure 5. Location of new network, connecting to SJ32491401	15
Figure 6. Total coverage of 2.559 ha of IA removal from Gatewen Road, Bersham Road, Maes Eithen, Rockwood Road and Victoria Road.....	16
Figure 7. Location of new connection point	19
Figure 8. Location of new network, connecting to SJ32491401	19
Figure 9. Online storage bifurcation	22

Tables

Table 1. HMA - DWF Parameters – single phase	4
Table 2. Hydraulic Assessment Results – Scenario 1 Single Phase.	6
Table 3. DWF Assessment - New Development.....	7
Table 4. Formula ‘A’ Assessment – Five Fords (Wrexham) Works CSO	7
Table 5. Hydraulic Assessment Results – Solution 1.....	17
Table 6. Hydraulic Assessment Results – Solution 2.....	21
Table 7. Hydraulic Assessment Results – Solution 3.....	24
Table 8. Solution Costs.....	24

Executive Summary

Dŵr Cymru Welsh Water (DCWW) has appointed RPS to undertake a Hydraulic Modelling Assessment (HMA) for a proposed development of 1500 residential units to be located on Lower Berse Farm, Ruthin Road, within the Five Fords (Wrexham) Wastewater Treatment Works (WwTW) catchment.

The development has been assessed using the connection point SJ32490701. This is a manhole located on the south-east corner of the development. 1400 units will flow via gravity to the connection point. The remaining 100 units will be served by two pumping stations, pumping to the aforementioned connection point.

A previous HMA study for the development indicated significant detriment. A new assessment was commissioned to account for updates to the HMA specification around the calculation of development flows and to revise the scope of options to resolve the detriment, reflecting the changed specification. The model from the previous HMA has been used as the base model for this HMA study. Prior to this hydraulic modelling assessment, the model underwent several upgrades.

The detriment assessment revealed that the addition of the Lower Berse Farm development to the model caused a total of 89.5 m³ of flooding detriment at two nodes. SJ32490701, the planned connection point, flooded by 48.6 m³ and SJ35482802, downstream where a large area of network from the north connects in, flooded by 40.9 m³. No CSO detriment was assessed due to the scope of this HMA study. The new development causes an increase in DWF at the WwTW of 9.5 l/s.

Three solutions have been identified to resolve the predicted detriment. The three solutions proposed are:

- Solution 1: Connect to SJ32491406 and 2.559 ha of IA removal. Estimated cost of £2,465,000.
 - Solution 2: Connect to SJ32491406. Estimated cost of £700,000.
 - Solution 3: Online storage bifurcation. Estimated cost of £1,210,000.
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1 Development System Analysis

1.1 Dry Weather Flow

The DWF for the residential properties has been calculated for the total development, shown in Table 1.

Parameter	Value	Comment
Population - P	4354.2	1500 properties.
Per Capita Return to Sewer Flow Rate – G	150 l/hd/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 150 l/hd/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration - I	0.872 l/s	10 % DWF (PG) assumed
Trade Flow – E (Primary School)	1.167 l/s	420-place school at 80 l/pupil/day allocation. 8-hour educational profile used. Value is average over 8 school day.
Total DWF Calculations		
P * G	7.559 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	9.599 l/s	PG + I + E
DWF Peak Hydraulic Assessment Multiplier	1 and 2	DWF Peaking factor for CSO (1) and flooding (2) level of performance investigation.

Table 1. HMA - DWF Parameters – single phase

1.2 Surface Water Run-off

Based on new specification creep will no longer be included as part of the development when undertaking an HMA. Following a review of Creep within DCWW's DWMP programme, industry guidance and available evidence, it was decided that there is insufficient evidence in Wales (all studies have been confined to England and Scotland). Therefore, there has been no 2% allowance for creep undertaken in this assessment.

2 Existing / Developed Comparison

2.1 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 entails 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 run in the existing and developed models.

2.1.1 Scenario 1 – Phase 1 (Total) - Connection Point SJ32490701

For the new development, the model predicted flooding detriment of greater than 1 m³ occurred in 2 manholes downstream of the development, one at the connection point (SJ32490701) and one downstream where a large area of network from the north connects in (SJ35482802). Table 2 highlights the detriment on the downstream trunk sewer to the WwTW with the addition of the 1500 units of the new development.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m ³)		Flooding Detriment	
			Existing	Developed	Absolute (m ³)	Percentage (%)
SJ32490701	SJ32490701	360 (summer)	0	48.6	48.6	-
SJ35482802	SJ35482802	1440 (winter)	0	40.9	40.9	-

Table 2. Hydraulic Assessment Results – Scenario 1 Single Phase.

2.2 DWF Assessment

In the new development model, the DWF is 385.04 l/s, compared to 375.54 l/s in the existing model, shown in Table 3. Therefore, the addition of the new development has increased the DWF at the WwTW by 9.5 l/s.

Model	DWF l/s
Existing	375.54
New Development	385.04
Absolute Difference	+ 9.5

Table 3. DWF Assessment - New Development

2.3 Formula 'A' Assessment

Formula 'A' flow is a measure of the continuation flow required at a CSO prior to spill occurring. Formula A is passed if pass forward flow (PFF) exceeds Formula A. The current PFF at Five Fords (Wrexham) Works CSO is based on the consent dated 2003. The Formula A values are reported in Table 4.

Model	Pass Forward Flow (l/s)	Formula A (l/s)	DWF (l/s)	Passes Formula A
Existing	808	1867.79	375.54	No
Total development	808	1895.45	385.04	No

Table 4. Formula 'A' Assessment – Five Fords (Wrexham) Works CSO

2.4 SPS Assessment

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

2.5 Flows Arriving at Five Fords WwTW

Using the 'typical year' simulation, it has been calculated that 9,654,723 m³ of flow arrives at Five Fords WwTW. With the new development, this figure increases to 9,925,903 m³. This corresponds to an increase of 271,180 m³ or 2.7 %.

2.6 Changes From the Previous Assessment

The updated development flows have resulted in slight changes to the detriment compared to that which was predicted in the previous assessment. The key difference is in the flooding detriment, which while significantly less based on the new assessment, now appears at two locations rather than only at the connection point. This is believed to be due to the significant reduction in total flows during wet weather. The local capacity is not as overwhelmed as under the previous specification so the rate of flooding from the connection point is reduced, leading to more flow being retained in the network and impacting downstream. The new spec also results in small reductions in the detriment experienced at the WwTW.

2.7 Network Performance Assessment Summary

- The hydraulic assessment shows that the connection point of the development, SJ32490701 will flood because of the addition of 1500 properties, with 48.6 m³ of flooding predicted.
 - One other manhole downstream, SJ35482802, is predicted to flood by 40.9 m³ as a result of the new development.
 - There is no predicted flooding at the nearby downstream DFL properties.
 - The addition of the new development increases the DWF at the WwTW by 9.5 l/s.
 - The WwTW CSOs fails Formula A in both the current (pre-developed) and post-development scenarios.
 - The development is predicted to increase flows to the WwTW by 271,180 m³ or 2.7 % in a typical year simulation.
-

3 Solution Development

The hydraulic assessment indicates that the addition of development flows causes detriment with regards to network performance. Therefore, solutions have been investigated to resolve this detriment caused by the development flows. Solutions have been derived for the total development.

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.

3.1 Discounted Solutions

Three solutions have been excluded from consideration as initial testing indicates they will not resolve the required detriment.

3.1.1 Lateral online storage tanks

This solution seeks to address the full development connecting to SJ32490701. The solution proposes a downstream flow control with an upsizing of the pipe downstream of the connection point and 2140 m³ of lateral online storage (Figure 1). This increases the online storage capacity of the trunk sewer to attempt to eliminate flooding detriment caused by the development.

The solution elements are as follows:

- Upsizing of SJ32490701.1. This should be done in multiple sections to accommodate ground levels. The first section is upsized from 380 mm diameter to 2000 mm diameter for 84.6 m, second to 1800 mm for 4 m and third to 1600 mm for 19 m.
- The total length to be upsized is 107.6 m.
- 5 x 160 m long 2000 mm diameter pipes. These fill up sequentially as flow backs up from the downstream network and drain down via gravity. These are in farmer's fields that will be part of the development.
- Downstream of these pipes is a flow control device, restricting pass forward flow to 16 l/s. This rate has been chosen to replicate the flows that passed through this part of the network before the insertion of the development, and thus will inhibit the opportunity for detriment.

Despite over 2000 m³ of storage, 3.7 m³ of flooding remains at the connection point in a M30-360 storm.

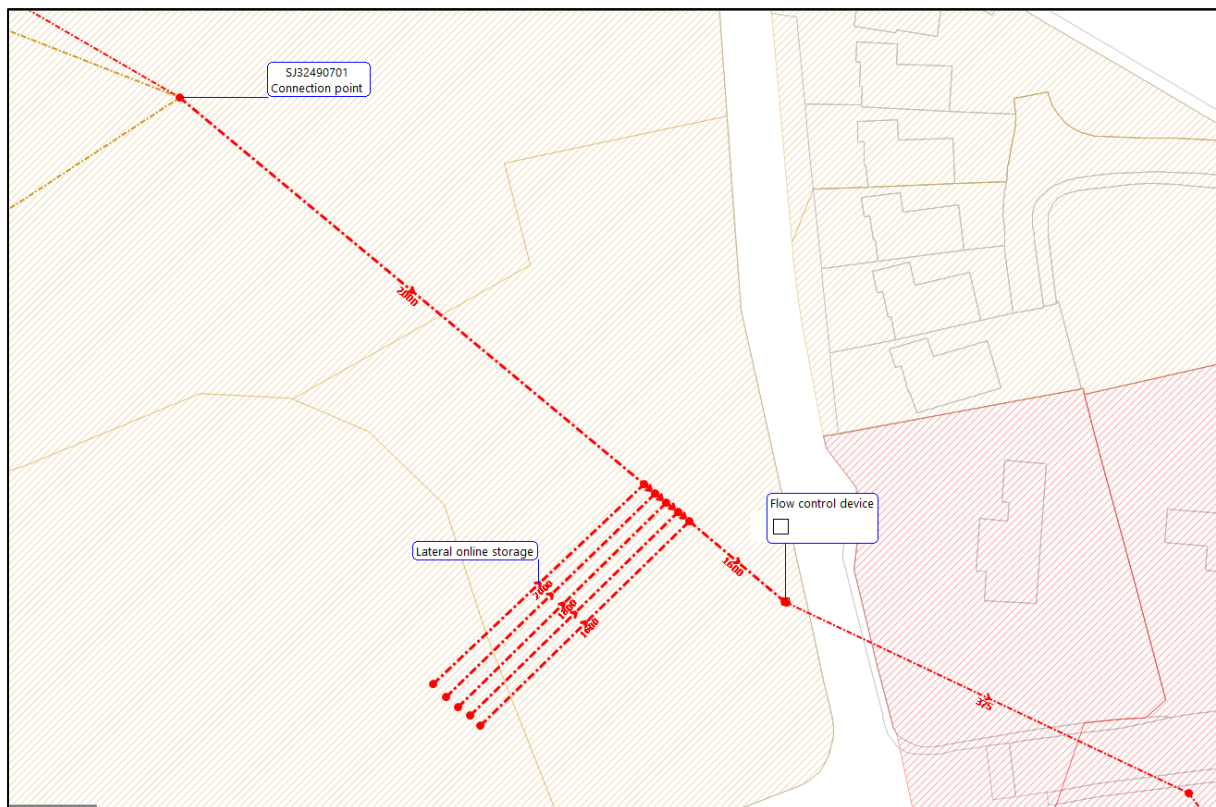


Figure 1. Discounted solution for lateral online storage

3.1.2 Trunk sewer pipe upsize.

This solution seeks to address the full development connecting to SJ32490701. The solution proposes a pipe relay and upsize immediately downstream of the connection point and a pipe relay and restriction ahead of the existing residential area to act as a flow control (Figure 2). This will hold flows in the online storage pipes and limit the pass forward flow to pre-development levels to prevent additional spills at the treatment works.

The solution elements are as follows:

- 131.2 m of new 2000 mm diameter pipes immediately downstream of the connection point.
- Abandon manhole SJ32490601 and associated downstream pipe in their current form.
- Build a new manhole on the junction of Homestead Lane and Bersham Road and new 225 mm diameter pipe from new manhole to SJ32491601. This pipe restriction will function as a flow control so that pass forward flows do not exceed pre-development levels.

The trunk sewer lies around 2 m below ground level in this section of the network. This restricts the ability to upsize the pipe further than 2 m and thus limits the ability to provide online storage directly on the trunk sewer. This option holds the storm flows in this area causes extensive flooding. 6087 m³ of flooding remains at the connection point in a M30-1440 storm.

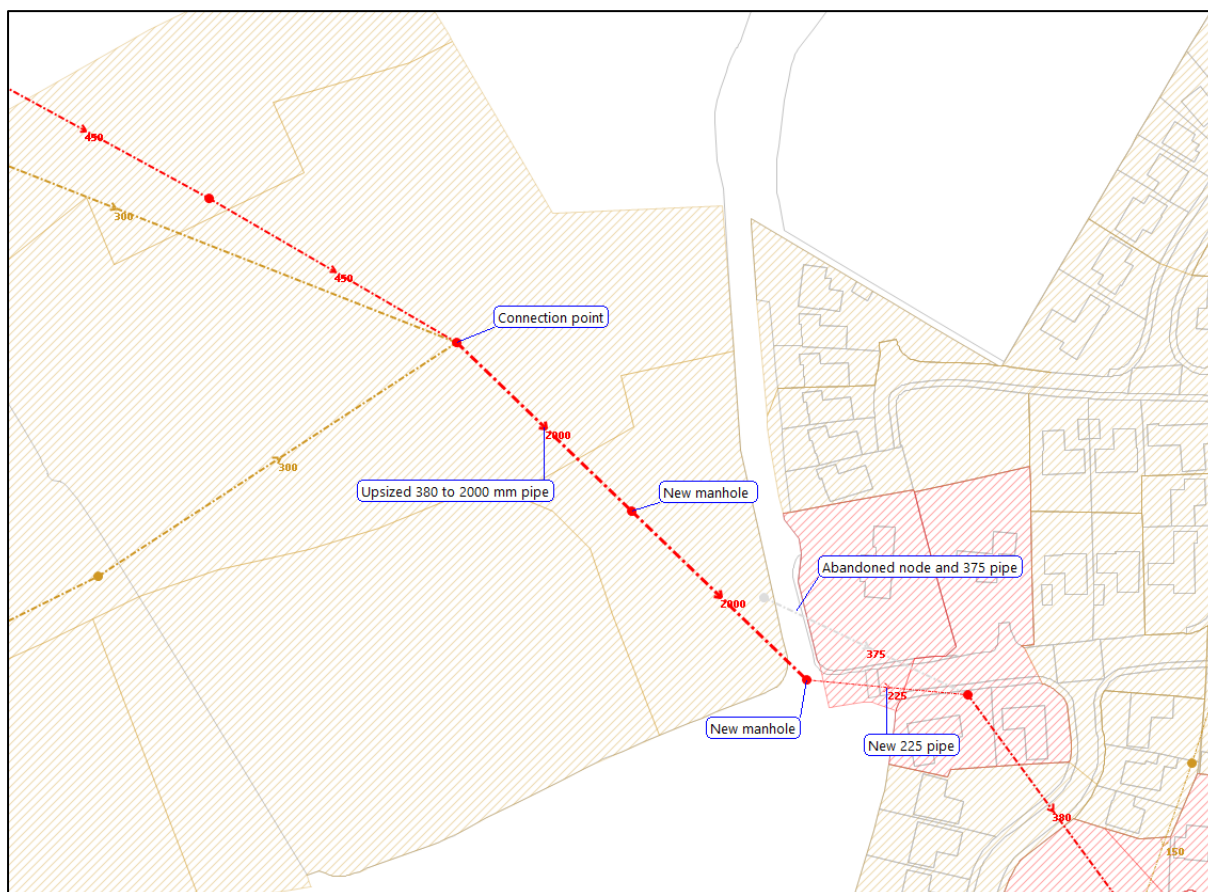


Figure 2. Discounted solution for online storage

3.1.3 Pump whole development upstream (to SJ31504201)

This solution seeks to address the full development connecting to SJ31504201 (not the original connection point of SJ32490701). The solution proposes the construction of a new pumping station that would send 100 % of the development flows to SJ31504201, upstream of the originally proposed connection point (Figure 3). This manhole is chosen as a new, upstream connection point as it was surveyed as part of this investigation so there is greater confidence in the invert levels the pump would connect into. This makes use of the capacity of the trunk sewer before the known restrictions at SJ32490701.1 and SJ32490601.1 which are caused by pipe diameter restrictions.

The solution elements are as follows:

- New pumping station within the development, with a pump rate of 21 l/s.
- A 0.7 km long rising main (approximately) connecting the development directly to SJ31504201.

This solution does not resolve the detriment at the original connection point SJ32490701 and so has not been taken any further. 32.1 m³ of flooding remains at SJ32490701 in a M30-240 storm. In addition, flooding is predicted at two nodes downstream of the new development (SJ35482802 and SJ35482904) where a large area of network from the north connects in. 49.8 m³ of flooding is predicted at SJ35482802 in a M30-30 storm and 10 m³ of flooding is predicted at SJ35482904 in a M30-15 storm.

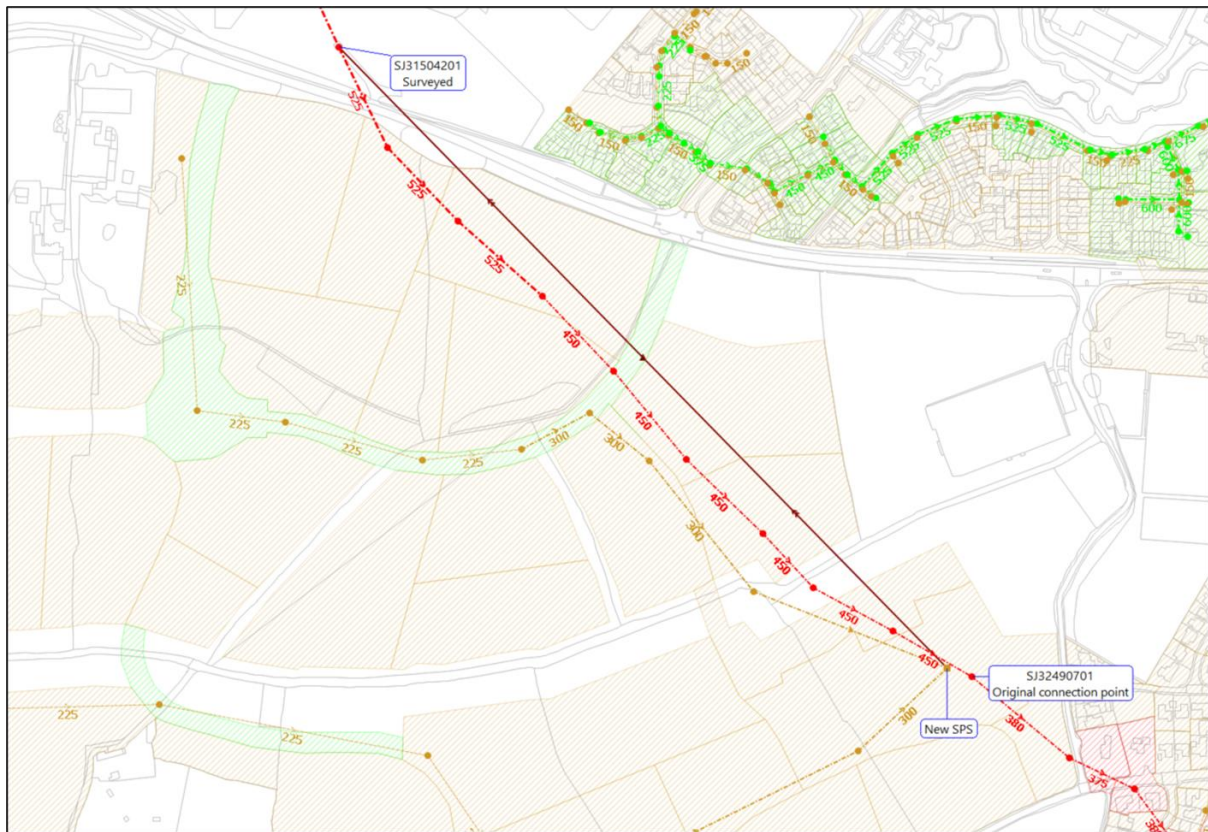


Figure 3. Discounted solution for a new SPS

3.2 Solution 1- Connect to SJ32491406 and IA removal.

3.2.1 Description

This solution addresses the full development to a connection point further downstream than initially proposed. The solution proposes the laying of a new length of sewer to connect the development to a manhole (SJ32491406) along a footpath, west of Foxwood Drive (Figure 5). Providing this alternative route means that none of the development flows are passed through the original connection point (SJ32490701) and this eliminates detriment experienced at this manhole. Two pipes west of Foxwood Drive will also need to be upsized from 225 mm to 375 mm diameter to avoid flooding detriment at the new connection point. This new length of sewer alone does not solve the flooding detriment; therefore, it is proposed that 2.559 ha of roof and road impermeable area is removed from subcatchments where IA surveys have been undertaken.

The solution elements are as follows:

- 360.6 m of new 225 mm diameter pipes running parallel to the trunk sewer near the original connection point, crossing the B5099 (Bersham Road), parallel to the footpath to the south, and connecting to manhole SJ32491401 before the footpath crosses the River Clywedog. Six new manholes to accommodate route around existing housing.
 - Upsize of two pipes after the new connection point, along the footpath and into Foxwood Drive. Upsize from 225 mm to 375 mm diameter. These have a total length of 105.5 m. Upsize and rebenching of 3 manholes to accommodate upsized pipes (SJ32491401 new volume of 2.88 m³, SJ32491406 new volume of 0.38 m³, SJ32492401 new volume of 2.54 m³).
 - 2.559 ha of roof and road impermeable area removed from 81 subcatchments. These areas have been taken from subcatchments which have been surveyed as part of Lower Berse Farm HMA and Gatewen Road HMA.
 - 0.415 ha of impermeable area to be removed from Gatewen Road area (roof and road). Costed assuming rain gardens are 10% of total area removed.
 - 0.192 ha of impermeable area to be removed from Bersham Road area (roof and road). Costed assuming rain gardens are 10% of total area removed.
 - 0.287 ha of impermeable area to be removed from Rockwood Road area (roof and road). Costed assuming rain gardens are 10% of total area removed.
 - 0.065 ha of impermeable area to be removed from Maes Eithen area (roof and road). Costed assuming rain gardens are 10% of total area removed.
 - 1.6 ha of impermeable area to be removed from Victoria Road area (roof and road). Costed assuming rain gardens are 10% of total area removed.
-

3.2.2 Notional Design Solution

There is model predicted flooding at SJ32490701 (the connection point) which is as a direct result of the development.

This solution proposes sending the flows south via new network, shown in Figure 4, consisting of 360.6 m of 225 mm diameter pipes. The original connection point is no longer used and SJ32491401 becomes the new connection point. With the addition of this length of network and the upsizing of two pipes from 225 mm to 375 mm (Figure 5), there is sufficient capacity in the system to accept the additional flows from the development without causing flooding detriment. The pipes required for conveying flows to the new connection point provide additional capacity in the network to alleviate flooding detriment and as such, form part of the solution cost.

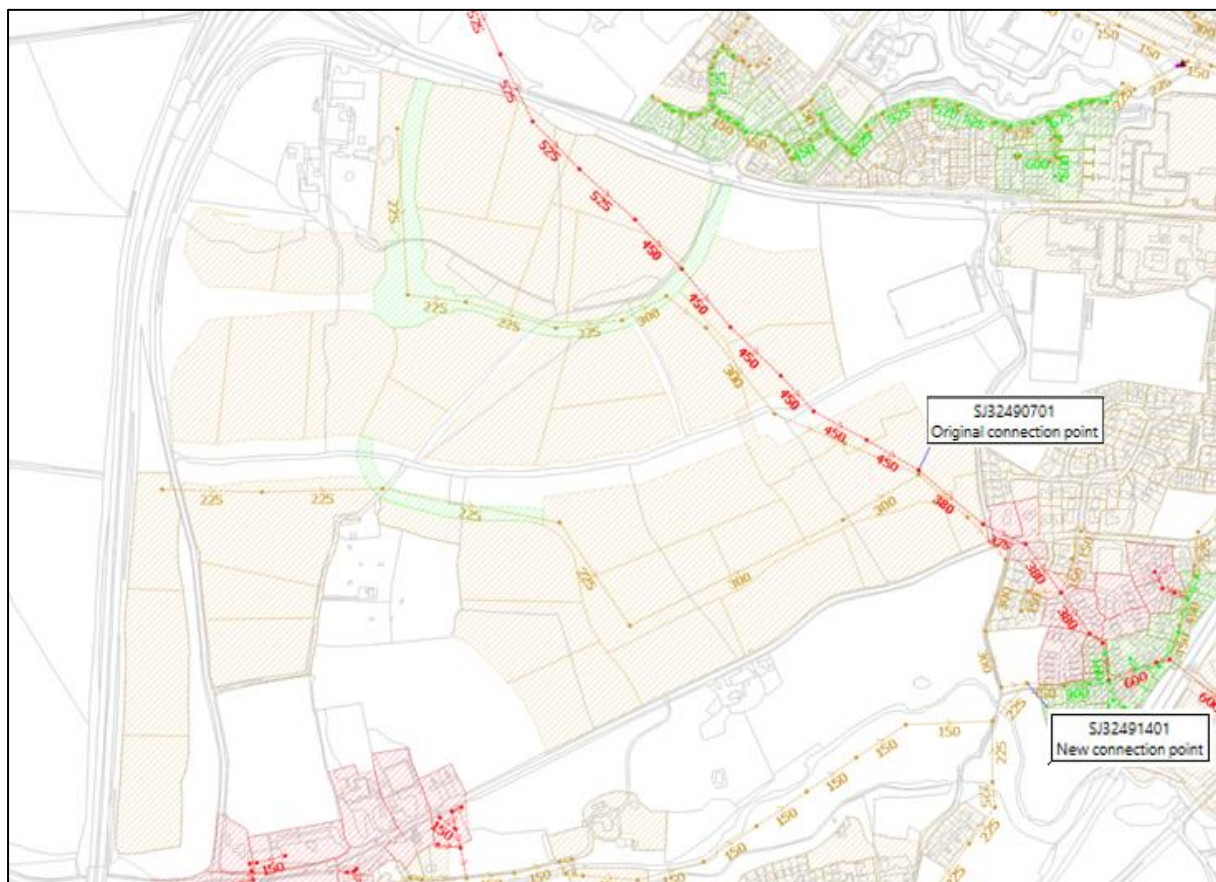


Figure 4. Location of new connection point

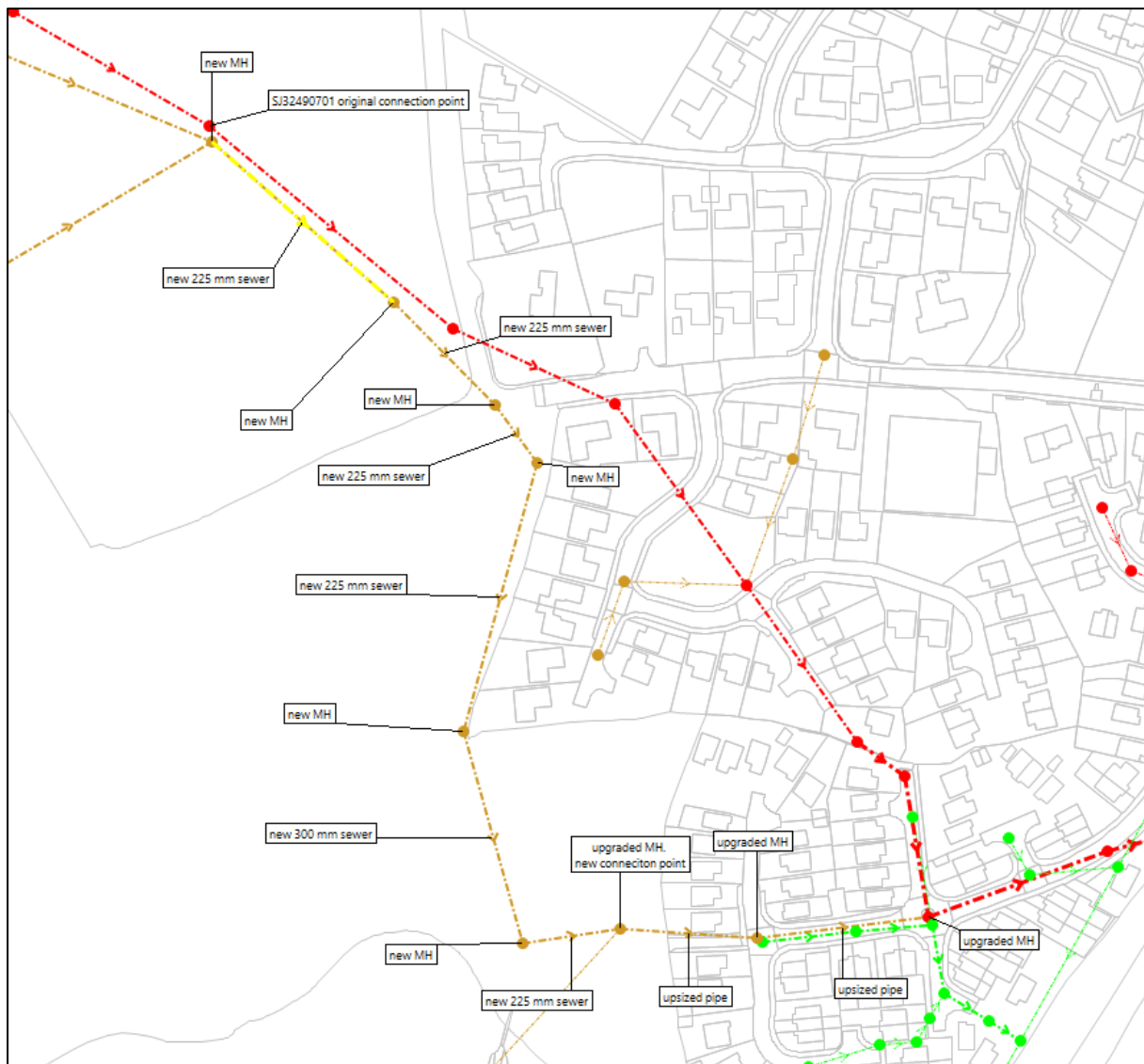


Figure 5. Location of new network, connecting to SJ32491401

This new length of sewer alone does not solve the flooding detriment and further interventions were necessary. Therefore, 2.559 ha of IA has been removed from 81 subcatchments, shown in Figure 6. This removes a significant amount of contributing area from the system and reduces the amount of flow being passed forward to the treatment works CSOs. Because of the extent of removal required, the subcatchments selected were dispersed across the catchment. Only subcatchments which had surveyed IA were selected as the rest of the model has poor model flagging for its contributing area.

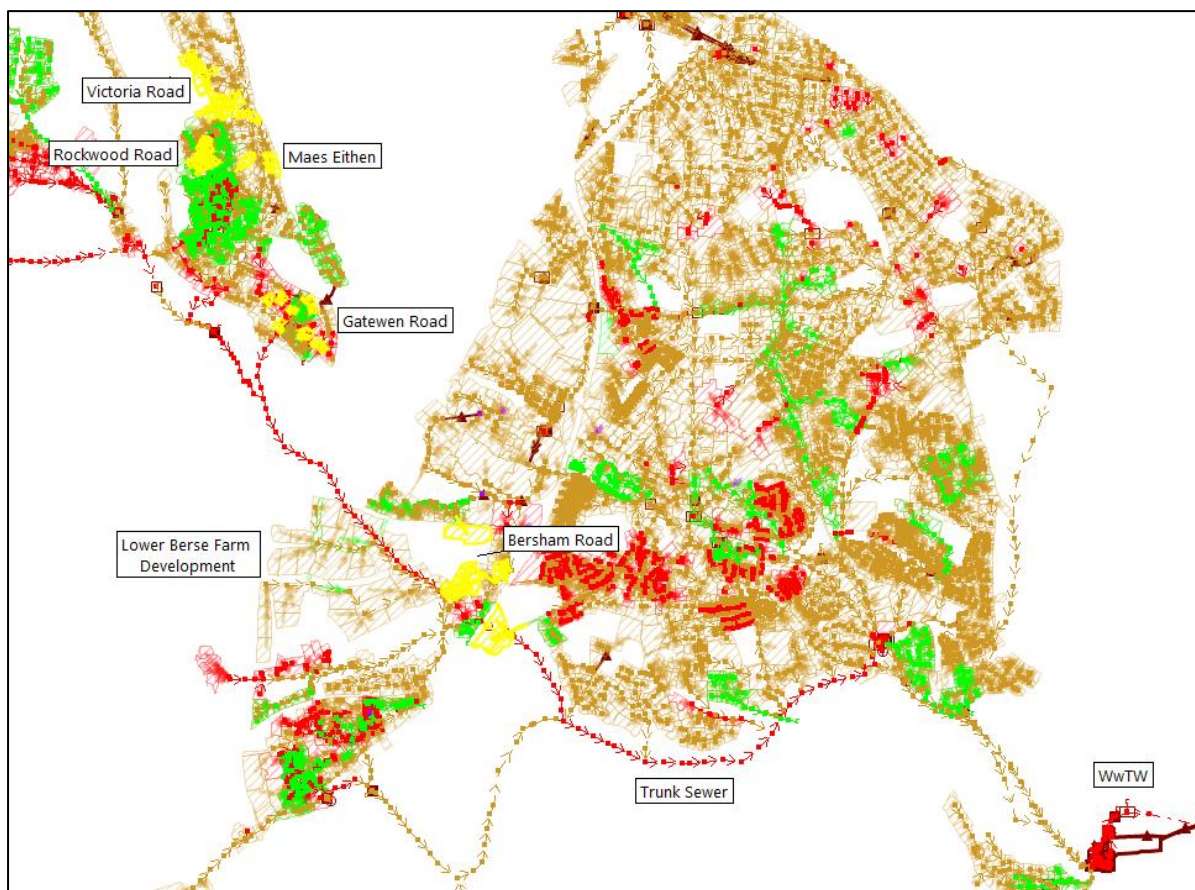


Figure 6. Total coverage of 2.559 ha of IA removal from Gatewen Road, Bersham Road, Maes Eithen, Rockwood Road and Victoria Road.

3.2.3 Solution Assessment

No increase in flooding volume is predicted in the assessment area after the implementation of the above solution, and with the construction of the full development.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m ³)			Flooding Detriment	
			Existing	Developed	Solution	Absolute (m ³)	Percentage (%)
SJ32490701	SJ32490701	360 (summer)	0	48.6	0	0	-
SJ35482802	SJ35482802	1440 (winter)	0	40.9	0	0	-

Table 5. Hydraulic Assessment Results – Solution 1.

3.2.4 Option Considerations

This solution does not resolve the CSO spill detriment at the WwTW downstream as a result of the development. Although the addition of the development causes CSO spill detriment, this solution does not make this detriment any worse. No further investigation has been undertaken due to the scope of this assessment.

The path modelled to the new southern connection point (SJ32491406) will need further detailed design to assess the feasibility of build. The new connection point has not been surveyed. Access to the farmer's fields south of Bersham Road would need to be granted to lay the new pipes there. If this option is taken forward, detailed investigation of local contributing area may be preferable and reduce cost of implementation – disconnecting the network in more concentrated areas is more efficient than doing it at multiple locations.

3.3 Solution 2- Connect to SJ32491406

3.3.1 Description

This solution addresses the full development to a connection point further downstream than initially proposed. The solution proposes the laying of a new length of sewer to connect the development to a manhole (SJ32491406) along a footpath, west of Foxwood Drive shown in Figure 7. Providing this alternative route means that none of the development flows are passed through the original connection point (SJ32490701) and this eliminates detriment experienced at this manhole. Two pipes west of Foxwood Drive need to be upsized from 225 mm to 450 mm diameter to avoid flooding detriment at the new connection point.

The solution elements are as follows:

- 360.6 m of new 300 mm diameter pipes running parallel to the trunk sewer near the original connection point, crossing the B5099 (Bersham Road), parallel to the footpath to the south, and connecting to manhole SJ32491401 before the footpath crosses the River Clywedog. Six new manholes to accommodate route around existing housing.
- Upsize of two pipes after the new connection point, along the footpath and into Foxwood Drive. Upsize from 225 mm to 450 mm diameter. These have a total length of 105.5 m. Upsize and rebenching of 3 manholes to accommodate upsized pipes (SJ32491401 new volume of 3.28 m³, SJ32491406 new volume of 0.52 m³, SJ32492401 new volume of 2.54 m³).

3.3.2 Notional Design Solution

There is model predicted flooding at SJ32490701 (the connection point) which is as a direct result of the development.

This solution proposes sending the flows south via new network, shown in Figure 4, consisting of 360.6 m of 300 mm diameter pipes. The original connection point is no longer used and SJ32491401 becomes the new connection point. With the addition of this length of network and the upsizing of two pipes from 225 mm to 450 mm (Figure 8), there is sufficient capacity in the system to accept the additional flows from the development without causing flooding detriment. The pipes required for conveying flows to the new connection point provide additional capacity in the network to alleviate flooding detriment and as such, form part of the solution cost.

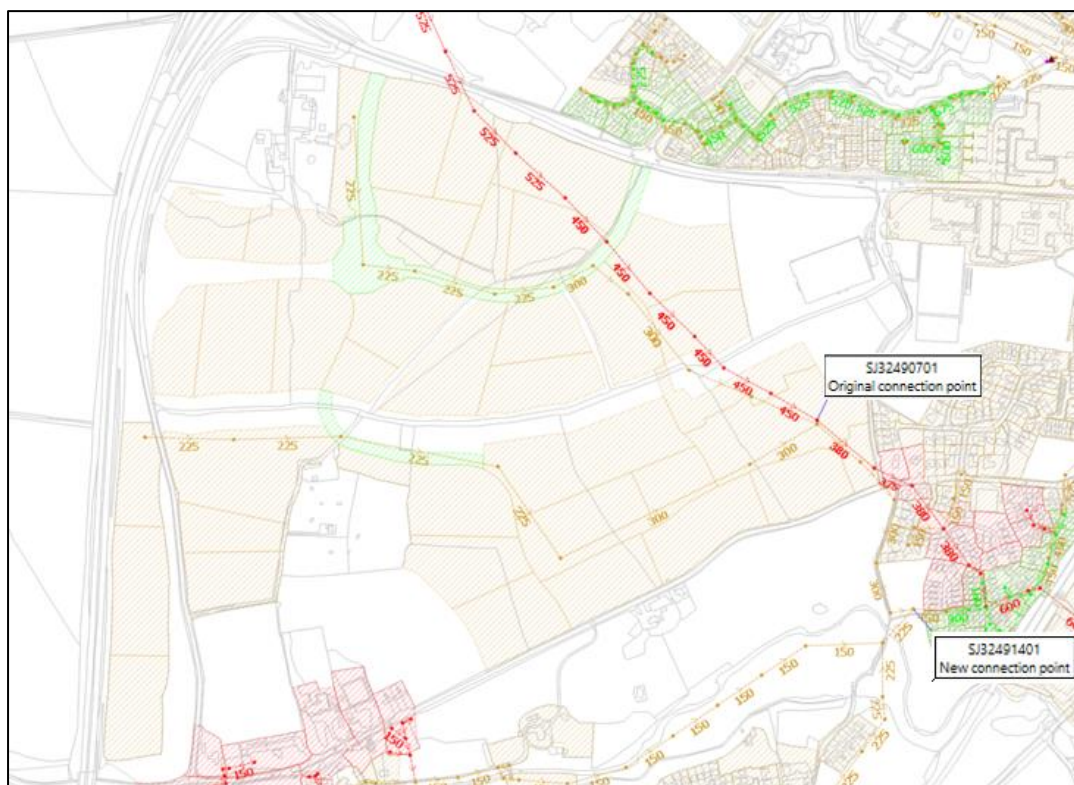


Figure 7. Location of new connection point

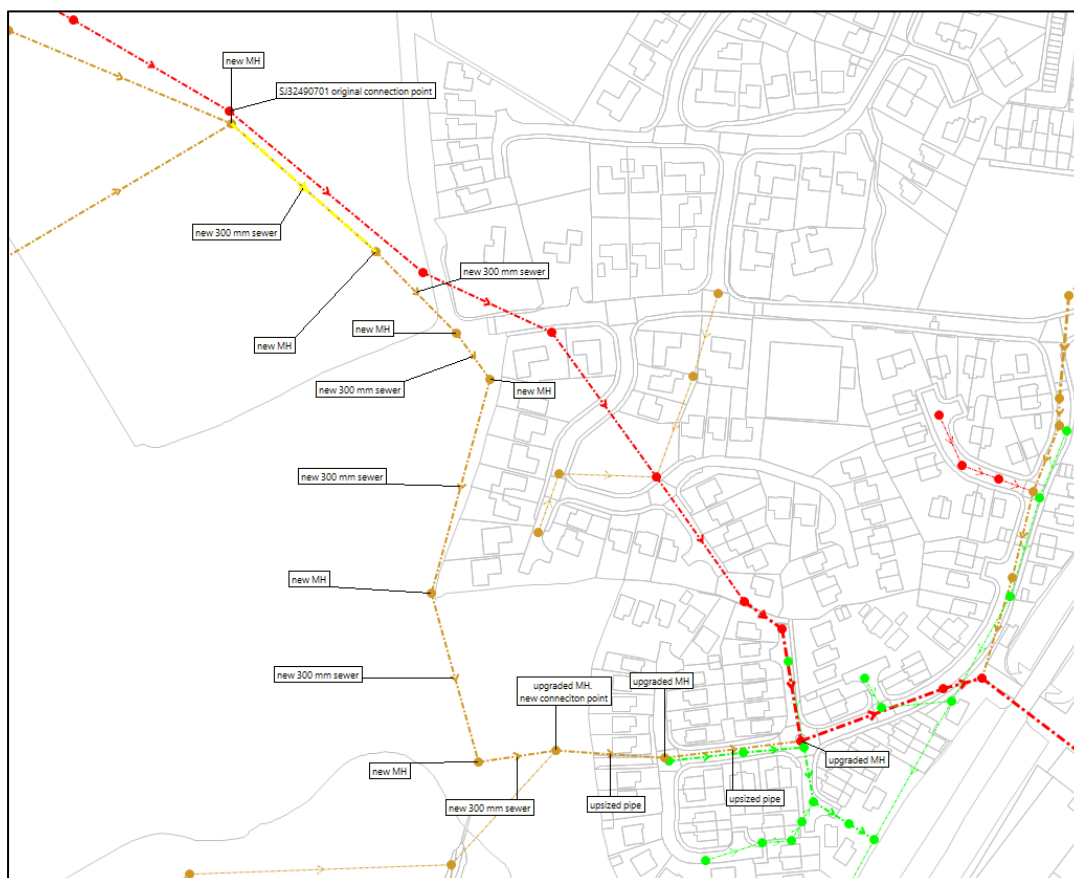


Figure 8. Location of new network, connecting to SJ32491401

3.3.3 Solution Assessment

No increase in flooding volume is predicted in the assessment area after the implementation of the above solution, and with the construction of the full development.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m ³)			Flooding Detriment	
			Existing	Developed	Solution	Absolute (m ³)	Percentage (%)
SJ32490701	SJ32490701	360 (summer)	0	48.6	0	0	-
SJ35482802	SJ35482802	1440 (winter)	0	40.9	0	0	-

Table 6. Hydraulic Assessment Results – Solution 2.

3.3.4 Option Considerations

This solution does not resolve the CSO spill detriment at the WwTW downstream as a result of the development. Although the addition of the development increases the CSO spill detriment, this solution does not make this detriment any worse. No further investigation has been undertaken due to the scope of this assessment.

The path modelled to the new southern connection point (SJ32491406) will need further detailed design to assess the feasibility of build. The new connection point has not been surveyed. Access to the farmer's fields south of Bersham Road would need to be granted to lay the new pipes there. If this option is taken forward, detailed investigation of local contributing area may be preferable and reduce cost of implementation – disconnecting the network in more concentrated areas is more efficient than doing it at multiple locations.

3.4 Solution 3- Online storage bifurcation

3.4.1 Description

This solution seeks to address the full development connecting to SJ32490701. The solution proposes laying of two new pipes as a bifurcation to SJ32490701.1 highlighted in Figure 9. The aim is for the bifurcation to be used in the event of higher flows and for the existing network to be utilised during normal flow conditions. Flows enter the bifurcation via a high-level weir that flows into two new parallel 1700 mm diameter pipes. Flow is controlled by an orifice and flap valve at the downstream end with a maximum flow of 15 l/s. The flap valve ensures flows are retained within the bifurcation when the network downstream is surcharged.

The solution elements are as follows:

- 2 x ~100 m of new 1700 mm diameter pipes acting as a bifurcation via high level weir from the connection point.
- Orifice and flap valve that connect the two pipes back into SJ32490601. This restricts the flow to 15 l/s so that the storage is utilised, and flows can be returned to the system in DWF events.

3.4.2 Notional Design Solution

There is model predicted flooding at SJ32490701 (the connection point) which is as a direct result of the development.

This solution proposes adding two 1700 mm pipes from the connection point (SJ32490701) to function as online bifurcation storage. A weir into the bifurcation is set at 0.115 m above the soffit of the incoming pipe. This works to take flows in storm events and store them in the set of 1700 mm pipes. The weir is set at the lowest possible level without DWF passing through the bifurcation. An orifice after the bifurcation is set at the highest possible rate before passing too much flow downstream, to limit flows back into the set of pipes which would otherwise cause flooding. A flap valve downstream of the orifice is input to eliminate the possibility of flows backing up into the set of pipes. This is illustrated in Figure 9.

With the addition of two 1700 mm pipes, a weir, orifice and flap valve, there is sufficient capacity in the system to accept the additional flows from the development without causing flooding detriment.

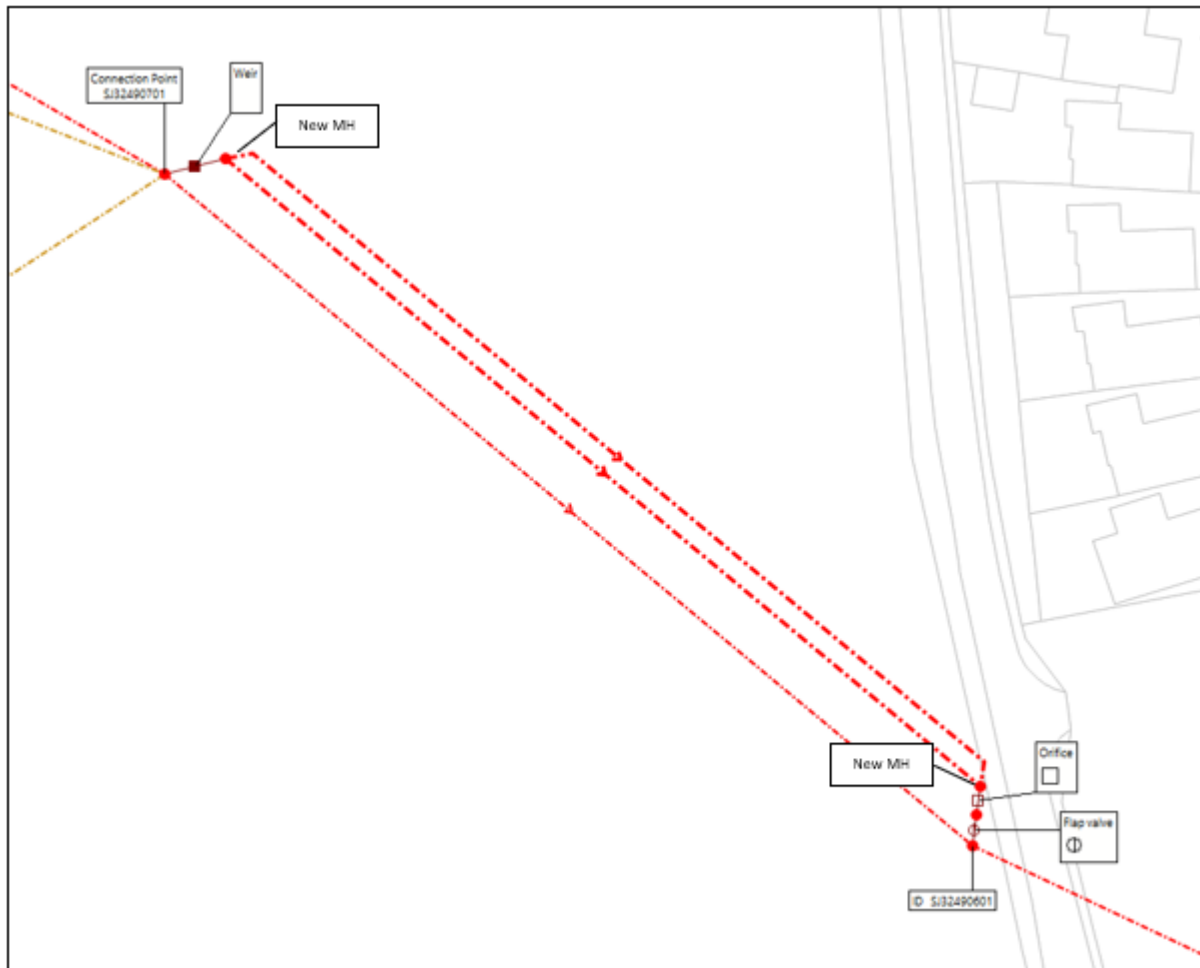


Figure 9. Online storage bifurcation

3.4.3 Solution Assessment

No increase in flooding volume is predicted in the assessment area after the implementation of the above solution, and with the construction of the full development.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m ³)			Flooding Detriment	
			Existing	Developed	solution	Absolute (m ³)	Percentage (%)
SJ32490701	SJ32490701	360 (summer)	0	48.6	0	0	-
SJ35482802	SJ35482802	1440 (winter)	0	40.9	0	0	-

Table 7. Hydraulic Assessment Results – Solution 3.

3.4.4 Option Considerations

This solution does not resolve the CSO spill detriment at the WwTW downstream as a result of the development. Although the addition of the development increases the CSO spill detriment, this solution does not make this detriment any worse. No further investigation has been undertaken due to the scope of this assessment.

This simulation results indicate that there is sufficient pipe capacity in the existing pipes upstream and downstream of the location where the storage is applied.

It is assumed that there will be no issues acquiring the land needed to build the online bifurcation storage. The cost of this solution does not include the cost of purchasing land required for the construction of this storage.

3.5 Solution Summary

- Solution 1 provides a hybrid grey and green solution. The grey part consists of creating a new connection point further downstream with the addition of six new pipes and manholes and the upsizing of two pipes. The green part consists of the removal of 2.559 ha of impermeable area from 81 subcatchments throughout the network to resolve the flooding detriment.
 - Solution 2 provides a fully grey solution. It consists of creating a new connection point further downstream with the addition of six new pipes and manholes and the upsizing of two pipes.
 - Solution 3 provides a fully grey solution. This consists of laying two new pipes as online bifurcation storage with the addition of a weir, orifice, and flap valve to resolve the flooding detriment.
-

4 Solution Costs

The solution costs provided are based on the AMP 7 Year 4 DCWW Cost and Carbon Estimating Tool (CCET). This cost model predicts costs based on final costs of completed scheme. This is intended to be a high-level cost estimate. It is recommended that a detailed cost estimate is undertaken during the detailed design phase.

Solution	Description	Costs
Solution 1- New connection point and IA removal	Laying of 360 m of new 225 mm diameter pipes including 6 new manholes to accommodate route around existing housing. Connect into existing network at new proposed connection point, downstream of original one. Upsize of 106 m of sewer from 225 mm to 375 mm, including upsize and rebenching of 3 manholes to accommodate upsized pipes (SJ32491401 new volume of 2.88 m3, SJ32491406 new volume of 0.38 m3, SJ32492401 new volume of 2.54 m3). Removal of 2.559 of IA across 5 areas	£2,465,000
Solution 2- New connection point	Laying of 360 m of new 300 mm diameter pipes including 6 new manholes to accommodate route around existing housing. Connect into existing network at new proposed connection point, downstream of original one. Upsize of 106 m of sewer from 225 mm to 450 mm, including upsize and rebenching of 3 manholes to accommodate upsized pipes (SJ32491401 new volume of 3.28 m3, SJ32491406 new volume of 0.52 m3, SJ32492401 new volume of 2.54 m3).	£700,000
Solution 3- Online storage bifurcation	Addition of two 1700 mm pipes to provide online bifurcation storage. A weir upstream of the storage. An orifice and flap valve downstream of the storage to limit flows back into the pipes.	£1,210,000

Table 8. Solution Costs

The costing assumes that solutions would be developed in-house. Furthermore, it is assumed that new sewer construction will be undertaken through open cut techniques. More cost-effective techniques may be possible but have not been costed.

Solution 1 assumes the 360 m of new 275mm diameter pipes will be laid through grassland. Six new manholes will be constructed to support the new network. Two pipes will be upsized from 225 mm to 375 mm. The cost of pipe upsize assumes urban normal depths with three associated manhole enhancements. This solution assumes that the impermeable area removal is undertaken through the creation of bioretention or raingardens. This is a first pass estimate of how much the removal would cost but it should be considered that with detailed investigation and design, there would be a mixture of SUDs features and connecting to existing network. The amount of area removed in this solution demonstrates the quantity required to remove detriment rather than those locations being the actual focus of intervention. Detailed costing has therefore not been undertaken and an assumption of five separate areas of removal was costed as a best estimate. The raingardens have been costed, as per DCWW guidance, through 0.1 ha of raingarden per 1 ha of IA removal.

Solution 2 assumes the 360 m of new 300 mm diameter pipes will be laid through grassland. Six new manholes will be constructed to support the new network. Two pipes will be upsized from 225 mm to 450 mm. The cost of pipe upsize assumes urban normal depths with three associated manhole enhancements.

5 Conclusion & Recommendations

- The proposed development is south of Ruthin Road, Wrexham. This is located to the east of the Wrexham city centre.
 - The size of the development is approximately 53 ha. The developer aims to build the development of 1500 units in one phase.
 - 1400 of the units will drain via gravity and the remaining 100 will drain via two pumping stations.
 - The proposed development has been assessed using an existing connection point of SJ32490701, in the southeast corner of the site.
 - The model used in this study is the AMP7 DWMP 2020 base model, which was last verified in 2014 but has had model upgrades conducted during other HMAs.
 - The hydraulic assessment indicates that there is no flooding detriment around the two DFL properties downstream. There is a total of 48.6 m³ of flooding detriment at the connection point. One other manhole downstream (SJ35482802) is predicted to flood by 40.9 m³ as a result of the new development.
 - Three solutions were discounted as they do not resolve the flooding detriment.
 - Solution 1 consists of a new section of network, connecting the development further downstream and in doing so, avoiding the known pipe restriction location that was causing the flooding detriment. The solution also consists of the removal of 2.559 ha of impermeable area from 81 subcatchments throughout the network to resolve the flooding detriment. This solution is estimated to cost £2,465,000. This solution is a first pass approximation as the exact methods and location of impermeable area removal will have to be reviewed at detailed design.
 - Solution 2 consists of a new section of network, connecting the development further downstream and in doing so, avoiding the known pipe restriction location that was causing the flooding detriment. This solution is estimated to cost £700,000.
 - Solution 3 consists of laying two new pipes as online bifurcation storage to resolve the flooding detriment. This solution is estimated to cost £1,210,000.
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6 List of Abbreviations

DWF – Dry Weather Flow

WwTW – Wastewater Treatment Works

HMA – Hydraulic Modelling Assessment

CSO – Combined Sewer Overflow

DWMP – Drainage and Wastewater Management Plan

PFF – Pass Forward Flow

DFL – Definitive Flooding List

IAS – Impermeable Area Survey

CCET - Cost and Carbon Estimating Tool

SPS – Sewerage Pumping Station

SUDS - Sustainable Drainage Systems

DCWW - Dŵr Cymru Welsh Water
