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Dŵr Cymru Welsh Water

Newport Flood Mitigation

NRW Solution Report

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Contents

Tables

Figures

Photographs

Appendix A

Proposed Solution

Appendix B

Options Not Progressed

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1 Introduction

1.1 Project Brief

This document outlines the solution to resolve rainfall induced flooding of 63 properties in a low-lying area of Newport and long-term approach for the catchment.

This document will summarise the sources, pathways and receptors to flooding, as per Annex 1.8 of NRW's Technical 'How to Comply' guidance[1]. It will discuss the optioneering that took place to achieve the proposed temporary solution to protect these properties with a local pumping station, while a catchment wide solution is developed and implemented.

1.2 Newport Flooding

Figure 1 – Area of interest - location of flooding properties and temporary solution within Newport

[1] How to comply with your environmental permit, Additional guidance for: Water Discharge and Groundwater (from point source) Activity Permits (EPR 7.01), NRW (2014)

Figure 2 - Location of properties effected by flooding 23 December 2020

As a result of significant rainfall on the 23rd of December 2020, 63 properties suffered from external and internal flooding. These were located within Orchard Street, Margaret Street and Courtney Street in central Newport. Most properties are situated alongside a raised railway embankment, causing water to accumulate at the backs of these properties. On the other side of the train tracks, a new residential development is currently being constructed next to the River Usk and properties to the south along Courtney Street also suffered from flooding. Information relating to individual properties cannot be shared due to GDPR.

Photograph 1 - Orchard Street on the 23rd December 2020 (Image Source: Gareth Everett/Huw Evans Agency)

The event caused serious disruption to the community just before Christmas day. Dŵr Cymru Welsh Water (DCWW) investigated the root cause of flooding and considered options to mitigate the risk of this flooding re-occurring.

2 Investigations

2.1 Hydraulic Model Update

The hydraulic model has undergone several updates to ensure it represents the local flooding area and wider catchment.

The hydraulic model represents the wastewater network across the Newport catchment, where all flows drain to Nash WwTW. Figure 3 below shows a simplified schematic of the network and where the flooding area of concern is situated in relation to it. The Newport Tunnel Sewer is a deep trunk sewer that conveys sewage flows across the city to Orb SPS where flows are then pumped to Nash WwTW.

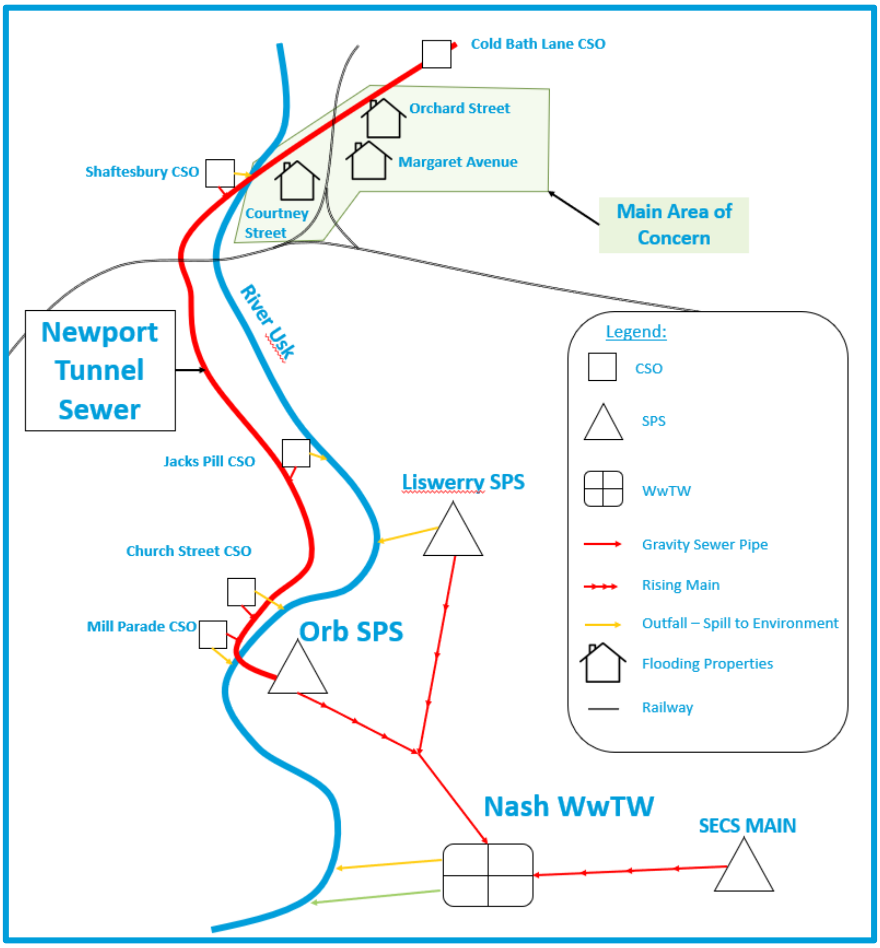


Figure 3 - Newport Wastewater Network Schematic

Upgrades to the model have occurred over the years to better represent the network. Flow Monitoring across the catchment upstream of Orb SPS occurred in 2013, where a verified model was produced. A total of 21 Flow monitors were installed, 4 of which were installed locally to the flooding area of concern. The model then underwent upgrades during AMP6 to better understand the Newport Tunnel Sewer and the CSO assets along it. Finally, since the investigation into the flooding area of concern began in February 2021, further upgrades have been brought to the model. These were:

- Updates to Nash WwTW and Orb SPS were carried out after discussions with DCWW operatives in March 2021.
- Manhole surveys were carried out in June 2021 and helped improve local confidence around the flooding properties.

- A verification exercise was carried out in August 2021 to better improve the representation of flows arriving to the CSOs along the Newport Tunnel Sewer and Orb SPS using telemetry data. This improved confidence in the Orb Catchment as a whole.

2.2 Root cause to Sewer Flooding

The hydraulic model replicates sewer flooding for design storms and timeseries rainfall data. During extreme rainfall events, high catchment inflows drain into the Newport Tunnel Sewer, which becomes hydraulically overloaded. Existing CSOs along the tunnel designed to limit these flows become tide locked in high tide scenarios, resulting in the whole network surcharging. This results in low lying manholes within the area of interest flooding the surround streets and properties.

The problem is further exacerbated by the local topography and existing infrastructure, with overland flow paths accumulating behind the raised railway embankment.

2.2.1 Newport Tunnel Sewer, Orb SPS & Tide Locked CSOs

Hydraulic modelling has established the root cause of sewer flooding is extreme rainfall events. These can also coincide with a high tide scenarios. This causes sewer flows to spill out of low-lying manholes around the flooding properties.

Newport is made up of large fully combined sewerage areas that accumulate into the Tunnel Sewer. Although CSOs are in place to provide relief during heavy rainfall events, the outfalls can become tide/river locked.

The design philosophy of the Orb SPS from the year 2000 is to pass forward a maximum consented flow of 1,396l/s to Nash WwTW. However, when extreme weather events coincide with high tide, the tunnel becomes hydraulically overloaded and results in the backing up to the smaller pipes shown around the flooding properties in Figure 4.

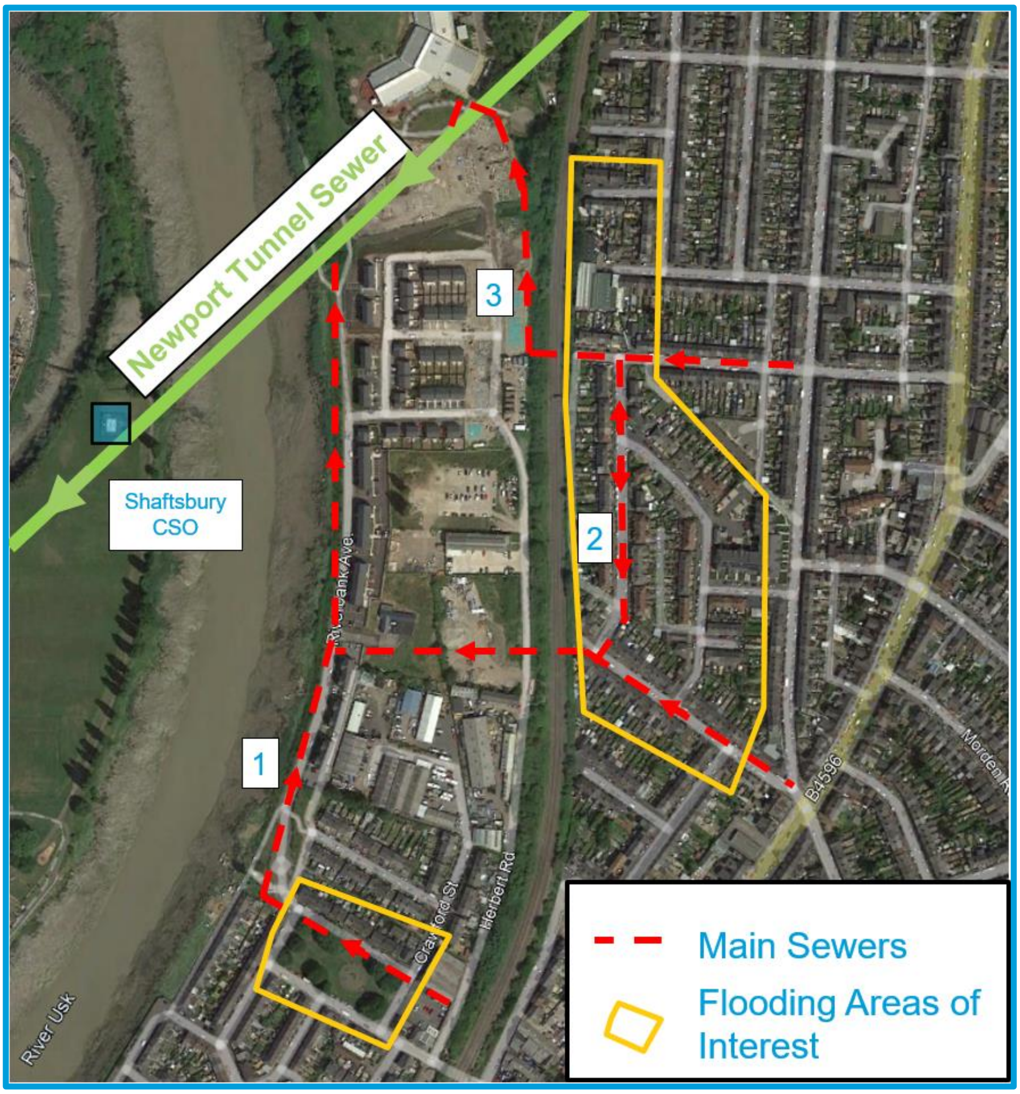


Figure 4 - Main Sewers around Flooding Areas of interest.

Figure 5, Figure 6 and Figure *7* provided below are long sections from the hydraulic model of the numbered main sewers shown in Figure 4. They demonstrate the lower ground levels around the area of concern results in sewer flooding.

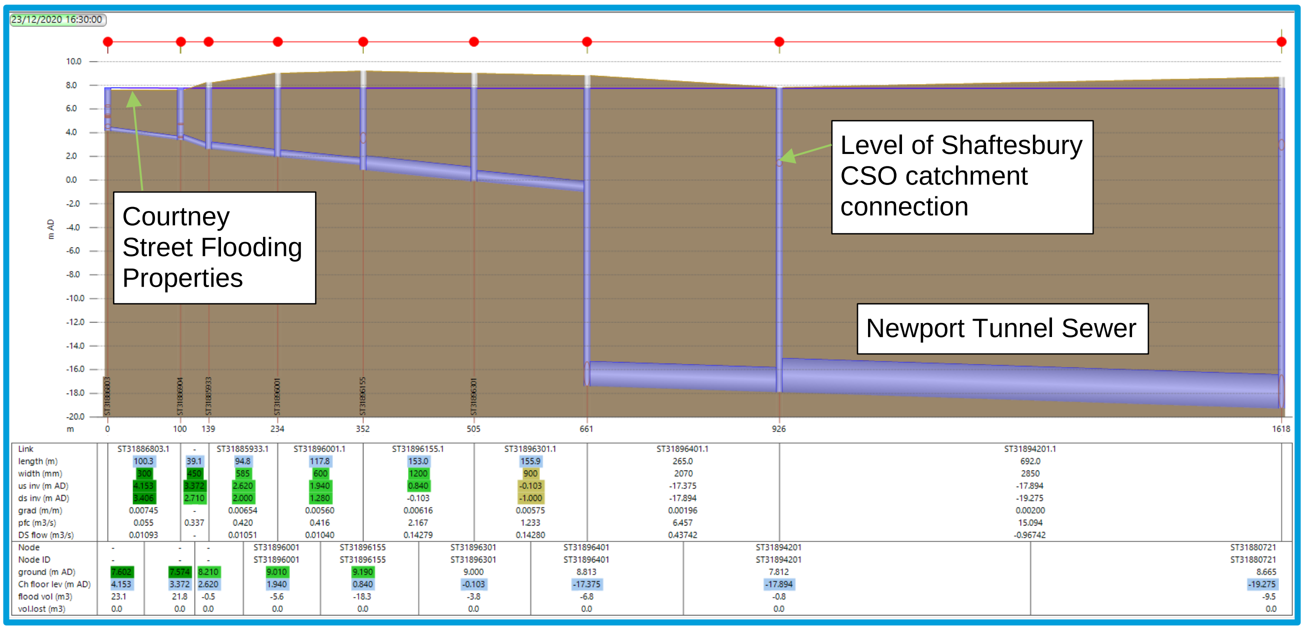


Figure 5 - Long Section 1 – Tunnel Sewer to Courtney Street peak surcharge levels on December 23rd Event

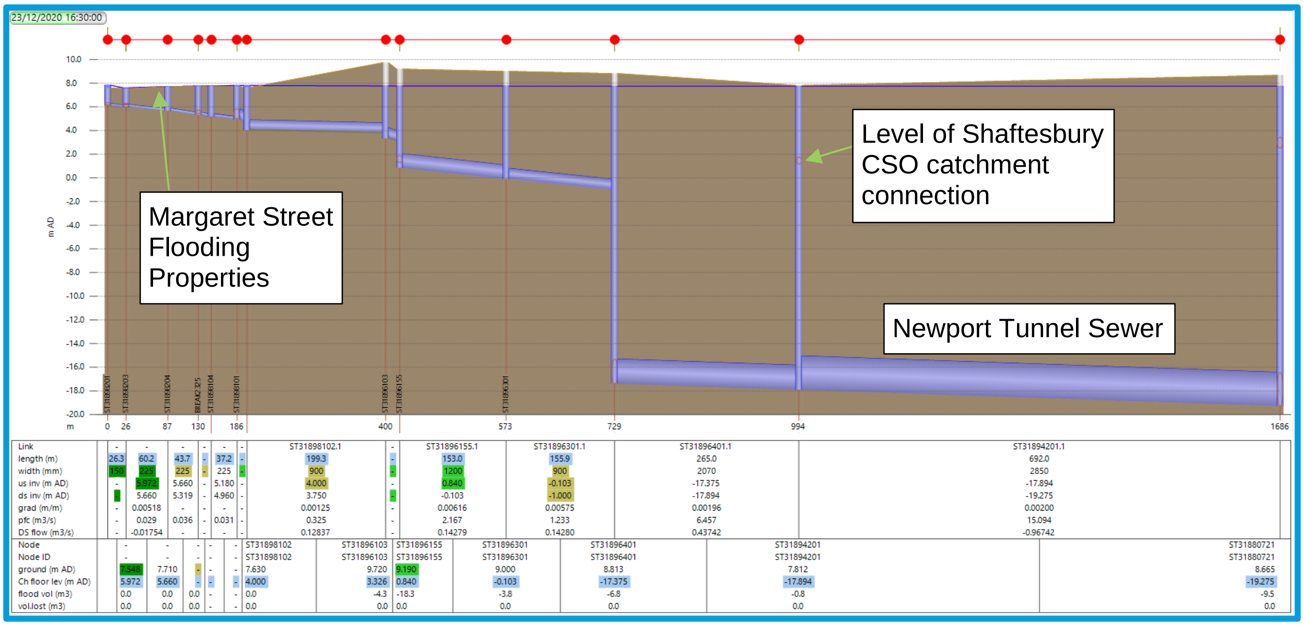


Figure 6 - Long Section 2 – Tunnel Sewer to Margaret Street peak surcharge levels on December 23rd Event

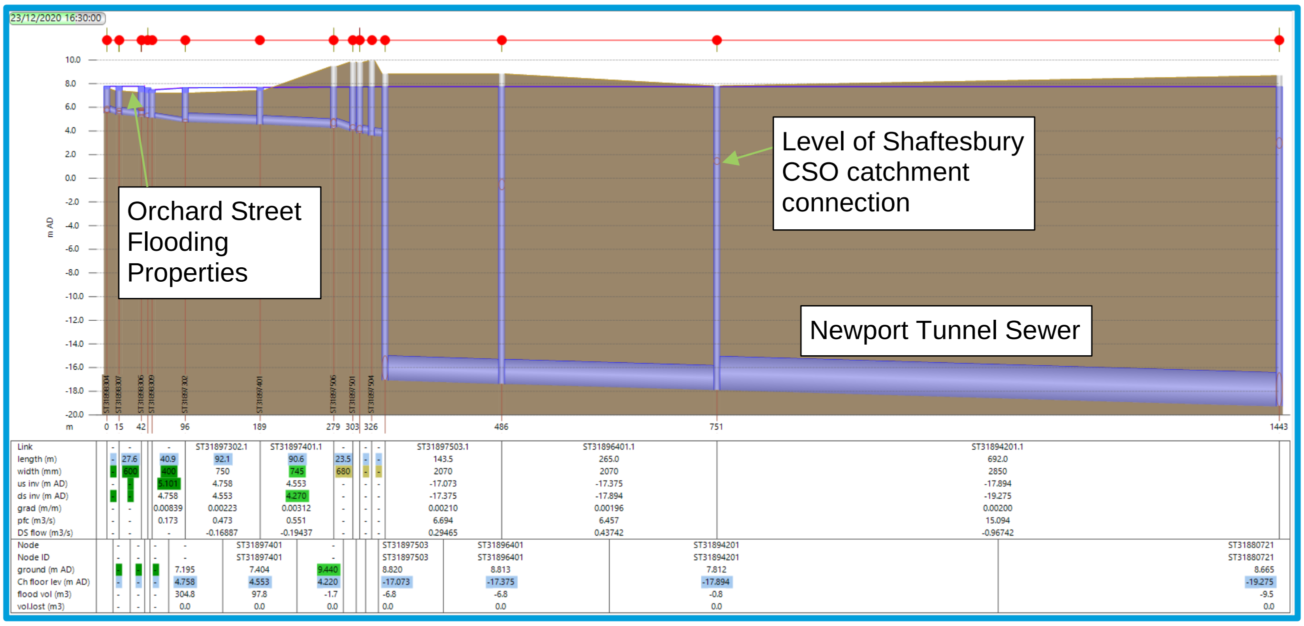


Figure 7 - Long Section 3 – Tunnel Sewer to Orchard Street peak surcharge levels on December 23rd Event

Knowing the significant impact the 23rd of December 2020 event had on the local area, the predicted flood volumes were used as a threshold to better understand the flooding pathway to the receptors. The manhole surveys carried out in June 2021 confirmed evidence of high surcharge in these low-lying chambers and confirm what is shown in the hydraulic model.

2.2.2 Overland Flow Paths

The area of flooding concern is a local low point in the wider Newport catchment. Glass surface overland flow mapping shows the predicted flow accumulation after 50mm of rainfall falls in the area around the flooding properties (See Figure 8). The raised railway embankment prevents the pathway of water to the river and causes surface water to accumulate at the backs of properties along Margaret Street.

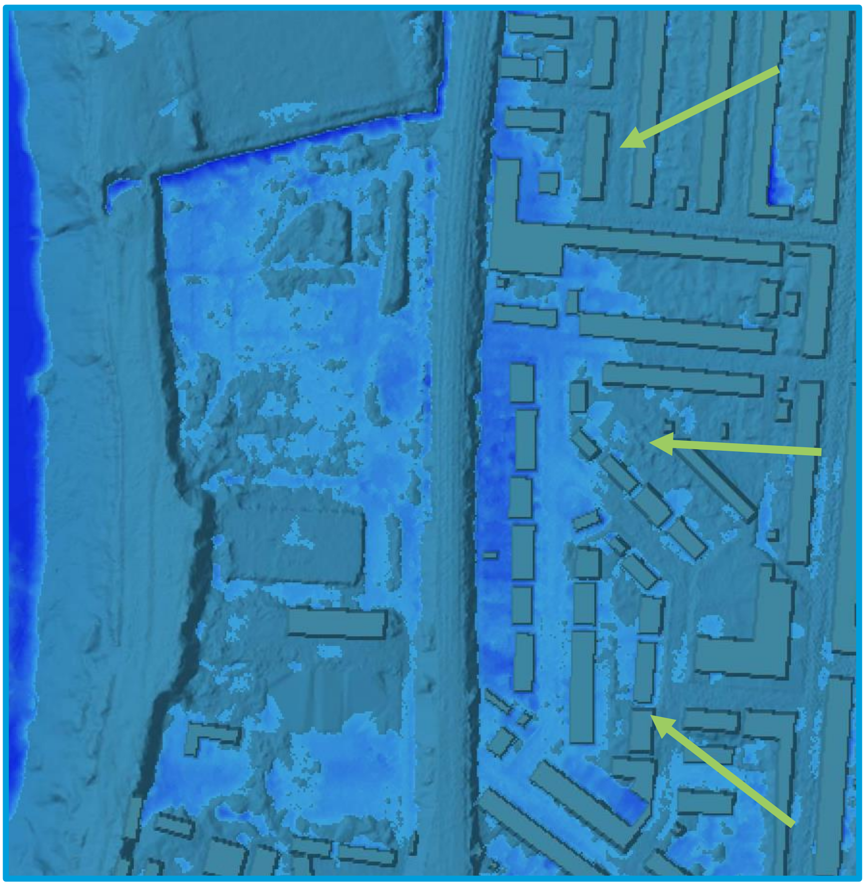


Figure 8 - Glass floor overland flow mapping for 50mm of Rainfall, consistent with December 23rd 2020 Event. (Source: SCALGO Live)

NRW's Flood Risk Assessment Wales map agrees with the overland flow analysis. Figure 9 shows the area being at risk of flooding due to Surface Water & Small Watercourses. The overland flow exacerbates sewer flooding, as flows that would otherwise drain to the River Usk are instead held around the flooding properties.

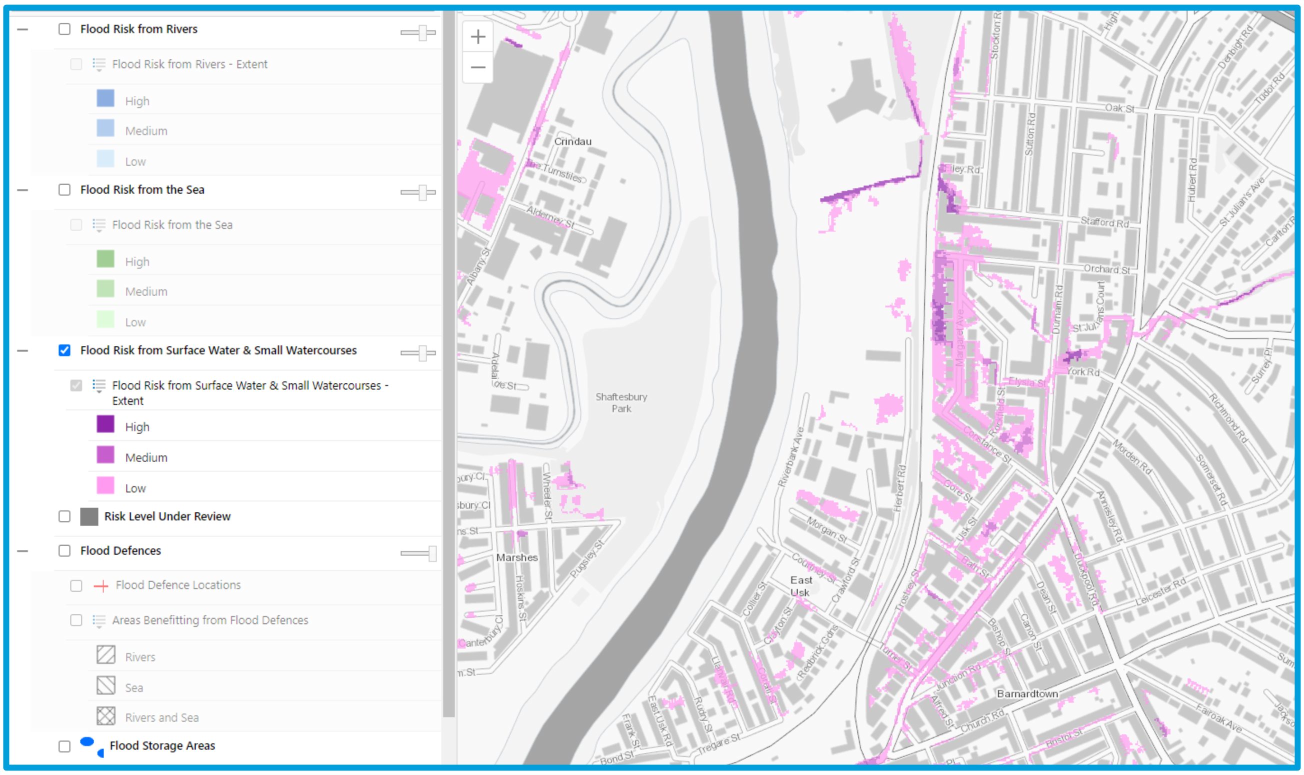


Figure 9 - NRW Flood Risk Mapping in flooding area of concern. (NRW Flood Risk Map Viewer)

3 Options not progressed

Several options to mitigate flood risk were considered during the early stages of the design. However, many were not feasible. A Local RainScape Option, Storage Option, Cut & Pump Option and Shaftesbury SPS Option were all investigated for their constructability, ability to protect against flooding, and an estimated monetary and carbon cost.

3.1 Local RainScape

The first option considered was to remove upstream impermeable area to reduce surface runoff entering the sewer (known as RainScape). A considerable area of RainScape was tested, where 26ha of impermeable area upstream was removed. However, this provided little protection against flooding as the root cause stems from the wider Newport catchment and Tunnel Sewer hydraulically backing up. The option would also be cost-prohibitive and take a considerable amount of time to deliver.

This option was further discounted due to the inability to re-route the surface water in the local area. A surface water (SW) culvert also runs through the flooding area, taking a small brook from St Julian's area of Newport from the east and discharges, via a drainage ditch, to the River Usk. The drainage ditch becomes tide locked in high tide scenarios (when flooding is prevalent) and the new development's surface water system also discharges to the same ditch, hence it was determined that adding any more surface flow to the ditch could result in detrimental flooding elsewhere in the local area.

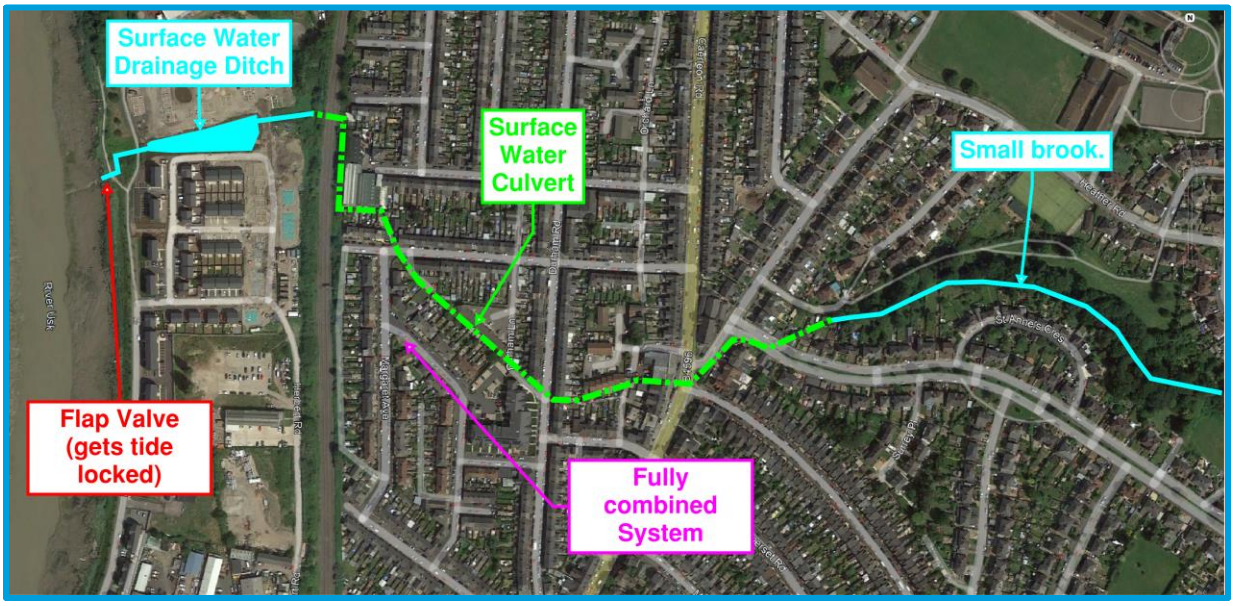


Figure 10 - Surface Water Culvert around Flooding Area

3.2 Storage

From an early stage, a local storage option was discounted as a significantly large storage tank would be required to retain the high storm flows from the tunnel and protect properties. Constructing this in a highly urbanised area is not feasible.

Initial modelling suggested approximately 12,000m^3 of storage would be required to provide protection against a 1 in 5 year storm with high tide. Due to the size of the tank required, this option was not considered in further detail.

3.3 Cut & Pump + Shaftesbury Modification

This option considered constructing two new storm pumping stations to pump flows around the Orchard Street area directly into the Newport Tunnel. An optimisation exercise found that storm flow rates of 173/s and 198l/s on top of 50l/s for Dry Weather Flow at both sites would be necessary to resolve flooding on the 23rd of December event.

This option also involves constructing a new 1200mm diameter high level overflow pipe at the existing Shaftesbury CSO to allow more flow to discharge here. This is because the new pumping would introduce more flow into the Tunnel Sewer instead of around the flooding area of concern.

Although this option mitigated flooding in the area of concern, it was found that this option had two drawbacks:

1. An 80% increase in predicted spilled volume at Shaftesbury CSO for the 23rd December 2020 Event.
2. As more flow is forced into the tunnel, this causes the exacerbation of flooding in other parts of the Newport catchment, especially in large storm events where a 200% increase in predicted flooding volumes occurs out of 90 manholes in other areas of the catchment in a 1 in 10 storm.

As this option moves the flooding problem elsewhere in the catchment, it was discounted as a suitable option.

3.4 Shaftesbury Pumping Station

This option considered constructing a new pumping station at Shaftesbury CSO which forces pumped storm flow out of Newport Tunnel when extreme storms coincide with high tide by utilising the existing outfall at the CSO. This will lower levels in the trunk and ultimately resolve flooding around the flooding properties. To provide up to a 1 in 10 storm protection, a 1500l/s pumping station would be required. The constructability of this scale of pumping station was assessed at the proposed site and a proposed site layout can be found in Appendix B.

Although this option tackles the root cause of flooding by directly pumping from the surcharging Newport Tunnel, it's location on the other side of the river means larger volumes of storm water need to be pumped out compared to placing a pumping station closer to the flooding properties. Also, there was uncertainty about utilising the existing outfall at Shaftesbury CSO.

This option was found to be unaffordable and was not taken further.

3.5 Costings of Options not progressed

The capital and carbon costs of these options were estimated, consistent with the level of detail considered at optioneering stage.

Table 1 - Costing of options not progressed

Option Name	Approx. Level of Protection at flooding area	Estimated Option Cost (£)	Estimated Total Carbon Cost over 40 years (kg CO2e)
Local RainScape (26ha)	N/A	£26,000,000[1]	1,168,000[2]
Storage Tank (12,000m^3)	Up to 1 in 5	£24,000,000[3]	4,320,000[4]
Cut & Pump + Shaftesbury Modification	Up to 1 in 10	£1,270,000	927,000
1500l/s Shaftesbury Pumping Station	Up to 1 in 10	£1,900,000	280,000

[1] Cost based on approx. £1M/ha taken from delivered DCWW schemes

[2] Carbon cost based on high-level estimate of 160,000kg CO2e/ha of RainScape from DCWW's Unit Costing Database (UCD) spreadsheet. Estimated Carbon Sequestration over 40 years has been included.

[3] Cost based on approx. £2000/m3 from DCWW's UCD.

[4] Carbon cost based on high-level estimate of 300kg CO2e/m3 of Storage from DCWW's UCD. Operational Carbon Cost has been included.

All other costs and carbon costs calculated using DCWW's UCD.

4 Solution

The final solution to alleviate flooding is to carry out catchment wide surface water removal activities to reduce flows entering the Newport Tunnel Sewer. This will prevent hydraulic overload from causing flooding and also the opportunity to provide multiple other benefits within the wider catchment.

However, this final solution requires extensive catchment wide survey and modelling to be undertaken, followed by detailed optioneering prior to delivery at scale. This is likely to take at least 5 to 10 years. In order to provide protection to the flooding properties until this final solution is implemented, a temporary solution is required. This involves constructing a new local pumping station which provides an alternative pathway for storm water to be moved away from the flooding properties. It significantly reduces the risk of detrimental flooding of people's properties.

4.1 Final Solution

The proposed final solution to alleviate flooding for the 63 properties around Orchard Street is the widespread reduction of surface water entering the hydraulically overloaded Newport Tunnel Sewer. This will prevent the Tunnel Sewer from backing up to the flooding properties. It can also provide other benefits such as reductions in spilled volumes at existing CSOs as well as reductions in the amount of pumped/treated flow in the catchment.

Typical surface water removal opportunities include Blue-Green Infrastructure (BGI), included as part of DCWW's RainScape initiative. BGI Solutions provide opportunities for wider benefits to the community by providing new green space to urban areas all the while protecting them from sewer flooding.

As several different areas of Newport contribute flows into the Tunnel, looking at just surface removal opportunities locally around the properties will not resolve flooding completely and instead, investigating the whole catchment upstream of Orb SPS must be considered.

To facilitate the implementation of this type of solution, extensive catchment wide survey (over winter and summer months) is required. This survey will seek out these surface water removal opportunities, build increased confidence in the hydraulic model, and allow for the optioneering stage to take place. Optioneering will entail solution feasibility and development until a multi-phased delivery of the solution can be implemented across Newport.

A catchment approach to solutions will need to consider other regional risks and drivers, including sea level rise.

Figure 11 provides a timeline summarising this approach for Newport. The final solution will not provide protection of the flooding properties for at least 5 to 10 years. This means residents will continue to live with the risk of flooding. Therefore, a temporary solution is required to provide the necessary protection of these 63 flooding properties until the final solution is implemented.

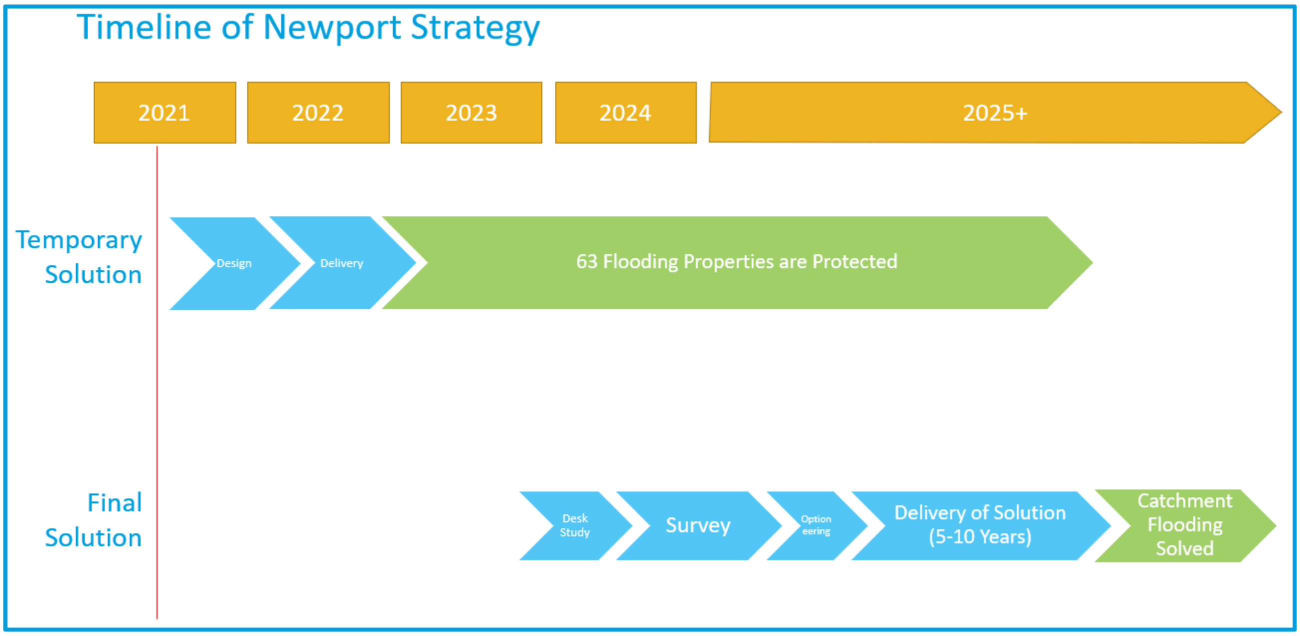


Figure 11 - Proposed Timeline of Newport temporary and final solutions

4.2 Temporary Solution

As the flooding properties will be at risk for an extended period of time until a final solution is implemented, a temporary solution is required to ensure this risk of flooding is mitigated in the shorter term. The options discussed in Section 3 were all re-considered again as temporary solutions, including variations of these options.

The temporary solution aims to minimise surcharging network before it causes detrimental flooding to properties. It consists of constructing local emergency relief pumping stations to activate in extreme storms. It considers engineering, hydraulic and spatial constraints alongside flood protection.

An optimization exercise was carried out in April 2021 where 3 potential pump locations local to the flooding area of concern were all considered either in conjunction or independently. The two drivers for the optimization process were:

a. to resolve the flooding at the flooding manholes outside flooding properties

b. to reduce spill volumes to the environment as much as possible

The 23rd of December 2020 event was ran as the optimization storm and the analysis found that two pumping stations of pump rates 409l/s and 437l/s would result in $0m^3$ of flooding around the properties. However, for this event alone, the pumping stations would spill approx. $9800m^3$ to the environment.

Post this early optimization process, outline design was carried forward and it was found that a singular pumping station of 300l/s would provide the necessary protection for storms up to a 1 in 5 return period and significantly reduce residual flooding volumes for larger return period storms. Also, a reduction in the spilled volumes to the environment is achieved in comparison to the initial number of pumping stations and pump rates considered.

The location of the pumping station means storm flows surcharging up from the Tunnel Sewer can be pumped out of the network locally before detrimental flooding occurs. As the root cause exercise found that flooding occurs when extreme storm events coincide with high tide scenarios, this pumping station provides the means to alleviate the local network while existing CSO outfalls in the network are tide locked. The other options discussed in Section 3, namely the Pump & Cut Solution, causes detrimental flooding elsewhere in the catchment while the 1500l/s SPS at Shaftesbury CSO requires much larger pump rates (and hence increased spilled volume to the environment) to achieve a similar level of protection as this temporary solution.

Table 2 - Costing of temporary solution

Option Name	**Approx. Level of Protection at flooding area**	**Estimated Option Cost (£)**	**Estimated Total Carbon Cost over 40 years (kg CO2e)**
Temporary solution (1x300l/s Local SPS)	1 in 5	£750,000	46,741

The timescale for this temporary solution is shown in Figure 11 and highlights how it will provide the necessary protection to the 63 flooding properties around the area of concern until the final solution is implemented.

5 Summary of Receiving Waters at Discharge Location

The River Usk is designated as a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC).

At the discharge point, the river is classified as a transitional water body with a 2018 WFD status of Moderate (Moderate status against dissolved inorganic Nitrogen).

Using NRW data from 2015-2020, the BOD, Ammonia and DO mean values and standard deviations have been taken for the river at the Newbridge on Usk monitoring point, approx. 9 km upstream (ST 38504 94821). This real data translates to the river having a Good BOD Status, a High Ammonia Status and High DO Status.

The River Usk drains to the Severn Estuary, which is designated as a SAC and a Special Protection Area (SPA).

The nearest current bathing waters are located near Barry, approximately 30 km away from the proposed discharge point. The nearest shellfish waters are in Swansea Bay, approx. 60 km to the West of the discharge point. With these distances from the discharge location, the temporary solution is unlikely to have an impact on these sensitive waters.

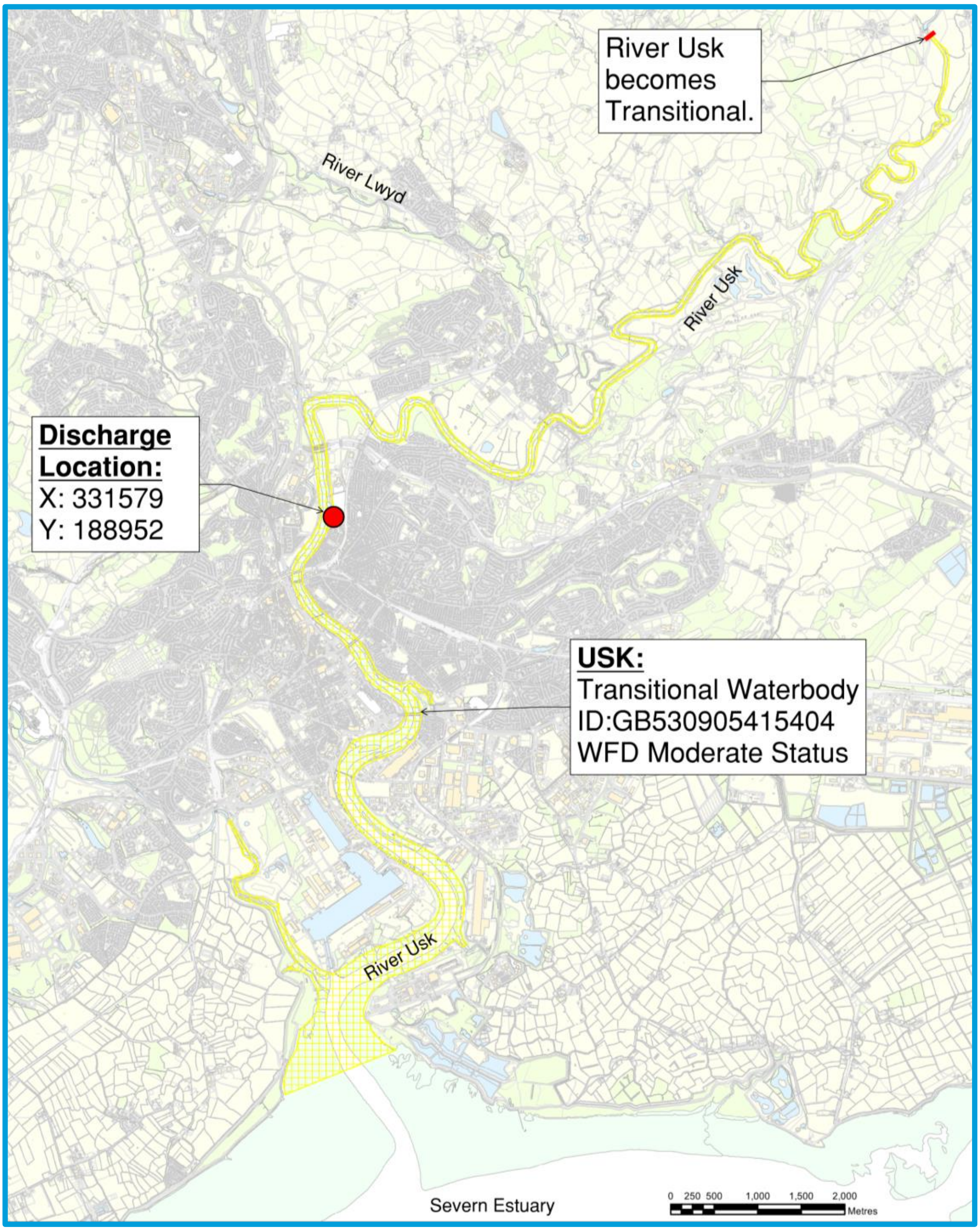


Figure 12 - Discharge Location

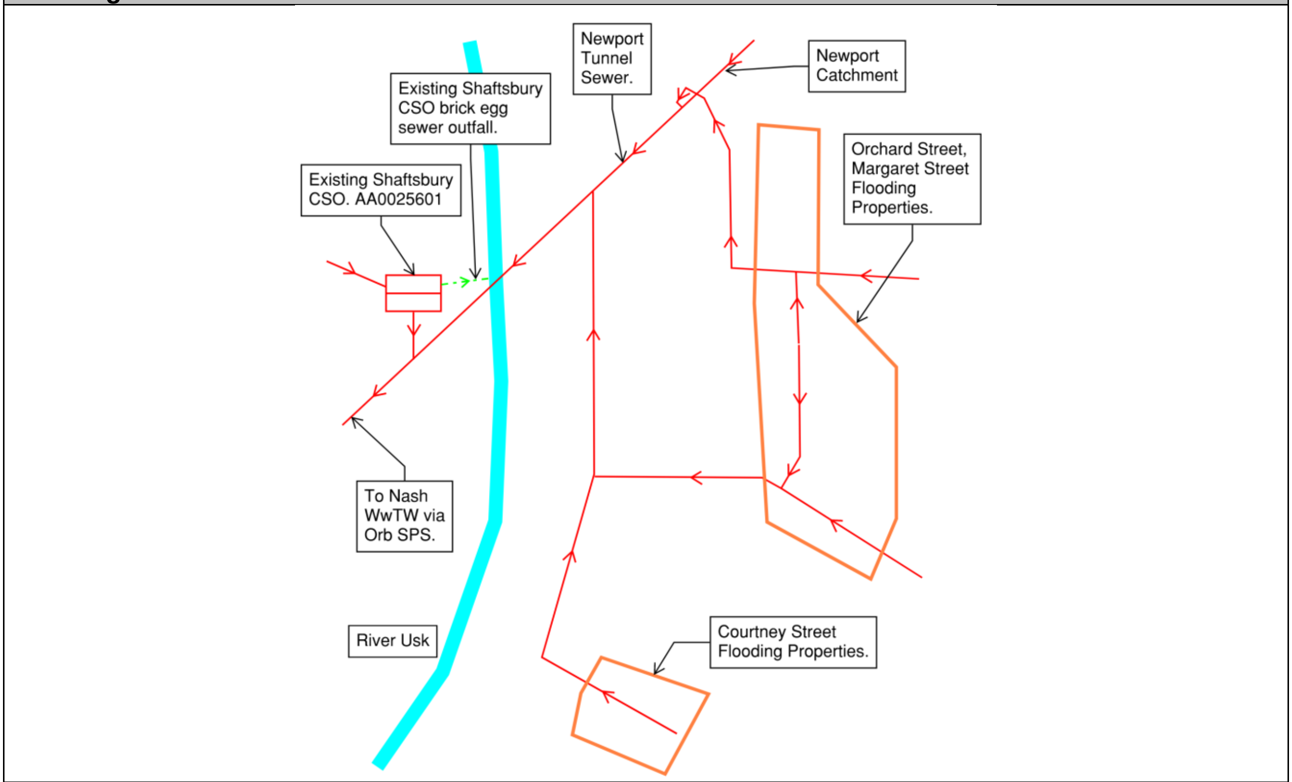
6 Existing and Proposed Performance

The temporary solution involves discharging stormwater to the River Usk during extreme storm events. The solution provides protection for up to 1 in 5 return period storms and significantly reduces residual flooding for larger return periods. The hydraulic model predicts 3 activations in 2019 and 2020 and further analysis showed these were tied to large UK storm events.

A water quality impact assessment was carried out in line with industry guidance and shows the temporary solution will have No Impact against the strictest WFD Thresholds.

6.1 Schematic

Existing Scenario Schematic



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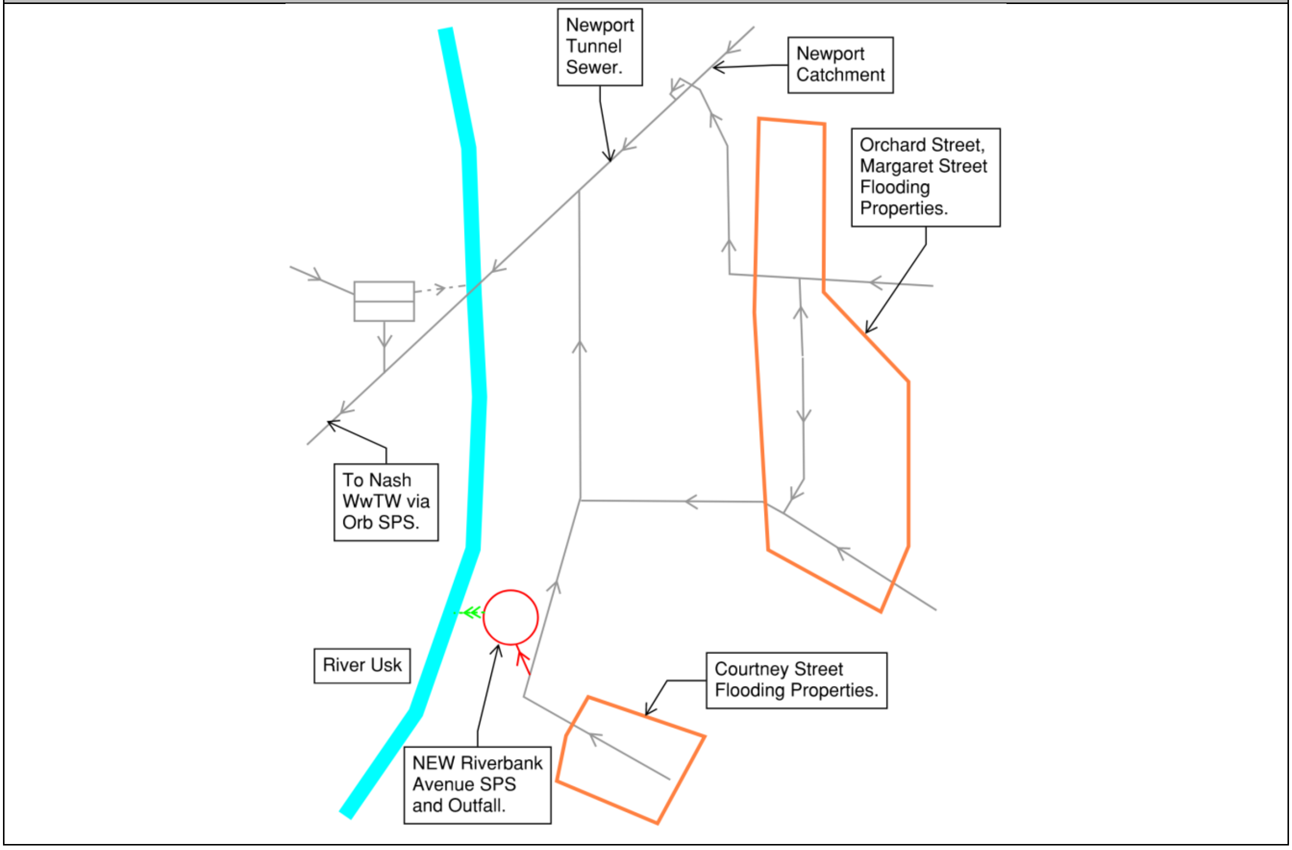
Proposed Scenario Schematic



6.2 Existing Performance

The existing situation in Newport results in flooding when extreme storm events coincide with high tide scenarios. The December 23rd 2020 event caused detrimental flooding to 63 properties. Without intervention, these properties will continue to be at risk of sewer flooding.

6.3 Proposed Performance

The temporary solution is designed to protect these 63 flooding properties. The pumping station rated to 300l/s provides the necessary protection for storms up to a 1 in 5 return period and significantly reduces residual flooding volumes for larger return period storms.

The hydraulic model was ran for 5 years and gives an indication of predicted annual spill frequency and annual spill volumes as shown in Table 3.

Table 3 - Summary of annual predicted pump activations

Year	Total Rainfall at Lodge Farm Frog Raingauge (NGR: ST3218491183) (mm)	SPS Predicted Annual Spill Frequency (no.)	Predicted Annual Spill Volume (m^3)
2016	1,098	4	4,320
2017	825	0	0
2018	925	0	0
2019	1,181	3	5,255
2020	1,259	3	7,290

The pump's switch on level has been chosen to ensure storm flow is removed from the network before it causes detrimental sewer flooding to properties. As the network surcharges in extreme weather events and high tide means existing CSOs are unable to alleviate it, the activation of the pump station provides an alternative pathway for flow that would otherwise cause flooding to be moved away from people's properties.

Figure 13 below shows the 2020 activations in more detail. The activations correlate with major storms that occurred over the year in addition to the flooding event that occurred on the 23rd of December.

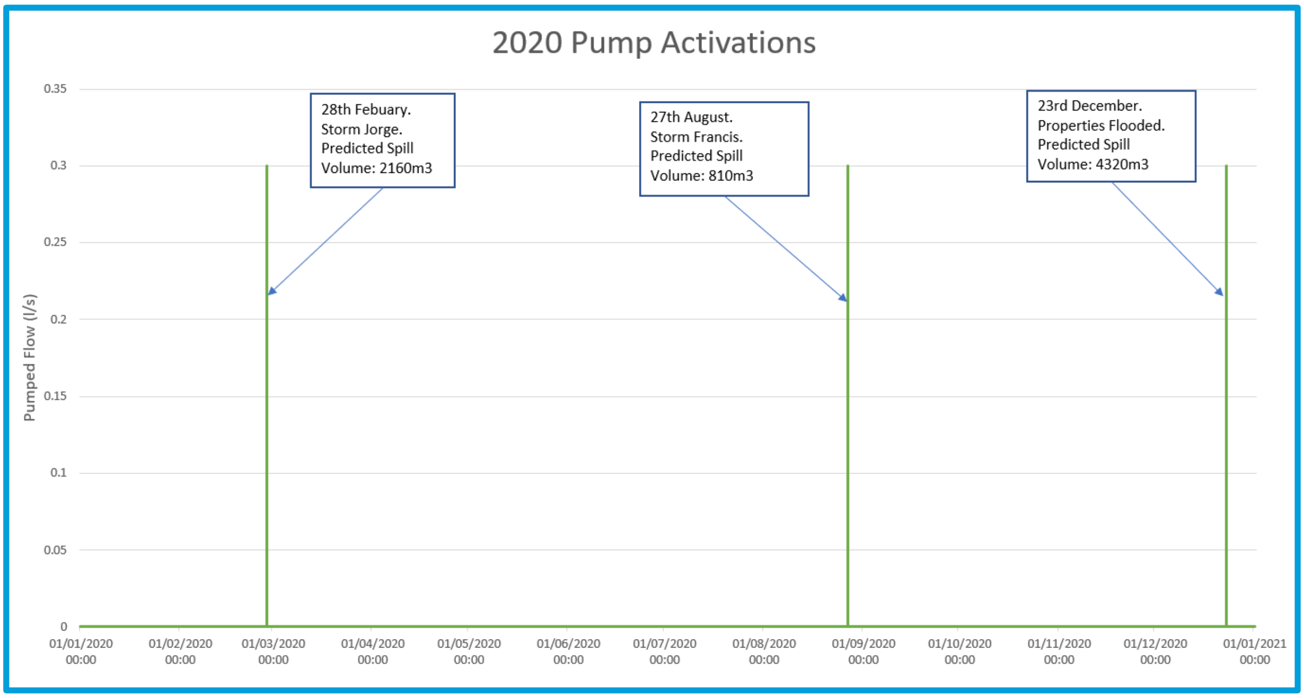


Figure 13 - 2020 Pump Activations

The return period of the events when these 2020 activations occurred has been calculated using joint probability analysis:

Table 4 - Joint Probability of Events where Pump activations are predicted for 2020

Event	Estimated Rainfall Return Period using FEH Online	Estimated Probability of tide locking during storm event	Joint Probability of Event
28th February 2020	1 in 2.01	1 in 2.5	1 in 5.025
27th August 2020	1 in 3.02	1 in 2.5	1 in 7.55
23rd December 2020	1 in 5.48	1 in 2.5	1 in 13.7

This analysis assumes that the tide level and rainfall are independent.

The return period of the rainfall events was calculated using the Flood Estimated Handbook (FEH) Web Service at the raingauge location (Lodge Farm Frog, NGR: ST3218491183).

6.4 Water Quality Analysis

The temporary solution will involve discharging stormwater flows to the River Usk containing dilute sewage that would otherwise cause property flooding. The river at the discharge location is described as a tidal river which are defined as typically river channels that are only partially affected by tide levels.

A water quality analysis has been undertaken to understand the impact of additional effluent caused by the temporary solution has on the watercourse and clearly convey the assumptions in the approach and analysis.

6.4.1 Approach

The Stormwater Overflow Assessment Framework (SOAF)[2] involves a Water Quality Assessment to assess the impact CSOs have on water courses. It is an industry standard approach and will be adopted for the purpose of this assessment. The SOAF Transitional and Coastal Water (TRaC) Addendum[3] was produced to provide a water quality impact methodology for overflows discharging to transitional and coastal waters.

The discharge location is best described as an Estuary/Near Tidal Limit since the River Usk at this location has a defined river channel and the low flow condition (when poorest water quality is most likely) is to be dominated by the river discharge when the tide is out.

For an Estuary/Near Tidal Limit discharge location, the SOAF TRaC Addendum allows for the standard river-style SOAF approach. Therefore, A dilution check of 8:1 of the Q95 of the riverine component of the flow to Dry Weather Flow is carried out first.

The guidance then states that “Where 8:1 dilution is not achieved, a more detailed assessment, to assess localised impacts […] using established river SOAF modelling techniques should be applied”.

The standard Level 1 SOAF Water Quality approach allows for the use of Innovyze’s Infoworks Integrated Catchment Modelling (ICM) inbuilt Urban Pollution Management (UPM) Tool to carry out a statistical modelling analysis. The tool follows the UPM3 Manual[4], which sets out the different 99th percentile thresholds to use. This tool is more advanced than a dilution check and uses discharge volumes directly from the hydraulic model and user inputted site-specific information to conduct the analysis. Time series outputs from the sewer model are mixed with random picks of upstream river flow and quality to build a statistical model against different Water Framework Directive (WFD) thresholds, the strictest of which is WFD High Status.

[2] Storm Overflow Assessment Framework (SOAF) Version 1.6 (002) March 2018
[3] Storm Overflow Assessment Framework (SOAF)Transitional and Coastal Water Addendum. Intertek on behalf of the Intermittents Task & Finish Group. October 2021.
[4] Urban Pollution Management Manual – Third Edition. Foundation for Water Research (FWR) 2012.

To aid this report, it was decided to carry out both the dilution check and the UPM Tool as per the SOAF guidance to give an indication of the impact the temporary solution has on the watercourse.

6.4.2 Inputs & Assumptions

The following inputs and any associated assumptions for this analysis have been summarised below:

- Wallingford HydroSolution's QUBE tool has been used to calculate the river flow data. Data was retrieved from the downstream end of the River Usk at the Tidal Limit. Although it is approximately 9 km U/S of the discharge location, the true flows at the discharge point will be greater than this and is it likely the tidal flows will be of a similarly large order of magnitude and hence a conservative approach to the river's actual flow data has been taken. A mean river flow of 30.09m^3/s and a Q95 of 4.208m^3/s was used.
- Real sample data from NRW's monitoring point 41000/R USK, NEWBRIDGE / ST 38504 94821 (approx. 9km U/S) has been used to input background BOD, Ammonia and DO levels into the tool. The data spans between 2015 and 2020 and increases the overall accuracy of the analysis.
- This approach considers the discharge effluent in isolation. There are other nearby assets that have not been added to the analysis. However, it has been assumed their impact would only form part of the existing baseline and should not be considered when assessing only the impact of the proposed temporary solution. Also, using actual sample data mitigates this somewhat and this is the SOAF default approach.
- The UPM tool considers only two pollutants, BOD and Ammonia, as per the agreed process.
- 2020's discharge volume was used for the analysis, where a total annual spill volume of 7,290m^3 was predicted to discharge to the river. The river flows and background pollutants are randomised over a year long period and mixed with this time series data. This is then carried out 10 times and averaged to understand the number of exceedances per year against different thresholds. 2020 was selected as it has the highest predicted annual spill volume compared to other years.
- The impact the temporary solution has on the Severn Estuary has not been carried out.

6.4.3 Results

The 8:1 dilution check was met, where a Q95 flow for the River Usk of 4,208l/s is greater than 8 times the DWF value upstream of the pumping station, calculated as 3.7l/s according to the verified hydraulic model. As a further check, the DWF of the whole Orb catchment has also been calculated as 298.9l/s, which still meets the dilution check against Q95 of the river flow.

As for the River SOAF Level 1 UPM Approach, it was found that the temporary solution has **no impact** against High WFD Status Thresholds. This is the strictest threshold and means the tool predicts there is a very small increase in the number of times pollutant levels reach 99 percentile concentrations set out by the UPM3 Manual.

To account for any inaccuracy in the hydraulic model and this approach, when the spill duration for each pump activation was doubled (and hence spill volume doubled), there was still **no impact** against High WFD Status Thresholds.

7 Solution Summary

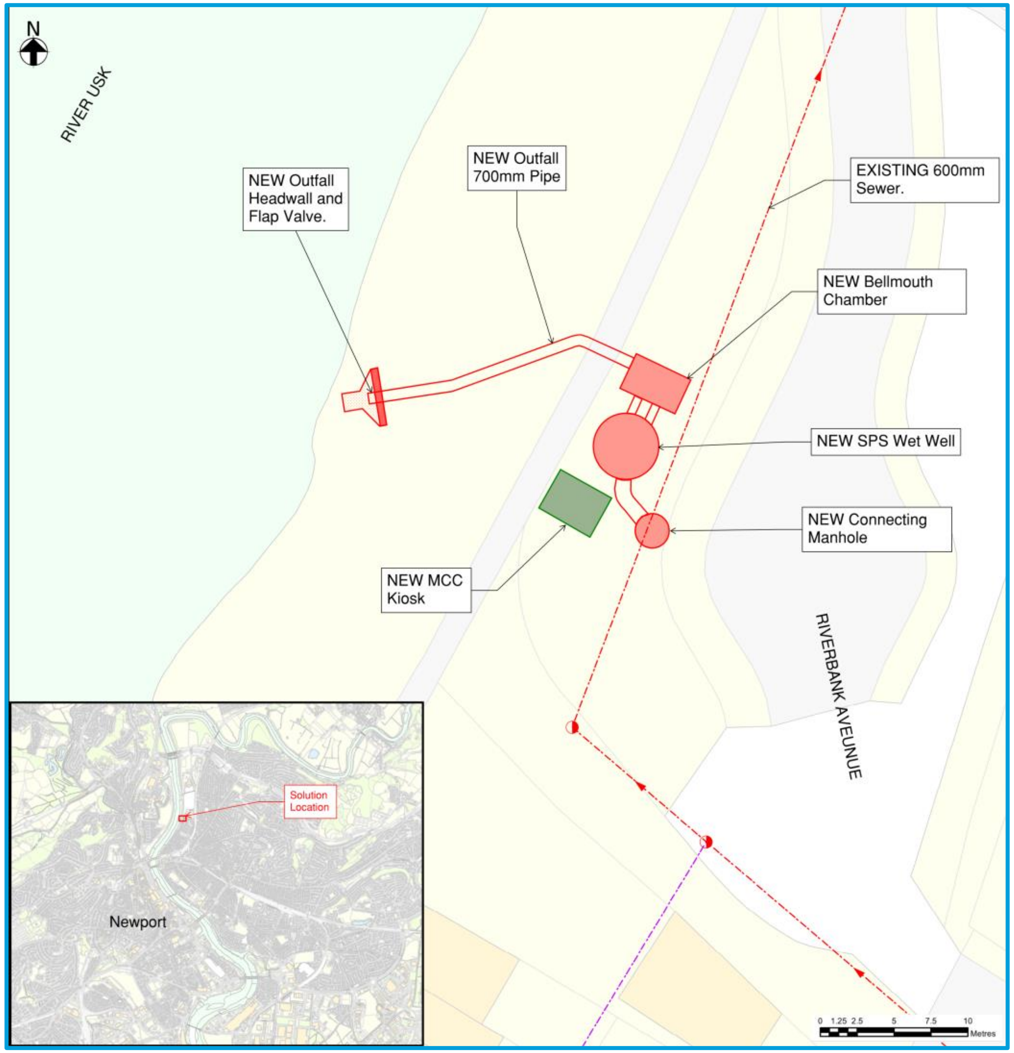
The final solution will involve a catchment wide survey to seek opportunities to reduce incoming high flows to the Newport Tunnel and by doing so, resolve flooding not only at the 63 flooding properties around Orchard Street, but across the whole catchment. The solution will involve implementing RainScape amongst other options across the catchment and provide wider benefits to the community by doing so.

However, the extensive catchment survey, modelling, optioneering and multi-phased delivery of the solution mean it will be at least 5 to 10 years until flood protection is provided to residents.

A temporary solution is proposed to provide flood protection until the final solution is implemented. This involves constructing a relief pumping station to alleviate the network during extreme rainfall, that can coincide with high tides. The temporary solution provides an alternative pathway for storm water to be pumped out of the local network that would otherwise cause detrimental flooding of properties.

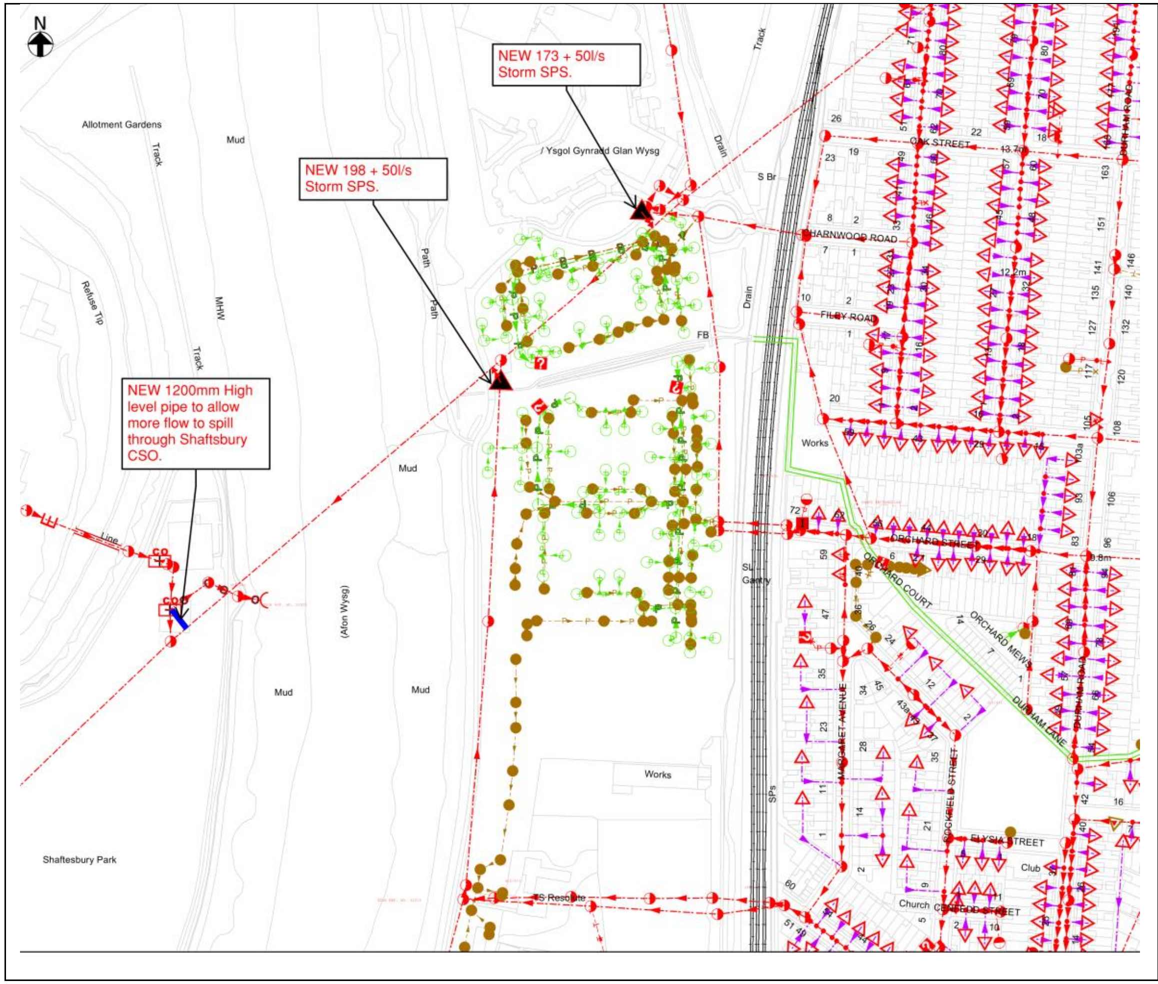
Appendix A

Proposed Solution


N
RIVER USK
NEW Outfall Headwall and Flap Valve.
NEW Outfall 700mm Pipe
EXISTING 600mm Sewer.
NEW Bellmouth Chamber
NEW SPS Wet Well
NEW Connecting Manhole
NEW MCC Kiosk
RIVERBANK AVEUNUE
Solution Location
Newport
0 1.25 2.5 5 7.5 10
Metres

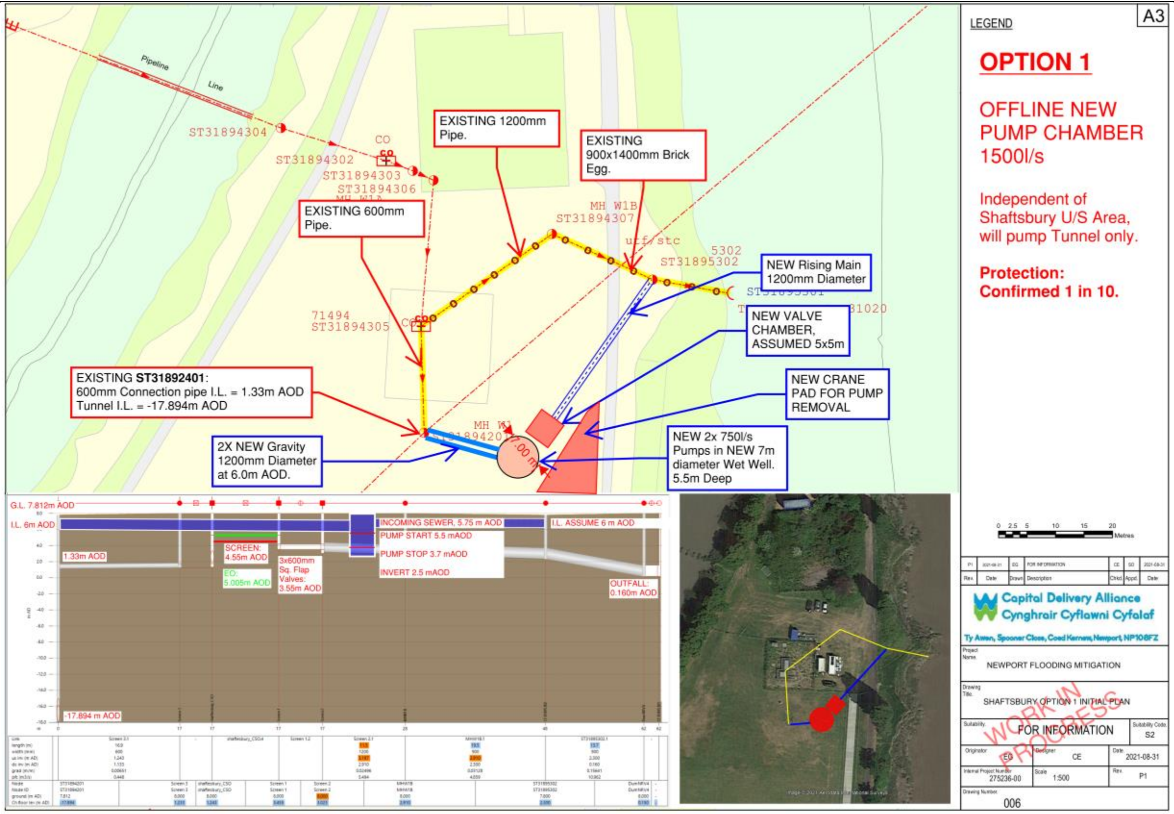
Appendix B

Options Not Progressed



Cut & Pump + Shaftesbury Modification

- Two New Storm Pumps to force flow away from flooding properties and into Newport Tunnel Sewer.
- Constructing new 1200mm diameter high level pipe at Shaftesbury CSO.



Shaftesbury Pumping Station

- New 1500l/s SPS to allow tunnel alleviation.
- 2 new 1200mm connections off tunnel to new Wet well.