Dŵr Cymru Welsh Water

Zonal Studies Methodology

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7th September 2016

Report Reference: Zonal Studies Methodology V4

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Amendment Record

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01	Ivan Gaston		Initial Issue	
02	Trystan Alun Davies	Bradley Hurford	General Revision	22/12/2015
03	Trystan Alun Davies	Bradley Hurford	General Revision	29/06/2016
04	Trystan Alun Davies	Bradley Hurford	Update to growth, critical assets and data sources	07/09/2016

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B10 Anglesey North Operations Workshop Original.pdf
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Dŵr Cymru Welsh Water Cost Benefit Methodology for Zonal Studies V2.pdf
L21 Abergavenny Cwmtillery Chronological Analysis.pdf
L21 Abergavenny Cwmtillery Mains Repair Analysis.pdf
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L21 Abergavenny Cwmtillery Customer Acceptability Analysis.pdf
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1 Executive Summary

A Zonal Study is a holistic investigation into the factors influencing performance at a Water Quality Zone level. Through the utilisation of all mains hydraulic modelling, statistical analysis and by capturing the experience and knowledge of local operations the Zonal Study is able to identify the root cause of poor performance within the Water Quality Zone in an integrated approach. All the outputs from the Zonal Studies are to be evidential, auditable and quantative. It therefore allows for targeted investment within the zone to most appropriately improve long and short term performance for the benefit of our customers and the business. Zonal Studies are a collaborative and integrated business as usual tool that will act as a streamlining tool through the capital gateway process and give a joined up strategic approach to investment.

2 Aim of Zonal Studies

The main aim of a Zonal Study is to identify investment requirements to achieve or exceed the desired performance targets while delivering regulatory outcomes, mitigating risk of asset deterioration and failure and optimising the asset whole life cost. This a cyclical process of continuous improvement, linked to other business functions, and is summarised in **Figure 1**.

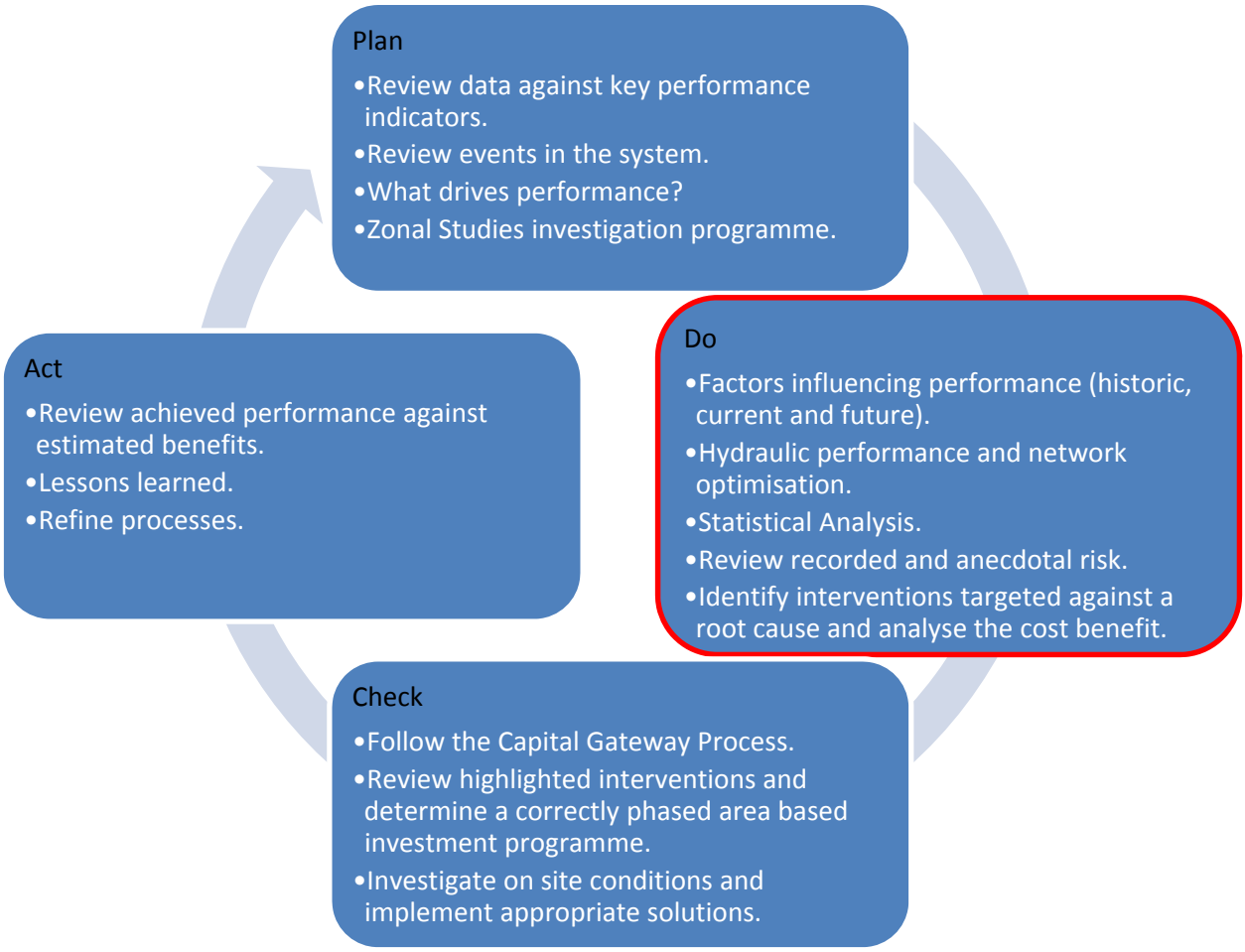


Figure 1: The Complete Zonal Studies Process

3 Zonal Study Key Steps

There are four key steps to the Zonal Studies process.

1. Targeting and Ranking
2. Root Cause Analysis
    a. Hydraulic Modelling
    b. Data Analysis
    c. Operations Workshop
3. Scheme Selection
4. Review and Finalise Reports

4 Targeting Zonal Studies

Zonal Studies are targeted by an annual assessment of key performance indicators using data from the most recent three year period. Currently the Zonal Studies programme is targeted against customer acceptability (appearance, taste and odour customer contacts). The 86 Water Quality Zones in Dŵr Cymru Welsh Waters' operating area are then ranked in ascending order (**Figure 2**), all using the software package Tableau 8.2. The Water Quality Zones are then sense checked against any capital maintenance that would have impacted the area during the three year period. This allows for the consistent and appropriate targeting of the Zonal Studies programme.

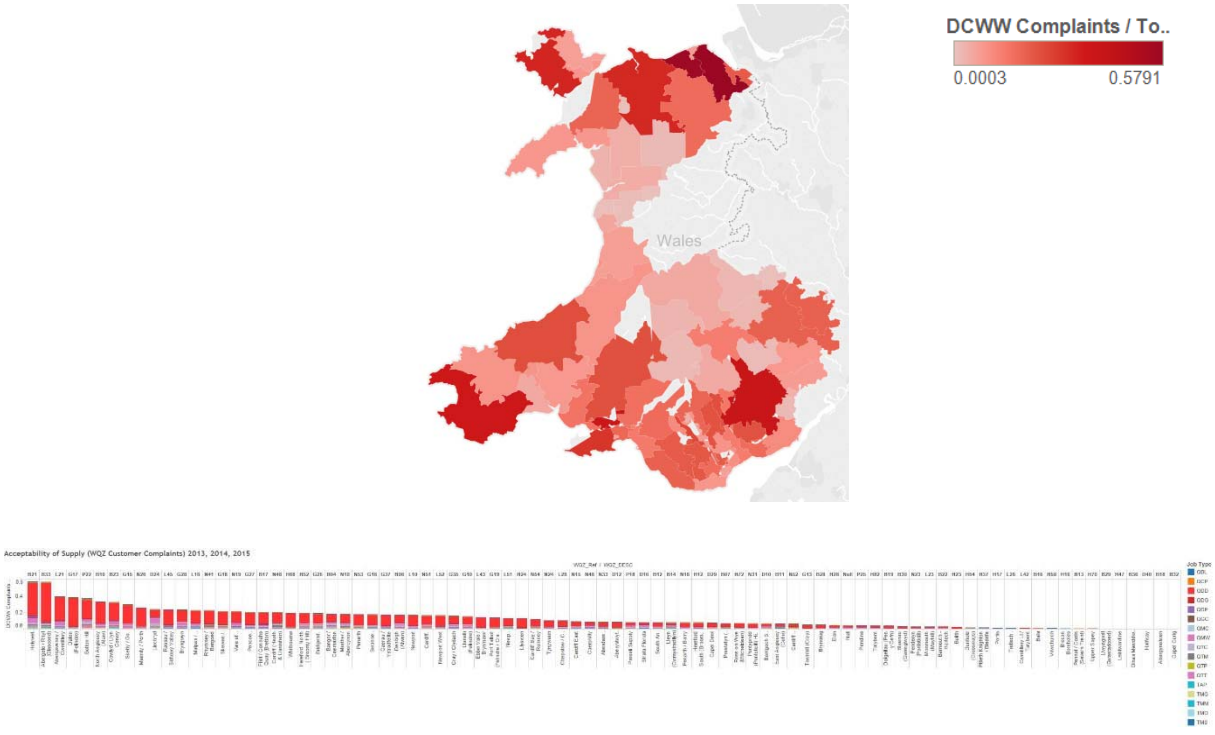


Figure 2: Performance review of Customer Acceptability

This review allows for the prioritised planning and completion of a fit for purpose all mains hydraulic model of the Water Quality Zone, led by the Dŵr Cymru Welsh Water Hydraulic Modelling Team, if one does not exist.

4.1 Measuring Performance

Dŵr Cymru Welsh Waters' Measures of Success considered in the Zonal Studies are:

- A1 Safety of Drinking Water - Considered by all MP failure codes.
- A2 Customer Acceptability of Water - Considered by all customer quality complaint codes.
- A3 Reliability of Supply - Considered by Customer Minutes Lost (CML), minutes per property.
- D2 At Risk Customers - Defined as customers who have experienced the same complaint or issue at least once a year for the last three years.
- F1 Asset Serviceability - Considered by bursts per 1000m.
- F2 Leakage - Considered by Ml/d.

As displayed on the previous page the performance of each Water Quality Zone directly aggregates to the company performance and targets. As such all benefits and impacts, whether scheme, Water Quality Zone or company, also have to be measured on the same, company level, scale.

A1 Safety and Acceptability of Drinking Water.

Although this is displayed as a percentage in the Measures of Success table it is measured as a numeric value by individual count, i.e. 2.

A2 Customer Acceptability of Water.

Customer Acceptability of Water is measured by complaints per 1000 population across all customer quality complaint codes. The estimated population for Dŵr Cymru Welsh Waters area of operations in August 2015 is 3,068,659. The calculation is displayed below.

Customer Acceptability of Water = (Number of Records) / 3,068,659 x 1000.

A3 Reliability of Supply.

Reliability of supply is measured by Customer Minutes Lost. The estimated number of customers for Dŵr Cymru Welsh Waters area of operations in August 2015 is 1,403,811. The calculation is displayed below.

Customer Minutes Lost (Reliability of Supply) = (time x properties) / 1,403,811 x 60.

D2 At Risk Customer Services.

Defined as customers who have experienced the same complaint or issue at least once a year for the last three years. This information will be supplied by Dŵr Cymru Welsh Water and is measured in a numeric value by individual count.

F1 Asset Serviceability.

Asset Serviceability is measured by bursts per 1km across all mains. The estimated length of mains for Dŵr Cymru Welsh Waters area of operations in August 2015 is 28,613,443m. The calculation is below.

Asset Serviceability = (Number of bursts) / 28,613,443 x 1000.

F2 Leakage.

Leakage is currently calculated on a DMA (District Metered Area) level basis. Leakage is to be attributed to the proportion of ferrous mains within the DMA.

This can then be succinctly captured in a performance table as featured in **Table 1**. The first two columns capture the specific measure of success being looked at. The third column shows the current company performance with the performance of the Water Quality Zone being studied in brackets. The forth column shows the required AMP6 company performance targets with the required performance targets of the Water Quality Zone being studied in brackets. The fifth column displays the maximum predicted improvement in the Water Quality Zone measure of success performance post intervention. Although the Zonal Study aims to achieve or exceed the desired performance targets in each zone it is not expect that this will always be the case (note the differences between, performance, targets and maximum potential benefits in **Table 1**).

	MoS	Current Company Performance (WQZ Ref)	Required AMP 6 Company Performance (WQZ Ref)	WQZ Predicted Maximum Benefit Post Intervention
A1	Safety of Drinking Water	99.997% (0)	100% (0)	100%
A2	Customer Acceptability (contacts/1000 pop/year)	3.2 (0.06)	1.23 (0.04)	0.0396
A3	Reliability of Supply (mins/customer/year)	48 (0.33)	12 (0.157)	0.041
D2	'At Risk' Customers	850 (20)	425 (10)	10
F1	Asset Serviceability (bursts per km)	0.123369 (0.0017)	0.152026 (0.0014)	0.0003
F2	Leakage	184 Ml/d (3.29 Ml/d)	169 Ml/d (1.74 Ml/d)	2 Ml/d

Table 1: Example Performance Table

For the purposes of any study the performance and targets of each area is provided. Also provided is the data used to generate these figures.

5 Hydraulic Performance Assessments

The purpose of conducting a hydraulic performance review of the study area is to understand the constraints that the water experiences as it passes through the network and the implications that may have on the service provided to our customers.

5.1 Growth and Development

As a statutory consultee Dŵr Cymru Welsh Water is frequently consulted on the capability of the networks to sustain development. Evaluating growth over the timeframe of a local development plan as part of the Zonal Study will allow for a detailed assessment of the suitability of the current network, any potential investment or even if growth can be a solution. A sequential maximum day hydraulic modelling assessment is necessary for every development within the study area in accordance with the Dŵr Cymru Welsh Water's Clean Water Modelling Specification to assess the impact of development and what, if any, new assets are required. All developments are to be collated in the below growth table (**Table 2**). The latter two columns in this table state whether the development can be supported and from which main.

Site Ref	Name	Development Type	No. of Props / Units to be built / ha developed	Assessed Demand (l/s)	Permitted / Not Permitted	Suitable Connection (BNG)
H0303	Land adjoining Hafan y Waun	Residential	129	0.93	Permitted	123456, 123456

Table 2: Development Estimated Consumption

Create an A3 pull out of a plot geographically displaying all development sites labelled with the site ref. The results of the hydraulic modelling assessment are to discuss the impacts of the development on the network, if any, and levels of serviceability achieved at the development and the critical points in the network. If the current network configuration is insufficient then levels of service resolutions are to be provided as schemes and noted at the base of the table. A growth model is to be provided in **Appendix A**.

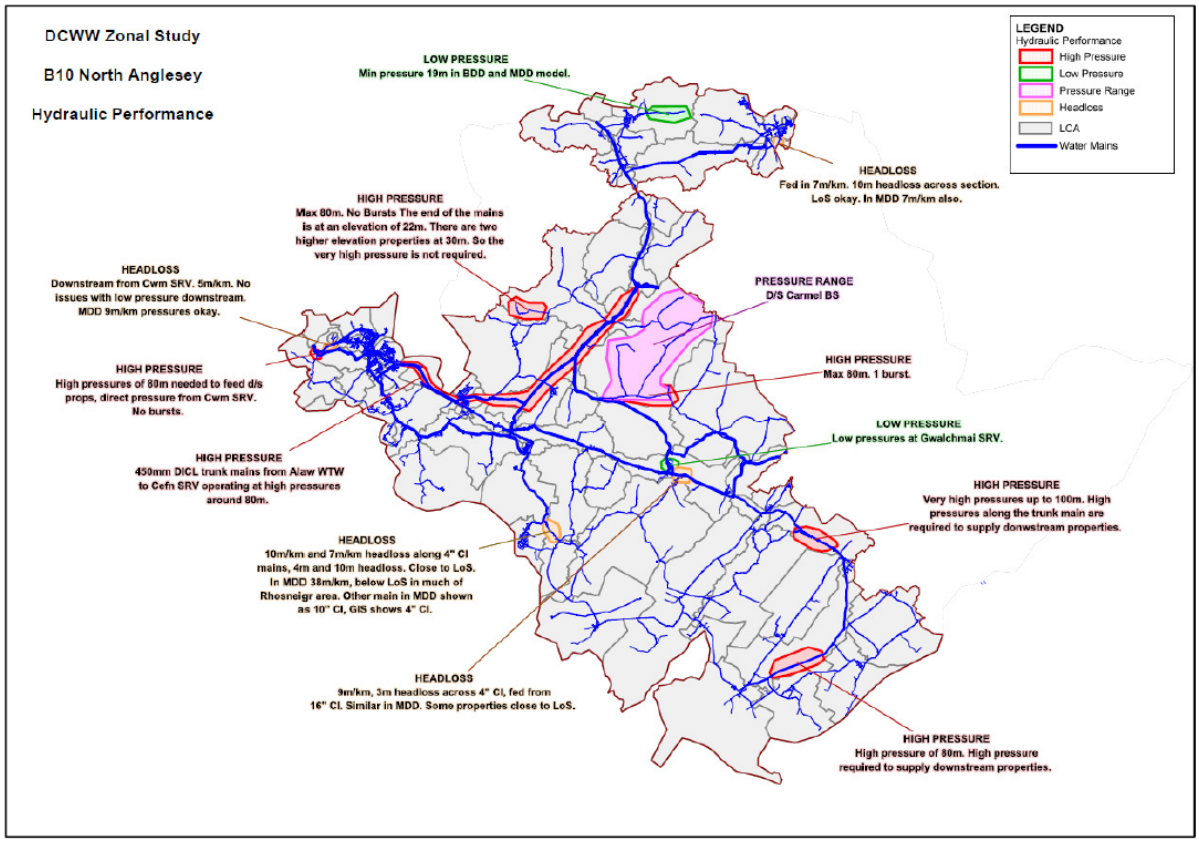
5.2 Hydraulic Performance

The below hydraulic metrics are to be analysed for current network conditions and potential network conditions following the growth assessment. A general overview of the system performance is necessary followed by detail on areas where Dŵr Cymru Welsh Water's minimum and maximum standards are breeched and to highlight any schemes that will aliveiate the issue.

Hydraulic Measure	Dŵr Cymru Welsh Water's Standards
Pressure	Minimum pressures of 15m at the customer's property. Maximum pressures in distribution areas of 70m Note pressure ranges of greater than 20m
Headloss	Maximum headloss gradients >5.0 m/km
Velocity	Note low mains velocities < 0.01 m/s Note high mains velocities > 1 m/s Maximum mains velocities > 3 m/s Note areas where shear stress is < 0.9 N/m² Note areas where water age exceeds 144 hours

Table 3: Dŵr Cymru Welsh Water's Hydraulic Standards

A summary plot highlighting areas of the network that fall outside of Dŵr Cymru Welsh Waters' tolerances concerning high pressure, low pressure, high pressure range, high headloss and high velocity is to be provided as an appropriately sized image with the hydraulic analysis section for both the current and future network. See **Figure 3**.



Hydraulic Measure	Polygon Colour
High Pressure	Dark Red Outline, Light Red Fill
Low Pressure	Dark Green Outline, Light Green Fill
High Pressure Range	Dark Magenta Outline, Light Magenta Fill
High Headloss	Dark Orange Outline, Light Magenta Fill
High Velocity	Dark Yellow Outline, Light Yellow Fill

Figure 3: B10 North Anglesey Hydraulic Performance Plot 2015 and Dŵr Cymru Welsh Water's Standard Legend Colours

Detailed plots of the hydraulic analysis are to be provided in **Appendix A**.

5.3 Non-Infrastructure Performance Review

Conducting a review of the non-infrastructure assets in the study area allows for the understanding of individual assets current and potential future performance and the impacts these can have on customers and the business. This is to begin at the source water and water treatment works using corporate and operations workshop information. The below **Tables 4** and **5** set out the detail required and format for capturing service reservoir and water pumping station information.

Table 4 : N26 Maerdy Porth Service Reservoirs										
Service Reservoir	Location (BNG)	Top Water Level (AOD) (m)	Volume (m^3) and Compartments	Properties Supplied		IMS Retention Time		Modelled Retention 2016	Modelled Retention 2030 (total growth)	Asset Notes
				Total	Direct	Summer (hrs)	Winter (hrs)			
Ffaldau (Ferndale)	298800, 197350	294m	Total 6675 Tank 1 2225 Tank 2 2225 Tank 3 Mothballed Tank 4 2225	17,113 (Trebanog SRV 6,228) (Porth SRV 5,190)	5,695	19	26	50	36	Retention exceeds 48 hours. Reduce operating level for 5 years until completion of downstream development. Asset inlet is level controlled by a ball valve. Customer acceptability contacts relating to chlorine. Secondary booster at site is not automated. Remaining asset condition is good.

Note:
Retention is to be analysed from the level of the average operating level down to the level of the outlet main or the minimum draw down level if the level of the outlet main is not available.

Table 5 : N26 Maerdy Porth Water Pumping Stations									
Water Pumping Station	Location (BNG)	Number of Pumps	kW Rating	Rated Capacity (Ml/d)	Energy Usage (kWh/Ml) and Efficiency (%)	Properties Supplied		Operation	Asset Notes
						Total	Direct		
Cymmer Hill	302368, 190587	2 (1 Isolated)	90	113m lift at 4.85 Ml/d. Model average output of 3.2 Ml/d. Insufficient capacity for future development	439.5 kWh/Ml 72.4% efficiency	Trebanog SRV (6,228)	0	Variable speed drive	PRV fitted at inlet (100m input - 20m output). No brown-out switch on WPS which trips in bad weather. Old BT comms line failures impact WPS supply. Pump number 1 needs to be reinstated to cater for future development. Building in a poor state of repair.

5.4 Air Valve Analysis

Conduct a network wide longitudinal analysis to determine if air valves are situated in suitable locations or if there are any missing air valves at suitable locations. Lidar data is to be used where available to improve the accuracy of the assessment. Note and air valves suspected of being faulty causing burst and potential quality issues. Recommendations are to be made in the report for new air valves with the detailed assessment to be contained within **Appendix A**.

5.5 Upstream Contact Tracing

Tracing helps to identify less obvious pipes that could be root cause of poor performance. Use the hydraulic model to trace upstream from each customer contact or water quality failure to identify the pipes that carried the water that eventually led to a customer contact. By superimposing traces for each contact it is possible to build up a layer showing the number of times a pipe potentially contributed to a historic contact. Obviously the pipes nearest the water treatment works will be identified in every trace, but further into the system it may be possible to locate sections of mains that could be contributing to issues some distance from the contacts or failures.

Tracing is not conclusive evidence that an asset is causing problems or is a risk in future. The technique is useful in adding weight to other indications of root causes. The outputs of this analysis are to be included in a plot in the report.

5.6 Innovative Model Analyses

Innovative modelling analysis, such as strategic or local network optimisation, the valve criticality module, the effectus module, surge analysis, etc. are to be employed to help run the network more effectively and to understand the impact of an event driven operational change and the resilience that is present within the current network.

5.7 Contingency Analysis

The purpose of the contingency analysis is to assess the ability to provide a water supply to customers in the event of an incident. This analysis takes account of the network capacity and focuses on rezoning the network, appropriate tankering locations and isolation areas that are too large or require a high number of valves to isolate. In any event Dŵr Cymru Welsh Water can deploy 1000m of 50mm lay flat hosing (rated at 60m) to assist as well as a tanker fleet detailed in **5.7.2. Tankering**. Following this it will be apparent what areas we can resupply and how in any incident but also areas where we would be unable to supply any service, these are to be noted in the report. The outputs of these analyses are to be discussed in the report as an assessment of the whole network contingency. Full details are to be provided in **Appendix A**.

5.7.1 Network Rezoning

In the event of an incident the primary method for ensuring the continuation of supply will be to rezone the network. This assessment looks at the ability to supply the local network if the inlet main is lost. There is a rank of five categories that is used to assess rezoning feasibility.

0 = More data required
1 = Existing contingency
2 = Existing contingency, additional resilience may benefit
3 = No effective contingency, minor solution required
4 = No contingency

0. More data required

This will be where the Leakage Control Area (LCA) forms the zone boundary with valves shown connecting to the adjacent zone but the model/s for the adjacent zone are not available at the time of analysis. There are also no other points of connectivity within the zone or feasible locations to create connectivity. Consideration is still required for tankering locations and isolation areas.

1. Existing contingency

There is sufficient capacity to supply all of the Leakage Control Area (LCA) whilst maintaining levels of service close to that under normal operation. There are multiple alternative pathways to supply the local network. No evidence of significant risk to maintaining supply.

2. Existing contingency, additional contingency may benefit

Levels of service are maintained but the network is stressed. High headloss and velocities observed through the alternative routes leading to a large diurnal pressure range impacting performance to some degree in the adjacent Leakage Control Areas. Assets such as water pumping stations or pressure reducing valves may need to be altered in this, or supplying, Leakage Control Areas to accommodate the required demand. The alteration to these assets will not increase pressure by greater than 20m from normal operating conditions or exceed 70m pressure within distribution. Consider recommending additional supplies, tankering locations and reducing isolation areas.

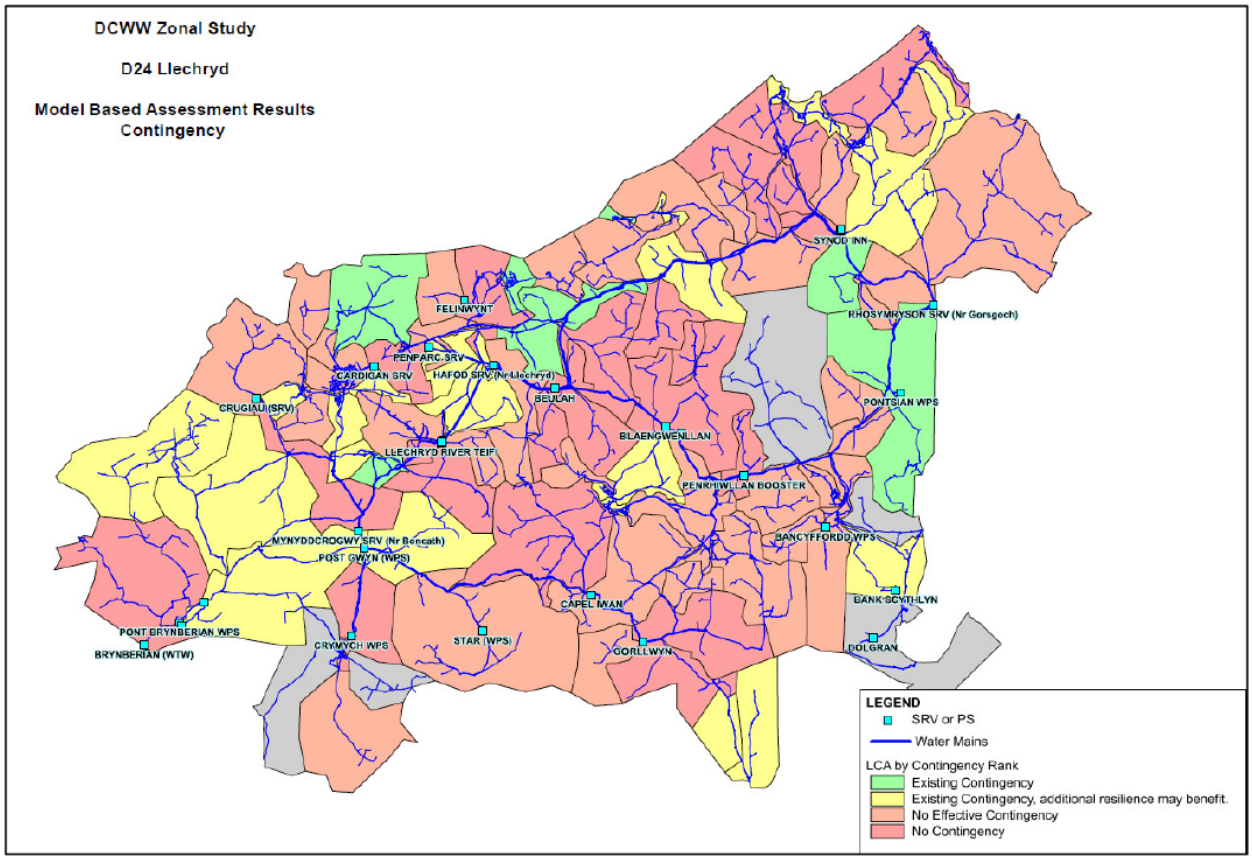
3. No effective contingency, minor solution required

Levels of service are not maintained and the network is stressed. High headloss and velocities observed through the alternative routes leading to large diurnal range impacting performance in the adjacent Leakage Control Areas. Assets such as water pumping stations or pressure reducing valves may need to be altered in this, or supplying, Leakage Control Areas to accommodate the required demand. The alteration to these assets will increase pressure by greater than 20m from normal operating conditions or exceed 70m pressure within distribution. Consider recommending additional supplies, tankering locations and reducing isolation areas.

4. No contingency

There is no contingency in this section of the network. If the inlet main is lost the Leakage Control Area cannot be supplied through rezoning. Recommend contingency schemes to accommodate additional supplies, tankering locations and reducing isolation areas where relevant.

The output of this analysis is to be included as a geographical plot in the report, coloured as detailed in **Figure 4**, with full details of the analysis to be provided in **Appendix A**.



Contingency Rank	Leakage Control Area Colour
0 - More Data Required	Dark Grey Outline, Light Grey Fill
1 - Existing Contingency	Dark Green Outline, Light Green Fill
2 - Existing Contingency, additional contingency may benefit	Dark Yellow Outline, Light Yellow Fill
3 - No Effective Contingency, minor solution required	Dark Orange Outline, Light Orange Fill
4 - No Contingency	Dark Red Outline, Light Red Fill

Figure 4: D24 Llechryd Contingency Analysis Plot and Dŵr Cymru Welsh Water's Contingency Analysis Legend Colours

5.7.2 Tankering

With tough targets to achieve for Customer Minutes Lost tankers are now being used not just to help manage large incidents but reduce the impact of smaller incidents on day to day network operations.

Dŵr Cymru Welsh Water employ three sizes of tankers, 16 25m³ artics, 7 18m³ demountables and a 5 13m³ rigids, all have pumps with the capability to deliver 10 l/s to 70m delivery head. Due to refilling times the retention time of a tanker cannot be less than 2 hours at maximum demand. An appropriate size tanker should be recommended based on the flow in the Leakage Control Area or potentially isolated area. The tankers would be ideally placed to ensure that minimum levels of service are maintained, to prevent flow reversal and, where possible, pass through the meter site for proof of flowing water to the regulator. However it is accepted that some Leakage Control Areas may be required to be split up into several tankering isolated areas due to the local conditions, such as configuration, demand or topography. Relevant recommendations should be made regarding extra XOX (valve, hydrant, valve) complexes required to support a tanker or multiple tanker locations within a Leakage Control Area or given area. The outputs of this assessment are to be discussed in the report, and in detail in **Appendix A**, and are to be provided as a shapefile of hydrant locations and their respective supply areas.

5.7.3 Isolation Areas

The size of an isolation area can cause a large impact on the properties affected and the operational mitigation used in the event of an incident. By assessing the below conditions appropriate recommendations can be made for the installation of XOX (valve, hydrant, valve) complexes.

1. Identify mains at risk of >3hr repair by material/size and mitigation available.
2. Identify mains with >4 valve operations to isolate.
3. Identify areas with a high number of properties in an isolation area.

5.7.4 Critical Assets

The contingency analysis also has to take into account critical assets and crossings that are within the study area. The definition of a critical asset is contained in **Table 6** below.

Asset Type	Criticality Definition
Source Water	Population Served > 5000
WTW	Population Served (direct feed) > 5000
WPS	Direct Population Served > 5000
SRV	Population Served (direct Feed) > 5000 and or with a cascade to another SRV with < 20 Hrs Storage
Trunk Mains both Potable and Raw Water including pipe bridges	Population Served >5000, not able to be served by alternative source. Crossing Vital infrastructure Rail – Main line e.g. Paddington Swansea and Holyhead Rail Classification. Crossing Vital infrastructure Major Road e.g. M4, A5, A470, A483, A465, A40, A49. Unable to isolate and rezone 450mm plus > 15 bar

Table 6: Critical Asset Definition

However a critical asset is also quantified as an asset that, in the event of a failure, Dŵr Cymru Welsh Water would be unable to maintain supply by any means to affected areas. The contingency assessments conducted in the Zonal Study allow us to understand the ability to isolate, rezone and tanker to any area. Any asset that:

1. Cannot be isolated while maintaining supply through a rezone or a short bypass,
2. Affected areas cannot be rezoned onto another supply, or
3. Requires > 50% tankering capacity at any one time to supply affected areas

Are to be noted as critical assets in the study area. The use of a plot to present the findings is acceptable where relevant. The Zonal Study is also to note where there are pipes crossing water courses, railway crossings and major highway crossings on a plot.

5.8 Is the Network Suitable?

A conclusion should be made at the hydraulic performance analysis reflecting on the results of the assessments. Although the condition and capacity of the network and assets are important this should also look at wider strategic plans such as; Total Loss Contingency Plans, Water Resources Plan, Drought Provision, etc. Highlight key issues identified and the suitability of the network, and assets within it, in its current format and for future purposes.

6 Data Analysis

Data analysis simplifies the relationship between cause and effect of incidents within the network over time. This data is often held in different corporate systems and brining it together allows us to paint a picture of an area's performance.

6.1 Chronological Analysis

A Chronological analysis will assess the correlations between contacts, failures (PVC and threshold across all determinands and parameters), bursts and pipe materials and condition. This will allow a simplified attribution of a failure and an impact. It will highlight the larger issues in an area as well as smaller continuous background issues. Relevant discussion is required in the report highlight key issues, trends and causes. An example of a Chronological Analysis plots can be found in **Appendix A**.

6.2 Spatial Analysis

Spatial Analysis will allow for the assessment of the geographical clustering of issues (contacts, failures, bursts, etc). This will aid in analysing interdependencies between issues and potential common causes. Relevant discussion is required in the report highlight key issues, trends and causes. An example of Spatial Analysis plots can be found in **Appendix A**.

6.3 Leakage Analysis

Leakage performance and targets are provided at a District Metered Area (DMA) level. These targets are set against our end of AMP6 targets which represents a tougher challenge than the 'best achieved leakage to date' figure. Correlate leakage against areas, material types and metering confidence from available sources and provide relevant commentary with and accompanying appropriately sized plot.

6.4 Corporate Risk

It is important to review the risk that is already kept within the corporate systems in the form of Drinking Water Safety Plans and Investment Manager Risks and Needs. Do the risks raised in either of these align to issues brought forth in the hydraulic and data analyses?

7 Operations Workshop

An operations workshop will follow the desktop review (performance assessment, risk review, hydraulic and statistical analysis). The aim of the operations workshop is to capture the knowledge and experience of the people who work the assets on a day to day basis. This allows the Zonal Study to identify anecdotal risks that are not otherwise captured within the corporate systems. This is an opportunity to highlight areas of poor performance and also to flag up opportunities for network optimisation to improve the way the system operates and performs.

Findings from the analysis conducted to date, problem areas and suggested interventions are discussed with key stakeholders who run and influence the systems.

The framework partner is required to have conducted the analyses before the workshop and send relevant informative plots with some narrative to the named Dŵr Cymru Welsh Water Project Manager. The Project Manager will then distribute these to the stakeholders. These plots and the results of the investigations conducted prior to the workshop will be used to question the stakeholders during the break out session.

Operations Workshop attendees to include, but not restricted to:

- Water Assets representative to chair
- Asset Performance Manager
- Water Asset Engineers and Technicians
- Distribution Manager
- Network Analyst
- Operations Supervisor, Inspectors and Technicians
- Leakage Manager, Supervisor and Technician (upstream and downstream losses)
- Catchment Scientist
- ME&I Supervisor
- Production Operations Supervisor and Engineers
- Process Scientist
- Water Quality Scientist
- Network and Production Risk Managers
- Hydraulic Modelling Team Representative
- Developer Services Representative
- Framework Partner

Outline agenda:

- Attendee introductions and an introduction to Zonal Studies (5 mins)
- Understanding of the zone operation (35 mins)
    - Introduction to the operation of the zone
    - Source Water and Water Treatment Works – historic, current and future issues
    - Asset performance review (Service Reservoirs and Water Pumping Stations)
    - Questions
- Identified Zonal Issues (35 mins)
    - Review of Drinking Water Safety Plans, IM Risks and Needs
    - Schemes currently in AMP6 plan
- Break (10 mins)
- Break Out Session (30 mins)
- Potential Solutions (35 mins)
    - Review Performance data – capture operational mitigations
        - Hydraulic Performance

        - Water Quality and Customer Acceptability
        - Customer Minutes Lost and Contingency
        - Leakage
        - Reactive Activity
    - Framework Partner identified holistic solutions, opportunities and queries
- AOB and meeting close out (5 mins)

A key output from the operations workshop are the annotated A0 schematic and GIS plots from the breakout session as these are detailed and geographically reference issues. The framework partner is to make an electronic copy of these onto one A0 GIS plot updated with the detailed notes of the discussion held and overlaid with the key points from the hydraulic and spatial analysis provided at the workshop (see **Appendix A**).

8 Scheme Selection

8.1 Scheme Types

Each scheme proposed in the Zonal Study has to be feasible and proportionate to long term performance improvements. For example, a trunk main has a low velocity due to its size and is causing dirty water. The system cannot be optimised to increase the flow to a reasonable level. Therefore cleaning is not a viable option so a renewal with a recommended downsizing should be promoted. Dŵr Cymru Welsh Water considers eight scheme types, as detailed in **Table 7**. The requirements for each scheme in the schemebook can be found in **Appendix B**.

Scheme Types	Heading and Scheme Colours	Scheme Definitions
Mains Renewal	Orange	Evidence of deterioration (bursts, NDT testing results, hydraulic restrictions, elevated irons/quality failures, etc).
Mains Cleaning	Green	Evidence of issues effecting customer acceptability or water quality failures and no evidence of deterioration.
Abandonment	Red	There is no longer a requirement for an asset in the network.
Pressure Management	Sky Blue (asset circled in red)	Installing or reconfiguring existing pressure regulating equipment.
Contingency	Blue (asset circled in red)	Schemes proposed to improve network contingency (XOX (valve, hydrant, valves), fixed jumper hydrants, connecting mains, tanks, pumping stations, etc)
Network Optimisation	Purple	Reconfiguration of the operation of the network by altering the sources or trunks that an area is fed from, creating or combining network areas or by reconfiguring the way water flows in a network.
Investigation	Yellow	Dŵr Cymru Welsh Water to investigate further. An effect can be observed but no evidence can be provided for a root cause. An asset is suspected of being a cause. Developments that cannot be supported or require network alterations are required to be investigation schemes.
Monitoring	Pink	An area of concern or a potential issue that may impact measures of success.

Table 7: Dŵr Cymru Welsh Water's Scheme Colours and Descriptions

8.2 Scheme Costs

All solutions, unless otherwise stated, are to be costed using the Dŵr Cymru Welsh Water Solution Target Pricing Tool. Standardised costs are applied to each scheme type. This should generate a cost above what would be expected in reality which is taken into account by Dŵr Cymru Welsh Water when assessing which schemes to progress after the final report. It is also recognised that schemes may contains aspects of other scheme types, such as a new link main as a contingency scheme. These are to be costed in the standardised methods for the relevant aspects.

8.2.1 Mains Renewals

All mains renewals are to be costed using the method; open cut urban, all depths and a new long side service connection for each service connected to the asset. The size of the main is to be costed using the existing, or metric equivalent, of the main being replaced. If there is the requirement or opportunity to downsize or upsize the main then this should be noted in the scheme description and scheme sheet but not costed for.

8.2.2 Mains Cleaning

All mains cleaning schemes are to be costed using the below rates defined (includes enabling costs).

Main Size	Cost per m to Clean
< 100mm	£5.14
100 – 150mm	£6.19
150 – 200mm	£8.29
200 – 250mm	£10.39
250 – 300mm	£13.54
300 – 350mm	£15.64
350 – 400mm	£17.74
400 – 450mm	£19.84
450 – 500mm	£24.04
> 500mm	£36.54

8.2.3 Abandonment

All abandonments are to be costed using the cutting and capping per mains size method as determined in the Solution Target Pricing Tool. If new services are needed the cost as a service in a mains renewal.

8.2.4 Pressure Management

All pressure management schemes are to be costed using the method:
New PRV: £10,800.
Optimising (flow modulation on existing PRV at a meter): £2,500.
Optimising (reducing or increasing a fixed pressure outlet): £500.
These do not include valve operations outside of the PRV complex.

8.2.5 Contingency

To install a new hydrant costs £3,000 and new valve costs are detailed below. These are inclusive of enabling costs and double flow stops.

Valve Size	Cost to Install a Valve
< 100mm	£6,000
100 – 150mm	£12,000
150 – 200mm	£20,000
200 – 450mm	£30,000
450 – 700mm	£71,000
700 – 1000mm	£91,000
> 1000mm	£152,000

8.2.6 Network Optimisation

The PRV optimising costs are stated above and the valve operating costs are detailed below.

Valve Size	Time Required and Hourly Cost	Cost to Plan Work and Operate Valve
< 100mm	4 hours at £40 per hour	£160
100 – 150mm	8 hours at £40 per hour	£320
150 – 200mm	10 hours at £40 per hour	£400
200 – 450mm	16 hours at £40 per hour	£640
450 – 700mm	24 hours at £40 per hour	£960
700 – 1000mm	32 hours at £40 per hour	£1,280
> 1000mm	40 hours at £40 per hour	£1,600

A cost of £104.52 per Ml for 2.5 times the volume of the main if an optimisation will result in flow reversals or for increased demands at the required peak flow. An additional cost of £30 per hour for operations time to flush is required.

8.3 Cost Benefit Analysis

The cost benefit analysis for the proposed interventions utilises an adapted version of the Dŵr Cymru Welsh Water Cost Benefit Methodology, which will be provided for the study. The slight change is that the Dŵr Cymru Welsh Water Cost Benefit Methodology focuses on specific contacts as opposed to potential number of affected customers. By focusing on the risk and not the contacts the Zonal Study is able to more effectively target long term performance. The outputs of the cost benefit methodology give a 'for every £1 spent = £x benefit' for each scheme. This is then plotted on a curve against the cumulative cost of solutions with specific solutions labelled. See **Figure 5** for an example. Solutions are required to be named according to their cost benefit ranking (i.e. 1, 2, 3, etc…) which is to be considerate of interdependencies as described in the cost benefit methodology.

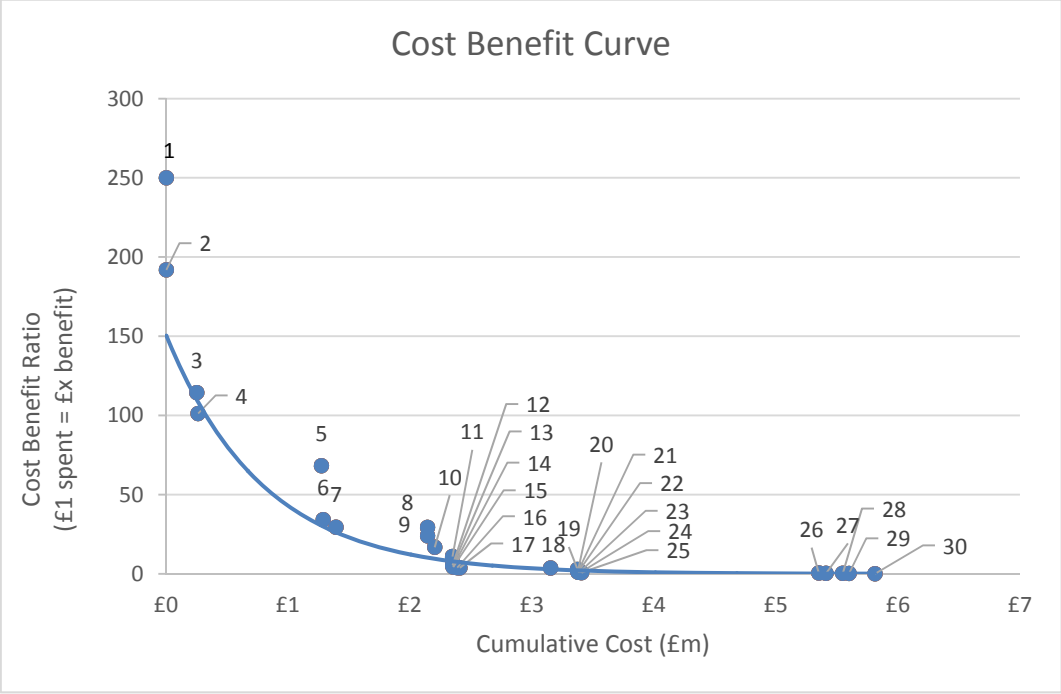


Figure 5: Cost Benefit Curve

In the Scheme Benefits section of the report, below the cost benefit curve, a table of solutions by cumulative cost, in cost benefit ranking order, is required (**Table 8**).

Cumulative Cost (£m)	Solutions	No. of Solutions
0-1	1, 2, 3, 4	4
1-2	5, 6, 7	3
2-3	8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18	11
3-4	19, 20, 21, 22, 23, 24, 25	7
4-5		0
5-6	26, 27, 28, 29, 30	5
Monitoring	31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41	11
Investigation	42, 43, 44, 45, 46, 47, 48	7

Table 8: Optimised Solutions Output

9 Review and Finalise Reports

9.1 Report Structure

Executive Summary — Brief outline of the report and a summary of conclusions and recommendations

Introduction — A general introduction including the purpose of the study, performance and targets against measures of success (use **Table 1**), Key drivers and deliverables.

Study Area Description — A detailed description of the study area from source to tap.

Risk Assessment — Detailed review of the hydraulic, statistical and risk analyses.

Solutions Summary — A summary of the solutions identified, accompanied by an overview plot, and detail for any non-standard analyses or solutions.

Scheme Benefits — Detailed conclusions covering an overview of the impacts on the measures of success, highlighting of other issues, scheme benefits summary, predicted performance improvement and the cost benefit analysis.

Appendix A — Hydraulic Analysis, Air Valve Analysis, Contingency Analysis and Shapefiles, Chronological Analysis, Spatial Analysis and Ops Workshop Plots.

Appendix B — Scheme Overview Plot, Schemebook, Scheme GIS Shapefiles, Needs Scoring Sheet.

Appendix C — Executive Summary Report

9.2 Reporting Standards

Parameter	Details	Example/Notes/Actions
Attachment Names	Draft and Final Report Summary Report Growth Model Air Valve Analysis Contingency Analysis Contingency Shapefiles Needs Scoring Sheet Shapefiles	WQZ Ref WQZ Name Draft/Final Zonal Study Report WQZ Ref WQZ Name Zonal Study Summary Report WQZ Ref WQZ Name Growth Model MDD WQZ Ref WQZ Name Air Valve Analysis.xlsx WQZ Ref WQZ Name Contingency Analysis.xlsx WQZ Ref WQZ Name Tankering Points/Supply Area Polygons WQZ Ref WQZ Name Needs Scoring Sheet WQZ Ref WQZ Name Scheme Type Points/Lines/Polygons
Boundary / Location Name	Water Quality Zone District Metered Area Leakage Control Area	WQZ Reference WQZ Name DMA Name (DMA Reference) LCA Name (LCA Reference)
Unsuitable Assets / Asset Operation	GRP Mains Ball Valves Manual Chlorine Dosing SRV Retention >48 hours Abandoned assets not severed from the system	Replace / Abandon Change Controller Automated Dosing Optimise the tank/supplied areas or abandon if not needed. Abandon
Acronyms	All	To be avoided as much as reasonably possible

9.3 Review Sessions

9.3.1 Draft Review

The operations review meeting follows the issuing of the Draft Zonal Study Report. The aim of this meeting is to ensure that the Final Zonal Study Report is sufficiently accurate to enable the sign off of the report and the progression of the proposed solutions through the capital gateway process. The meeting will highlight any inaccuracies that may have been featured in the report and will review proposed solutions.

Operations Review Meeting attendees to include, but not restricted to:

- Water Assets representative to chair
- Asset Performance Manager
- Water Asset Engineers and Technicians
- Distribution Manager
- Network Analyst
- Operations Supervisor, Inspectors and Technicians
- Leakage Manager, Supervisor and Technician (upstream and downstream losses)
- Catchment Scientist
- ME&I Supervisor
- Production Operations Supervisor and Engineers
- Process Scientist
- Water Quality Scientist
- Network and Production Risk Managers
- Hydraulic Modelling Team Representative
- Developer Services Representative
- Capital Delivery Representative
- Framework Partner

Outline agenda:

- Attendee introductions and an introduction to the Zonal Study Report (5 mins).
- The framework partner will present the report and its findings covering off the following points on a chapter by chapter basis (30 mins):
    - What does the chapter aim to achieve
    - What analysis was conducted
    - Key points that the analysis displayed
- The framework partner will then present the Scheme Book and the root causes each scheme targets (60 mins).
- AOB and meeting close out (5 mins)

Alterations made to the report and the schemes following the review process are to be documented. This document is to be provided with the final report.

9.3.2 Final Review

The signoff meeting is the final stage of the Zonal Study review. The aim of this meeting is to gain the approval of the report, its findings and the proposed solutions. This will enable the implementation of the proposed solutions through the capital gateway process.

Attendees to include, but not restricted to:

- Water Assets Network Lead
- Asset Performance Manager
- Water Asset Engineers
- Network Analyst

- Distribution Manager
- Head of Distribution
- Head of Water Assets
- Head of Capital Delivery
- Hydraulic Modelling Manager
- Capital Delivery Manager
- Framework Partner

Agenda

- Attendee introductions and an introduction to the Zonal Study Report (5 mins)
- Review the report and its findings against the draft review (40 mins)
- The framework partner will then present the Scheme Book and the root causes each scheme targets (40 mins).
- Signoff the report:
    - Asset Performance Manager
    - Distribution Manager
    - Head of Distribution

10 Project Management and Timescales

Dŵr Cymru Welsh Water project roles are allocated at the outset of each Zonal Study accompanied by relevant contact information. Any enquiries regarding the project are to be directed to the named Dŵr Cymru Welsh Water Project Manager. A project schedule is provide in **Table 10** but this only provides allocated time and not specific dates.

Milestone	Time Allocated (Weeks)	Cumulative Time (Weeks)
Project award and commencement	-	-
Data collection and verification	1	1
Statistical analysis	3	4
Hydraulic analysis	3	7
Operations workshop	1	8
Solution Development	4	12
Draft report with all supporting information	1	13
Review meeting	2	15
Final report with all supporting information	1	16
Project sign off	1	17

Table 10: Project Schedule

This is to be presented in a format similar to the below Gantt Chart (**Figure 6**) inclusive of the modelling activities relevant to the study area.

Figure 6: Example Gantt Chart

This chart will be used to inform a weekly conference call and a monthly face to face meeting with the named Project Manager. Any risks and opportunities to the project are to be discussed in this call. The frequency of catch ups will be determined by the named Project Manager specific to the needs of the project/s. Issue and opportunity reporting is not restricted to these forums and is encouraged through regular contact with the Project Manager.

11 Data Sources

Where possible data is to be used from business as usual processes to minimise duplicated effort. As information changes overtime always ensure that the most up to date methodology, specifications and information sources are being used. If any issues with data collection are experienced contact the named Dŵr Cymru Welsh Water Project Manager

Category	Data - Description	Source
AIM Deterioration Modelling Outputs and Asset Condition Data	Trunk AIM Data	Water Assets
	Distribution AIM Data	Water Assets
	Non-infrastructure AIM Data	Water Assets
	Service Reservoir condition data	Water Assets
AMP6 MoS Figures and Performance	MoS Figures and WQZ Performance and Targets	Water Assets
	CML Performance	Water Assets
	Customer Acceptability Performance	Water Assets
	Water Quality Performance	Water Assets
	Asset Performance Data (unplanned maintenance)	Water Assets
At Risk Customers	At Risk Customers	Water Assets
Capital Delivery Tracker	AMP6 Schemes and Shapefiles	Water Assets
DG2 Register	DG2 Register	Water Assets
Drought Measures Report	Appendix 1 – Water Resource Zone Summaries	Dŵr Cymru Welsh Water Website
Drinking Water Safety Plans	Catchments	Water Assets
	Water Treatment Works	Water Assets
	Networks	Water Assets
	Service Reservoirs	Water Assets
DWI Events	Index of DWI Events and Actions	Water Assets
Cost Benefit Analysis	Cost Benefit Methodology for Zonal Studies V2	Water Assets
Customer Complaints and Quality Data Shapefiles	Quality Sample Data	GIS
	Customer Complaint (Quality)	GIS
	Customer Complaint (Interruption)	GIS
	Customer Complaint (Low Pressure)	GIS
	Customer Complaint (High Pressure)	GIS
	DG7 Customers	GIS
Network Shapefiles	Cl. Boundary Valves	GIS
	Cl. Pipe Repairs	GIS
	Cl. Control Valves	GIS
	Cl. Hydrants	GIS
	Cl. Meter	GIS
	Cl. Network Structure	GIS
	Cl. System Valves (Distribution)	GIS
	Cl. System Valves (Trunk)	GIS

	Cl. Water Main	GIS
	Water Quality Zone	GIS
	DMA	GIS
	LCA	GIS
	Postcode	GIS
	Customer Info	GIS
	Seeded Properties	GIS
Background Layers	OS 50K	GIS
	OS 10K	GIS
	Area (B/W)	GIS
Growth	Local Development Plans	Local Authority
	Committed Sites	Water Assets
	Joint Housing Land Availability	Water Assets
	Infill	Water Assets
	Development Plans - Objections	Water Assets
	Dŵr Cymru Welsh Water Clean Water Hydraulic Modelling Specification	Hydraulic Modelling Team
Investment Manager Reports	WQZ Risks Report	Water Assets
	WQZ Needs Report	Water Assets
	WQZ Solutions Report	Water Assets
IMS Documents	Water Treatment Works	Infozone
	Service Reservoirs	Infozone
	Water Pumping Stations	Infozone
Leakage Spreadsheet	DMA Leakage Performance and Targets	Water Assets
Hydraulic Models and Reports	Calibrated, BDD and MDD	Hydraulic Modelling Team
Quality Sample Data	Data for all determinands / parameters	Water Assets
Reactive Activity	High frequency alarm analysis conclusions	Water Assets
	Network - Reactive Activity	Water Assets
Schematics	Schematic of the WQZ	Infozone
Total Loss Contingency Manual	Measures identified to improve network resilience	Infozone
Water Resources Management Plan	Water Supply Demand Balance	Dŵr Cymru Welsh Water Website

12 Appendix A

12.1 Hydraulic Performance Plots

Create appropriately sized hydraulic performance plots for current and future conditions across the below measures. An overview page is required for the hydraulic performance plots explaining what each measure means and why certain results or good or bad. This is so that any potential reader can understand them. The overview page is to be accompanied by the plots mentioned in **Figure 3**. Areas that exceed where Dŵr Cymru Welsh Water's minimum and maximum standards, as shown in **Table 3**, are to be annotated. The hydraulic model for growth accompanies this appendix.

12.1.1 Minimum and Maximum Pressure

Pressure	Node Colour
< 10m	Red
10 – 15m	Orange
15 – 30m	Yellow
30 – 45m	Green
45 – 70m	Blue
> 70m	Black

12.1.2 Pressure Range

Pressure Range	Node Colour
< 5 m	Blue
5 – 10 m	Green
10 – 15 m	Yellow
15 – 20 m	Orange
20 – 30 m	Red
> 30 m	Red (double thickness), labelled with pressure range

12.1.3 Minimum and Maximum Velocity

Pipe Velocity	Pipe Colour
< 0.5 m/s	Blue
0.5 – 1.0 m/s	Green
1.0 – 1.5 m/s	Yellow
1.5 – 2.0 m/s	Orange
2.0 – 3.0 m/s	Red
> 3.0 m/s	Red (double thickness), labelled with velocity

12.1.4 Maximum Headloss

Pipe Headloss Gradient	Pipe Colour
< 1.0 m/km	Blue
1.0 – 2.5 m/km	Green
2.5 – 5.0 m/km	Yellow
5.0 – 10.0 m/km	Orange
10.0 – 20.0 m/km	Red
> 20.0 m/km	Red (double thickness), labelled with headloss gradient

12.1.5 Water Age

Water Age	Pipe Colour
< 24 hrs	Blue
24 – 48 hrs	Green
48 – 72 hrs	Yellow
72 – 96 hrs	Orange
96 – 144 hrs	Red
> 144 hrs	Red (double thickness), labelled with water age

12.1.6 Shear Stress

Shear Stress	Pipe Colour
< 0.01 N/m²	Red
0.01 – 0.1 N/m²	Orange
0.1 – 0.5 N/m²	Yellow
0.5 – 0.9 N/m²	Green
0.9 – 1.5 N/m²	Blue
> 1.5 N/m²	Black

12.2 Air Valve Analysis

Create an appropriately sized plot for containing the locations of recommended air valve locations. Attach with this an excel file displaying the locations (in BNG and latitude - longitude) and the elevation of the proposed asset, see **Air Valve Analysis.xlsx** attached.

12.3 Contingency Analysis

Attach an A3 plot of the contingency assessment and an excel file displaying the relevant information required for both the rezoning and tankering assessments, see **Contingency Analysis.xlsx** attached. Also create GIS Shapefiles for the tankering points and the polygons for the areas they supply.

12.4 Chronological Analysis

Please see the attachments **L21 Abergavenny Cwmtillery Chronological Analysis** and **L21 Abergavenny Cwmtillery Mains Repair Analysis**.

12.5 Spatial Analysis

Please see the attachments **L21 Abergavenny Cwmtillery Water Quality Analysis, L21 Abergavenny Cwmtillery Customer Acceptability Analysis, L21 Abergavenny Cwmtillery Customer Minutes Lost Analysis,** and **L21 Abergavenny Cwmtillery Burst Analysis**.

12.6 Operations Workshop Plot

Please see the attachments **B10 Anglesey North Operations Workshop Original** and **B10 Anglesey North Operations Workshop Notes**.

13 Appendix B

13.1 Scheme Overview Plot

Please see the attachment **P22 Bolton Hill Overview Plot**.

13.2 Schemebook and GIS Shapefiles

The Scheme Book has been developed to suit the requirements of Dŵr Cymru Welsh Water. See **Pages 34** and **35**, each box is explained below:

Page 1 - Scheme Summary:

1. WQZ: H52. This is the Water Quality Zone reference number
2. LCA Ref: 1NHED253. This is the reference number of the specific Leakage Control Area which contains the solution.
3. LCA: NORTON PRV. This is the name of the Leakage Control Area which contains the solution.
4. Scheme: 2. This is the cost beneficial rank of the scheme and acts as the scheme number.
5. Pressure Management. This is the specific type of scheme.
6. Dŵr Cymru Welsh Water logo and space for contractor logo.
7. Description. Explanation of the risk and proposed solution
8. Details about the scheme drivers, impacts and benefits
9. Predecessor Scheme: A scheme on which the success of other schemes relies
10. Dependant Scheme: A scheme that relies on the implementation of a predecessor scheme.
11. Impacts on the measures of success and the cost of the solution.
12. Image of the proposed scheme containing all relevant information and using Dŵr Cymru Welsh Water GIS symbology.
13. Legend.
14. Coordinates at the location of an asset installation (such as a valve or hydrant) or the hydraulic start point of a scheme.

Page 2 - Scheme Justification:

1. Specific details, including total length and number properties directly connected to the asset being replaced, cleaned abandoned, monitored or investigated.
2. Proposed mains to be replaced, new valves, hydrants, optimisations and other assets. For replacements, cleans and abandonments a summarised table, similar to the below example, is required containing the material type, lining type (if relevant), diameter and length. An excel output providing more specific information on the age, etc. is to be provided for the total scheme book with each scheme on a separate tab.

Material	Diameter	Length (m)
CI	200	337.14
CI Total		**337.14**
CI (PU Lined)	200	85.97
CI (PU Lined)	300	2003.71
CI (PU Lined) Total		**2089.68**
DICL	150	118.51
DICL	100	1546.59
DICL Total		**1665.10**
MDPE	40	28.93
MDPE Total		**28.93**
Scheme Total		**4120.81**

This total length figure has to be replicated in the description on the front sheet and appropriately reflected in the scheme cost.

3. Details of the total properties benefiting from the scheme. This is to be summarised at Leakage Control Area level if the entire Leakage Control Area benefits, if not, it is to be summarised at postcode level.
4. Burst history
5. Customer impact history. The **Study Period (3 yrs)** informs the investment and the scoring, the **Historic (3-5 yrs)** is just for information to the reader.

13.3 Needs Scoring Sheet

See the **Zonal Studies Needs Scoring Sheet.xlsx**. This spreadsheet summarises all the scheme justification information required to rapidly input schemes into Investment Manager and progress them through the Capital Gateway Process. It also contains information that necessary for internal reporting purposes.

WN_002

WQZ: P22 LCA Ref: 22SG12D1 LCA: Pembroke St Scheme: 23

Pressure Management

Dŵr Cymru Welsh Water

MWH

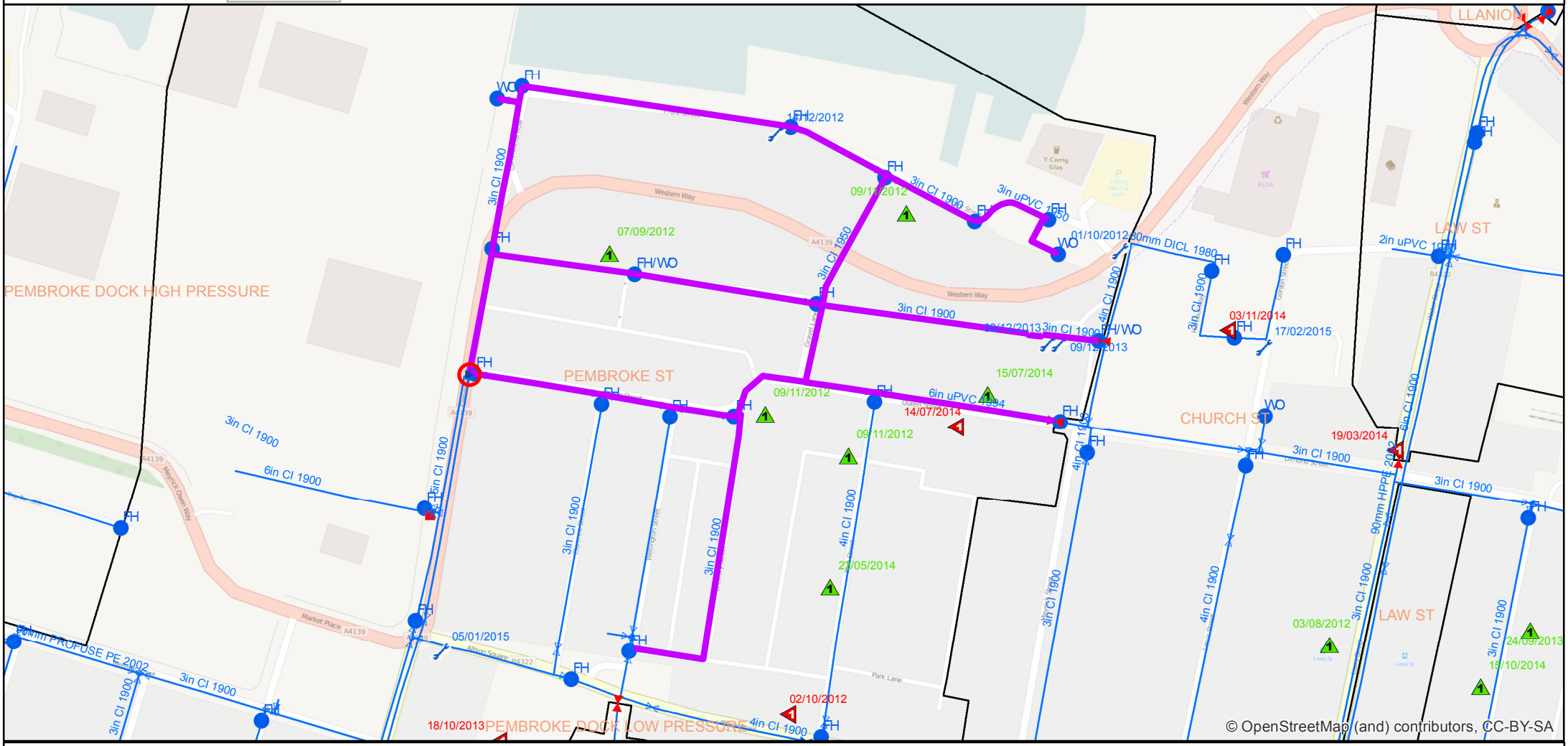
Description: Install new PRV at x/y: 196355, 203587 between the 2 T junctions; set outlet pressure at 25m to reduce the pressure for 261 properties. There has been 3 bursts in 3 years in this area.

Scheme Driver: Bursts
No. of Props Ben: 261

Benefits: Reduction in Bursts, CML & Leakage

Dependent Scheme:		Leakage Benefit (Ml/d):	0.004912	CML Benefit (mins/cust/yr):	0.002178
Linked Scheme:		Burst Benefit (no./km/yr):	0.000006	Customer Acceptability Benefit (complaints/1000pop/yr):	0
Predecessor Scheme:		Props at Risk Benefit (no.):			

Cost CAPEX/OPEX (£k):	10.8
Quality Benefit (PCV failures per yr):	0



Legend

- Mains Abandonment
- Mains Cleaning
- Mains Renewal
- Pressure Management
- Investigation
- Proposed Valves
- Proposed Hydrant
- Proposed PRV
- LCA Boundary

All other symbols use standard DCWW symbology

Coordinates: 196355, 203587

Ref : P22_1_PM

Date: 07/04/2016

WQZ: P22 LCA Ref 22SG12D1 LCA: Pembroke St Scheme 23

Pressure Management

Dŵr Cymru Welsh Water MWH

No. of Pipes 51 Total Length (m) 1,649 Total Cost (£k) 10.80

Proposed Replacement Mains

Properties Directly Affected

Total Props 261

Street	Town	Postcode	No. of Props
BREWERY STREET	PEMBROKE DOCK	SA726JS	47
QUEEN STREET	PEMBROKE DOCK	SA726JE	43
KING STREET	PEMBROKE DOCK	SA726JT	39
FRONT STREET	PEMBROKE DOCK	SA726JX	32
FRONT STREET	PEMBROKE DOCK	SA726JZ	26
QUEEN STREET	PEMBROKE DOCK	SA726JH	21
QUEEN STREET	PEMBROKE DOCK	SA726JL	15
FRONT STREET	PEMBROKE DOCK	SA726JY	10
QUEEN STREET	PEMBROKE DOCK	SA726JF	9
QUEEN STREET	PEMBROKE DOCK	SA726JJ	8
WELLINGTON STREET	PEMBROKE DOCK	SA726JR	5
THE DOCKYARD	PEMBROKE DOCK	SA726TD	2
COMMERCIAL ROW	PEMBROKE DOCK	SA726JU	2
MEYRICK STREET	PEMBROKE DOCK	SA726JD	1
COMMERCIAL ROW	PEMBROKE DOCK	SA726JN	1

Burst History

Burst Date	Cause Code	Pipe ID
14/12/2012	2	679821
09/12/2013	3	4148580
09/12/2013	3	4148580

Proposed Valve Intervention

Pipe ID	Size (mm)	X	Y	Type
7096437	75	196355	203587	New PRV

Proposed Hydrant Intervention

Other Proposed Assets

Proposed Network Operations

Attributable Water Quality and Customer Contact History

Linked WQ CC:

Linked No Water CC:

Linked WQ PCV Failure:

14 Appendix C

- Zonal Study Summary Report (Should not exceed 5-6 pages).
  - Cover Page.
  - Introduction – What is a Zonal Study and why has this zone been selected
    - Study Area Issues Summary – An overview of the main factors influencing performance within the study area.
  - Study Area – Brief description of the study area, the network and how it is supplied, customers served, seasonal or user driven large demand changes and elevation variances. Include a figure of the study area.
  - Solutions – A solutions and scheme benefit summary (including benefits table, cost benefit curve and optimised solutions output table).