Wellington Water Consultancy Panel

Connect Water

Porirua Network Improvement Programme

Wastewater Overflow Reduction Master Plan Strategy
November 2019

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Abbreviations

Abbreviation	Full name
ARI	Average Recurrence Interval
CBD	Central Business District
GIS	Geographic Information System
GWRC	Greater Wellington Regional Council
I&I	Inflow & Infiltration
JV	Joint Venture
LOS	Level of Service
PCC	Porirua City Council
PS	Pump Station
WCC	Wellington City Council
WWL	Wellington Water Limited
WWTP	Wastewater Treatment Plant

1 Introduction

1.1 Background

Over the past two years, Wellington Water Limited (WWL) has been working to develop a Network Improvement Programme (NIP). The NIP will be used to guide the wastewater network investment planning of the Porirua wastewater network. The network suffers from overflows due to capacity constraints which has resulted in the degraded health of the Porirua Harbour. Any increase in network capacity will trigger upgrades to the Porirua Wastewater Treatment Plant (WWTP). As the WWTP's discharge consent expires in April 2020, the network planning was coupled with the WWTP planning to develop the preferred master plan strategy.

Connect Water were engaged in early 2019 as the WWL Project Manager for the NIP and were also engaged as the engineering lead on the WWTP upgrade. WCS Engineering (WCS) were engaged to evaluate, optimise and prioritise wastewater network improvement alternatives and output a network master plan strategy.

1.2 Purpose

The purpose for completing the optimisation modelling was to identify the master plan strategy which will meet growth and network performance objectives. This report summaries the work completed to date including the output from WCS Engineering's Report[1] and information gaps that could form part of the future steps.

[1] Porirua Wastewater Catchment Alternatives Optimisation and Prioritisation, WCS Engineering (2019)

2 Wastewater Network Data

2.1 Wastewater Hydraulic Model

To enable the master planning process, WWL combined two existing ICM Infoworks (ICM) hydraulic models to create the Porirua Wastewater Network Model and provided the combined model to WCS:

- Northern Wellington (Johnsonville and Tawa)
- Porirua: Cannons Creek and trunk

These two ICM models were originally built by Mott Macdonald using MIKE URBAN before being converted to ICM. Stantec then completed a re-calibration of the Porirua model and OPUS completed a re-calibration of Northern Wellington model prior to the two models being combined by WWL.

WCS converted the combined ICM model into a separate software package, SWMM Version 5.1 to complete the optimisation. They completed the conversion by exporting inflows from ICM and importing them into SWMM. Once the optimisation was completed, WCS converted it back to ICM and completed the required calibration.

2.2 Design Storms

The design storms provided by WWL with the hydraulic model were reviewed by WCS and they considered them to be not reliable or representative of the intended Average Recurrence Interval (ARI) return periods. WWL engaged WCS to run a continuous model simulation of historic rainfall and perform a statistical analysis. Through this process WCS identified historic ARI storm events which allowed for the difference in the system response from the upstream and downstream network. The 6-month ARI was applied to the upper catchment (gravity sewers less than 300mm diameter) and the 1-year ARI applied to the lower catchment. A summary of the design storms selected by WCS verses the WWL selection is provided in Table 2-1.

Table 2-1 - Design Storms

Storm Event	WWL Selection	WCS Selection
6-month ARI	2/05/2013 storm event	9/12/2014 storm event
1-year ARI	30/08/2009 storm event	5/04/2017 storm event

To account for asset deterioration and climate change WCS Engineering applied a 17% increase to I&I to the baseline value in the 2057 model. It is recommended that this assumption be reviewed prior to proceeding with any further work on this programme.

2.3 Level of Service

WWL adopted the following Level of Service (LOS) performance standards for the project:

- Eliminate overflows from manholes during a 1-year Average Recurrence Interval (ARI) design storm.
- Eliminate overflows from constructed overflows during a 6-month ARI design storm.

2.4 Population Projection

Porirua is anticipating an accelerated growth based on the population estimate completed by BERL[2]. WWL updated the Porirua Wastewater Network model with this projection for Porirua City and Forecast ID projections for Wellington City[3] in February 2019 prior to supplying the hydraulic model to WCS. The population was forecast in 10-year increments to 2067. WWL instructed WCS to adopt the year 2057 to more closely align with the then proposed 30-year WWTP discharge consent duration.

Subsequent to this update and WCS commencing work, the growth projections were revised by PCC. The revision did not affect the total 2057 population, only how the growth was distributed over the catchment. Because the change did not affect the population connected to the WWTP and would have been unlikely to change the preferred network strategy for wastewater overflow reduction, WCS were not requested to update their population projection. However, any future modelling work used as part of concept design should adopt the revised growth, as the population change could affect the final infrastructure sizing.

2.5 Network Options

As part of the WWTP re-consenting process, network options were workshopped. The three short-listed network options, known as improvement alternatives selected and evaluated as part of the optimisation process were:

- Greater conveyance
- Twin storage – locating a large tank to the north of the city (e.g. Paremata) and a large tank to the south (i.e. City Centre)
- Combination of storage and conveyance

2.6 Storage Sites

To allow the network storage to be evaluated, WWL commissioned a selection study[4] to identify possible storage sites. A multi criteria analysis resulted in a short list of locations where storage should be practically considered. These sites and their maximum storage volume were provided to WCS.

2.7 Inflow and Infiltration Reduction

The Porirua wastewater network has insufficient capacity during wet weather events causing sewage overflows from many places within the network. By reducing I&I in the network, it is possible to reduce loading the network and reduce wet weather overflows. Eastern Porirua is the focus of a major central government funded renewal and intensification project through HLC which will result in many public sewers and private lateral connections being replaced. By managing I&I in the network the size of the upgraded pipes could be reduced or the upgrade avoided. A 25% reduction target was therefore adopted in that area and is considered achievable given the currently high levels.

[2] Population and Housing Projection, Porirua, BERL (2018)

[3] Porirua Wastewater Catchment Future Populations, WWL (2019)

[4] Porirua Wastewater Network Storage Site Selection, Connect Water (January 2019)

To understand the impact of the project on the Eastern Porirua network, WWL commissioned the development of the Eastern Porirua Wastewater Network Plan[5]. The plan identified the trunk sewers that will require replacement by upsizing as well as a scope recommended to form part of the I&I reduction programme. These works will also work towards reducing the apparent contamination of Kenepuru Stream:

- Review and recommend preferred replacement techniques including trenchless technology (including. relining and directional drilling) and materials for complete replacement (e.g. PE or other pre-fabricated manholes).
- CCTV of the public network to confirm structural grading and possible rehabilitation technique.
- Review of sewer location (i.e. under building).
- Hold point to select rehabilitation pathway (i.e. reline or fully replace on a new alignment).
- Development of a water tightness testing verification process.
- Smoke test, CCTV and water tightness test of all private laterals connecting to any sewer that forms part of the programme. If relining of the public sewer is adopted, the lateral connection known as the 'top hat' is rehabilitated even if the lateral passes all inspection testing.
- Undertake the recommended rehabilitation.
- Development of a policy or bylaw requiring laterals and all cross connections to be replaced/repaired at the property owners' expense.
- Development of a water quality monitoring programme that captures dry and wet weather variation to monitor the I&I and exfiltration rehabilitation programmes impact. This data would feed into a periodic review of the programme once every two years.

2.8 Wastewater Treatment Plan Options

The WWTP options were guided by the peak flow arriving at the WWTP from the network. The application of different network options (conveyance, storage or combination) changed the peak flow arriving at the WWTP, which results in different upgrade requirements. The WWTP currently has hydraulic limitations but limited upgrades can be completed to treat 1,500L/s. Whereas, increases above 1,500L/s trigger major upgrades to both the WWTP and the outfall. Planning to upgrade the WWTP to 1,500L/s is underway, and this limit was selected as part of the optimisation process.

2.9 Cost Data

WCS used the Table of Unit Rates (updated 2019 Rev 4 prepared by GHD Ltd) to develop the capital cost estimates used as part of the optimisation process.

[5] Eastern Porirua Wastewater Network Plan, Connect Water (November 2019)

2.10 Proposed Infrastructure Sizing

The key design criteria applied by WCS in the optimisation analysis is provided in Table 2-2.

Table 2-2 WSC Engineering Optimizer modelling assumptions

Criteria	Summary
Existing gravity sewers <= 300mm	Upgrade once surcharge exceeds 1m freeboard (freeboard = surface elevation – max water level) and 0.5m above pipe obvert
Existing gravity sewers >300mm	Upgrade once surcharge exceeds 0.5m freeboard and 0.5m above pipe obvert
New gravity sewers	New gravity sewers designed for 0.8 d/D (depth/Diameter) or equivalent q/Q (design flow/capacity – approximately 0.93)
Existing pressure mains	Existing pressure main velocity not to exceed 2.5m/s
New pressure mains	New pressure main velocity not to exceed 2.0m/s
Parallel pipe verses replacement	All sewer main improvements assumed to be parallel to existing sewer mains
Tidal boundary conditions	Not applied in the hydraulic model
Pump station upgrades	The existing pump station is upgraded if the required capacity is <1.4 times the existing capacity. Otherwise a new pump station is required

3 Network Optimisation

3.1 Master Plan

WCS conducted a high-level, system-wide analysis of conveyance, storage, I&I reduction and wastewater treatment plant alternatives. The optimised solution was designed to eliminate overflows for the selected LOS based on a total life-cycle cost. The preferred master plan strategy adopts a mixture of conveyance, storage and I&I reduction in Eastern Porirua whilst limiting the upgrades to PS20 and PS34 to avoid upgrading the WWTP past a treatment capacity of 1,500L/s.

WCS used the software 'Optimizer' linked to the hydraulic model and cost data to perform the master planning exercise to identify the least cost solution for each network option. The preferred master plan strategy identified five storage locations across the city as well as gravity sewer, pump station and rising main upgrades, I&I reduction and WWTP upgrades as being required to meet the agreed LOS.

3.2 Prioritisation

The preferred master plan strategy was then put through a scheduling optimisation process to select the sequence of implementation that achieved the maximum return on investment based on overflow reduction. The resulting schedule identified seven stages and is shown in Figure 3-1:

- Priority 1 –I&I reduction in Cannons Creek Upper, Ranui Upper and Waitangirua and upsize 400m of the Kenepuru Stream gravity sewer.
- Priority 2 –I&I reduction in Ascot Park, Cannons Creek Lower, Ranui Lower and upsizing 130m of the incoming gravity sewer to Pump Station 20 (City Centre).
- Priority 3 – Provision of new City Centre storage and upsizing 2.6km of its connecting gravity sewer from the north.
- Priority 4 – Gravity sewer upgrades (city wide), pressure main upgrades (city wide) and pump station upgrades (Whitby, Paremata, CBD, Titahi Bay).
- Priority 5 – Gravity sewer upgrades (city wide), Paremata storage.
- Priority 6 – Gravity sewer upgrades (city wide), North Plimmerton storage.
- Priority 7 – Gravity sewer upgrades (city wide), Whitby and North Wellington Storage, pump station upgrades (Pukerua Bay, Plimmerton, Titahi Bay).

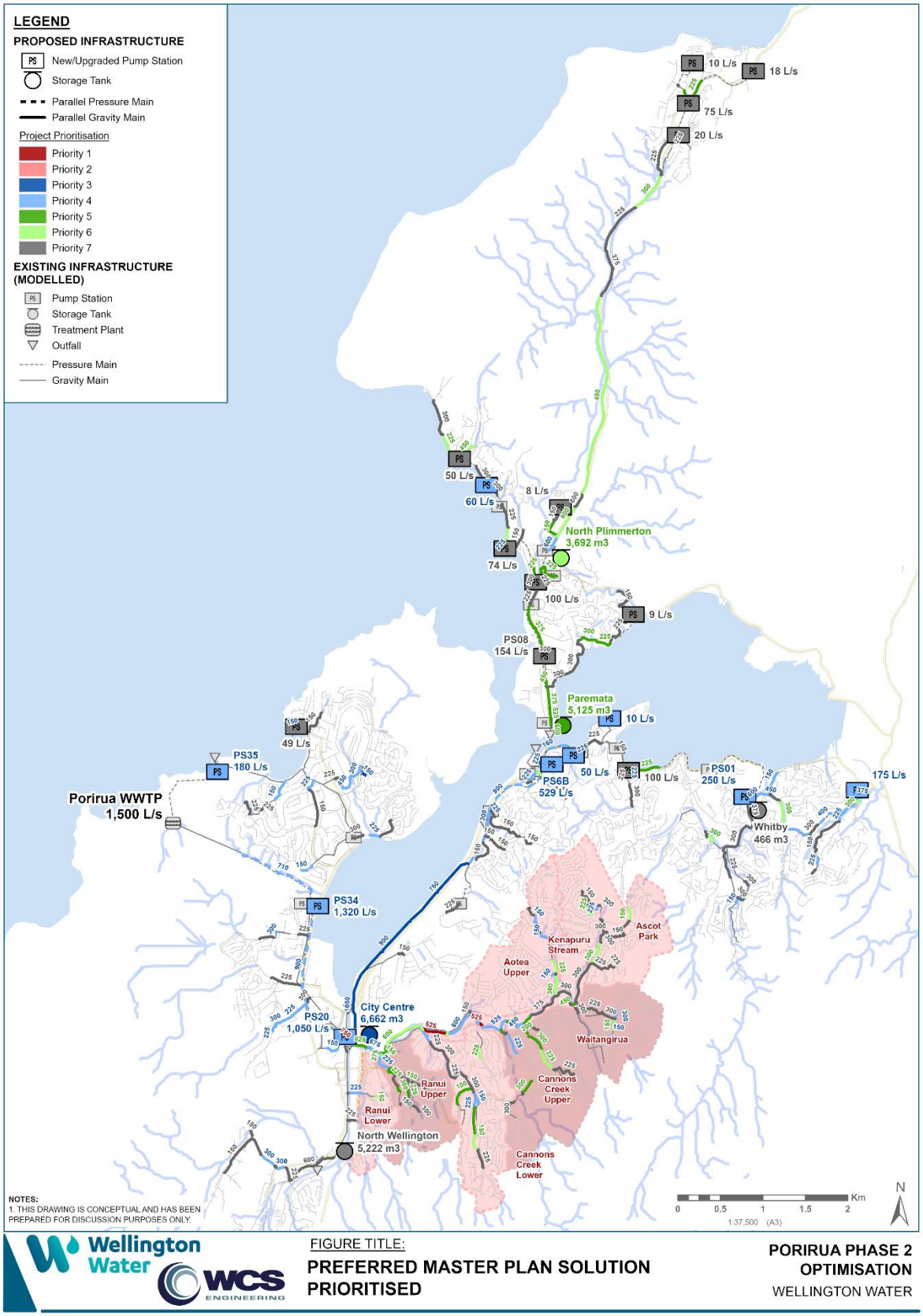

Figure 3-1 - Prioritisation

4 Cost

The cost estimates covered in Section 4.0 are extracted from the Capital Cost Estimate Development Report[6]. WCS provided the network designs for each of the optimisation scenarios used to define the base estimate. These capital cost estimates were based on the Table of Unit Rates (updated 2019 Rev 4 prepared by GHD Ltd). The master planning stage capital cost estimates were prepared in accordance with the WWL Cost Estimation Manual. The wastewater storages and pump stations were deemed to be a Level 1 estimate and the gravity sewers and pump stations were deemed to be a Level 2 estimate.

To account for additional construction costs on land with non-standard features (e.g. through existing utilities, or areas vulnerable to seismic activity), percentage uplifts were applied to the capital cost estimates. Land purchases were also taken into consideration. This added detail was not included as part of the WCS analysis which is why separate cost estimates were prepared for the preferred master plan strategy.

4.1 Current Population verses New Development

WCS completed an optimisation scenario to understand what proportion of the preferred master plan strategy is required to bring the existing network up to meeting the target LOS for the current population (2019 population). As the current population assessment was completed in the SWMM model it is an uncalibrated output (refer to Section 2.1 for further explanation). To allow a fair comparison, the current population output was compared to the uncalibrated preferred master plan output. The comparison showed that 60% of the preferred master plan is required to improve the network for the current population. The cost breakdown is shown in Table 4-1 and Table 4-2.

Table 4-1 - Current Population

Infrastructure Upgrade	Master Plan Stage Capital Cost Estimate
New Gravity Sewers	$138 million
Pressure Mains	$16 million
New/Upgrading Pump Stations	$31 million
New Storage Tanks	$37 million
Inflow & Infiltration Reduction	$43 million
Upgrades to Existing Porirua WWTP	$7 million
Total	**$273 million**

[6] Wastewater Solutions and Costs – Preliminary Three Water Catchment Plan & Network Improvement Programme for Porirua, Rev D, Connect Water (2019)

Table 4-2 – Master Plan Strategy (not calibrated in ICM)

Infrastructure Upgrade	Master Plan Stage Capital Cost Estimate
New Gravity Sewers	$182 million
Pressure Mains	$22 million
New/Upgrading Pump Stations	$52 million
New Storage Tanks	$153 million
Inflow & Infiltration Reduction	$43 million
Upgrades to Existing Porirua WWTP	$7 million
Total	**$458 million**

4.2 Calibrated Master Plan Strategy Cost

Once the preferred master plan was identified, it was fed back into the WWL Porirua hydraulic model for calibration. The post calibration cost breakdown in shown in Table 4-3.

Table 4-3 Master Plan Strategy (Calibrated)

Infrastructure Upgrade	Master Plan Stage Capital Cost Estimate
New Gravity Sewers	$182 million
Pressure Mains	$29 million
New/Upgrading Pump Stations	$52 million
New Storage Tanks	$164 million
Inflow & Infiltration Reduction	$43 million
Upgrades to Existing Porirua WWTP	$7 million
Total	**$477 million**

4.3 Prioritisation Cost

The calibrated master plan strategy cost has been assigned with the prioritisation to output the required spend per priority in Table 4-4.

Table 4-4 - Priority Costing

Priority	Projects	Cost
1	I&I reduction in Cannons Creek Upper, Ranui Upper and Waitangirua	$16.2 million
	Upsize 400m of the Kenepuru Stream gravity sewer	$1.5 million
	WWTP Upgrade	$7.0 million
	Sub-total	**$24.7 million**
2	I&I reduction in Ascot Park, Cannons Creek Lower, Ranui Lower	$26.8 million
	Upsizing 130m of the incoming gravity sewer to Pump Station 20 (City Centre)	$1.5 million
	Sub-total	**$28.3 million**
3	Provision of new City Centre storage	$47.2 million
	Upsizing 2.6km of its connecting gravity sewer from the north	$37.3 million
	Sub-total	**$84.5 million**
4	Gravity sewer upgrades (city wide)	$24.4 million
	Pressure main upgrades (city wide)	$29.0 million
	Pump station upgrades (Whitby, Paremata, CBD, Titahi Bay)	$43.3 million
	Sub-total	**$96.7 million**
5	Gravity sewer upgrades (city wide)	$20.0 million
	Paremata storage	$40.6 million
	Sub-total	**$60.6 million**
6	Gravity sewer upgrades (city wide)	$28.8 million
	North Plimmerton storage	$31.2 million
	Sub-total	**$60.0 million**
7	Gravity sewer upgrades (city wide)	$68.6 million
	Whitby and North Wellington Storage	$44.6 million
	Pump station upgrades (Pukerua Bay, Plimmerton, Titahi Bay)	$9.0 million
	Sub-total	**$122.2 million**
	TOTAL	**$477.0 million**

5 Next Steps

The next steps required to further develop the Porirua Network Improvement Programme include:

- Review the climate change and asset deterioration assumption to determine if an update is required.
- Review Wellington City growth projection to determine if an update is required.
- Incorporate any population changes and connectivity within the hydraulic model.
- Consider including Wellington City's network as part of the optimisation process to identify opportunities for I&I reduction and storage before it connects to the PCC network.
- Include system-wide I/I reduction alternatives not just within the Eastern Porirua catchment.
- Include structural condition scores to discount the effective cost of I&I reduction.
- Run the hydraulic State file for at least two months, ideally three months to set the networks antecedence conditions.
- Re-run the optimisation process for the 2 EY / 1Y (constructed/unconstructed overflows) LOS to capture the hydraulic model updates to allow comparison to scenarios with a different LOS.
- Run the optimisation process to understand the cost effect for different LOS:
  - 2 EY / 2 EY (constructed/unconstructed overflows).
  - 4EY-2EY / 2 EY (location specific LOS for constructed overflows).
- Rerun prioritisation for preferred masterplan strategy incorporating any growth area priorities of PCC to develop the catchments master plan.
- Develop work plans for each of the projects identified as part of the master plan.
- Confirm the acceptable LOS for wet weather overflows with PCC and Greater Wellington Regional Council (GWRC) through the resource consenting process.

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