OREWA WEST WASTEWATER PROJECT AN INNOVATIVE SOLUTION

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ABSTRACT

Watercare installed a 3.2 km 450 and 630 OD wastewater trunk gravity pipe line to service a 235 ha greenfields development (9,400 people) in Orewa north of Auckland. The pipeline is up to 30 metres deep and crosses the Orewa River and a geological fault line.

The original concept solution was a conventional wastewater trunk collection system and consisted of several pump stations with the associated gravity and rising mains.

This paper deals with the development of an innovative and cost-effective solution and its successful implementation. The final solution was a gravity pipeline and one lifting pump station, eliminating all the in-line pump stations and corresponding rising mains. In addition, in-line operational storage was provided at minimal additional cost.

The route of the pipeline runs through hilly terrain which resulted in very deep manholes.

Durability and operational efficiencies were major considerations in the development of the final implemented solution and took into account Watercare's operational requirements. Learnings with regards to optimisation of concept designs can be of benefit to other future projects.

This paper demonstrates how a complex and challenging project can be solved by an innovative, cost-effective solution and successfully implemented.

KEYWORDS

trunk wastewater collection, innovation, cost-effective, operational efficiency

1 INTRODUCTION

The objective of this paper is to outline how the concept for the provision of the wastewater trunk network to service Orewa West was developed.

The Orewa West structure plan comprises 235 ha of greenfield land located to the west of the Orewa township and to the east of State Highway 1 (SH1). At final development this area will increase the population connected to the Army Bay wastewater treatment plant by estimated 9,400 people. The speed of the development required new wastewater infrastructure to be rapidly installed and to connect this area to the existing wastewater network.

After various reviews a conventional gravity sewer system was adopted to service this greenfield catchment on the basis of it being the least of life cost method for servicing the catchment.

The extent of the area to be serviced is depicted in **Figure 1: Orewa West Service Area** on the next page. GHD was commissioned to design the Orewa West Wastewater Trunk Network. The extent of this design commission is depicted in the blue line in **Figure 1**.

The greenfield area is owned by several developers and this necessitated close collaboration for them during the design and construction of the trunk main.

1.1 TOPOGRAPHY

The terrain is undulating and the trunk main needed to cross the following water bodies. Reduced levels (RL) are given:

- Stream north of Grand Drive: (RL 5)
- Northern Tributary of Orewa River: (RL 0)
- Orewa River: (RL 0)

The ground levels between these streams are:

- RL 10 between northern stream and tributary
- RL 30 between tributary and southern river

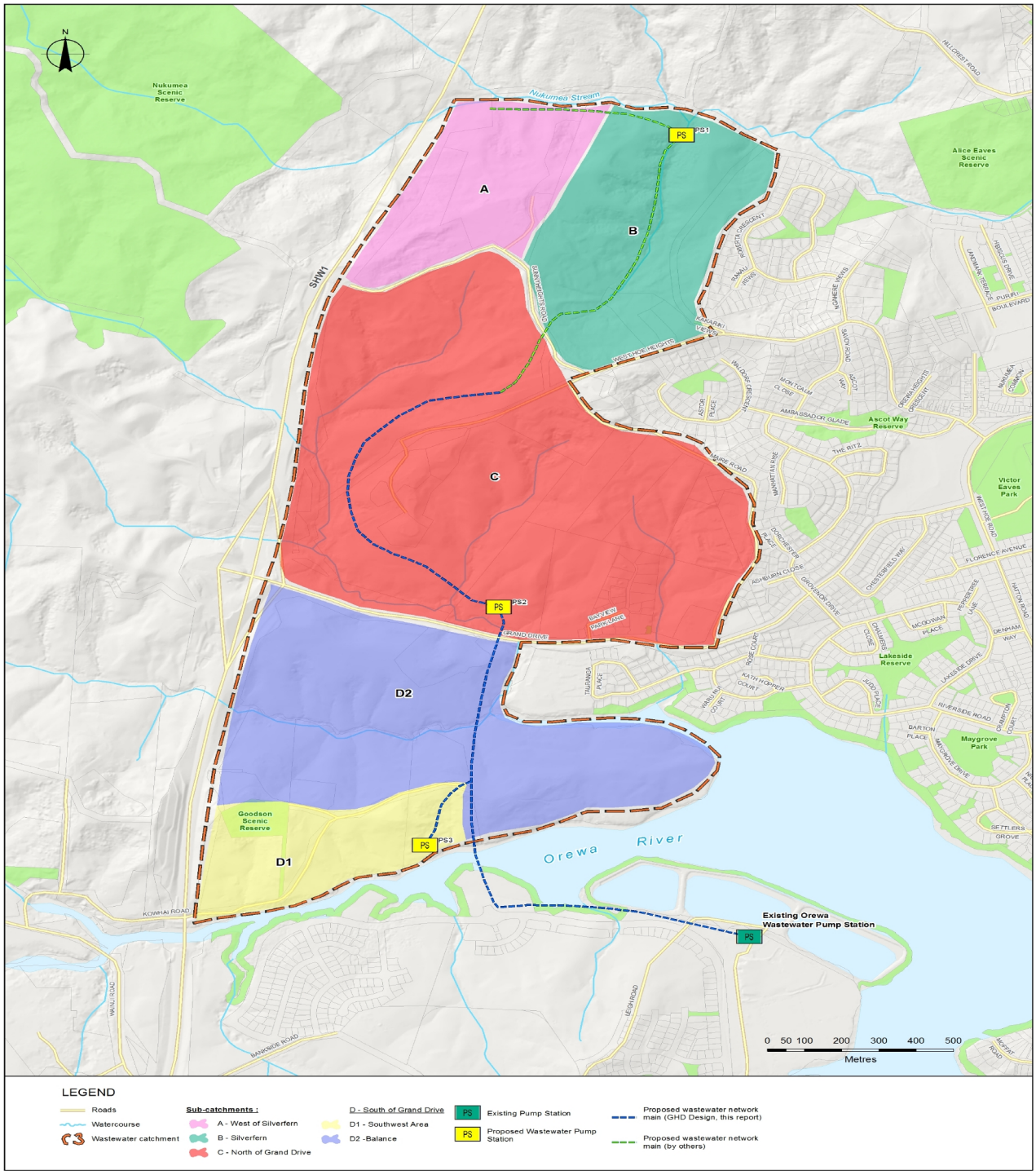
1.2 GEOLOGY

The pipeline route is traversed by a fault line running along the Orewa River. East Coast Bays formation forms the land north of the Orewa River. The area south of the Orewa River is alluvial sediments and marine muds overlaying the East Coast Bays formation.

2 ORIGINAL CONCEPT

The original concept solution for the project is also depicted on **Figure 1** on the next page. This is the same as Option 1 that is discussed in more detail further on.

Figure 1: Orewa West Service Area and Original Concept



3 DESIGN REQUIREMENTS

3.1 WATERCARE DESIGN GUIDELINES

It was a Watercare requirement that all project design must comply with the Watercare Guidelines for Design of Wastewater Reticulation and Pumping Stations.

3.2 OPERATIONAL EFFICIENCIES

A further project requirement was to minimise operational issues relating to low initial flows and odours. This was achieved by diverting the existing upstream sub-catchment to discharge into the new trunk main and by designing a gravity line that achieves self-cleansing velocities and thereby minimising septicity and odour producing slimes.

Operation costs were also effectively minimised by eliminating several pump stations and the gravity syphon and having only one lift pump station.

3.3 CONSENT REQUIREMENTS

Each new pump station would have required the application for a land use resource consent and overflow discharge consent.

The requirement for new land use consents were eliminated by having a gravity pipeline that terminated in a lift pump station that was located within the existing wastewater designation at the existing Orewa pump station. This existing pump station already has an existing consented overflow, negating the need for any new discharge consent.

3.4 STORAGE REQUIREMENTS

Storage is required to mitigate wet weather peak flows. Such storage is normally provided at the location of each new pump station. This storage requirement was cost-effectively achieved by increasing the size of the last 1,800 metres of the gravity line to effectively create an in-line storage "tunnel". Large manholes in this section were also required for construction purposes and also contributed to the storage.

4 OPTIONS STUDY

4.1 OPTIONS

To effectively meet all project requirements, it was decided to review Concept Options to determine the best way forward. Options progressively resulted in the main pump station being shifted from the north to the south, until it eventually resulted in a lift pump station next to the existing Orewa pump station. All options were thoroughly reviewed and resulted in the following two final options:

4.1.1 OPTION 1: SEVERAL PUMP STATIONS, RISING MAINS AND GRAVITY SYPHON (ORIGINAL CONCEPT)

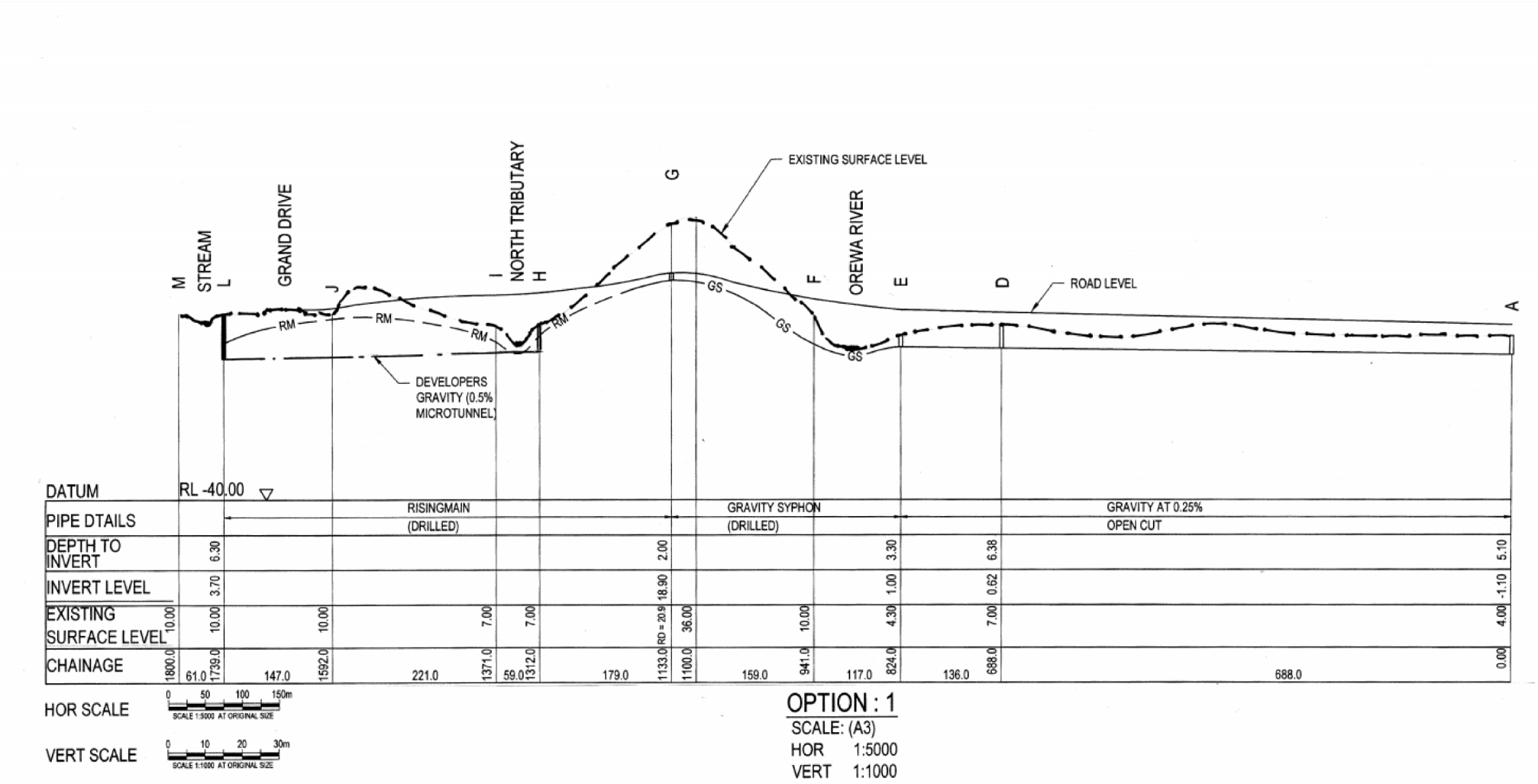
This option would have involved a conventional gravity sewer system through the middle of the Orewa West catchment, typically following the existing and proposed road routes as shown in **Figure 2** on the next page. This option includes two pump stations located within the structure plan area. These pump stations would have required the purchase of land and the obtaining of the necessary resource consents. Storage would need to be provided at each pump station. It would also require significant lengths of rising mains and a gravity syphon to cross the Orewa River.

A pipe bridge across the Orewa River was considered as an alternative to the syphon but was rejected due to the significant visual impact.

A longitudinal section is schematically depicted in **Figure 3** overleaf.

Figure 2: Option 1 Plan Layout

Figure 3: Option 1 Longitudinal Section



4.1.2 OPTION 2: AS FINALLY ADOPTED AND BUILT

This option is similar to Option 1 but the 3.2 km gravity sewer system will be deeper and larger in diameter with a single lift station adjacent to the existing Orewa pump station as shown in **Figure 4** on the next page. No land purchase for the lift station is required and the larger diameter sewer and larger manholes will provide the required storage. These larger manholes were also required for construction purposes. There are no rising mains or syphons with this option.

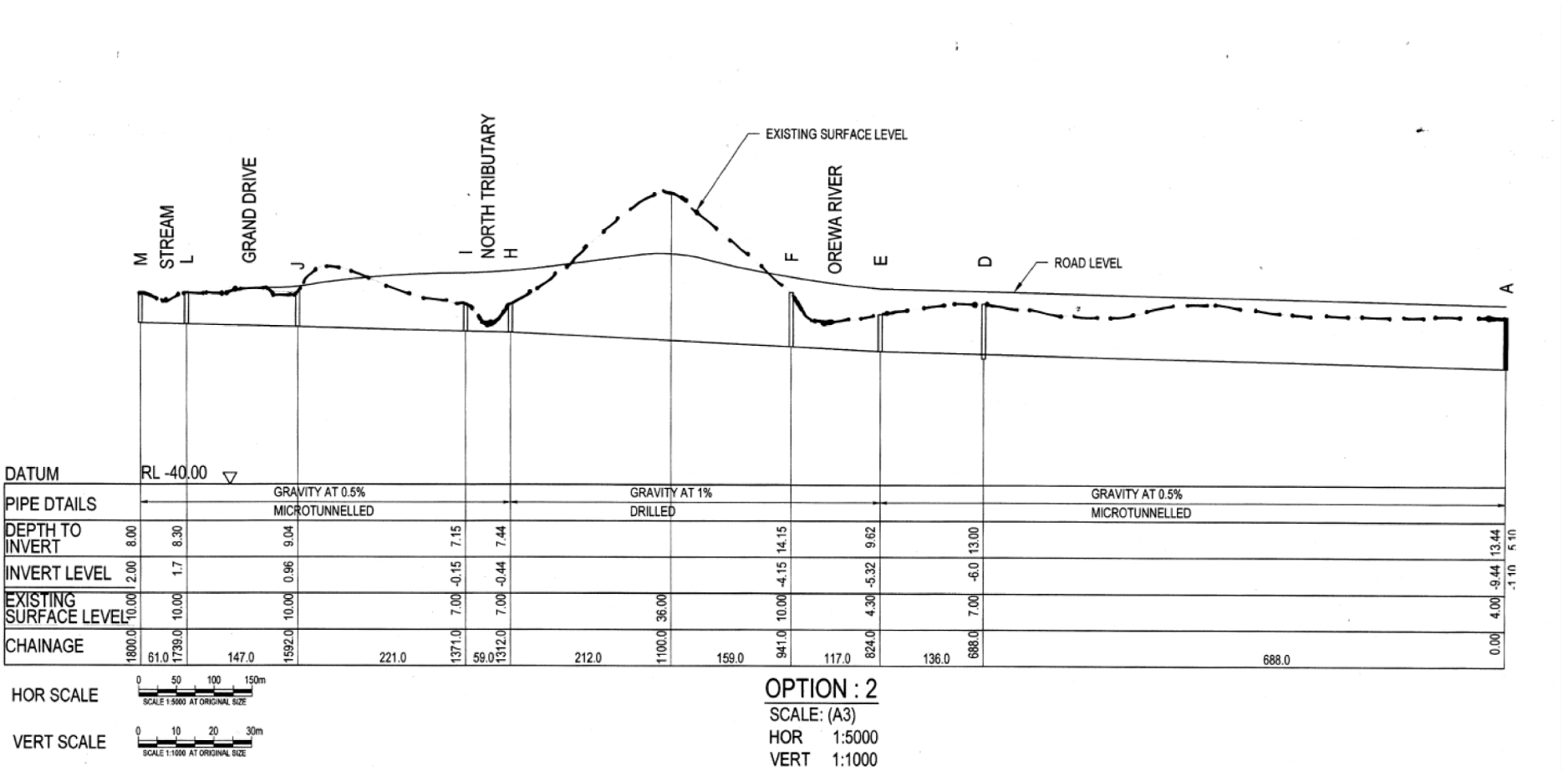
The concept will have two flow regimes, dry weather and wet weather.

- During dry weather operation all flow will be conveyed by gravity to the Orewa pump station, where a lift pump station will discharge flow into the existing pump station.
- During wet weather operation:
    - In normal wet weather events, the lift pump station will lift flows into the Orewa pump station.
    - In significant wet weather events, the system shall be designed to surcharge with the flow spilling directly into the existing Orewa pump station.

A longitudinal section is schematically depicted in **Figure 5**

Figure 4: Option 2 Plan Layout

Figure 5: Option 2 Longitudinal Section



4.2 COMPARISON OF OPTIONS

The two options were compared against each other as follows:

4.2.1 COST ESTIMATES

Whole life cost estimates, including capital and operational & maintenance costs as net present value (NPV) were determined for each option and these are summarised in the Table 1 below:

Table 1 Summary of Whole Life Costs

	Capital	NPV	Total
Option 1	$19M	$2M	**$21M**
Option 2	$15M	$1M	**$16M**

Long term operation and maintenance cost of the trunk collection system were significantly reduced by the adoption of Option 2 as can be seen by the lower NPV value in the table above.

Based upon whole life cost, Option 2 proved to be significantly more cost-effective.

4.2.2 MEETING WATERCARE'S REQUIREMENTS

Watercare Wastewater Standards require (recommend) that new assets avoid (limit) where ever possible:

- Gravity syphons
- Pipe bridges
- Pump stations

In the context of servicing the Orewa West catchments, this is only achieved with Option 2 although a lift station is still required.

An added advantage of Option 2 is that it does not require any rising mains.

4.2.3 OPTIONS COMPARISON TABLE

A detailed comparison between the two options is contained in Table 2 below:

Table 2 Options Comparison Table

Note: Read with Option Maps, Figures 2 to 5.

		Option 1	Option 2	Comment
		Pump stations, Rising Mains and Gravity Syphon	Deep Drill Line and Lift Station	
a	Pump Station Locations			
		North and adjacent to Grand Drive and north of Orewa River.	Adjacent to existing Orewa pump station.	
b	Number of Pump Stations			
		Two pump stations.	One Lift Station.	Watercare's policy is to minimise number of pump stations, so Option 2 preferred. Also lift pump station for Options 2 is smaller than main one for Option 1.
c	Depth of Pump Station Structure			
		Pump Station Wetwell: 12m.	Terminal Structure (Lift Station): 18m.	Option 1 has an advantage here.
d	Flows			
		Large pump station, pumping Peak Wet Weather Flows of 107 L/s. Small pump station, pumping Peak Wet Weather Flows of 7 L/s.	Lift pump, pumping Peak Wet Weather Flows of 114 L/s. Surcharging will be below ground levels and below local collection network.	The advantage of Option 2 over Option 1 is that extreme wet weather flows can spill over into existing Orewa pump station Storage Tank.
e	Storage			
		Wet weather flow storage tank required at large pump station (8 hours of Average Dry Weather Flow). Volume 500 cubic metre.	In-line storage by providing larger diameter pipe for last section of gravity line and larger diameter manholes. (8 hours of Average Dry Weather Flow). Volume 500 cubic metres.	The advantage of Option 2 over Option 1 is that no storage tank is required as storage will be in-line.

		Option 1	Option 2	Comment
		Pump stations, Rising Mains and Gravity Syphon	Deep Drill Line and Lift Station	
f	Rising Mains and Gravity Syphons			
		300 OD 600 m Rising Main 450 OD 350 m Gravity Syphon.	Nil.	The advantage of Option 2 over Option 1 is that no rising main and no gravity syphons are required, which operationally is much better.
g	Gravity Pipelines			
		450 OD 825m at 0.25% grade into Orewa pump station - Open cut (2m to 3m deep).	630 OD 1,350m Microtunnelled @ 0.5% grade. 450 OD 450m drilled @ 1% grade.	
h	Ease for Developers to connect to Network			
		Developers need to: • Build small pump station north of Orewa River and Rising Main. • 350 ID 430m gravity main Microtunnelled @ 0.5%. • Build gravity pipelines connected to manholes on Trunk Line.	Developers need to build gravity pipelines to easily connect to manholes on Trunk Line.	With Option 2 developers can easily connect to Network Main. With Option 1 it is much more difficult for developers, as an extra pump station and a microtunnelled gravity main back to large pump station are required.
i	Servicing Area west of SH1			
		Pipelines for servicing this area would need to be built through to the existing Orewa pump station.	Pipelines for servicing this area can easily connect. New existing pipeline capacity adequate for flows west of SH1.	Option 2 much more favourable for connection of pipelines servicing area west of SH1.
j.1	Operational Aspects: Odour			
		Associated odour issues very significant and need to be designed for and managed. Rising Main long with greater septicity. Odour beds required at pump stations. Odours need to be managed for gravity syphon.	Odour issues insignificant. Existing odour bed at existing Orewa pump station adequate.	Option 2 has a distinct advantage with odour issues being insignificant. Ongoing management of odour issues and septicity and maintenance of odour beds for Option 1.

		Option 1	Option 2	Comment
		Pump stations, Rising Mains and Gravity Syphon	Deep Drill Line and Lift Station	
j.2	Operational Aspects: Gravity Syphon			
		Ongoing maintenance and flushing of gravity syphon.	No syphons.	It is preferable not to have gravity syphons (i.e. Option 2) due to ongoing maintenance requirements and issues.
j.3	Operational Aspects: Pump Station maintenance			
		Pump station north of Grand Drive, Rising Main and Gravity Syphon.	Lift Station next to Orewa pump station would need regular maintenance that can be done at same time as Orewa Pump Station.	Option 2 requires less maintenance.
k	Planning Aspects			
		Landuse and discharge consents required for pump stations.	No consent required. Permitted Activity.	Option 2 preferred.
l.1	Electrical Issues: Power supply and cable to pump station			
		Power supply to be brought to new pump stations.	Power supply on site.	Power supply cost to pump stations is lowest for Option 2.
l.2	Electrical Issues: Radio Signal to new pump station site			
		Two pump stations.	Extension of existing radio and telemetry on site.	Option 2 preferred.
m.1	Geotechnical and Constructability Issues: Pipelines			
		Pump station Wetwell: 12m.	Pump station Wetwell: 18m Gravity Pipeline: Drilling at 1%. Gravity Pipeline: Microtunnelling at 0.5%.	Option 1 easier.
n	Costs			Refer to Section above.

5 HEALTH & SAFETY, SAFETY IN DESIGN AND INNOVATIONS

The minimisation of pump stations and elimination of rising mains, gravity syphons and pipe bridges are deemed good safety in design features and innovations.

The contractor of the works, McConnell Dowell Constructors Ltd, came forward with a significant, safety in design feature, particularly with regards to the construction of the deep manholes in glass reinforced plastic (GRP) (deepest manhole 25 metres). The original design was a conventional sheet piles and build up with concrete rings. The GRP manhole was installed by creating a hole with a Soilmec and dropping in the GRP sleeve and grouting it up. A manhole can be installed in three days saving time and money without putting any worker into the excavation.

Photograph 1: Installation of GRP Glass Deep Manhole

Photograph 2: 600 metre of 630 OD PE pipe string ready to be pulled into place

6 CONSTRUCTION DIFFICULTIES

During the design stage some of the developers confirmed that their roads bulk earthworks would be completed before the pipeline works are going to be constructed. However, these bulk earthworks were delayed due to unforeseen consenting approval issues. This created construction difficulties, for example additional access roads, much deeper manholes and pipeline construction. This resulted in drilling rigs being located much further back from manholes to achieve the start invert levels.

7 MINING REGULATIONS

The new Mining Regulations were introduced in December 2013 which had a major impact on the project. This was the first Watercare project classified as a mine. The changes required included new mining personnel, additional management plans and mining equipment to improve the safety of all construction personnel. These regulations imposed a time delay and had a significant cost impact on the project to the tune of $650,000.

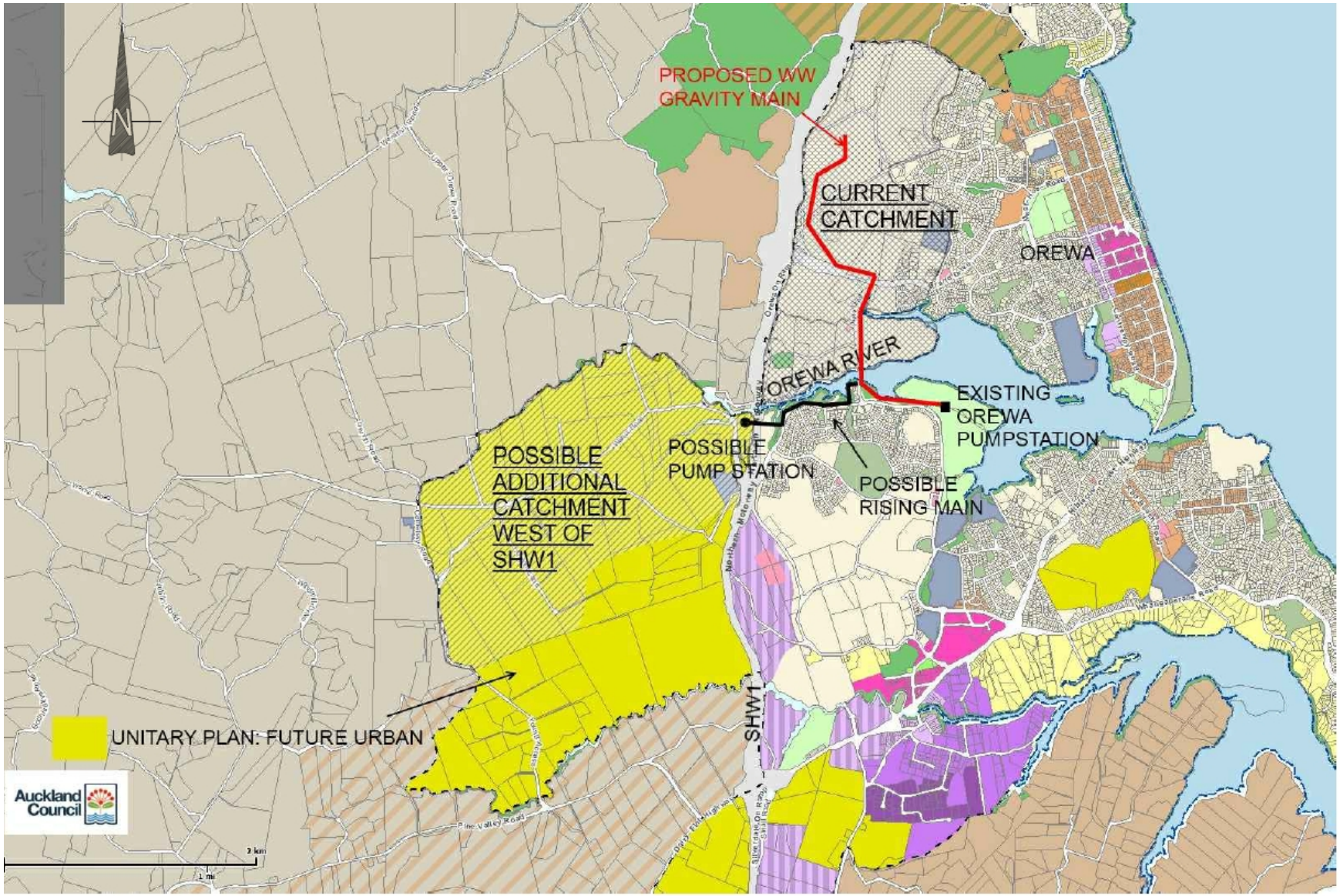
8 FUTURE DEVELOPMENT WEST OF SH1 IN OREWA

Since the original concept was approved it became apparent that the Auckland Unitary Plan will make provision for an additional 350 ha greenfield land west of the current SH1 for residential properties. This area will also be required to connect to the wastewater network that ultimately discharges to the existing Army Bay wastewater treatment plant.

The design was adapted to accommodate in-line emergency storage and any additional flow from the proposed greenfields west of SH1. Any development west of SH1 can connect into this gravity main without any additional pipeline construction parallel to the new gravity main to the Orewa pump station.

The possible future area west of SH1 at stage of design is depicted in **Figure 6** overleaf.

Figure 6: Possible Development West of SH1



9 CONCLUSIONS

The design and construction of a wastewater network trunk gravity line and lift station to service an estimated 9,400 people in Orewa West was successfully completed in an innovative, cost-effective and safe manner. A thorough review of alternative options was the key to success.

The final solution was a gravity pipeline with one lift pump station, eliminating the need all the in-line pump stations and associated rising mains. In addition in-line operational storage was provided at very little additional cost.

Long term operation and maintenance cost of the trunk collection system and operational risk relating to odour generation were significantly reduced by the adoption of this solution.

Durability and operational efficiencies were also achieved.

ACKNOWLEDGEMENTS

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GHD Ltd

REFERENCES

Opus International Consultants Ltd, September 2012, Report to Watercare: *Orewa West, Hibiscus Coast Gateway and Silverdale Industrial, Wastewater Strategy, 3-aw868.00*