New Plymouth District Council

3-Waters Renewals Forecast Review Report

July 2020

Disclaimer

This report has been prepared by GHD for New Plymouth District Council and may only be used and relied on by New Plymouth District Council for the purpose agreed between GHD and the New Plymouth District Council as set out Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than New Plymouth District Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

Executive Summary

GHD has been engaged by New Plymouth District Council to review the 3-waters renewal forecast. This report captures the review findings for 3-waters asset renewal forecast, as well as recommendations for actions to be taken to improve the accuracy of the forecast.

The scope of this review report includes:

- Infrastructure Management Team's approach and methodology to determining renewals works and financial forecasts
- The underlying data that reflects the current state of its 3-waters networks and need for investment, and that is inputted into the analysis of renewals needs and financial forecasts
- The resulting renewals works programme and financial forecasts from its analytics using the underlying data and assumptions
- Reviewer's recommendations on process and practice improvements.

Summary review findings by the reviewer (GHD) of these aspects are as follows, with details contained in the further sections of this report.

The level of confidence of NPDC's financial forecasting are deemed by the report authors to be as follows, based on the confidence in the methods and analyses of assessment combined with the quality (accuracy, completeness and currency) of the underlying data.

Network	Methods and Analyses Used - Financial Forecast	Data Quality - Accuracy	Data Quality - Completeness	Data Quality - Currency	Confidence Level of Resulting Financial Forecasts
Wastewater	High	High (condition assessment) Very High (age)	Moderate to High 94% known condition by value, 85% known condition by length, 99% age known	High (condition assessment) Very High (age)	Moderate to High
Drinking Water	High	Moderate[1] (condition assessment) Very High (age)	Moderate 88% known condition by value, 85% known condition by length 99% age known	High (condition assessment) Very High (age)	Moderate
Stormwater	High	Low (condition assessment) Very High (age)	Low (1% known condition by value, 99% age known)	Low (condition assessment) Very High (age)	Low

The above data quality percentages apply to piped assets.

Council's Approach, Methodology and Analytics to Determine Renewal Needs and Financial Forecast

The reviewer believes that the Infrastructure Management Team has robustly applied appropriate industry practice in their approach, methodology and analytics to deriving evidence-based, risk-based renewals work programmes and financial forecasts. This has included age-based analytics, as well as innovative techniques using condition, criticality and statistical simulation to estimate the probability of failure.

[1] Moderate due to the method being used for condition assessment of drinking water systems (using pipe break-down analysis and some AC pipe sampling compared to wastewater pipes that have been assessed via CCTV inspection)

Therefore the reviewer's confidence level with respect to Council's approach and methodology to determine renewal needs and financial forecast is ***High for all 3-waters networks*.**

Council's Results Determining Renewals Works and Financial Forecast

The reviewer believes, based on available data, that the Infrastructure Management Team has given a credible account for the need to increase 3-waters renewals investment, has not over-stated that need, and which reflects lowest whole of life costs as ageing assets deteriorate past a maintainable state.

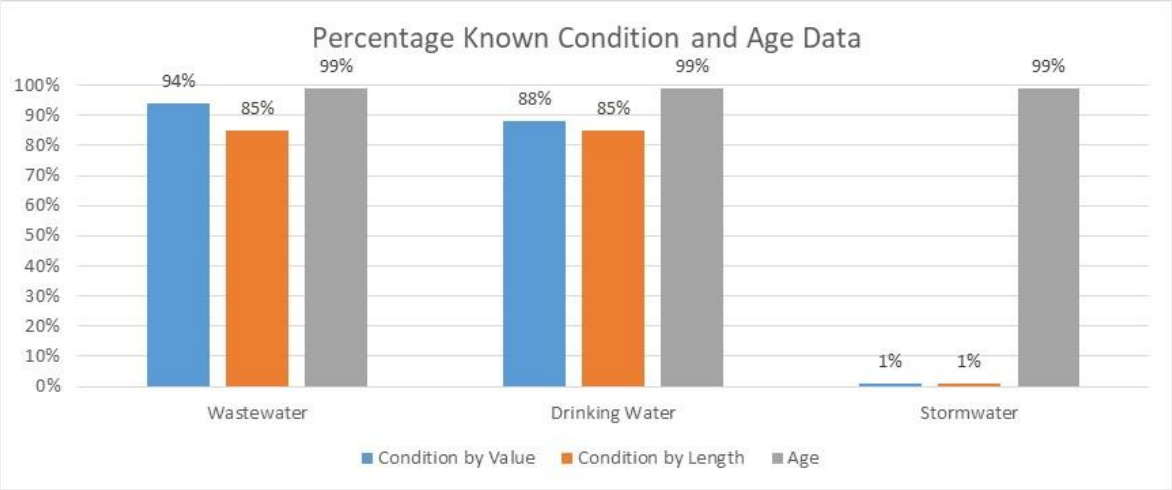
The reviewer's confidence level, based on condition by value of assets[2], with respect to Council's renewals work programmes and financial forecasts is

- ***Moderate to High for Wastewater,***
- ***Moderate for Drinking Water*** *and*
- ***Low for Stormwater.***

The above resulting Confidence Levels of Financial Forecasts are largely dependent on the level of completeness of the underlying condition data by value rather than by length. This is because value-base analysis (in comparison with length-base analysis) will weigh the critical pipes higher than the smaller non-critical assets. Critical pipes are typically higher value and higher risk. This fulfils NPDC's risk-based approach in forecasting the 3-waters pipe renewals.

Wastewater condition data is 94% known by value and 85% known by length, while its age data is 99% known by age. Drinking water condition data is 88% known by value and 85% known by length, while its age data is 99% unknown by age. Stormwater condition data is only 1% known by value and 1% known by length, while its age data is 99% known by age. We note that stormwater condition inspection budgets were terminated by Council in 2008, but have been budgeted to recommence in 2020. The above known data percentages apply to piped assets only.

The levels of known asset data are illustrated in the following chart.



The reviewer believes that Council staff do have a **very good awareness and appreciation** of the gaps in data and how they are going to improve the data, analysis and accuracy of renewals forecasts.

Reviewer's recommendations on process and practice improvements

The reviewer has made a number of process and practice recommendations for improvement, including aspects such as:

1. That Council seriously consider the Infrastructure Management Team's advice

[2] Analysis based on value rather than length enables us to focus on the critical assets.

a. That there is now a backlog of approximately $126 million of assets that have reached the end of their operating lives

b. To adopt the recommendation for the financial forecast uplift from current renewals budgets average $7.1 million per year to between $19.7 million and $31.1 million per year for the next 10 years. This is to address the backlog of deferred renewals and appropriately fund the ongoing forecast renewals requirements

2. Collect and document gaps in asset condition data and alignment between documents to improve confidence in network state reporting, renewals analytics, renewal programmes development and financial forecasts for all 3-waters. The reviewer acknowledges that some of this has started with the reintroduction of budget for stormwater CCTV inspections as of 1 July 2020.

3. Criticality is one of the factors that contributes into the renewal forecast. As such, we recommend the following factors to be considered or more clearly defined:

   a. Importance level, condition vulnerability and severity,

   b. Understanding which critical assets are delivering service to which critical areas or facilities.

   c. The customer perspective, such as number of customers being served.

4. Further investigation is recommended to determine specific asset failure modes so as to better inform the types of renewal (and maintenance) required.

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 Background

GHD has been engaged by New Plymouth District Council (NPDC) to review the 3-waters renewal forecast. This report captures the review findings for 3-waters asset renewal forecast in addition to potential assets failure modes, and recommendations for actions to be taken to improve the accuracy of the forecast.

Delivery of this work highlighted a number of key contextual matters which are relevant for both the current state and future outlook. These include:

- A considerable quantity of the assets (approximately 35%) are in poor or very poor condition
- Current renewal expenditure being significantly below the depreciation rate and asset need for renewals
- CCTV inspection of stormwater pipes has been suspended since 2008
- Council undertook major cuts in expenditure (mostly in stormwater renewal budget) during the Global Financial Crisis in 2008.

Gaps in asset knowledge resulting from the absence of condition investigation and reduced works can create problems with asset vulnerability and service reliability in the future. In addition, if asset renewal is not programmed and the respective budget is not forecasted, this positioned is accentuated.

To address this situation and better understand the required expenditure for renewal activities, NPDC have completed significant work around expected asset lives, risk, backlog, and renewal projections through the process of preparing the 2021 AMPs.

1.2 Scope

The scope of this project required the review of:

- Infrastructure Management Team's approach and methodology to determining renewals works and financial forecasts
- The underlying data that reflects the current state of its 3-waters networks and need for investment, and that is inputted into the analysis of renewals needs and financial forecasts
- The resulting renewals works programme and financial forecasts from its analytics using the underlying data and assumptions
- Reviewer's recommendations on process and practice improvements.

The scope incorporated two work streams:

(1) Renewals Forecast Review; including:

- Analysing the asset data completeness, accuracy and level of confidence (evidence basis), including condition, age and criticality of assets (risk basis), and other inputs or assumptions and methods used to develop the 3-Waters renewals programme and financial forecast (budget requirement).
- To the extent and level of detail that can be derived from existing council-provided information, identifying potential and probable failure modes as well as the underlying potential consequence of failure for critical and non-critical assets. The context of this

was to confirm that renewal investment is targeted to critical components and their failure modes to inform the types of renewal (and maintenance) required

- Reviewing the existing renewals programme and renewal financial forecast (budget requirement).
- Producing a renewals' forecast review report for each of the Council's 3-waters asset portfolios that confirms the confidence of council's renewals forecasts. If the reviewer believes that Council's current renewal forecasts are not appropriate, they will, if possible from desktop study, also give indicative appropriate renewals funding levels with associated assumptions and levels of confidence.
- The International Infrastructure Management Manual (IIMM) 2015 and the Better Business Case approaches and methods are to be used to review, assess and report on the levels of confidence in the 3-waters renewal data, analytics, programme and financial forecasts. This included consideration of the alignment of the renewals programme to Council objectives and stakeholder levels of services; and that the renewals are planned to:
    - Ensure the reliability of the existing infrastructure to deliver the service it is installed to facilitate
    - Ensure the infrastructure meets the desired Level of Service (LoS)
    - Reduce the likelihood and risk of asset failures, particularly of critical assets

(2) Process and Practice Recommendations; including:

- Developing a list of recommendations to improve the 3-waters renewals programme development processes, data and financial forecasts.
- Considering whether NPDC would achieve the lowest whole of life costs as ageing assets deteriorate past a maintainable state.

2. Overview of the Assets

2.1 NPDC 3-Waters Assets

The New Plymouth District Council owns and operates Drinking Water, Wastewater and Storm Water systems that have a gross current replacement value of approximately $1.36 billion (Three Waters Renewals Funding Report, 2020).

Table 1 NPDC 3-Waters Replacement Cost and Depreciation

Asset Class	Replacement Cost	Annual Depreciation
Drinking Water	$ 335,016,794	$ 4,558,071
Wastewater	$ 650,011,446	$ 8,317,809
Stormwater	$ 372,912,108	$ 3,785,737
Total	**$1,357,940,348**	**$16,661,617**

Figure 1 shows the proportion of the existing budget compared to the backlog[3] and annual depreciation.

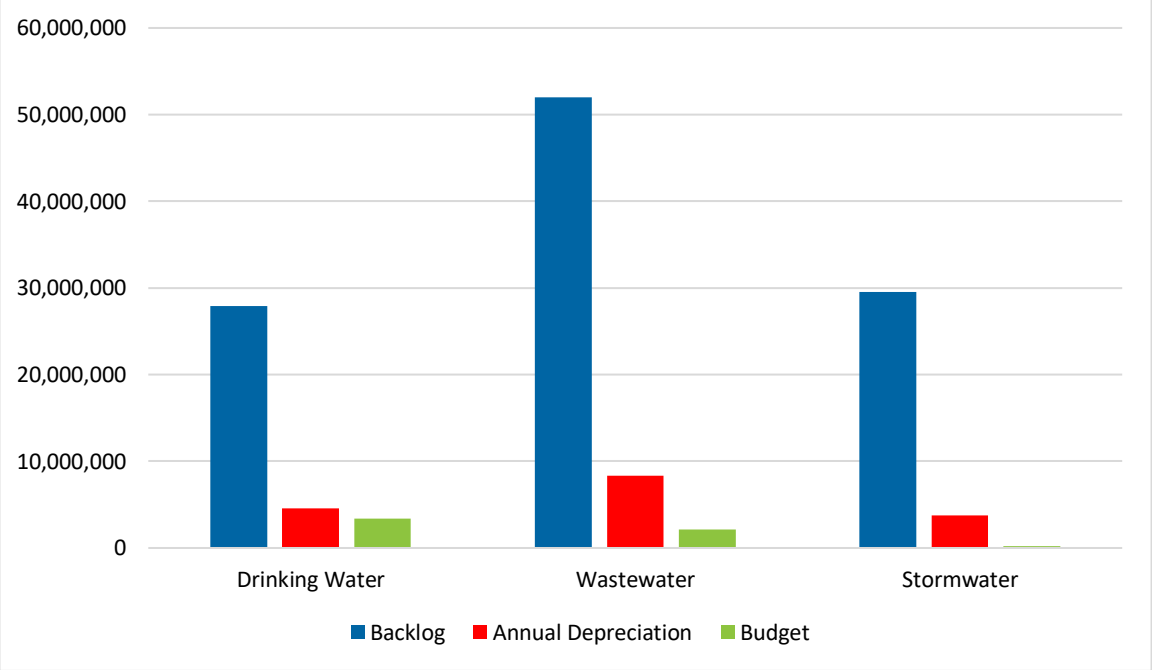


Figure 1 NPDC 3-Waters Backlog, Annual Depreciation, and Budget

3-Waters renewals budgets have been reduced since 2012, with the current renewals funding approximately 65% lower than pre 2012 funding levels.

3-Waters renewals budgets currently total $71 million over the 10 years of the 2018-28 Long Term Plan. When compare to 3-waters average annual depreciation ($16.6 million), the dedicated budget for 3-waters average annual renewal is not enough ($7.1 million). While $126 million is waiting to be resolved (3-Waters Renewal Forecast, 2019), this will cause even larger backlog and put a significant risk of disruption to the city's infrastructure. Some of

[3] Backlog is the value of assets that have exceeded their expected useful life.

these assets (aged over 100 years, see Figure 2) are critical ones that disruption to them can be significantly costly, and affect the community's health, well-being, and culture.

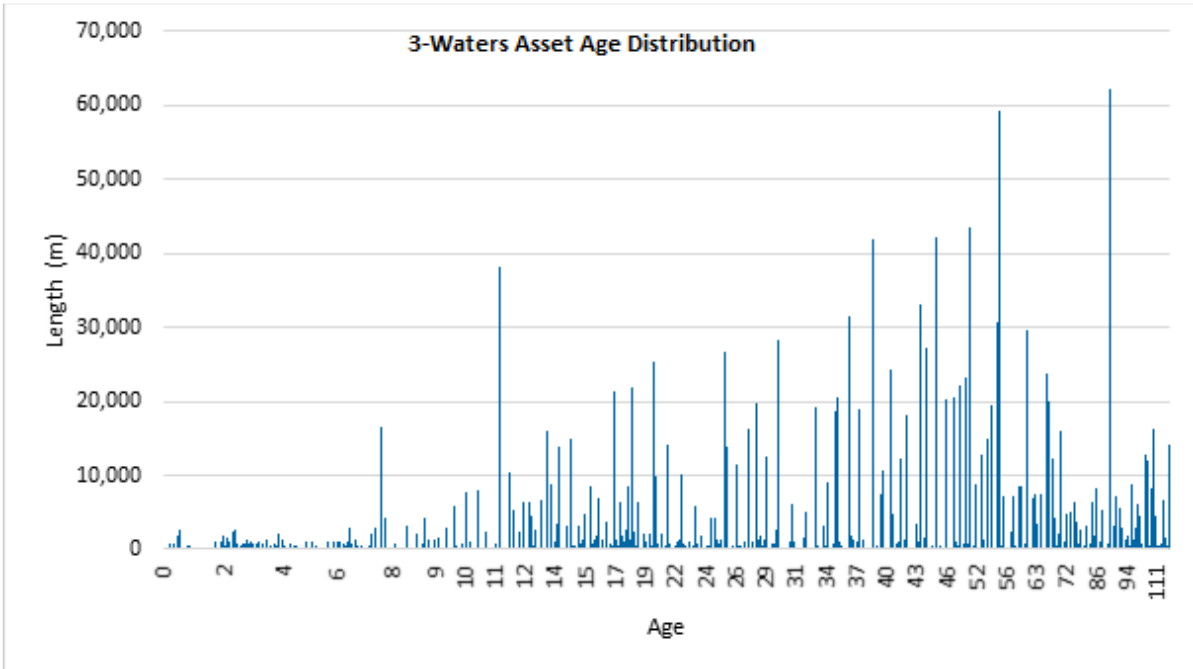


Figure 2 3-Waters Assets Age Distribution (Reticulation Renewals Inventory Data, 2019)

When the assets are not replaced when they need to be, a backlog forms and assets can fail when they are most needed. Figure 3 shows the budget required to address the 3-water assets renewal over the next 50 years, including trend line shown in red.

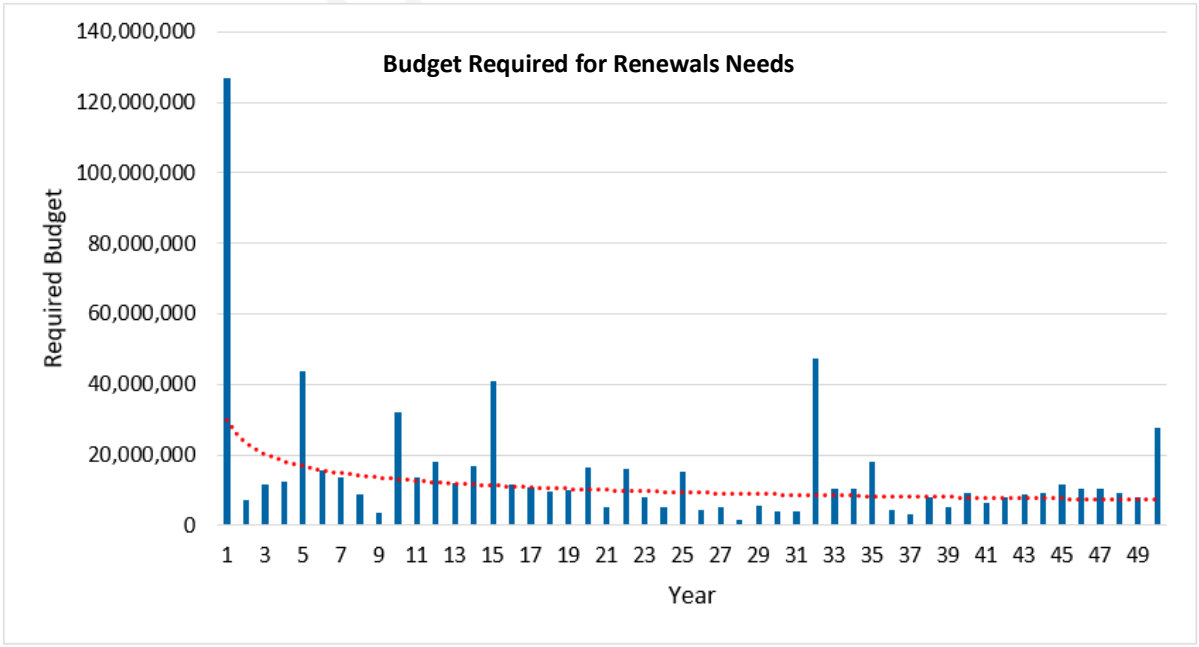


Figure 3 Budget Required to meet Renewal Needs over the next 50 Years (Reticulation Renewals Inventory Data, 2019)

2.2 Existing Pipeline Condition

The 3-waters condition assessment is based on a combination of age, CCTV, and pipe failure analysis. NPDC's 3-water assets age database is claimed to be complete (99.4% of asset ages are available). However, the condition assessment of the assets is an area that needs further attention over the next years.

While 88% of drinking water pipes and 94% of wastewater pipes condition are known[4] (graded from very poor to excellent), approximately 99% of stormwater pipes have either not been inspected or the inspection data is outdated.

Drinking water condition assessment has been based mostly on breakage and maintenance history as an analogue for condition, plus some AC pipe sampling. The wastewater pipes condition assessment has been based on CCTV inspection. According to the existing documents, stormwater pipes CCTV inspection has been suspended since 2008.

Figure 4 and 5 show the condition of drinking water, wastewater, and stormwater assets by value (gross current replacement cost GCRC) and by length respectively.

Figure 4 Drinking Water Pipes Condition by Value (GCRC)

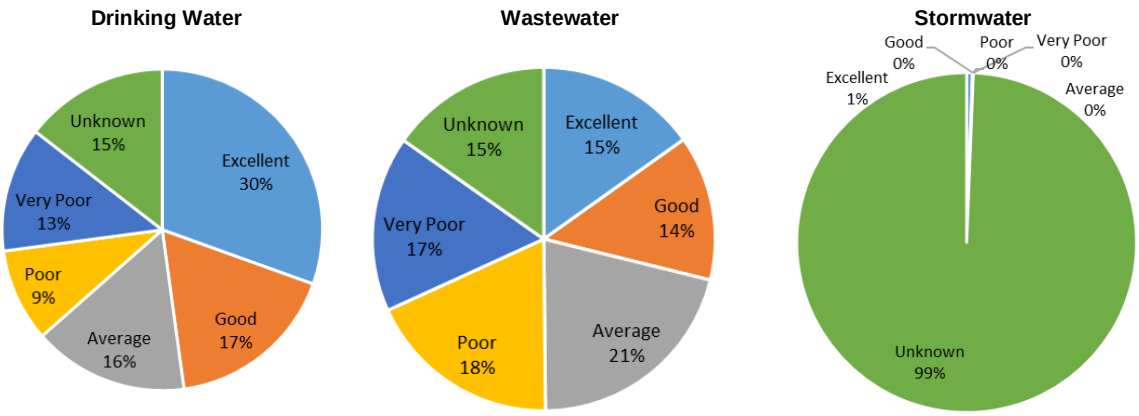


Figure 5 Drinking Water Pipes Condition by Length

[4] It should be noted that these numbers are correct for piped assets.

3. Review Approach

The project incorporated three main activities in reviewing the NPDC 3-waters assets forecast review as follows:

- Kick-off and Discovery
- Review and Renewals Forecast Review
- Process and Practice Recommendations

The Kick-off and discovery included meeting with NPDC specialists and asset managers to identify the existing data and information and understand the method developed and used by NPDC to forecast the renewals.

The main part, renewal forecast review, has been undertaken through a comprehensive review of the existing data and method. The project team has been in close contact with the NPDC asset management team, asking for further information and explanation.

Two different approaches have been take to review the NPDC's asset renewal forecast:

1- Top-down approach

The future investment required addressing both the current backlog due to the historical under-investment and future deterioration has been reviewed. In addition, the budget that has been dedicated to the renewal has also been investigated to identify the shortcomings (existing condition). The top-down review enables us to understand how the forecasted numbers look like in a big picture.

2- Bottom-up approach

NPDC's data quality, including completeness, accuracy, and currency has been investigated. Additionally, the method being used by NPDC to make the forecast has also been overseen. This approach enables us to identify if the right method is being applied on the right data to achieve the right results.

4. Review Results

4.1 Alignment with NPDC's Vision, Community Outcomes, and Key Objectives

This project is aligned with the following NPDC visions:

	Putting people first *Aroha ki te Tangata*
	Caring for our place *Manaaki Whenua, manaaki tangata, haere whakamua*

It also aligns with the council's strategic direction for **Growth** to direct a cohesive strategy that strengthens the city and township and **Industry** to strengthen and manage rural economy, industry, the port, and the airport.

NP District Council's key objectives for the three waters service are (Water, Wastewater, and Stormwater AMPs – General Volume):

- To provide a safe, healthy and efficient service at an affordable cost.
- To minimise the impact of high density human populations on the environment.
- To ensure infrastructure can meet both current and future demand within our defined levels of service.
- To comply with the Drinking Water Standards for New Zealand 2008 (DWSNZ) and TRC's Regional Fresh Water Plan for water and stormwater services, respectively.
- To protect public health and the environment.
- Provide an acceptable level of resilience in emergency situations.
- To continuously improve asset management practices.

We believe that the Infrastructure Management Team's renewals investment proposal in 3-waters is aligned to council objectives and level of service requirements.

4.2 Existing Data and Information – A High Level Review

GHD has reviewed existing data and information, and believes that the approach, methods and results are logical and comprehensive.

Data level of confidence is assessed **Moderate to High** for both Wastewater and Drinking Water and **Low** for Stormwater. While the data quality is generally high for piped assets, the non-piped assets suffer from lack of data completeness and condition record. 3-waters asset data requires improvements in some aspects; particularly the following data issues:

- Non-piped assets data (e.g. plant and equipment) to be captured and recorded appropriately.
- Appropriate data and information documentation to be carried out.
- Cross-control between the documents to be carried out to minimise number mismatches. For instance:
    - Backlog numbers do not match in the following documents:
        - 3-Waters Reticulation Renewals Inventory ($47 M)

        - 3-Waters Renewal Forecast ($80 M)
    - Depreciation value differences are noted between the 2016 and 2019 valuations:
        - 3 waters renewal funding report 2020 based on the 2019 valuation: water ($4.5 M), wastewater ($8.3 M), stormwater ($3.8 M)
        - 3 waters AMPs 2016 based on 2016 valuation : water ($4.4 M), wastewater ($5.2 M), stormwater ($2.7 M)

The main documents used in this review include the followings:

Three Waters Renewal Funding Report (PDF – Version B, 2 June 2020)

The document describes NPDC's asset management enablers including asset management strategy and the framework being used, budget (historic budgeting, operational budget history including actual operating budget and 2000 budget adjusted for growth and inflation, asset valuation history, renewal budget history, etc.), data and information management, capability, and competency.

The document reflects a well-established methodology (backed by the 3-Waters ECM forecasting spreadsheets, described below) in providing a band (range) instead of a single number.

Consolidated 10 year Forecast (xls, DL 13July 2020)

The spreadsheets (xls) above details piped and non-piped asset various renewals forecasts and methods in support of the Three Waters Renewal Funding Report.

ECM_8274558_v14_Trunk and Dis Main (1) Water Main Renewals Forecast (xls),

ECM_8286747_v5_Wastewater Renewal Budget Monte Carlo analysis (xls), and

ECM_8294434_v1_2020 Stormwater Monte Carlo analysis (xls)

The spreadsheets (xls) above include application of Monte Carlo method on the NPDC innovative method of classifying assets based on their criticality and condition. The calculations have been applied to the 3-waters assets to estimate the probability of failure and the budget required to replace the assets of higher criticality and poorer condition.

3-waters Renewal Forecast (xls)

This is NPDC's initial forecast of the likely order of magnitude that renewals budgets need to be set at. This is largely based on forecasts of remaining useful lives and there is ongoing work to do more sophisticated forecasting that brings in criticality and condition ratings. This forecast analyses the assets with less than one (1) year remaining useful life (the backlog). The 3-waters backlog is as per Table 2.

Table 2 Summary of 3-Waters Renewal Backlog (age-based)

Asset Class	Sum of GCRC (2019)	Backlog/Total Assets
Water	$28,194,721	26%
Wastewater	$51,999,848	47%
Stormwater and Flood Protection	$29,518,132	27%

Total	**$109,712,701[5]**	**100%**

Plant and equipment gross current replacement cost (GCRC) is recorded zero until 2022. NPDC confirmed that the above ground assets suffers from quality issues, mainly incompleteness. In contrast, the reticulation data is considered reliable.

Pipe Age at Renewal (xls)

This is some analysis of NPDC's historic pipe data to look at their age based on the date they were replaced. The intention was to look at how much of the original design lives Council was actually realising as a way of validating the design lives in its inventories. As the sample size is small, lower degree of certainty is expected.

A number of the pipes have been replaced before the end of their design life. These pipes were replaced because of their condition (reactive renewal) rather than their age.

Reticulation Renewals Inventory Data (xls)

This includes asset inventory data (raw data) that sits behind renewals analysis. In summary, the 3-waters suffer from $112 million backlog (age-based) plus $15 million oncosts[6], coming up to $126 million in total.

Probability distribution conditions (ppt)

This presentation explains the how the remaining useful life is adjusted for assets with different criticality levels. It also contains the distributions assigned to assets with different criticality and condition levels. This also documents how the Monte Carlo simulation is applied to estimate the probability of failure.

Reticulation Renewals Inventory Data (xlsx)

This contains 3-waters asset register, renewal forecast for the next 20 and 50 years, and asset replacement costs.

State of the District's Infrastructure – Council Briefing 18/12/2019 (pdf)

This document presents the existing condition of the 3-waters assets, the renewal budget, assets condition, and other planning, financial and risk information.

2019 Valuation reports for 3waters infrastructure (pdf, xls)

Includes the latest 3-waters asset valuation undertaken by WSP-Opus. This includes a report that indicates the valuation methodology and a spreadsheet that includes the assets' valuation.

Other documents that have been reviewed include:

- Water Supply AMP (2018-2028)
- Wastewater AMP (2018-2028)
- Stormwater AMP (2018-2028)
- New Plymouth District's Long Term Plan (2018-2028)
- Asset Management Strategy 2018
- Collated 2019 Valuation of Infrastructure Asset
    - 3-Water Network Assets
    - Plant and Equipment for 3-Waters, Solid Waste, and Treatment Plants

[5] Excluding approximately 15% oncosts.
[6] Oncost to allow for valves, hydrants, etc. when replacing the main asset

- New Plymouth National Performance Review (2018/19): Water Supply, Wastewater, and Stormwater
- Pipe age at renewal
- 3-Waters Reticulation Renewals Inventory
- Plant and Equipment Renewals Inventory
- Asset Management Competency Framework
- 3-Waters Capability Assessment
- Draft Asset Management System (v 0.3)
- Risk and Criticality Assessment for Wastewater Pumps
- State of the District's Infrastructure – Council Briefing 18/12/2019
- 3-Waters Budget History

4.3 Renewals Forecast Approach and Methodology

NPDC has adopted an evidence-based, risk-based approach and methodology to predict asset renewal needs and derive financial forecasts. This included detailed consideration of

- Asset condition, age and criticality
- Asset deterioration analytics
- Asset lifecycle analytics
- Statistical technique (Monte Carlo integration) to estimate the probability of failure

In summary, the reviewer believes that the Infrastructure Management Team has robustly applied appropriate industry practice in their approach and methodology to deriving evidence-based, risk-based renewals work programmes and financial forecasts. This has included age-based analytics, as well as innovative techniques using condition, criticality and statistical simulation to estimate the probability of failure. Therefore the reviewer's confidence level with respect to Council's approach and methodology to determine renewal needs and financial forecast is ***High for all 3-waters networks*.**

Usually, the local authorities use age for renewal forecast and condition assessment for individual assets' renewal planning. Condition inspection is usually costly and cannot be carried out for a large number of assets. Age-based renewal analysis may not be accurate because the asset's actual condition can, for a variety of reasons, be better or worse compared to its age.

NPDC has benefited from condition assessment data (drinking water and wastewater) when available and used age as an indicator for condition when condition assessment data is not available.

NPDC has combined age, condition, and criticality to develop a more accurate and practical renewal forecast, especially for its critical assets that serve more customers or serve critical users (e.g. hospitals, education centres, etc.). Considering asset criticality helps NPDC to focus on the assets that their functionality is important for a wider or most important range of residents.

The approach uses both age and condition indicators to measure and estimate the asset's **current condition**) by:

- Using age-based condition ratings for water pipes, wastewater rising mains, wastewater gravity pipes that do not have CCTV and most stormwater pipes (no CCTV).
- Using inspection based condition ratings for wastewater and stormwater pipes with CCTV results.

The challenge of shifting the different categorisations from the 3rd Edition to the 4th Edition of the New Zealand Pipe Inspection Manual has been addressed very well. Very poor condition (IIMM scoring) is correctly assumed grade 5 (4th Edition of the NZ Pipe Inspection Manual) with less than three years remaining useful life.

NPDC's method classifies the assets based on their criticality. In summary, the more critical an asset is and the poorer condition it has, the more urgently it needs to be replaced.

Table 3 and Table 4 show the renewal forecast classification based on "asset criticality and age", and "asset criticality and condition" respectively.

Table 3 Renewal Forecast Classification based on Asset Criticality and Age (Renewal Profile Calculations, 2020)

Condition	Criticality	Worst Case	Most Likely	Best Case
Very Poor	Critical	Remaining useful life is 0% of design life	Remaining useful life is 0% of design life	Remaining useful life is 5% of design life
	Important	Remaining useful life is 0% of design life	Achieves 95% of design life	Remaining useful life is 10% of design life
	Moderate	Achieves 90% of design life	Achieves 100% of design life	Achieves 110% of design life
	Non-critical	Achieves 90% of design life	Achieves 100% of design life	Achieves 130% of design life
Poor	Critical	Achieves 85% of design life	Achieves 90% of design life	Achieves 95% of design life
	Important	Achieves 90% of design life	Achieves 95% of design life	Achieves 100% of design life
	Moderate	Achieves 90% of design life	Achieves 100% of design life	Achieves 110% of design life
	Non-critical	Achieves 90% of design life	Achieves 100% of design life	Achieves 130% of design life
Average or Above	Critical	Achieves 85% of design life	Achieves 90% of design life	Achieves 95% of design life
	Important	Achieves 90% of design life	Achieves 95% of design life	Achieves 100% of design life
	Moderate	Achieves 90% of design life	Achieves 100% of design life	Achieves 110% of design life
	Non-critical	Achieves 90% of design life	Achieves 100% of design life	Achieves 130% of design life

Table 4 Renewal Forecast Classification based on Asset Criticality and Condition (Renewal Profile Calculations, 2020)

Condition	Criticality	Worst Case	Most Likely	Best Case
Very Poor	Critical	Remaining useful life is 0% of design life	Remaining useful life is 0% of design life	Remaining useful life is 5% of design life
	Important	Remaining useful life is 0% of design life	Remaining useful life is 0% of design life	Remaining useful life is 5% of design life
	Moderate	Remaining useful life is 0% of design life	RUL = -0.060 * score + 12	Remaining useful life is 10% of design life
	Non-critical	Remaining useful life is 0% of design life	RUL = -0.060 * score + 12	Remaining useful life is 30% of design life
Poor	Critical	Remaining useful life is 0% of design life	Remaining useful life is 0% of design life	Remaining useful life is 5% of design life
	Important	Remaining useful life is 0% of design life	RUL = -0.070 * score + 10.5	Remaining useful life is 5% of design life
	Moderate	Remaining useful life is 0% of design life	RUL = -0.070 * score + 13.5	Remaining useful life is 10% of design life
	Non-critical	Remaining useful life is 0% of design life	RUL = -0.070 * score + 13.5	Remaining useful life is 30% of design life
Moderate	Critical	Most likely – 5% of design life	RUL = -0.5479 * score + 27.4	Remaining useful life is 5% of design life
	Important	Most likely – 5% of design life	RUL = -0.5479 * score + 34.4	Remaining useful life is 5% of design life
	Moderate	Most likely – 10% of design life	RUL = -0.5479 * score + 37.4	Remaining useful life is 10% of design life
	Non-critical	Most likely – 10% of design life	RUL = -0.5479 * score + 37.4	Remaining useful life is 30% of design life
Good or Very Good	Critical	Achieves 85% of design life	Achieves 90% of design life	The longer of

Condition	Criticality	Worst Case	Most Likely	Best Case
				RUL = -1.6 * score + 51.6 and RUL = 0.95*design life – age
	Important	Achieves 90% of design life	Achieves 95% of design life	The longer of RUL = -1.6 * score + 51.6 and RUL = design life - age
	Moderate	Achieves 90% of design life	Achieves 100% of design life	The longer of RUL = -1.6 * score + 51.6 + 0.1 * design life and RUL = 1.1*design life - age
	Non-critical	Achieves 90% of design life	Achieves 100% of design life	The longer of RUL = -1.6 * score + 51.6 + 0.3*design life and RUL = 1.3*design life - age

There are three ways to resolve the backlog:

1- ***Do nothing*****.** This approach will add to the backlog over time and increases the risk of asset disruption.

2- ***Prioritise and accomplish backlog renewal first***, then proceed with the upcoming renewals. This would impose a significant cost to the Council and may not be practical. This approach would not be a risk-based approach because pipes in the backlog may not present the greatest risk and may not need to be replaced first.

3- ***Prioritise and accomplish the combined backlog and upcoming renewals over a certain timeframe*****.** This is usually the most feasible solution to address the backlog, especially when the backlog is considerable. NPDC's method is taking this approach to address the backlog and prioritises the asset renewals based on their criticality and condition, regardless of whether it is an historical backlog or upcoming renewal. This is a risk-based approach as the priority is given to the highest risk assets first, where risk is a combination of both criticality (consequence of failure) and condition or age (likelihood of failure).

While the criticality assessment method being used is very well established, the following areas could be improved to obtain better results:

a. Criticality method to be more clearly defined, formulated, and documented, taking into account the following factors:

   - Importance Level
   - Condition (based on age, break rate, and CCTV inspection data)
   - Vulnerability (including 'business as usual' deterioration based on the pipe material)

b. The method (which was developed in 2012) to be reviewed with consideration to the following:

   - Weighting and scoring process: Based on anecdotal data, the number of people involved in the weighting and scoring process does not seem to be adequate (approximately 10 people have been asked to weigh the "severity").
   - Source/justification of the criteria: The criteria need to have appropriate reference. The reference can be existing literature, interviews, etc.
   - Severity categorisation: The severity classification needs to be defined clearly. For example, it is not clear why the pipe diameter has been divided to less than 450mm, between 450mm and 900mm, and over 900mm.

- Severity measures: Some of the severity measures do not look appropriate. For example, using buffer zones (e.g. 100m around critical facilities such as hospitals) as a severity measure may not be as appropriate for assessing criticality of an asset as understanding which assets are delivering service to the critical facility.

Refer to Appendix A for further information.

4.4 Resulting Renewal Programme and Forecast

GHD's 'top-down' review found annual depreciation is approximately $17 million and a backlog of very poor condition piped assets in the order of at least $130 million. A 10-year period to address historical backlog and allow for depreciation could therefore be in the order of $300 million total over the 10 years.

GHD's 'top-down' review findings are consistent with the Infrastructure Management Team advice. NPDC's 3-waters is suffering from a $126 million renewals backlog and the Infrastructure Management Team proposed recommendation for the financial forecast uplift from current renewals budgets average ($7.1 million per year) to between $19.7 million and $31.1 million per year for the next 10 years. This is to address the backlog of deferred renewals and appropriately fund the ongoing forecast renewals requirements.

GHD's 'bottom-up' review findings are captured in the following sections.

4.4.1 Age-based Approach

Based on the age analysis (3-Waters Reticulation Renewals Inventory, 2019) and regardless the existing backlog, the following $141 million budget will be required to accomplish 3-Waters assets renewals over the next 10 years[7]:

- Drinking Water: $24.6 million
- Wastewater: $80.2 million
- Stormwater: $36.2 million

To wipe the backlog in the next 10 years and stay up-to-date on renewals, the following $250 million budget needs to be met:

- Drinking Water: $52.5 million
- Wastewater: $132.2 million
- Stormwater: $65.7 million

4.4.2 Condition-based Asset Renewal Forecast

In the other hand, condition-based renewal analysis indicates that $349 million is required to be dedicated to wipe the backlog in the next 10 years and stay up-to-date on renewals.

The condition-based backlog and renewal forecast have been calculated as below:

- Backlog = assets in very poor condition
- Renewal forecast = assets in poor condition that will slip into very poor condition over the next 10 years[8].

Drinking water and wastewater assets backlog and renewal forecast are calculated as per below:

[7] The period from 2020 until 2029
[8] Assuming that asset condition brackets obey normal distribution, half of the poor condition assets slip into very poor condition over the next 10 years.

Drinking water

Backlog (Assets in very poor condition) = very poor (%) * total asset replacement cost = 14% * $335 M = $47 M

Assets in poor condition = poor (%) * total asset replacement cost = 11% * $335 M = $36.9 M

Renewal forecast (Assuming half of poor assets need replacement over the next 10 years) = $18.45 M

Wastewater

Backlog (Assets in very poor condition) = very poor (%) * total asset replacement cost = 22% * $650 M = $143 M

Assets in poor condition = poor (%) * total asset replacement cost = 23% * $650 M = $149.5 M

Renewal forecast (Assuming half of poor assets need replacement over the next 10 years) = $74.8 M

Stormwater

Backlog assumed $29.5 M (age-based)

Renewal forecast assumed $36.2 M (age-based)

4.4.3 NPDC's Innovative Approach in Renewal Forecast

NPDC Infrastructure Management Team devised an innovative approach to adjust the renewal forecast considering asset age and condition, asset criticality and using statistical simulation to estimate the probability of failure. This method has been introduced in section 4.3.

NPDC's innovative analysis for all assets (pipes, plant, equipment etc) shows that $254 million budget is required to be spent on 3-waters renewals over the next 10 years:

- Drinking Water: $70.0 million
- Wastewater: $151.7 million
- Stormwater: $25.5 million

We agree that age-based analysis may not be ideal for identifying budget adequacy to minimise the critical assets failure risk. Condition-based budget analysis shows that NPDC will require $65.5 million and $217.8 million to spend on water and wastewater assets renewal. From this point and assuming that NPDC's condition assessment is accurate, while NPDC's method will address the existing condition-based backlog, it is not expected to keep assets confident over the next 10 years.

Table 5 shows the renewal forecast, backlog, and NPDC method in addressing the 3-water assets' backlog and renewal requirements over the next 10 years[9].

[9] The period from 2020 until 2029

Table 5 3-Waters Asset Renewal Forecast Results

(A) Asset Class	(B) Renewals forecast (age based) over next 10yrs	(C) Backlog (age)	(D) Backlog (condition 5- very poor[1], age for SW)	(E) Renewal Forecast (condition, SW age)	(F) (B) + (C) Renewals forecast (age) PLUS Backlog (age)	(G) (D) + (E) Renewal forecast (condition) PLUS Backlog (condition)	(H) NPDC Method to forecast renewals over the next 10 years	(I) Asset depreciation over the next 10 years
Drinking Water	$24.6 M	$27.9 M	$47 M	$18.5 M	$52.5 M	$65.5 M	$77.0 M	$44 M
Waste-water	$80.2 M	$52.0 M	$143 M	$74.8 M	$132.2 M	$217.8 M	$151.7 M	$46 M
Storm-water	$36.2 M	$29.5 M	$29.5 M[3]	$36.2 M [4]	$65.7 M	$65.7 M	$25.5 M	$27 M
Total	**$141 M**	**$109.4 M[2]**	**$219.5 M**	**$129.5 M**	**$250.4 M**	**$349.0 M [5]**	**$254.2 M**	**$117 M**

Sources:

(B) 3-Waters Reticulation Renewals Inventory (DW v14, WW v1, SW v1))

(C) 3-Waters Renewal Forecast

(D) Pipe Condition Breakdown and Three Waters Renewals Funding Report

(E) Pipe condition breakdown

(H) ECM Renewal Forecasts (NPDC's methodology), and Consolidated 10 year Forecast DL 13July 2020

Table Notes

(1) Assuming none of the unknown assets are in very poor condition.

(2) Excluding oncosts. The total backlog including oncosts is $126 M as stated in the Infrastructure Manager's report dated in 2 June 2020.

(3) Stormwater backlog assumed $29.5 M (age-based backlog).

(4) Stormwater renewal forecast assumed $36.1 M as per age analysis (source: 3-Waters Reticulation Renewals Inventory).

As the NPDC's method forecasts required renewal budget for 3-waters assets (and not limited to piped assets), the reviewers have calculated the condition-based forecast and renewal requirements based on the whole assets replacement cost. As such, it has been assumed that the 3-waters asset conditions obey the "piped assets" condition.

A high-level analysis shows that NPDC's renewal forecast will decrease the backlog and address some critical assets renewals. However, it may not address all of the critical assets and backlog at the end of the 10-year period for the wastewater and stormwater assets. To improve it, NPDC could allocate budget closer to the maximum renewal forecast amount (shown in Table 6 below).

Table 6 NPDC Renewal Forecast (Min and Max) versus Renewal Requirement

(A) Asset Class	(B) NPDC Renewal Forecast (Minimum)	(C) NPDC Renewal Forecast (Maximum)	(D) Renewal Requirement – Renewal forecast (condition) PLUS Backlog (condition)	(E) (C) – (D) Variance
Drinking Water	$53.0 M	$100.9 M	$65.5 M	+$35.4 M
Wastewater	$128.1 M	$175.4 M	$217.8 M	-$42.4 M
Stormwater	$16.6 M	$34.5 M	$65.7 M	-$31.2 M
Total	**$197.7 M**	**$310.7 M**	**$349.0 M**	

The confidence of the Infrastructure Management Team's method in prioritising the critical assets renewal based on their current condition is ***High***.

We believe that the method used by NPDC is logical, practical and credible. NPDC's method will decrease the risk of critical assets failure over the next 10 years. NPDC's method reflects lowest whole of life costs as ageing assets deteriorate past a maintainable state. Conversely, under-investing in renewals will increase the backlog and increase operation and maintenance costs.

In summary, the reviewer's confidence level with respect to Council's renewals work programmes and financial forecasts is

- ***Moderate to High for Wastewater,***
- ***Moderate for Drinking Water and***
- ***Low for Stormwater.***

These results are largely due to the incompleteness of underlying condition data which inputs the renewals analytics. Wastewater condition data is 6% unknown by value and 15% unknown by length, while its age data is only 1% unknown by age. Drinking water condition data is 12% unknown by value and 15% unknown by length, while its age data is only 1% unknown by age. Stormwater condition data is 99% unknown by value and 99% unknown by length, while its age data is only 1% unknown by age.

Data quality improvements and better alignment of the information will enable the infrastructure team to:

- Increase forecast accuracy
- Decrease risks related to critical assets failure
- Optimise operation and maintenance costs

The reviewer believes that Council staff do have a **very good awareness and appreciation** of the the gaps in data and how they are going to improve the data, analysis and accuracy of renewals forecasts.

In summary, the reviewer believes that Infrastructure Management Team's advice to address the backlog of deferred renewals and appropriately fund the ongoing forecast renewals requirements is credible. That is:

- A backlog of approximately $126 million of assets that have reached the end of their operating lives
- The recommendation for the financial forecast uplift from current renewals budgets average $7.1 million per year to between $19.7 million and $31.1 million per year for the next 10 years.

4.5 Failure Modes

The extent and level of detail of existing council-provided information indicated that considerable work was undertaken to identify the criticality of assets to the failure of network service delivery, as well as underlying potential consequences of failure for critical and non-critical assets. Therefore, there is some risk-based targeting of renewal investment to critical components and their failure to inform renewal programmes requirements.

However, there did not appear sufficient information to derive specific potential and probable asset failure modes. Further investigation is recommended to determine specific asset failure modes so as to better inform the types of renewal (and maintenance) required.

5. Process and Practice Recommendations

The following recommendations are derived from the sections of this report.

1. That Council seriously consider the Infrastructure Management Team's advice
    a. That there is now a backlog of approximately $126 million of assets that have reached the end of their operating lives
    b. To adopt the recommendation for the financial forecast uplift from current renewals budgets average $7.1 million per year to between $19.7 million and $31.1 million per year for the next 10 years. This is to address the backlog of deferred renewals and appropriately fund the ongoing forecast renewals requirements
2. Collect and document gaps in asset condition data and alignment between documents to improve confidence in network state reporting, renewals analytics, renewal programmes development and financial forecasts for all 3-waters. The reviewer acknowledges that some of this has started with the reintroduction of budget for stormwater CCTV inspections as of 1 July 2020. Refer to section 4.2 for further information.
3. Criticality is one of the factors that contributes into the renewal forecast. As such, we recommend the following factors to be considered or more clearly defined:
    a. Importance level, condition vulnerability and severity,
    b. Understanding which critical assets are delivering service to which critical areas or facilities.
    c. The customer perspective, such as number of customers being served.
4. Further investigation is recommended to determine specific asset failure modes so as to better inform the types of renewal (and maintenance) required.

Appendix A – 3-Waters Criticality Assessment

A.1. Water Criticality Assessment

The factors NPDC has identified as the contributing factors to the criticality of water mains are summarised as follows.

Table 7 Contributing Factors to the Criticality of Water Mains (Water, wastewater, and stormwater mains criticality, 2012)

Factor	Criteria	Severity
Economic Factors Primarily related to Replacement and Operation & Maintenance Costs. Replacement and O&M costs typically increase with the increase in the pipe size and depth, material, the number of private properties it can potentially flood proximity to railway lines or railway road easements and location in right of way	Size/ Diameter (mm)	<= 100
		100-225
		>225
	Pipe Depth	<1.5 m
		1.5-5.0m
		>5
		Unknown
	Material	Ductile Iron/Cement lined ductile iron (DI, CLDI)
		Plastics (PVC, MPVC, Poly-H, Poly-M, Poly-L, UPVC)
		Cast iron (CI)
		Concrete (CONC)
		Cement lined steel (ST-CL)
		Coppern (COPP)
		Unlined steel (ST, ST-GST,ST-SWS)
		Asbestos cement (AC)
		Mannesman steel (MANN)
		Other, Unknown
	Railways	Crosses or within a railway reserve or location in a railway easement
		Does not Cross or not within a railway reserve or not located in a railway easement
	Roads	**Highways** - Within state highway road reserve
		Primary Arterial roads - pipe crosses road (5 metre buffer)
		Primary Arterial roads - pipe does not cross the road
		Secondary Arterial roads - pipe crosses road (5 metre buffer)
		Secondary Arterial roads - pipe does not cross the road
		Collection roads - pipe line crosses road (5 metre buffer)
		Collection roads - pipe does not cross the road
		Local roads -pipe crosses road (5 metre buffer)
		Local roads - pipe does not cross the road
Environmental Factors (influence of the assets failure on the environment)	Water bodies	Within 20m of priority water body.
		Within 20m of non-priority water body, lakes and wells.
Social/Cultural Factors (Influence of the assets failure on the society)	Critical customers	Hospitals
		Schools
		Dialysis patients

Factor	Criteria	Severity
		Health providers (Dentists etc)
		Vet doctors
		Marae
	Other customers	Bulk water customers
		Food/cafes places
		Hair dressers
		Zoned rural areas-20m buffer
		Zoned residential areas-20m buffer
		Zoned commercial areas-20m buffer
		Zoned industrial areas-20m buffer
	Fire fighting consideration	Zoned rural areas-20m buffer
		Zoned residential areas-20m buffer
		Zoned commercial areas-20m buffer
		Zoned industrial areas-20m buffer
	Reticulated wastewater service	Serviced by reticulated wastewater service-20 m buffer
		No reticulated wastewater service

A.2. GHD Review on Water Main Criticality

The following issues have been identified in the water main criticality assessment method:

- What is called **Factor** may be better to be translated to **Dimension**.
- What is called **Criteria** may be better to be translated to **Indicators**.
- What is called **Sensitivity** may be better to be translated to **Indicator Value**.
- Criticality is one of the factors that contributes into the renewal forecast. As such, we recommend the following factors to be considered: importance level, condition, and vulnerability.
- The indicators to be justified. Specifically, the following indicators:
    - Roads
    - Water bodies
    - Reticulated wastewater service
- The indicator values (severity) to be justified. Specifically, the following ones:
    - Pipe diameter classification
    - Pipe depth classification
    - Buffers: roads, hospitals, etc. Buffering around a critical user may not be the best way of categorising the surrounding assets' criticality.
- All potential critical users to be captured. This includes but not limited to emergency services, civil defence, hospitals and healthcare, education, central and local governments, business and industry, prisons (if any), and other lifeline utilities.
- Non-critical users to be classified as per standard Importance Level.

A.3. Wastewater Mains Criticality Assessment

The factors NPDC has identified as the contributing factors to the criticality of wastewater mains are summarised as follows.

Table 8 Contributing Factors to the Criticality of Wastewater Mains (Water, wastewater, and stormwater mains criticality, 2012)

Factors	Criteria	Severity
Economic Factors	Size/ Diameter (mm)	<=150
		>150-450
		>450
	Pipe Depth	<2
		2-5m
		>5
		Unknown
	Material	Earthenware
		Plastics (PVC, PE)
		Concrete
		Cement lined steel
		Unlined steel
		Asbestos cement
		Other
	Railways	Crosses or within a railway reserve or location in a railway easement
		Does not Cross or not within a railway reserve or not located in a railway easement
	Pressure	Pumped rising main
		Not pumping main
Environmental Factors **Note:** Other environmental factors that could be included in future relate to potential overflow as well as hydraulic failure, due to the limited capacity of the sewer segment in question. Measured using values for the dry weather and wet weather flows i.e if the sewer is surcharged under dry weather conditions, or if surcharged under wet weather flow condition	Water Bodies	Within 20m of priority water body.
		Within 20m of non-priority water body, lakes and wells.
Social/Cultural Factors	Location	Highways - Within state highway road reserve
		Primary Arterial roads - sewer line crosses road (5 metre buffer)
		Primary Arterial roads - sewer does not cross the road
		Secondary Arterial roads - sewer line crosses road (5 metre buffer)
		Secondary Arterial roads - sewer does not cross the road
		Collection roads - sewer line crosses road (5 metre buffer)
		Collection roads - sewer does not cross the road

Factors	Criteria	Severity
		Local roads - sewer line crosses road (5 metre buffer)
		Local roads - sewer does not cross the road
		CBD-Business Area A
		CBD-Business Area B
		CBD-Business Area C
		Hospital - 100m buffer
		Dentist/health services/Rest Homes- 100m buffer
		Veterinary Clinics- 100m buffer
		School, shopping complexes - 100m buffer.
		Parks/beaches/play grounds/walkway/golf course- 100m buffer.
		Marae-100m buffer
		Airport-100m buffer

A.4. GHD Review on Wastewater Main Criticality

The following issues have been identified in the wastewater criticality assessment method:

- What is called **Factor** may be better to be translated to **Dimension**.
- What is called **Criteria** may be better to be translated to **Indicators**.
- What is called **Sensitivity** may be better to be translated to **Indicator Value**.
- Criticality is one of the factors that contributes into the renewal forecast. As such, we recommend the following factors to be considered: importance level, condition, and vulnerability.
- The indicators to be justified. Specifically, the following indicators:
    - Roads
    - Water bodies
    - Reticulated wastewater service
- The indicator values (severity) to be justified. Specifically, the following ones:
    - Pipe diameter classification
    - Pipe depth classification
    - Buffers: roads, hospitals, etc. Buffering around a critical user may not be the best way of categorising the surrounding assets' criticality.
- All potential critical users to be captured. This includes but not limited to emergency services, civil defence, hospitals and healthcare, education, central and local governments, business and industry, prisons (if any), and other lifeline utilities.
- Non-critical users to be classified as per standard Importance Level.

The table below shows an example of the factors contributing into wastewater renewal forecast and the indicators to measure the factors.

Table 9 An Example of How the Factors and Indicator Should Look Like – Factors Contributing into Wastewater Renewal Forecast

Factor	Indicator (criteria)	Indicator value / severity
Criticality: Number of customers being served by the asset (consequence of failure)	Pipe Size (Diameter) mm	<=150
		>150-450
		>450
Importance of customers or users being served (consequence of failure)	Importance Level (IL)	Hospitals and healthcare
		Emergency services
		Civil defence
		NP Council
		Prisons (if applicable)
		Age care facilities
		Marae (culturally significant) -100m buffer
		CBD Area A
		CBD Area B
		CBD Area C
Condition (Probability of Failure)	Age	Age<20% Design Life
		40%<Age<21% DL
		60%<Age<41% DL
		80%<Age<61% DL
		81% DL<Age
	Condition assessment result (inspection)	Very poor
		Poor
		Moderate
		Good
		Excellent
Vulnerability (Probability of Failure)	Material	Earthenware
		Plastics (PVC, PE)
		Concrete
		Cement lined steel
		Unlined steel
		Asbestos cement
		Other
	Location	**Railway:** Crosses or within a railway reserve or location in a railway easement
		Railway: Does not Cross or not within a railway reserve or not located in a railway easement
		Highways - Within state highway road reserve
		Primary Arterial roads - sewer line crosses road (5 metre buffer)
		Primary Arterial roads - sewer does not cross the road
		Secondary Arterial roads - sewer line crosses road (5 metre buffer)
		Secondary Arterial roads - sewer does not cross the road
		Collection roads - sewer line crosses road (5 metre buffer)

Factor	Indicator (criteria)	Indicator value / severity
		Collection roads - sewer does not cross the road
		Local roads - sewer line crosses road (5 metre buffer)
		Local roads - sewer does not cross the road
		Airport-100m buffer
	Pressure status	Pumped rising main
		Not pumping main

Importance level classifications for 3-water assets are shown as follows.

Table 10 Importance Level Classification

Importance Level	Description	Comment
IL1	Low importance facilities	Utilities providing a service to: • Public recreational areas
IL2	Normal facilities	Utilities providing a service to: • Residential properties, commercial and industrial areas
IL3	Important facilities	Utilities providing a service to: • Primary schools, colleges or adult education facilities • Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities. • Airport terminals, principal railway stations with a capacity greater than 250. • Correctional institutions. • Emergency medical and other emergency facilities not designated as post-disaster. • Power-generating facilities, water treatment and wastewater treatment facilities and other public utilities not designated as post-disaster. • Other facilities that play an important role in enabling the community to function, e.g. central business district, significant businesses. Trunk main utilities serving a downstream population of more than 10,000 people. Trunk mains providing water supply to downstream fire hydrants that are important for firefighting in the aftermath of an earthquake.
IL4	Facilities with post-disaster functionality	Utilities providing a service to: Facilities designated as essential facilities Facilities with special post-disaster function Medical emergency or surgical facilities Emergency service facilities such as fire, police stations and emergency vehicles garages Utilities or emergency supplies or installations required as backup facilities for post-disaster response. Designated emergency shelters, designated emergency centres and ancillary facilities.

A.5. Stormwater Criticality Assessment

The factors NPDC has identified as the contributing factors to the criticality of stormwater are summarised as follows.

Table 11 Contributing Factors to the criticality of Stormwater Network (Water, wastewater, and stormwater mains criticality, 2012)

Factor	Criteria	Severity
Economic Factors Primarily related to Replacement and Operation & Maintenance Costs. Replacement and O&M costs typically increase with the increase in the pipe size and depth, material, the number of private properties it can potentially flood, proximity to railway lines or railway road easements and location in right of way	Size/ Diameter (mm)	<=450
		>450-900
		>900
	Pipe Depth	<2
		2-5m
		>5
		Unknown
	Material	Earthenware (GEW, FT)
		Plastics (PVC, UPVC, MPVC, PVC-UL,PVC-HW, POLY-H, POLY-M, NFLO)
		Concrete (CONC, CON-SR, CLASSX, CLASSY, CLASSZ, RCFJ, RCOJ, RCRRJ, RC-TUN
		Aluflo
		Unlined steel (ST, ST-CL, ARMCO, HELICO)
		Asbestos cement (AC)
		Other/ Unknown
		Earth tunnels
	Railways	Crosses or within a railway reserve or location in a railway easement
		Does not Cross or not within a railway reserve or not located in a railway easement
Environmental Factors **(influence of the assets failure on the environment)**	Water Bodies	Pipes conveying water courses (priority water bodies not considered as for the others)
		Consider ways to factor assets that cross streams e.g. Culvert above a stream
Social/Cultural Factors (Influence of the assets failure on the society)	Location	**Highways** - Within state highway road reserve
		Primary Arterial roads - pipe crosses road (5 metre buffer)
		Primary Arterial roads - pipe does not cross the road
		Secondary Arterial roads - Pipe crosses road (5 metre buffer)
		Secondary Arterial roads - Pipe does not cross the road
		Collection roads -Pipe crosses road (5 metre buffer)
		Collection roads - Pipe does not cross the road
		Local roads -Pipe crosses road (5 metre buffer)
		Local roads - Pipe does not cross the road
		CBD-Business Area A
		CBD-Business Area B
		CBD-Business Area C
		Hospital - 100m buffer
		Dentist/health services/Rest Homes- 100m buffer
		Veterinary Clinics- 100m buffer
		School, shopping complexes - 100m buffer.
		Marae-100m buffer
		Airport-100m buffer

A.6. GHD Review on Stormwater Criticality

The following issues have been identified in the stormwater criticality assessment method:

- What is called **Factor** may be better to be translated to **Dimension**.
- What is called **Criteria** may be better to be translated to **Indicators**.
- What is called **Sensitivity** may be better to be translated to **Indicator Value**.
- Criticality is one of the factors that contributes into the renewal forecast. As such, we recommend the following factors to be considered: importance level, condition, and vulnerability.
- The indicators to be justified. Specifically, the following indicators:
    - Roads
    - Water bodies
    - Water bodies
- The indicator values (severity) to be justified. Specifically, the following ones:
    - Pipe diameter classification
    - Pipe depth classification
    - Buffers: roads, hospitals, etc. Buffering around a critical user may not be the best way of categorising the surrounding assets' criticality.
- All potential critical users to be captured. This includes but not limited to emergency services, civil defence, hospitals and healthcare, education, central and local governments, business and industry, prisons (if any), and other lifeline utilities.
- Non-critical users to be classified as per standard Importance Level.

GHD

Level 3, GHD Centre
27 Napier Street
T: 64 9 370 8000 F: 64 9 370 8001 E: aklmail@ghd.com

N:\NZ\Auckland\General\Admin\Advisory\Clients\NPDC\12530342 - 3 Waters\05 Report\12530342 NPDC 3Water Renewal Forecast Review - Final v1.1 15Jul20.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Issue 1.0	B.Balaei, G.Syred	David Walker		David Walker		14 July 2020
Issue 1.1	B.Balaei, G.Syred	David Walker		David Walker		15 July 2020

www.ghd.com