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## Economics Work Package



# THE COST AGGREGATION MODEL AND INDICATIVE LIFE CYCLE COST ESTIMATES FOR VARIOUS INTERVENTION SCENARIOS FOR THE TE AWARUA-O- PORIRUA WHAITUA COLLABORATIVE MODELLING PROJECT

## DRAFT REPORT

Prepared by Sue Ira, Koru Environmental Consultants Ltd on behalf of Greater Wellington Regional Council

Te Awarua-o-Porirua Collaborative Modelling  
Project

December 2018



Environmental Consultants Ltd

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DRAFT Report prepared for Greater Wellington Regional Council.

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25 September and 17 December 2018

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## DISCLAIMER

Whilst every effort has been made to ensure the integrity of the data collected and its application through the COSTnz and UPSW models, the author does not give any warranty as to the accuracy, completeness, currency or reliability of the information made available in this report and expressly disclaims (to the maximum extent permitted by law) all liability for any damage or loss resulting from the use of, or reliance on the Model or the information or graphs provided through them.

Costs presented in this report are indicative life cycle cost estimates and are based on current available information and should be read in the context of the assumptions presented in this report. Cost information has been gathered and modelled in order to gain an understanding of the relative difference in cost between different solutions, not the actual cost of each solution.

Any decision that is made after using this data must be based solely on the decision-makers own evaluation of the information available to them, their circumstances and objectives.

## EXECUTIVE SUMMARY

The purpose of the overall modelling project is to collaboratively generate information and knowledge to support the Te Awarua-o-Porirua (TAoP) Whaitua Committee make recommendations for land and water management in the TAoP Whaitua. The project will produce modelling outputs and knowledge describing the current environmental, social, cultural and economic conditions in TAoP Whaitua, as well as potential outcomes that might result under a number of urban and rural land and water management scenarios developed and specified by the Committee.

This report forms part of the urban and rural intervention work briefs and is the culmination of a series of economic work briefs that address the decision-making needs of the TAoP Whaitua Committee. The purpose of this report is to document:

- the Cost Aggregation Model (CAM) and the life cycle cost approach used to quantify the indicative cost estimates of different interventions;
- the results of the CAM for different water management units (WMUs) and scenarios;
- key messages.

The CAM is a calculation tool that uses a life cycle methodology to bring together and assess the various cost components of stormwater and wastewater interventions. The development of the CAM has been a significant undertaking by GWRC, and is the first LCC model in New Zealand to integrate stormwater and wastewater mitigation with land-use and contaminant reduction. It is the culmination of a series of economic and biophysical modelling work packages which has facilitated the development of indicative LCC estimates of various intervention scenarios on a WMU basis. The CAM is an Excel-based LCC model which integrates cost with different intervention types for different landuses. Section 1.2 summarises the reports which have provided contributing information and data sources for the CAM. The life cycle modelling undertaken is consistent with previous New Zealand stormwater LCC models and the Australian/New Zealand Standard 4536:1999<sup>1</sup>. A description of the scenarios modelled is provided in the report and the resulting economic report cards are presented in Appendix A.

Key messages and results from the CAM are summarised below.

### Understanding the results

When interpreting the cost results, attention should be focused on patterns and relative differences between scenario results, as opposed to the absolute dollar cost figure. This is because life cycle cost analyses are economic and mathematical analyses that allow for comparisons between scenarios on a consistent basis, taking no account of topography, water balance assessments in and between catchments, nor funding and financial constraints or opportunities. Key points to keep in mind when reading the cost results include:

- The purpose of LCC is to allow “like for like” comparison of differing urban development and mitigation scenarios, and are additional to the Existing and BAU scenarios.
- The LCCs are indicative cost estimates and emphasis should not be placed on a specific dollar amount.
- The focus should rather be on the range of relative difference between difference scenario LCC.

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<sup>1</sup> Australian/New Zealand Standard. (1999). Life Cycle Costing: An Application Guide, AS/NZ 4536:1999. Standards Australia, Homebush, NSW, Australia and Standards New Zealand, Wellington, NZ.

- The assessment does not make any assumptions about the feasibility, uptake, timing or optimisation of interventions, or about financing, governance or distributions of costs for particular catchments or activities.

#### TAoP Whaitua-wide indicative cost estimates

The rural and urban stormwater costs range from around \$4.7-\$7.5 million per year under the Improved scenario to \$13.1-\$17.8 million per year under the Water Sensitive scenario. The wastewater costs range from around \$2.1-\$2.6 million per year.

*Annual rural and urban stormwater indicative LCC estimates over 50 years for the whole of the TAoP Whaitua<sup>2</sup>*

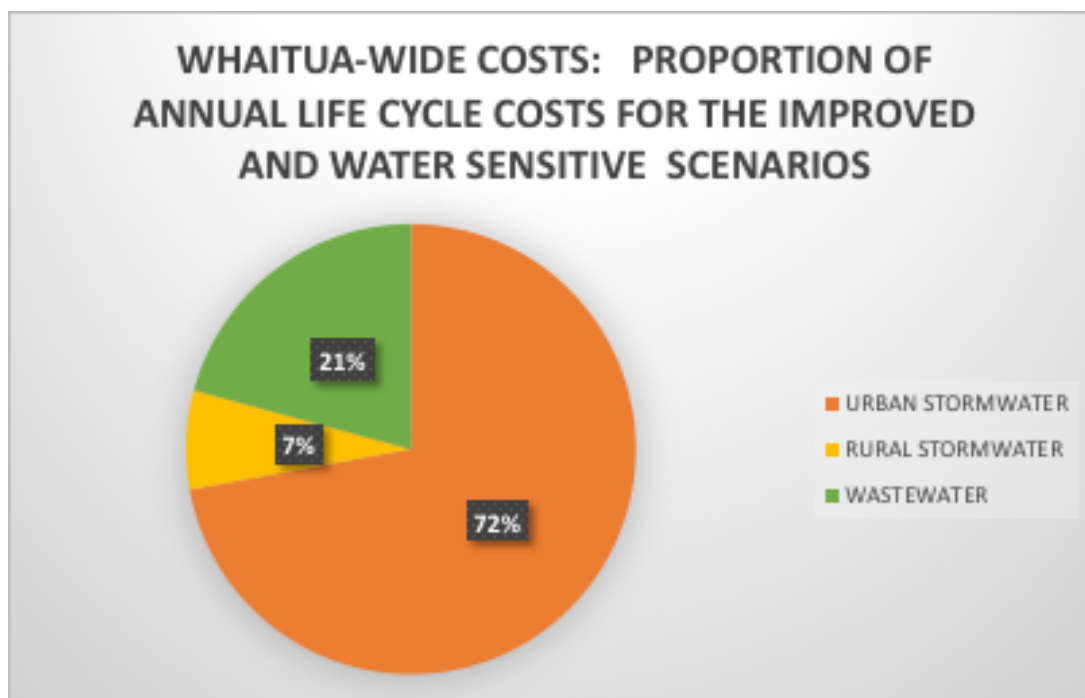
RURAL AND URBAN STORMATER	Range of total life cycle cost \$/ year	
	Low	High
Improved	\$ 4,743,683	\$ 7,493,174
Water Sensitive	\$ 13,139,441	\$ 17,762,245

*Annual wastewater indicative LCC estimates over 50 years for the whole of the TAoP Whaitua<sup>2</sup>*

WASTEWATER	Range of total life cycle cost \$/ year	
	Low	High
Improved	\$ 2,142,852	\$ 2,619,099
Water Sensitive	\$ 2,180,595	\$ 2,657,095

The life cycle costs of urban stormwater interventions are the largest portion of costs modelled under the Committee's scenarios.

*Proportion of Annual LCC for the Improved and Water Sensitive scenarios across the whole of the TAoP Whaitua*



<sup>2</sup> Annual costs have been derived by dividing the total indicative LCC estimate by 50 years. This has been done as the costs are only indicative representations of likely differences in cost between scenarios and do not provide an indication of the financing, governance or implementation costs to councils, developers or ratepayers.

These urban stormwater costs are generated from scenario interventions in existing urban areas as well as greenfield and infill development. Costs associated with mitigating the impacts of greenfield development are expected to be at the lower end of that cost range while costs associated with infill development are expected to be at the higher end of the cost range. This is because land prices and the difficulty of working within existing services and site constraints, along with increased land costs, tend to push infill and retrofit interventions towards the higher level of the cost range.

## **Key messages**

### *Urban stormwater intervention indicative cost estimates*

- The effect of doubling on-site treatment from Improved to Water Sensitive is the dominant cost driver within the data. As a result, the Water Sensitive scenario indicative cost estimates are approximately double those of the Improved scenario.
- The Water Sensitive scenario is, in general, more cost efficient at removing contaminants such as zinc, copper and sediment than the Improved scenario on a whaitua-wide basis.
- Due to the wide-spread application of on-site stormwater mitigation in the Water Sensitive scenario, the largest share of the costs within the value chain are assigned to private and commercial properties.

### *Rural intervention indicative cost estimates<sup>3</sup>*

- The rural costs are dominated by the indirect costs incurred through loss of productive rural land.
- Rural costs are a small proportion of the total costs, but important in rural catchments and likely to be highly variable across different properties.
- There are feasibility issues with some interventions, and the distributions of rural costs may cause hardship for some landholders. This may impact on the gains achievable.

### *Wastewater intervention indicative cost estimates*

- There is not a great deal of difference between the Improved and Water Sensitive scenario costs for wastewater, and it is likely that the differences are within the error margins of the model. Maintenance costs for wastewater are based on engineering experience – no actual cost data was available.
- Wastewater costs are likely to be under-estimated as there is insufficient cost data to account for costs relating to fixing illegal cross-connections, and a catchment-scale cost model is unable to account for such site-specific costs.

### *Property prices and holding costs*

- In general, the literature shows a consistent increase in house prices in close proximity to green infrastructure/spaces world-wide, however, the quantum of this increase varies significantly between countries. Based on this literature (approximately 74 studies) one could expect that there is likely to be a difference in property prices between the Existing and BAU, and Improved and Water Sensitive scenarios. Lack of on-going maintenance can cause property values to decrease in the long term.
- The interventions could increase urban property holding costs in the order of 1% - 4%.

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<sup>3</sup> Harris, S and Doole, G. 2017. *Te Awarua-o-Porirua Collaborative Modelling Project – Work Brief 11 RM. Assessment of rural economics and mitigation costs.*

# TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY</b> .....	<b><i>i</i></b>
<b>1. Background</b> .....	<b>1</b>
1.1 Introduction and purpose of this report.....	1
1.2 Contributing information.....	2
<b>2. Life cycle costing</b> .....	<b>3</b>
2.1 Caveat and limitations.....	4
<b>3. Development of the Cost Aggregation Model (CAM)</b> .....	<b>5</b>
3.1 Cost assumptions – data sources .....	5
3.1.1 Stormwater cost information .....	5
3.1.2 Wastewater Cost information .....	5
3.1.3 Life Cycle Cost assumptions.....	6
3.2 Land use data .....	6
3.3 Modelled Scenarios .....	6
3.4 The Cost Aggregation Model.....	10
<b>4. Results and Discussion</b> .....	<b>11</b>
4.1 Understanding the costing results .....	11
4.2 CAM results and discussion .....	11
4.2.1 TAoP Whaitua-wide indicative life cycle cost estimates .....	12
4.2.2 Urban stormwater indicative cost estimates .....	14
4.2.2 Indicative cost estimates for the rural interventions .....	21
4.2.3 Wastewater interventions.....	23
4.2.4 Implications of the indicative cost estimates for property owners.....	24
<b>5 CONCLUSIONS AND KEY MESSAGES</b> .....	<b>25</b>
5.1 Conclusions .....	25
5.2 Key messages .....	25

## APPENDIX A CAM INDICATIVE LCC ESTIMATE REPORT CARDS

## LIST OF FIGURES

Figure 1	Phases in the life cycle of a stormwater practice and potentially associated costs (adapted from Taylor, 2003).....	4
Figure 2	The Cost Aggregation Model .....	10
Figure 3	Alternate distributions of scenario intervention costs within the urban development value chains .....	11
Figure 4	Proportion of Annual LCC for the Improved and Water Sensitive scenarios across the whole of the TAoP Whaitua .....	13
Figure 5	Proportion of Annual LCC for the Improved and Water Sensitive scenarios across the whole of the TAoP Whaitua on a per dwelling basis .....	14
Figure 6a – i	Total indicative cost estimates per Water Management Unit: LCC \$/dwelling/year (based on a 50 year life span) .....	15
Figure 7a and b	Proportion of urban stormwater LCC by value chain occurrence within the Porirua at Kenepuru Drive WMU .....	19
Figure 8	TAoP Whaitua-wide cost efficiencies for zinc and copper.....	21
Figure 9	TAoP Whaitua-wide cost per rural property for rural mitigations.....	22



# 1. Background

## 1.1 Introduction and purpose of this report

The purpose of the overall modelling project is to collaboratively generate information and knowledge to support the Te Awarua-o-Porirua (TAoP) Whaitua Committee make recommendations for land and water management in the TAoP Whaitua. The project will produce modelling outputs and knowledge describing the current environmental, social, cultural and economic conditions in TAoP Whaitua, as well as potential outcomes that might result under alternate urban and rural land and water management scenarios developed and specified by the Committee.

The focus of current stormwater and run-off management practices in Porirua is largely on flood control and sedimentation remediation, with the water transport aspect paramount. Alternative approaches to the uses of rainfall, the contaminants contained in stormwater and their sources have the potential to create diverse positive effects at multiple scales and across a number of dimensions. This change in focus would impact the economic possibilities of water use, and urban and rural based effects on receiving waterbodies, which in turn may impact the extent of ecosystem services experienced by the community. This leads to flow-on effects for community wellbeing and liveability in the TAoP Whaitua.

Potential changes in operational focus of stormwater engineering practices beyond rainwater conveyance to intervention practices such as source control and treatment have been explored by the Committee and modelling leadership group. These scenarios explore how rainfall may be utilised and treated to take account of community preferences for the condition of the receiving waterbodies and uses of water. The interventions within these scenarios create costs over and above the existing, business as usual, conveyance and flood control function currently funded as a collective good paid for by landowners as a way of targeted rates, levies and charges.

A change in operational focus to the wastewater network has also been explored by the Committee. The Porirua wastewater network is separate from the stormwater system and comprises approximately 596km of piped network supported by 15699 manholes, 76 pump stations and 72 other fittings (such as valves) (*pers. comm.* Tim Strang (Wellington Water), via email dated 4 April 2017). Wellington Water's freshwater quality monitoring programme (commencing in 2014) has highlighted that there are significant levels of *E. coli* in the harbour tributaries, with 5 of the 9 monitoring sites exceeding national guideline levels (>1000 cfu) (Wellington Water, 2017: *Porirua Wastewater Network Improvement Plan: Improvement Options*. Draft 0.2). A number of network upgrades are explored by Wellington Water to reduce overflows, along with reducing infiltration and inflow between the stormwater and wastewater networks. These upgrades will incur costs over and above what has been envisaged through the LTP process.

This report presents a part of the urban and rural intervention work briefs and is the culmination of economic assessments that address the decision-making needs of the TAoP Whaitua Committee.

The purpose of this report is to document:

- The Cost Aggregation Model (CAM) – a tool used to bring together the costs of differing land use and stormwater treatment interventions.
- The life cycle cost approach used to quantify the indicative cost estimates of the different land use and intervention scenarios.
- The results of the CAM for different water management units (WMUs) and scenarios.
- Key messages that summarise the direct outcomes of the modelling and their implications.

## 1.2 Contributing information

A series of work briefs and associated reports are precursors to the CAM, and form the basis of the assumptions used within the model with respect to the intervention types, costs, land-use and rates/ population data. These reports include:

1. Ira, S J T. 2017. *Summary of potential solutions available for stormwater, wastewater and water supply provision*. Report prepared for Greater Wellington Regional Council as part of the Te Awarua-o-Porirua Collaborative Modelling Project.
2. Ira, S J T. 2017. *Summary of Life Cycle Costs for Stormwater Infrastructure Solutions*. Report prepared for Greater Wellington Regional Council as part of the Te Awarua-o-Porirua Collaborative Modelling Project.
3. Ira, S J T. 2017. *Effect of Water Sensitive Urban Design Solutions and Green Space on Property Values: A Literature Review*. Report prepared for Greater Wellington Regional Council as part of the Te Awarua-o-Porirua Collaborative Modelling Project.
4. Ira, S J T. 2018. Unpublished report on avoided costs of water sensitive urban design.
5. Harris, S and Doole, G. 2017. *Te Awarua-o-Porirua Collaborative Modelling Project – Work Brief 11 RM. Assessment of rural economics and mitigation costs*.
6. Nick Taylor and Associates, with M.E. Consulting. 2017. *Draft Report: Te Awarua-o-Porirua Collaborative Modelling Project. Social Assessment: Baseline*.
7. Wellington Water. 2017. *Porirua Wastewater Network Improvement Plan: Improvement Options*. Draft 0.2.
8. Wellington Water: email correspondence from Tim Strang, dated 4 April 2017 containing cost information for the stormwater, water supply and wastewater network, and scoping of costs of different wastewater network and treatment plant upgrade options.
9. Jacobs (2019). *Porirua Whaitua Scenario Modelling technical report. IZ080700*. [Includes details of the landuse and interventions as specified to determine contaminant concentrations for each WMU].
10. TAoP CMP Development Scenario Spreadsheet. Received via email from Brent King on 12 July 2017 (specifies assumptions for each of the urban and rural intervention scenarios).

## 2. Life cycle costing

The CAM is a calculation tool that uses a life cycle methodology to bring together and assess the various cost components of stormwater and wastewater interventions for differing landuses. A life cycle costing (LCC) approach has been previously used to assess costs associated with stormwater devices in Australia, the United States of America (USA) and the United Kingdom (UK) (Vesely *et al.*, 2006<sup>4</sup>). The Australian/New Zealand Standard 4536:1999<sup>5</sup> defines LCC as the process of assessing the cost of a product over its life cycle or portion thereof. The life cycle cost is the sum of the acquisition and ownership costs of an asset over its life cycle from design, manufacturing, usage, and maintenance through to disposal (Figure 1). The consideration of revenues and depreciation is excluded from LCC. A cradle-to-grave time frame is warranted because future costs associated with the use and ownership of an asset are often greater than the initial acquisition cost and may vary significantly between alternative solutions to a given operational need (Australian National Audit Office, 2001<sup>6</sup>).

LCC has a number of benefits and supports a number of applications and analyses (Lampe *et al* 2005<sup>7</sup>):

- It allows for an improved understanding of long-term investment requirements.
- It helps decision-makers make more cost-effective choices at the project scoping phase.
- LCC provides for an explicit assessment of long-term risk
- It reduces uncertainties and helps local authorities determine appropriate development contributions; and
- LCC assists decision-makers understand the relative cost difference between two or more management options without the full-blown costs of detailed engineering assessments.

The financial performance of alternative stormwater management approaches will depend on the sum and distribution over the life cycle of the device of costs associated with design, construction, use, maintenance, and disposal. LCC can be used for structuring and analysing this economic information. A LCC approach has been used in this project to quantify the cost implications of stormwater and wastewater interventions. The costs provided in this report are high level indicative estimates of stormwater and wastewater long-term costs, allowing comparisons between scenarios to be developed with a view to contrasting relative cost effectiveness and environmental performance between scenarios without costly, detailed engineering assessments.

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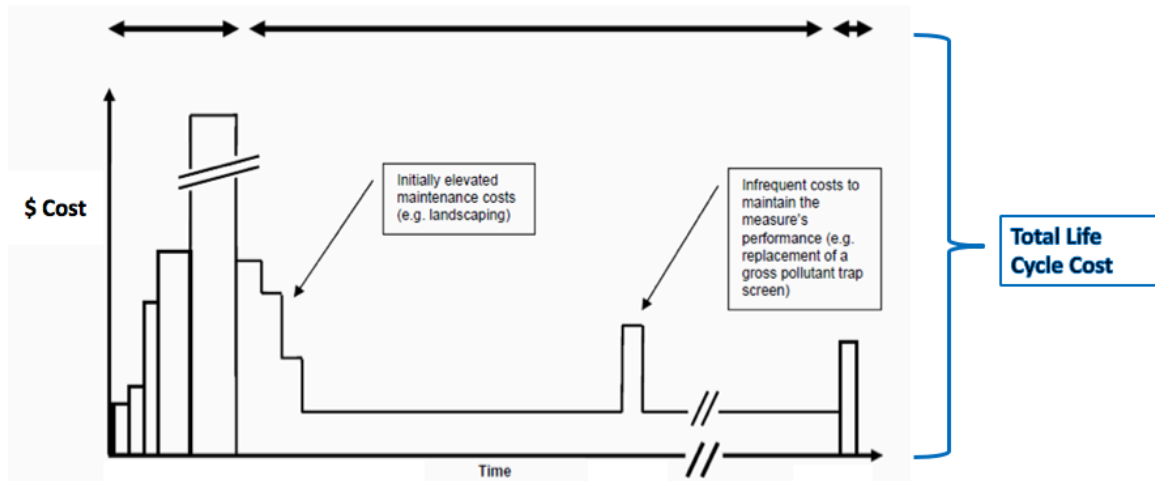
<sup>4</sup> Vesely, E-T., Arnold, G., Ira, S. and Krausse, M. (2006). *Costing of Stormwater Devices in the Auckland Region*. NZWWA Stormwater Conference.

<sup>5</sup> Australian/New Zealand Standard. (1999). *Life Cycle Costing: An Application Guide*, AS/NZ 4536:1999. Standards Australia, Homebush, NSW, Australia and Standards New Zealand, Wellington, NZ.

<sup>6</sup> Australian National Audit Office. (2001). *Life Cycle Costing: Better Practice Guide*. Canberra, Commonwealth of Australia.

<sup>7</sup> Lampe, L., Barrett, M., Woods-Ballard, B., Kellagher, R., Martin, P., Jefferies, C., Hollon, M. (2005). *Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems*. WERF Report Number 01-CTS-21T.

Figure 1 Phases in the life cycle of a stormwater practice and potentially associates costs (adapted from Taylor, 2003<sup>8</sup>)



## 2.1 Caveat and limitations

The purpose of the life cycle cost estimates is to understand the relative difference between different intervention scenarios. The total life cycle cost is the lump sum amount that a person would need today to meet all the costs of installing, maintaining and using that device over its lifetime. It is not a financial analysis of asset depreciation over time. A life cycle assessment makes no assumptions about the feasibility, timing, uptake or optimisation of interventions, nor about financing, governance or distributions of costs for particular catchments or activities.

The data used to develop the CAM is based on the best available cost information at the time of writing this report. However, cost information is notoriously variable<sup>9</sup>, and whilst every effort has been made to ensure the consistency and integrity of the data collected, reliance should not be placed on the actual costing figures. The focus should rather be placed on the range of indicative cost estimates for different scenarios. Decision-makers should rather use the life cycle costing information to understand the potential relative difference between the different management approaches.

<sup>8</sup> Taylor, A.C. (2003). An Introduction to Life Cycle Costing Involving Structural Stormwater Quality Management Measures. Cooperative Research Centre for Catchment Hydrology, Melbourne, Victoria.

### 3. Development of the Cost Aggregation Model (CAM)

The purpose of the CAM was to generate LCCs for a range of stormwater and wastewater interventions across a number of different scenarios and landuses. As a result, data from three different categories or areas were needed:

1. unit discounted LCCs for each intervention,
2. landuse data for each WMU, and
3. scenario assumptions for each intervention scenario.

The assumptions for each of these categories are discussed in sections 3.1 – 3.3.

#### 3.1 Cost assumptions – data sources

##### 3.1.1 Stormwater cost information

The Landcare Research COSTnz Model<sup>9</sup> and NIWA/ Cawthron “Urban Planning that Sustains Waterbodies” (UPSW) Costing Model<sup>10</sup> was used to generate LCC information about rain gardens and wetlands for the TAoP Whaitua.

COSTnz is a site-specific model and requires a good understanding of the local site conditions, contaminant inputs and stormwater device design. In general, the LCCs are assessed using a unit-based approach. COSTnz was used to generate LCCs for permeable paving, sand filters/ filter media and rain tanks.

Unit cost information for the rural interventions (riparian planting, fencing, retirement of land and pole planting) were obtained from Harris and Doole (2017)<sup>11</sup>. A standard LCC approach, in accordance with the Australian/ NZ Standard, was used to convert the unit costs obtained from Harris and Doole (2017) into indicative estimate LCCs.

LCCs of individual stormwater management devices, along with the assumptions made for each of these interventions and associated land costs are provided in:

- Ira, S J T. 2017. *Summary of Life Cycle Costs for Stormwater Infrastructure Solutions*. Report prepared for Greater Wellington Regional Council as part of the Te Awarua-o-Porirua Collaborative Modelling Project.
- Harris, S and Doole, G. 2017. *Te Awarua-o-Porirua Collaborative Modelling Project – Work Brief 11 RM. Assessment of rural economics and mitigation costs*.

##### 3.1.2 Wastewater Cost information

With respect to wastewater cost information, cost data for the wastewater intervention options was obtained from Wellington Water. These options were outlined in their draft report *Porirua Wastewater Network Improvement Plan: Improvement Options* (Wellington Water, 2017). No maintenance cost data was available for the wastewater improvement options. Based on discussions with Wellington Water (pers comm. Steve Hutchinson, 18/5/2018), an approach to estimating long term maintenance costs was agreed. Annual maintenance costs are based on an

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<sup>9</sup> Ira, S. J. T., Vesely, E-T., McDowell, C and Krausse, M. 2009. *COSTnz – A Practical Life Cycle Costing Model for New Zealand*. NZWWA Conference, Auckland.

<sup>10</sup> Ira, S.J.T., Batstone, C. and Moores, J. 2012. *The incorporation of economic indicators within a spatial decision support system to evaluate the impacts of urban development on waterbodies in New Zealand*. Seventh International Conference on Water Sensitive Urban Design Conference, Melbourne, Australia.

<sup>11</sup> Harris, S and Doole, G. 2017. *Te Awarua-o-Porirua Collaborative Modelling Project – Work Brief 11 RM. Assessment of rural economics and mitigation costs*.

engineering guesstimate of 4% of the mechanical and electrical capital cost, and 1% of the civil asset cost. On this basis, the schedule of costs was divided into civil assets and mechanical/ electrical assets, and assigned an annual maintenance cost of 1% and 4% respectively. In order to provide the TAoP Whaitua Committee with a range of costs, a high maintenance cost estimate was also modelled whereby the annual maintenance costs of the civil assets equated to 2% of the total cost of the asset, and 5% of the total cost of the mechanical/ electrical asset.

The cost of reducing infiltration and inflow (I/I) issues within the network has not explicitly been included in the model, however, some reduction will result from the proposed upgrade works (see Section 4.2.3 for further discussion on this item).

As with the rural cost information, a standard LCC approach, in accordance with the Australian/ NZ Standard, was used to convert the unit costs into indicative estimate LCC.

### 3.1.3 Life Cycle Cost assumptions

All the individual models discussed in Section 3.1.1 and 3.1.2 have the same life cycle costing assumptions, i.e.:

- All costs were inflated to a base year of 2017 using a 2.8% inflation rate.
- A life cycle analysis period and life span of 50 years was used for all model runs.
- A discount rate of 3.5% was used for calculation of the LCC. This discount rate was used as it was cost effective to use the same discount rate as previous life cycle costing work undertaken for the “UPSW Cost Model” and it is comparable to the 2017 PCC Closing Report<sup>12</sup>.
- For those models which are based on the “UPSW Costing Model”, please see Cawthron Report No. 2082 for further detail and explanations around the assumptions.
- Decommissioning costs were not included in the models as none of the solutions would be decommissioned after 50 years.
- A land cost factor was used to account for land costs associated with the urban stormwater management devices<sup>13</sup>.

## 3.2 Land use data

The land use data used within the CAM for each WMU was received from Jacobs (2019)<sup>14</sup>. The CAM landuse data for each WMU is therefore fully consistent with the reporting units modelled within the contaminant concentration work.

## 3.3 Modelled Scenarios

Assumptions for each of the scenarios modelled were provided by the TAoP Whaitua Committee and refined by the MLG. The Committee requested that four scenarios be modelled as part of the project, namely:

- Existing situation
- “Business as Usual” (BAU)
- an “Improved” scenario
- a “Water Sensitive” scenario

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<sup>12</sup> Porirua City Council. 2017. Closing Report for year ended 30 June 2017. Prepared by Ernst and Young.

<sup>13</sup> This factor was taken from the UPSW cost model and is not based on current land values but rather on a proportionality basis relating to land values documented in studies and relating to floodplain vs non-floodplain areas.

<sup>14</sup> Jacobs (2019). Porirua Whaitua Scenario Modelling technical report. IZ080700. March 2019.

For the CAM only the Improved and Water Sensitive scenarios were modelled. There is currently very little stormwater treatment as part of the existing situation and BAU scenarios for the TAoP Whaitua. Costs of the existing stormwater and wastewater network, along with costs of ongoing maintenance associated with these networks have therefore not been costed. Costs associated with these networks are borne through council rates, stormwater and wastewater charges. Therefore, and in line with the approach of “constant coarseness” modeling philosophy across the various technical models as well as the “reporting unit” scale of the models, only those costs additional to the Existing and BAU scenarios were modelled, as these are the only costs that are different across the scenarios.

Table 1 illustrates the different interventions and relative assumptions for the Improved and Water Sensitive scenarios.

Table 1 Different interventions and the relative assumptions for the Improved and Water Sensitive scenarios

Description	Areas treated	Assumed treatment performance target
<b>Improved scenario</b>		
Rainwater tanks on some new dwellings	50% of new greenfield and infill dwellings and 10% of existing dwellings	2,000 litre tanks
Limited treatment of road runoff in new urban developments with bioretention	40% of roads in greenfield and infill development	90% TSS removal 80% metals removal 40% nitrogen removal 60% phosphorus removal 90% <i>E. coli</i> removal
Construction sediment control practices	100% of construction areas	90% TSS, metal, nitrogen and phosphorus removal
Treatment of stormwater runoff in new urban developments with catchment scale devices such as wetland	All new paved and roof surfaces in greenfield and infill development areas	80% TSS removal 70% metals removal 40% nitrogen removal 50% phosphorus removal 90% <i>E. coli</i> removal
Treatment or replacement of existing high yielding zinc roofs	50% of existing residential, commercial and industrial roofs	Adopt low zinc roof contaminant generation characteristics
Fixing cross connections and broken pipes in the wastewater network	100% of urban areas	Adopt low urban <i>E. coli</i> yields
Media filter treatment of runoff from paved surfaces in commercial and industrial areas	50% of paved commercial and industrial areas	75% TSS removal 50% metals removal 40% nitrogen removal 40% phosphorus removal
Media filter treatment of runoff from major roads	50% of major roads	75% TSS removal 50% metals removal 40% nitrogen removal 40% phosphorus removal

Fencing and planting of most streams in pastoral areas with a 5m width	All REC order 2 or greater streams with catchment slope less than 15 degrees and pastoral land cover	80% TSS removal (streambank) 40% phosphorus removal 44% <i>E. coli</i> removal
Space planting of moderately erodible pastoral slopes	LUC class 6e land with pastoral landcover	70% TSS removal 70% particulate phosphorus removal (not dissolved)
Retirement of highly erodible pastoral slopes	LUC class 7e and 8 land with pastoral landcover	Adopt native forest rainfall runoff and contaminant generation characteristics
Reduce wastewater overflows to an average of 4 per year.	All overflows	40 largest overflow events retained from original (assumed BAU) timeseries (average 4 per year over 10 years)

Description	Areas treated	Assumed treatment performance target
<b>Water sensitive scenario</b>		
Rainwater tanks on most new dwellings with internal reuse of water	100% of new greenfield dwellings and infill dwellings, 50% of existing residential dwellings	10,000 litre tanks
Reduced impervious footprint in new development	100% of new greenfield and infill development	Reduced proportion of paved and roof surfaces and increased proportion of grass surfaces within new development areas
Treatment of stormwater runoff in new urban developments with source control devices such as permeable paving	50% of paved surface in new greenfield dwellings and 25% of infill dwellings	70% TSS removal 40% metals removal 40% nitrogen removal 40% phosphorus removal
Treatment of most road runoff in new urban developments with bioretention	90% of roads in greenfield and infill development	90% TSS removal 80% metals removal 40% nitrogen removal 60% phosphorus removal 90% <i>E. coli</i> removal
Construction sediment control practices	100% of construction areas	90% TSS, metal, nitrogen and phosphorus removal
Treatment of stormwater runoff in new urban developments with catchment scale devices such as wetland	All new paved and roof surfaces in greenfield and infill development areas	80% TSS removal 70% metals removal 40% nitrogen removal 50% phosphorus removal 90% <i>E. coli</i> removal
Treatment or replacement of existing high yielding zinc roofs	100% of existing industrial, commercial and residential roofs	Adopt low zinc roof contaminant generation characteristics



Fixing cross connections and broken pipes in the wastewater network	100% of urban areas	Adopt low urban <i>E. coli</i> yields
Media filter treatment of runoff from paved surfaces in industrial areas	100% of paved industrial areas	75% TSS removal 50% metals removal 40% nitrogen removal 40% phosphorus removal
Bioretention treatment of runoff from paved surfaces in commercial areas	100% of paved commercial areas	90% TSS removal 80% metals removal 40% nitrogen removal 60% phosphorus removal 90% <i>E. coli</i> removal
Wetland treatment of runoff from major roads	100% of major roads	80% TSS removal 70% metals removal 40% nitrogen removal 50% phosphorus removal 90% <i>E. coli</i> removal
Fencing and planting of most streams in pastoral areas with a 10m width	All REC order 2 or greater streams with catchment slope less than 15 degrees and pastoral land cover	80% TSS removal (streambank) 40% phosphorus removal 44% <i>E. coli</i> removal
Retirement of highly and moderately erodible pastoral slopes and	LUC class 6e, 7e and 8 land with pastoral landcover	Adopt native forest rainfall runoff and contaminant generation characteristics
Reduce wastewater overflows to an average of 2 per year.	All overflows	20 largest overflow events retained from original (assumed BAU) timeseries (average 2 per year over 10 years)

Some additional points which are worth noting include:

- **Roofing materials:** based on previous discussions with NZ Steel and Pacific Steel as part of the Upper Waitemata Harbour and Central Waitemata Harbour studies (Auckland Council Report TR2008-039<sup>15</sup>) it was found that, in general for residential areas, any roof that is being replaced is being done so with inert or low-zinc yielding roofing materials. The market demand for these is such that natural replacement of roofs (which would occur over time) takes care of this issue. The model would effectively be “double counting” costs if a sum for roof replacement were included, especially since natural replacement would occur over time. It is noted that timing of the implementation and uptake of mitigations is not part of the models.
- **Erosion and sediment control:** the erosion and sediment control mitigations proposed for construction sites are the same for all 4 scenarios and are not included in the CAM.
- **Permeable paving:** only the difference in LCC between concrete driveways vs permeable paved driveways are included in the CAM to account for the cost being “over and above” existing costs.

<sup>15</sup> Timperley, M.; Reed, J, 2008. Central Waitemata Harbour Contaminant Study. Predictions of Stormwater Contaminant Loads. Prepared by NIWA Ltd for Auckland Regional Council. Auckland Regional Council Technical Report 2008/039.

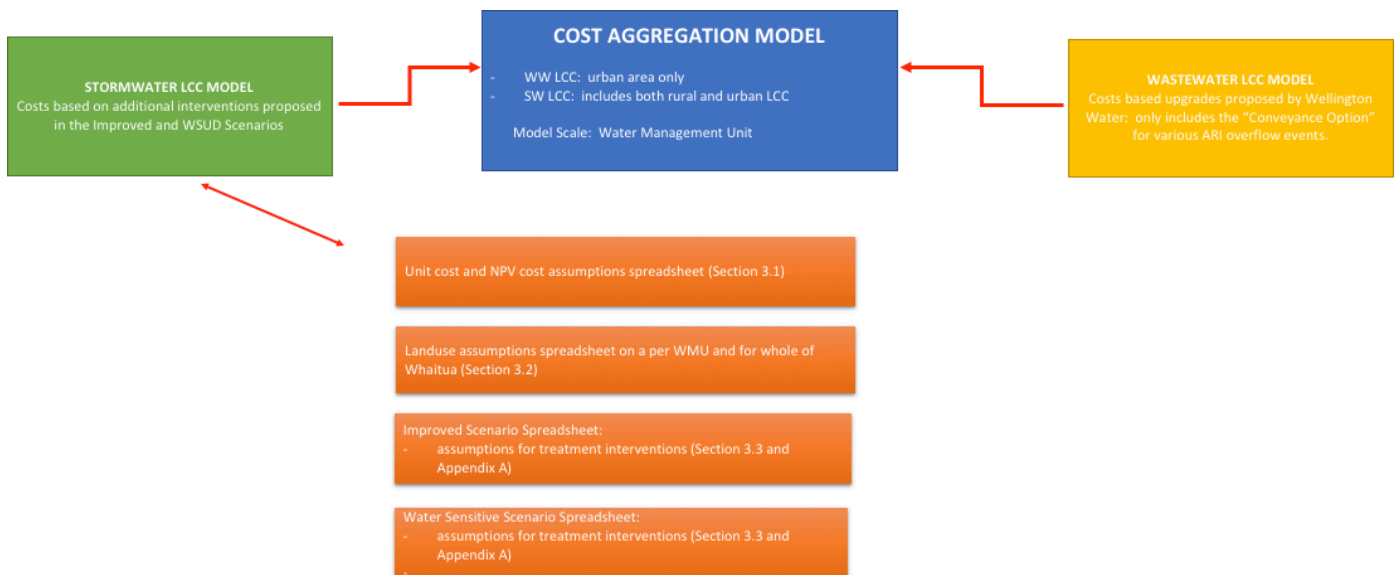
- **Media filters:** these devices relate to a range of different proprietary and sand bed filter type mitigation measures. The COSTnz model for sand filters has been used to represent this category of stormwater treatment.
- **Reduced earthworking and impervious area costs (water sensitive scenario):** an avoided cost reduction factor was used to account for reduced earth-working and impervious surfaces resulting from a water sensitive development approach. Based on an international literature review and 13 comparative case studies (4 of which are within New Zealand), an average avoided cost factor of 16% was used<sup>16</sup>. This percentage equates to the average reduction in the construction cost of a water sensitive subdivision over a traditional approach to land development.
- **Wastewater interventions:** only those costs provided by Wellington Water and associated with their proposed network upgrades were included in the CAM. The TAoP Whaitua Committee scenarios specified a reduction of, on average, 4 wastewater overflows per year in an Improved scenario and a reduction of, on average, 2 overflows per year in a Water Sensitive scenario. Additional costs of improvements to the wastewater network to improve I/I from leaking pipes and illegal cross-connections are not included in the CAM. These types of network upgrades are site-specific and have not yet been fully scoped.

### 3.4 The Cost Aggregation Model

The CAM is an Excel-based LCC model which integrates cost with different intervention types for different landuses, as described in Sections 3.1 – 3.3.

Figure 2 illustrates the format of the CAM and how the assumptions discussed in Sections 3.1 – 3.3 integrate within the model.

Figure 2 The Cost Aggregation Model



<sup>16</sup> Ira, S J T. 2018. Unpublished report on avoided costs of water sensitive urban design.

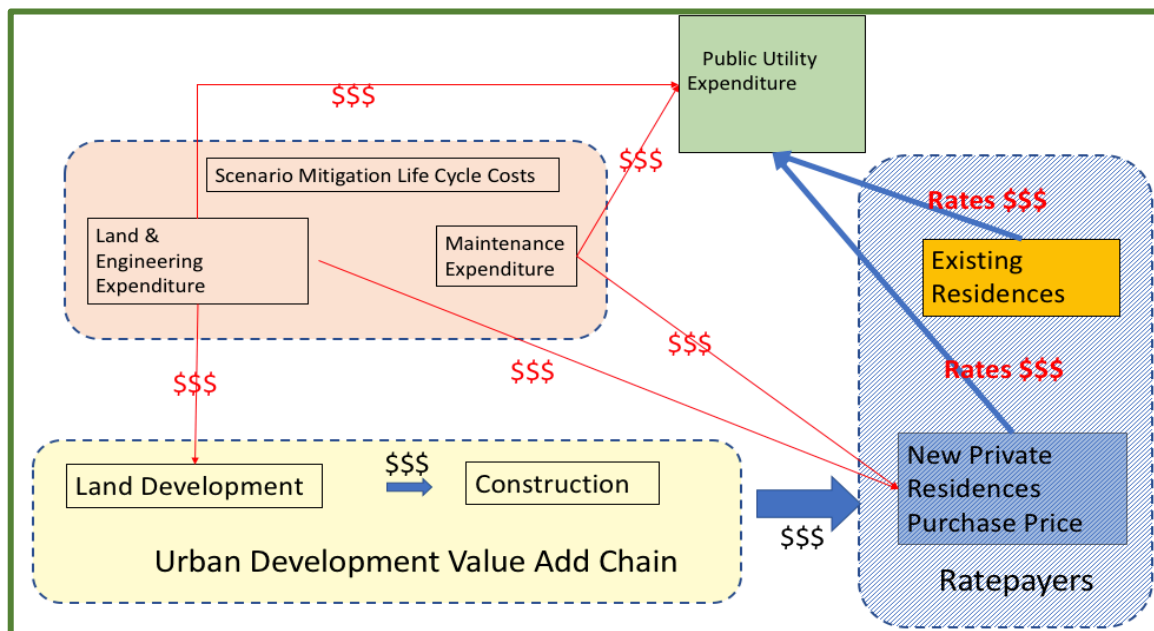
## 4. Results and Discussion

### 4.1 Understanding the costing results

Prior to presenting the indicative LCC estimates from the CAM, it is important to reflect on the context within which the data is presented.

- The TAoP Whaitua CAM builds on existing LCC work and is based on generating a total LCC over a 50 year analysis period (base date of 2017).
- The costs relate to best practice design of the mitigations and target treatment performance, and are based on the best available cost data.
- The costs are presented as ranges from low to high therefore expressing uncertainty due to cost data gaps or large variation in costs.
- When interpreting the cost results, look for patterns and relative differences between scenario results, do not focus on or use the absolute dollar cost figure. LCC allows “like for like” comparison of additional costs between scenarios, over and above BAU (which are constant across the intervention scenarios). The costs are indicative cost estimates.
- The assessment does not make any assumptions about the feasibility, timing, uptake or optimisation of interventions in specific WMU locations, or about financing, governance or distributions of costs for particular catchments or activities.
- The results are also presented in a way such that they highlight the distribution of costs in terms of where they fall within the value chain, i.e. whether they are developer-related costs, public utility costs or house-hold costs (Figure 3). In reality, all costs are borne in differing proportions by private individuals via “on-charging” from developers, network utility fees or rates (targeted and other wise), or everyday household costs.

Figure 3 Alternate distributions of scenario intervention costs within the urban development value chains



### 4.2 CAM results and discussion

The CAM was run for eight WMUs, namely:

- Titahi Bay;
- Belmont;
- Porirua at Kenepuru Drive;

- Lower Duck Creek (mouth);
- Pauatahanui (middle reaches);
- Kenepuru (mouth);
- Kenepuru (infill case study);
- Cambourne (greenfields case study);

These 8 WMUs were chosen by GWRC as they are illustrative of the differing mixes of landuses found throughout the TAoP Whaitua (i.e. existing rural, residential, commercial and industrial zonings), as well as greenfield and infill development areas.

In addition, the CAM was also run to determine the whaitua-wide indicative LCC estimates. A wastewater LCC model was built and run to determine the indicative LCC estimate of the proposed wastewater upgrades. A set of report cards for each WMU and the whaitua-wide and wastewater LCCs is included in Appendix A.

As discussed previously, the indicative LCC estimates are calculated for the Improved and Water Sensitive scenarios (Table 1) and are presented for three different groups of interventions:

1. Urban stormwater interventions – applied to both existing urban areas and greenfield and infill development areas (e.g. rain tanks, rain gardens, filter media, permeable paving, wetlands).
2. Rural interventions (e.g. fencing and planting of riparian margins, space planting, retirement of erosion prone slopes).
3. Urban wastewater interventions (e.g. wastewater network improvements to reduce wastewater overflows);

#### 4.2.1 TAoP Whaitua-wide indicative life cycle cost estimates

The rural and urban stormwater and urban wastewater indicative LCC estimates for the TAoP Whaitua are presented in Tables 2a and b. The rural and urban stormwater costs range from around \$4.7-\$7.5 million per year under the Improved scenario to \$13.1-\$17.8 million per year under the Water Sensitive scenario (Table 2a). The wastewater costs range from around \$2.1-\$2.7 million per year (Table 2b)

Table 2a Annual rural and urban stormwater indicative LCC estimates over 50 years for the whole of the TAoP Whaitua<sup>17</sup>

RURAL AND URBAN STORMATER	Range of total life cycle cost \$/ year	
	Low	High
Improved	\$ 4,743,683	\$ 7,493,174
Water Sensitive	\$ 13,139,441	\$ 17,762,245

<sup>17</sup> Annual costs have been derived by dividing the total indicative LCC estimate by 50 years. This has been done as the costs are only indicative representations of likely differences in cost between scenarios and do not provide an indication of the financing, governance or implementation costs to councils, developers or ratepayers.

Table 2b Annual wastewater indicative LCC estimates over 50 years for the whole of the TAoP Whaitua<sup>16</sup>

WASTEWATER	Range of total life cycle cost \$/ year	
	Low	High
Improved	\$ 2,142,852	\$ 2,619,099
Water Sensitive	\$ 2,180,595	\$ 2,657,095

These costs are generated from scenario interventions in areas of greenfield and infill development, with a smaller proportion of costs emanating from existing business and residential interventions. Costs associated with mitigating the impacts of greenfield development are expected to be at the lower end of that cost range while costs associated with infill development are expected to be at the higher end of the cost range. Infill intervention development may require land purchases, and the costs associated with the difficulty of working within existing services and site constraints, along with associated land costs, tend to push infill and retrofit interventions towards the higher level of the cost range in contrast to those incurred in greenfields developments.

Figure 4 illustrates that the life cycle costs of the urban stormwater interventions are the largest portion of costs modelled under the Committee’s scenarios. However, wastewater costs are likely to be under-estimated as there is insufficient cost data to account for costs relating to fixing illegal cross-connections, and a catchment-scale cost model is unable to account for such site-specific costs.

While the rural interventions represent a smaller portion of the intervention costs than the urban mitigations at a TAoP Whaitua scale, they can be expensive at a local scale if they were to fall solely on the individual rural property owners (Figure 5).

Figure 4 Proportion of Annual LCC for the Improved and Water Sensitive scenarios across the whole of the TAoP Whaitua

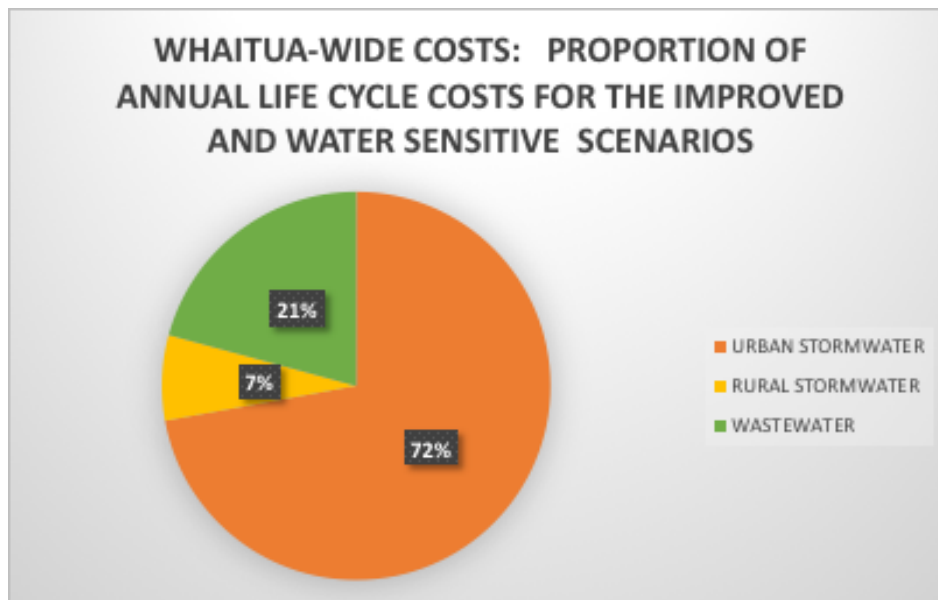
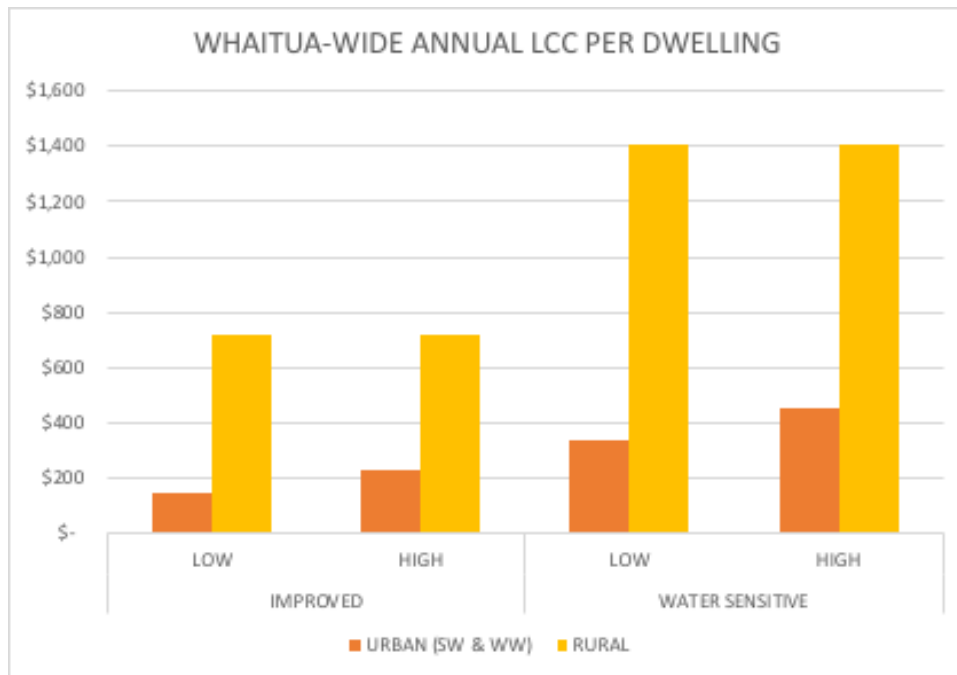


Figure 5 Proportion of Annual LCC for the Improved and Water Sensitive scenarios across the whole of the TAoP Whaitua on a per dwelling basis



#### 4.2.2 Urban stormwater indicative cost estimates

##### 4.2.2.1 Urban stormwater indicative cost estimates on a per dwelling basis

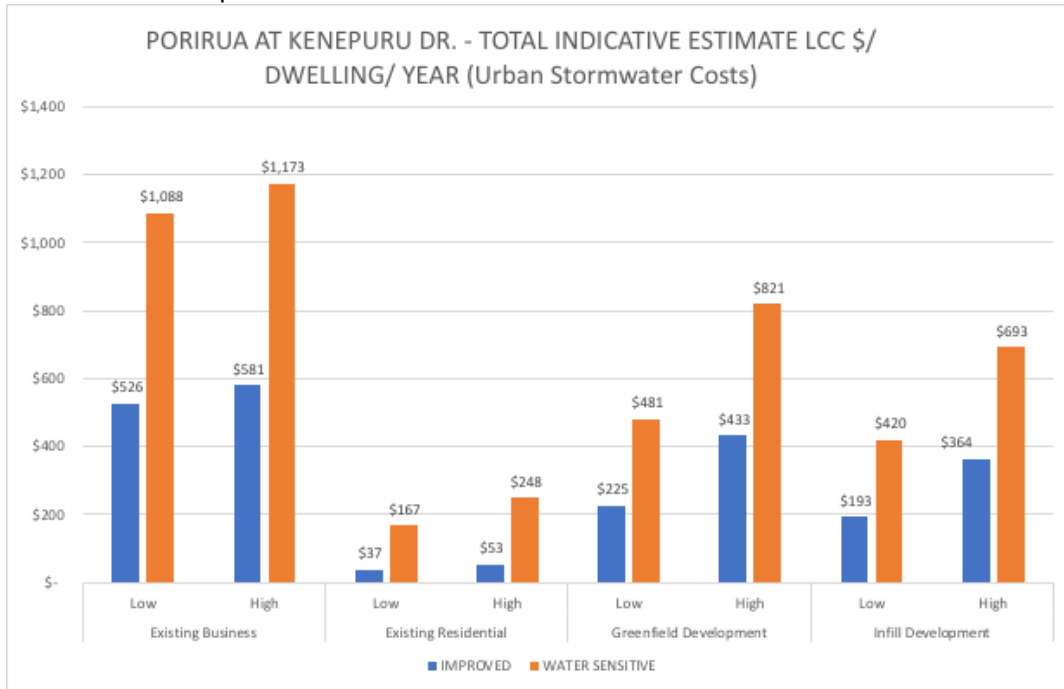
On a per dwelling basis, additional greenfield or infill dwellings incur additional costs over the BAU stormwater costs in the range of \$200 - \$830 per year (Figures 6a - i).

The analysis indicates that existing dwellings have relatively small increases in LCCs for stormwater interventions, being in the order of \$40 - \$280 per year depending on the WMU under consideration. When considering commercial and industrial areas, there is a larger range in the estimated stormwater costs per business between scenarios and across different WMUs than for residential land uses (Figures 6a - i). Depending on the WMU, Improved scenario costs per business are in the range of \$200-\$700 per year, and Water Sensitive scenario costs are typically double at around \$300-\$1600 per year.

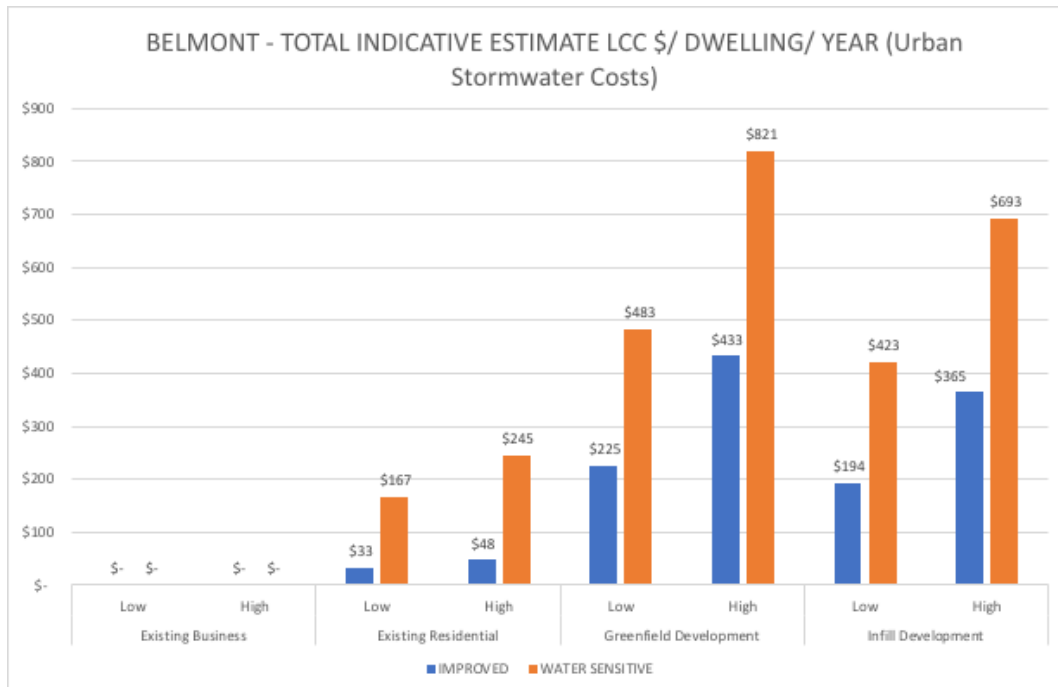
The effect of doubling on-site treatment from the Improved to the Water Sensitive scenario is the dominant cost driver within the data, and the differences in cost between the two interventions are as a result of this doubling effect. For the commercial and industrial areas, the Water Sensitive scenario is slightly more than double the Improved scenario as the mix of interventions are slightly more expensive on a unit cost basis. Differences between WMUs likely reflects higher variation in the number, size and form of commercial premises in different WMUs.

Figure 6a – i Total indicative cost estimates per Water Management Unit: LCC \$/dwelling/ year (based on a 50 year life span)

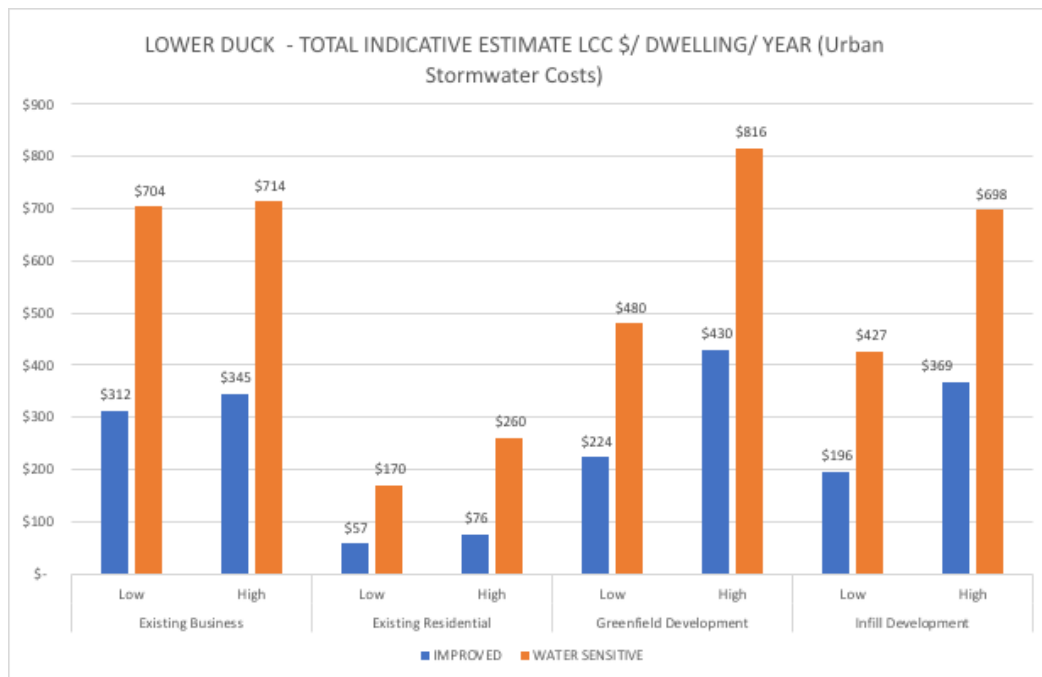
(a) Porirua at Kenepuru Drive



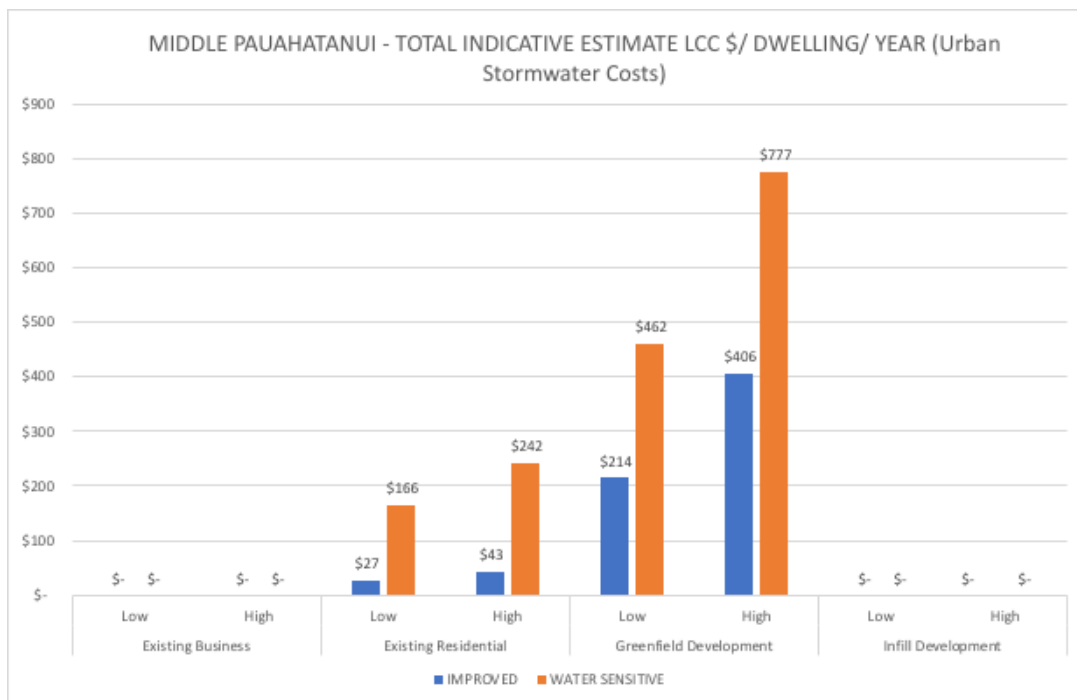
(b) Belmont



(c) Lower Duck Creek at mouth

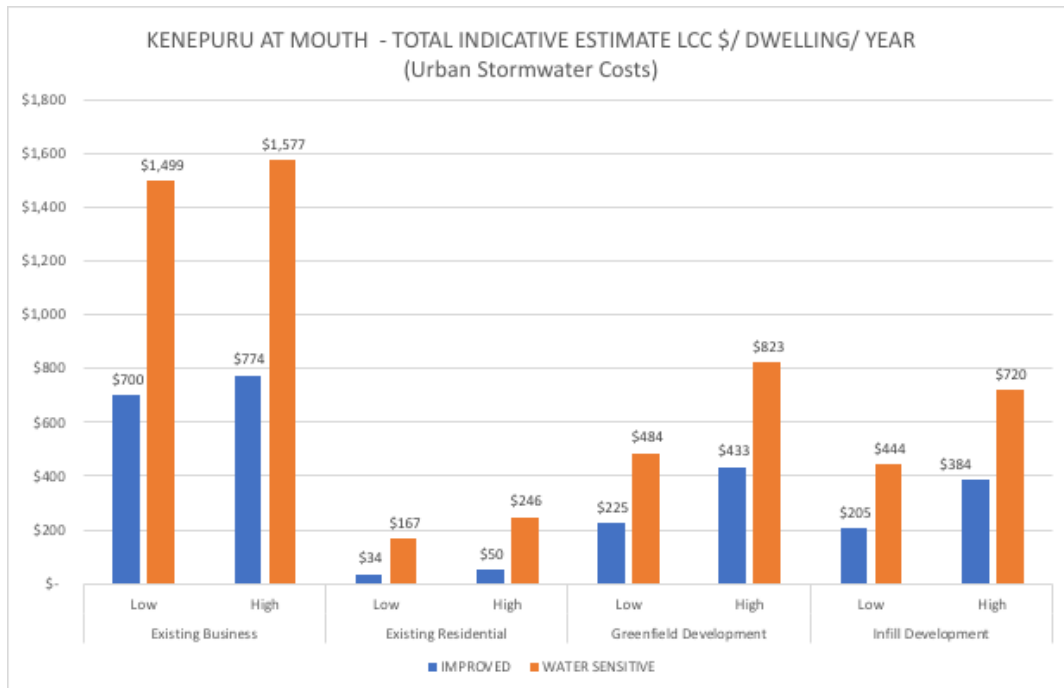


(d) Pauatahanui middle reaches

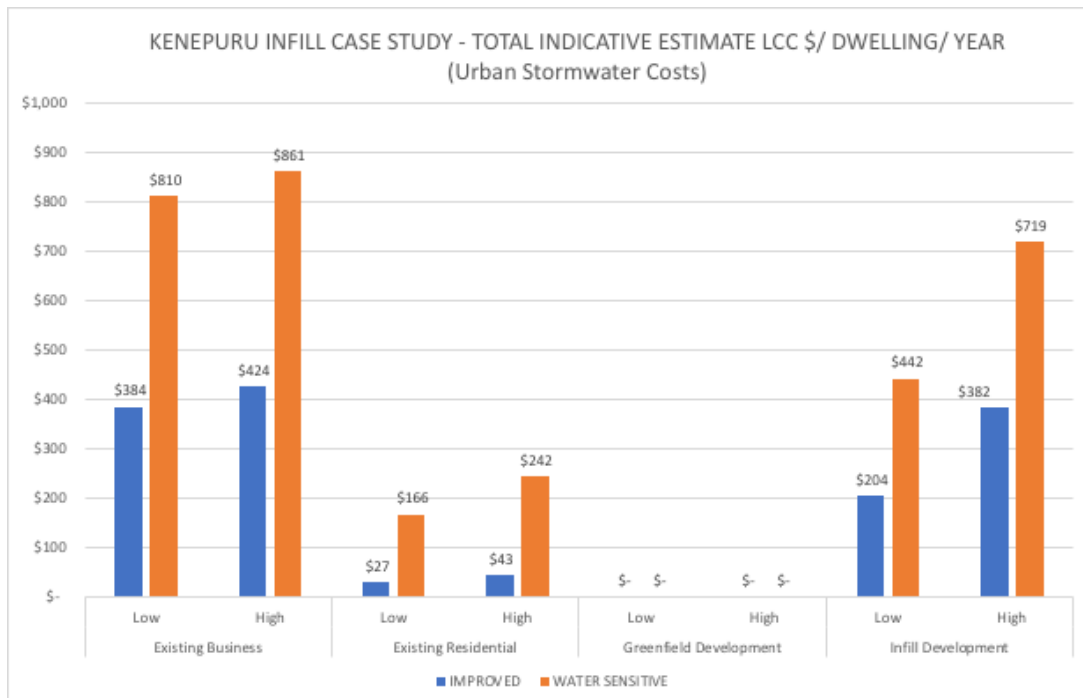




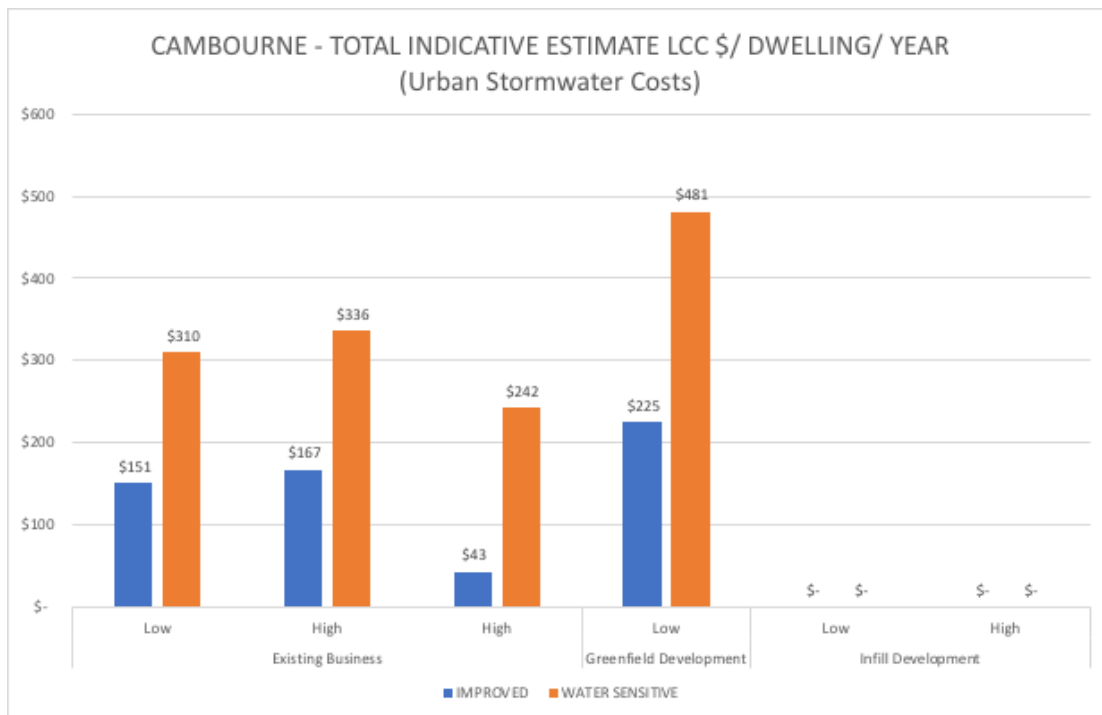
(e) Kenepuru at mouth



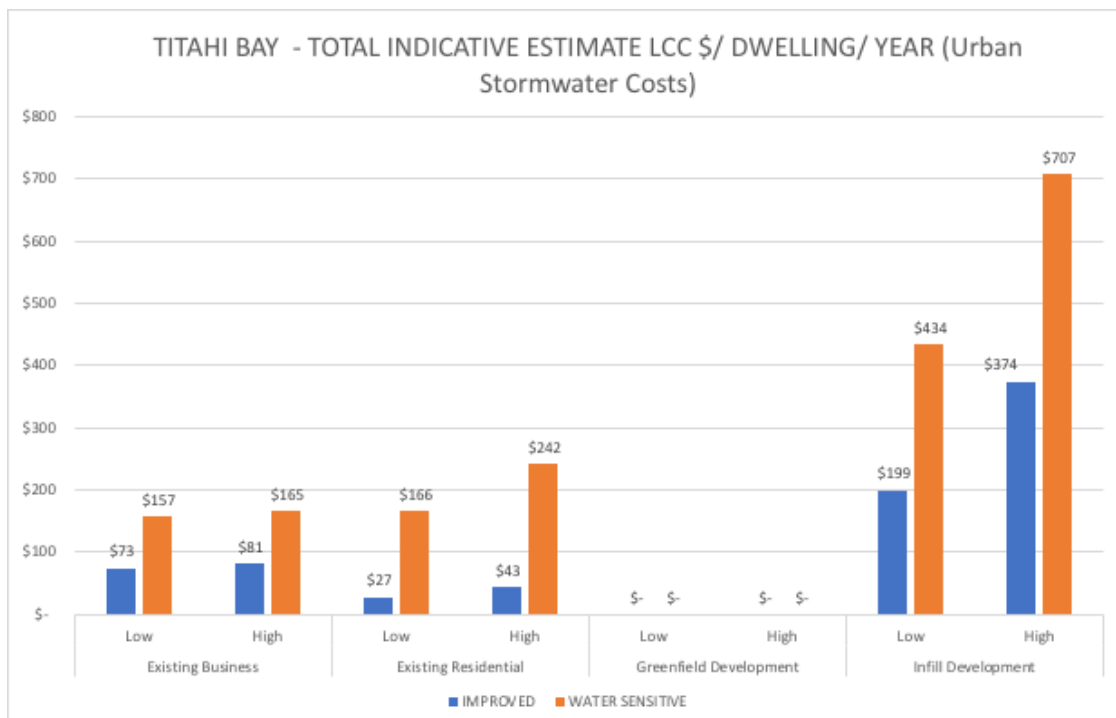
(f) Kenepuru infill case study



(g) Cambourne greenfield case study



(h) Titahi Bay



#### 4.2.2.2 Understanding stormwater cost occurrence within the urban development process

It is also important to understand where costs are distributed across the urban development value chain (Figure 3).

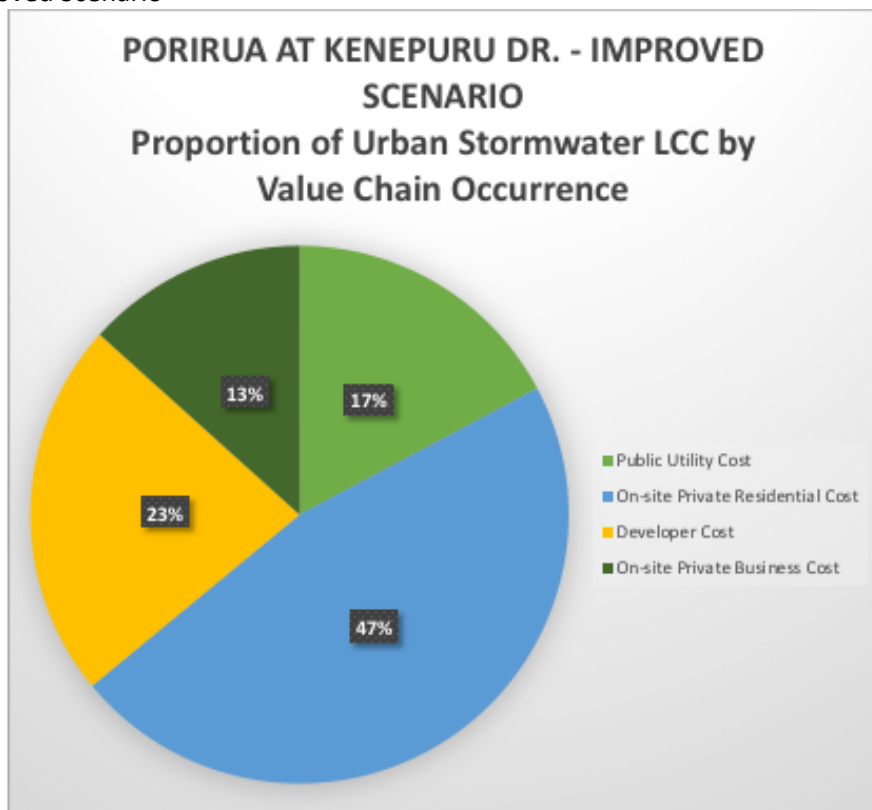
The Improved scenario includes a larger number of catchment-scale treatment devices such as stormwater treatment wetlands than the Water Sensitive scenario. These contribute to generating a higher share of total acquisition costs during the subdivision or land development phase than in the Water Sensitive scenario, and a higher share of publicly (network operator) on-going maintenance costs. By contrast, the Water Sensitive scenario involves a higher proportion of lot-scale mitigation methods for residential developments which sees a higher share of private residential costs in that scenario. Overall, the costs assigned to the private household make up the largest proportion within the value chain. This is the result of the high level of on-site stormwater management costs within both the Improved and Water Sensitive scenarios.

These findings are illustrated in the pie charts below for the Porirua at Kenepuru Drive WMU (Figure 7a and b). Similar pie charts for all the WMUs modelled are included in the report cards in Appendix A.

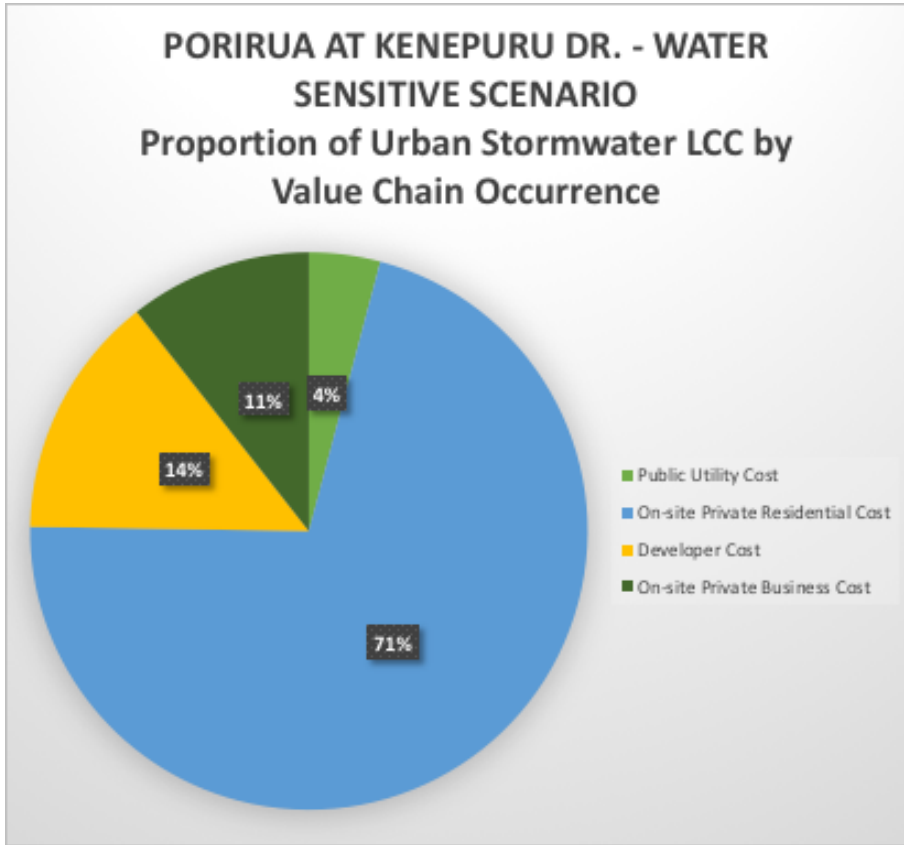
Whilst these graphs aid our understanding of where the cost of different interventions may fall, in reality, all homeowners and rate payers will bear the cost via the different channels within the value chain, i.e. developers on-selling houses, private owners building tanks, council/ network operators increasing rates / charges to pay for maintenance or upgrades.

Figure 7a and b Proportion of urban stormwater LCC by value chain occurrence within the Porirua at Kenepuru Drive WMU

#### (a) Improved Scenario



(b) Water Sensitive Scenario

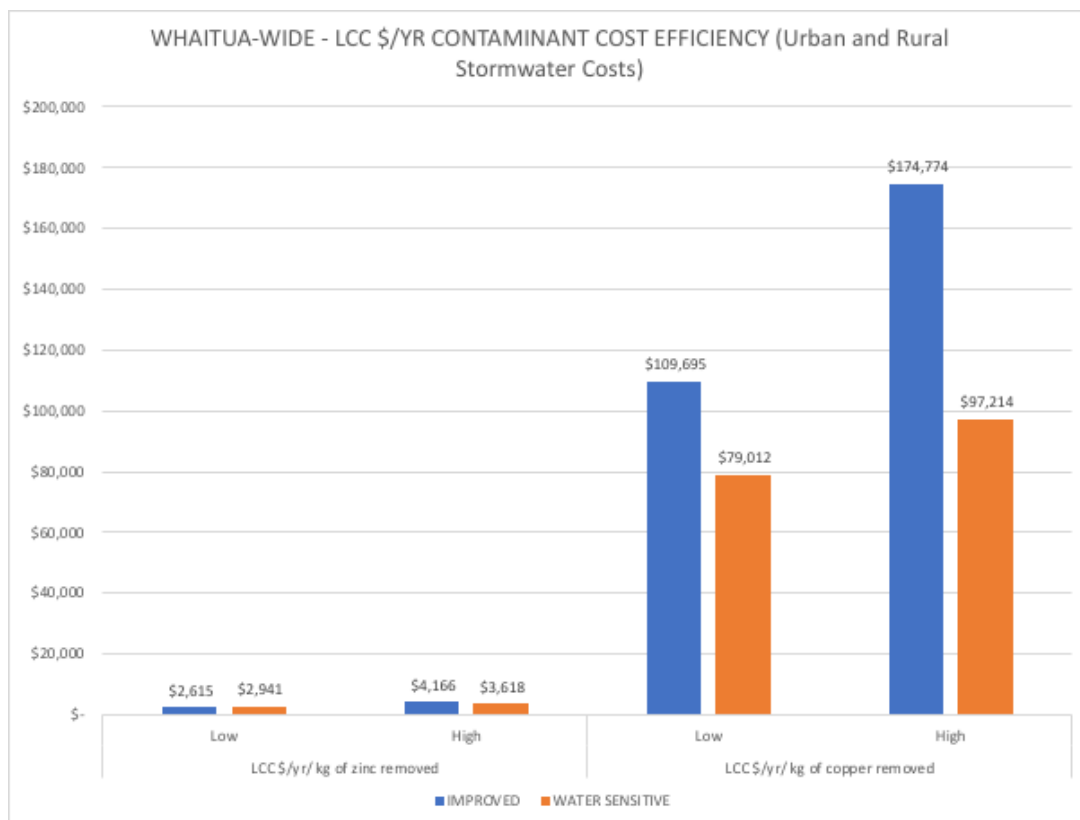


*4.2.2.3 Cost efficiency of scenarios*

In this section the relative efficiency of contaminant removal is compared between the intervention scenarios. When looking at the indicative LCC estimate per year in relation to the contaminant loads removed for zinc, copper and sediment, the Water Sensitive scenario is more cost effective than the Improved scenario on a whitua-wide basis. That is, the bundle of interventions in the Water Sensitive scenario tends to remove more contaminants for every dollar spent. An example of this pattern is shown in Figure 8 below for the analysis undertaken for the whole TAoP Whitua (Similar graphs for all the individual WMUs modelled are included in the report cards in Appendix A).

For the individual WMUs, the Water Sensitive scenario tends to be more cost effective than the Improved scenario for urban contaminants such as zinc and copper in greenfield dominated catchments. The Water Sensitive scenario is less cost effective in infill dominated catchments and this is likely due to the high level of bioretention treatment of infill high use roads.

Figure 8 TAoP Whaitua-wide cost efficiencies for zinc and copper



#### 4.2.2 Indicative cost estimates for the rural interventions

Information needed to analyse the costs of the scenario interventions in the rural sector was generated based on statistical data from Beef and Lamb NZ, and through a series of workshops and interviews with stakeholders in the rural community. Based on this information and in consultation with the rural stakeholders, unit costs used in the scenario analysis were generated for each rural intervention (riparian fencing and planting, pole planting and retirement). These are reported in Harris and Doole, 2017<sup>18</sup>.

The total life cycle cost for interventions in rural catchments, including land retirement, is \$31 million for the Improved scenario, and \$61 million for the Water Sensitive scenario. The indicative LCC estimate \$/year are \$625,000 for Improved and \$1,226,000 for Water Sensitive. A significant proportion of this cost (52% for Improved and 70% for Water Sensitive) is related to the land costs associated with riparian planting and retirement rather than the expenditure of putting in these interventions (e.g. fencing or pole planting).

While the rural interventions represent a smaller portion of the whaitua-wide LCC than the urban mitigations, they can be expensive at a local scale if they were to fall solely on individual rural property owners. This may be likely in the rural environment where there is large variation in the size and extent of treatments required based on the characteristics of a particular property.

<sup>18</sup> Harris, S and Doole, G. 2017. *Te Awarua-o-Porirua Collaborative Modelling Project – Work Brief 11 RM. Assessment of rural economics and mitigation costs.*

Figure 9 TAoP Waitua-wide cost per rural property for rural mitigations



Following the assumptions of where rural interventions are applied, approximately 45% of rural properties incur no costs. Around one third of properties have costs up to \$1,000 in the improved scenario, while nearly 20% of properties have costs up to \$1,000 and nearly 15% have costs between \$1,000 and \$5,000 in the Water Sensitive scenario. Around 1% of properties have costs of more than \$500,000 in both scenarios (Figure 9).

These figures suggest a strong skewing in the incidence of the rural costs. There is a likelihood that these costs could cause hardship to individuals, particularly where large proportions of a productive property are to be retired or taken out for riparian planting, and where fencing and planting costs are large relative to the size and returns from the property. This may impact on the gains achievable in rural parts of the catchment.

The Water Sensitive scenario provides improvements in *E. coli* and sediment from rural properties over the Improved scenario. In the Pauatahanui WMU, which is 97% rural, the Water Sensitive scenario produces improvements over the Improved scenario of around 35% reduction in *E. coli* concentrations and 13% reduction sediment loads. However, rural costs increase by around 150% between the two scenarios. For the Horokiri WMU, which is 99% rural, the Water Sensitive scenario reduces *E. coli* concentrations by around 33% more than the Improved scenario and reduces sediment load by a further 1%. The rural costs increase by 30% between the two scenarios.

Although there are some confounding effects, these results suggests that the increase in costs for these primarily rural catchments under the Water Sensitive scenario is sometimes matched with increased *E. coli* reductions, but may not be matched by an increase in sediment removal. It is likely that these results for the primarily rural catchments are reflective of the differences between the two scenarios across the rural area. However, the rural interventions should not be considered in

isolation from the urban interventions. A study undertaken by the Ministry for Primary Industries<sup>19</sup> indicates that contaminant management (especially sediment) from rural and urban areas should be considered jointly via an integrated catchment management approach if water quality objectives for urban areas are to be met.

#### 4.2.3 Wastewater interventions

The wastewater improvement cost estimates include improvements to the wastewater network that aim to reduce overflows and upgrades to the treatment plant. This analysis has used the costs associated with the 'Conveyance' option from Wellington Water's network improvement planning report<sup>20</sup>. These improvements are estimated at around \$2.1 to \$2.7 million per year for both scenarios, or around \$50-\$60 per dwelling per year over and above existing wastewater costs (currently \$385 per residential dwelling per year for Porirua City ratepayers).

The Conveyance Option aims to increase the capacity of the network and treatment plant capacity to handle all wastewater within the network for different sized storms. This translates to the two scenarios:

- A '3 month Average Recurrence Interval (ARI)' option designed for the size of storm expected, on average, 4 times per year and approximately corresponds to a design capacity that delivers 4 overflows per year (Improved scenario)
- A '6 month ARI' option designed for the size of storm expected, on average, 2 times per year and approximately corresponds to a design capacity that delivers 2 overflows per year (Water Sensitive scenario)

There is still some uncertainty as to whether these interventions and their associated costs achieve the levels represented in the scenarios or not. Wellington Water are continuing to refine both the potential network changes and associated costs at present. However, this is the best information currently available to illustrate magnitude of cost for different levels of improvements to the wastewater network.

Costs of improvements to the wastewater network to improve leaking pipes and cross connections, whilst likely to be significant, are uncertain and could not be explicitly evaluated as part of this study. Flow monitoring undertaken by Wellington Water<sup>21</sup> has identified that there are high levels of inflow and infiltration (I/I) throughout the network, including in some relatively new subdivisions within the Whitby area. Duck Creek and Cannons Creek have been identified as areas of concern. The modelling undertaken for the Conveyance Option did assume a 25% reduction of I/I in Cannons Creek (which is achievable under this option) and no reduction has been modelled for any of the other catchments. This is considered a conservative approach and therefore some of the costs associated with reducing I/I would have been included within the proposed Conveyance Option works<sup>20</sup>. I/I is also heavily influenced by the condition of private sewer laterals which are the responsibility of the property owner.

The costs estimated through this analysis largely fall to the network operator, in this case Wellington Water. Costs would be passed through to ratepayers following the agreements of the city councils with Wellington Water and the rating policies of the respective councils.

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<sup>19</sup> Ministry for Primary Industries. 2016. Urban Development and the NPS-FM: Lucas Creek Catchment Case Study. MPI Technical Paper No: 2016/66. Report prepared for MPI by NIWA.

<sup>20</sup> Wellington Water. 2017. *Draft Report: Porirua Wastewater Network Improvement Plan: Improvement Options*

#### 4.2.4 Implications of the indicative cost estimates for property owners

Both the Improved and Water Sensitive scenarios lead to increased costs resulting from urban stormwater and wastewater interventions since these interventions are assumed to be addition to existing interventions.

These interventions have the potential to achieve positive residential capital value effects. An international literature review undertaken for this project highlights that the adoption of stormwater interventions of a “water sensitive design” nature has the potential to lead to modest long term increases in property sales prices particularly for properties bordering or in close proximity to larger scale interventions like wetlands<sup>21</sup>. The size of this premium is highly variable, with a range of results reporting average increases between 3% and 8%. Conversely, the literature review also highlighted that a lack of on-going maintenance can cause property values to decrease in the longer-term.

The implications of these findings is that increased stormwater treatment could potentially add to the costs of holding a property, through both interest rate effects from increased purchase prices and the cost of implementing and maintaining interventions either privately or publicly.

Whilst not directly comparable to the additional indicative LCC estimates, the current costs of holding a property (either ownership or rental) give some context to the additional costs estimated in this analysis. At the time of writing, the estimated range of holding costs for a mid-value property is in the order of \$22,000 to \$39,000 per year for dwellings in Porirua and Wellington cities<sup>22</sup>.

The additional costs, expressed in annualised LCC terms for stormwater interventions for new residential dwellings, are in the range of \$200-\$830 per dwelling per year. The additional costs, expressed in annualised LCC terms for wastewater interventions to reduce overflows for connected residential dwellings, is in the range of \$40 - \$280 per dwelling per year. This leads to an approximate additional 1-4% of the current costs of holding a property. These additional costs and any associated increases in residential sales prices may increase the initial purchase price and holding costs for those that purchase both new and existing residential dwellings.

Because of the large variation in the size and characteristics of rural properties, the requirements for treatments may be highly variable. Some properties may have no need to change anything while others may need to make substantial changes to their land. These costs could cause hardship to individuals, particularly where large proportions of a productive property are to be retired or taken out for riparian planting, and where fencing and planting costs are large relative to the size and returns from the property.

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<sup>21</sup> Ira, S J T. 2017. *Effect of Water Sensitive Urban Design Solutions and Green Space on Property Values: A Literature Review*. Report prepared for Greater Wellington Regional Council as part of the Te Awarua-o-Porirua Collaborative Modelling Project.

<sup>22</sup> Based in: <https://www.interest.co.nz/property/tracking-wellingtons-housing-affordability>



## 5 CONCLUSIONS AND KEY MESSAGES

### 5.1 Conclusions

The CAM is a calculation tool that uses a life cycle methodology to bring together and assess the various cost components of stormwater and wastewater interventions with landuse changes. The development of the CAM has been a significant undertaking by GWRC, and is the first LCC model in New Zealand to integrate stormwater and wastewater mitigation with landuse and contaminant reduction. It is the culmination of a series of economic and biophysical modelling work packages which has facilitated the development of indicative LCC estimates of various intervention scenarios on a WMU basis. Section 1.2 summarises those reports which have contributed data and information for the assumptions used within the CAM. The life cycle modelling undertaken is consistent with previous New Zealand stormwater LCC models, and scenarios modelled are presented in Table 1. The LCC economic report cards are included in Appendix A .

### 5.2 Key messages

Costs are assessed as indicative estimates of LCCs. The reader should focus on the relative difference between scenarios.

#### **TAoP Waitua-wide costs**

- The rural and urban stormwater costs range from around \$4.7-\$7.5 million per year under the Improved scenario to \$13.1-\$17.8 million per year under the Water Sensitive scenario. The wastewater costs range from around \$2.1-\$2.6 million per year.
- Urban stormwater mitigation costs form the largest portion of modelled costs.
- The rural costs are dominated by the indirect costs incurred through loss of productive rural land.

#### **Urban stormwater interventions**

- The difference in costs between the Improved and Water Sensitive scenarios are relatively small and the effect of doubling on-site treatment from Improved to Water Sensitive is the dominant cost driver within the data (see Figures 6a – i).
- The high-end of the cost range estimate is appropriate for infill and retrofit situations. Land prices (and availability) and the difficulty of working within existing services and site constraints will drive up costs.
- The low-end of the cost range estimates are appropriate for greenfield situations.
- The Water Sensitive scenario includes a 16% 'avoided cost' saving in land development earthworks: this saving results from a different approach to development, and leads to reduced earthworks, reduced piping costs and reduced impervious surfaces. This effect is seen in the cost results (the Water Sensitive indicative costs estimates are just less than double the Improved estimates even though stormwater mitigation has been doubled in greenfield and infill areas).
- The Improved scenario models a higher share of public (on-going maintenance costs) and developer (total acquisition costs) expenditure from catchment scale methods (wetlands) than the Water Sensitive scenario. Due to the wide-spread application of on-site stormwater mitigation, the largest share of the costs within the value chain are assigned to the private and commercial properties.
- The per dwelling costs should be treated with caution since they are influenced by the number of existing dwellings as well as the proposed dwellings, and implementation pathways adopted by local authorities. In reality, decisions about spending sit with local government.

- When investigating the life cycle costs on the basis of \$/kg contaminant removed, the Water Sensitive scenario is more cost effective than the Improved scenario on a whitua-wide basis. Costs of removing copper are very high, and therefore opportunities for source control could be investigated to reduce the incoming contaminant load.

#### **Rural stormwater interventions**

- While the rural interventions represent a smaller portion of the intervention costs than the urban mitigations at a TAoP Whitua scale, they can be expensive at a local scale if they were to fall solely on the individual rural property owners. Furthermore, the cost of the loss of production on rural land as a result of land lost to retirement and riparian planting increases significantly in the Water Sensitive scenario over the Improved scenario. The percentage of the LCC which relates to losses from land production costs is approximately 25% higher in the Water Sensitive scenario than in the Improved scenario on a whitua-wide basis.

#### **Wastewater**

- There is not a great deal of difference between the Improved and Water Sensitive scenario costs for wastewater, and it is likely that the differences are within the error margins of the model. Maintenance costs for wastewater are based on engineering experience – no actual cost data was available.
- Wastewater costs are likely to be under-estimated as there is insufficient cost data to account for costs relating to fixing illegal cross-connections, and a catchment-scale cost model is unable to account for such site-specific costs.

#### **Property prices and holding costs**

- In general, the literature shows a consistent increase in house prices in close proximity to green infrastructure/spaces world-wide, however, the quantum of this increase varies significantly between countries. Based on this literature (approximately 74 studies) one could expect that there is likely to be a difference in property prices between the Existing and BAU, and Improved and Water Sensitive scenarios. Lack of on-going maintenance can cause property values to decrease in the long term.
- The interventions could increase urban property holding costs in the order of 1% - 4%.