A MODEL TO ESTIMATE THE COST OF STORMWATER IMPROVEMENTS FOR THE AUCKLAND REGION

Damian Young, Morphum Environmental Ltd
Jan Heijs, Auckland Council
Neil Blazey, Auckland Council
Jackie Zhou, Auckland Council

ABSTRACT

Auckland Council is responsible for the management of the estimated $2.5 billon dollars worth of stormwater infrastructure which services over 510,000 rateable properties within 235 catchment management areas. In order to meet strategic stormwater management objectives, define funding level gaps and reach stated levels of service, it is necessary to look forward into the future and estimate the amount of capital expenditure required to improve system function and performance.

This paper describes the development and outputs of a Stormwater Cost Estimation Model (SWCEM) designed to be a tool to estimate the "day one" cost needed to deliver improvement projects and programmes across the range of Auckland Council's stormwater activities in order to meet Council's objectives and Levels of Service. In particular the foundation datasets, levels of service assumptions and equations which make up the model will be discussed.

Development of the SWCEM has involved staff across multiple disciplines including GIS, Planning, Asset Management and Modelling. The consolidation of the Stormwater Unit from the legacy councils has provided an opportunity to draw together the best available data from across the region.

This exercise identified a range of costs to inform potential budget envelopes as well as a range of lessons learned and recommendations.

KEYWORDS

Stormwater, cost forecasting, asset management, modelling, strategic

1 INTRODUCTION

In order to meet strategic stormwater management objectives, define funding level gaps and reach stated levels of service, it is necessary to look forward into the future and estimate the amount of capital expenditure required to improve system function and performance in order to manage inherent flood risk damage and operational costs. The approach taken in this study has been to estimate these costs through the development of a Stormwater Cost Estimation Model (SWCEM), based in an excel environment, that can tap into the significant array of data now available to Auckland Council post transition. The vision behind this model is to define desirable future outcomes and then work backwards to calculate the cost to achieve them which can be described as a backcasting tool.

The model uses asset data from across the region to identify required works based on a number of assumptions and level of service options. The cost of the required works is then estimated using unit rates collected from numerous data sources and projects. In many cases the model uses different service options, e.g. 10 year pipe conveyance, to generate a range of costs that will assist in decision making.

This report provides the background, method and development details of the SWCEM and is a technical document. Morphum Environmental, in association with key Council Stormwater Unit staff, have been involved in the development of the SWCEM to support future planning of stormwater in the Auckland Region. The outputs from this project underpin the preparation of the Asset Management Plan for Auckland Stormwater and inform budget projections for long-term investment scenarios.

1.1 AUCKLAND ENVIRONMENTAL CONTEXT

Auckland is the largest and most diverse City in New Zealand with an estimated 1.44 million current inhabitants. Significant growth is expected with an additional 430,000 dwellings projected to be built in the next 40 years.

The mainland coastal margin is an estimated 1,600 km. The Tasman Sea borders the west coast, while the east coast opens onto the island-studded, sheltered Hauraki Gulf that leads into the Pacific Ocean.

The Auckland region has an estimated 16,500 km of permanently flowing streams and rivers, which increases to 28,000 km when intermittent and ephemeral rivers are included. Most drainage catchments are small with corresponding small streams and waterways that either drain to high energy coastal beaches and or low energy sensitive tidal inlets and estuaries.

1.2 AUCKLAND COUNCIL STORMWATER

Auckland Council is responsible for the management of the estimated $2.5 billon dollars worth of manmade stormwater infrastructure which services an estimated 510,220 rateable properties within the 261 catchment management areas being a total of 418,415 hectares. There are a total of 6500km of Council owned pipes with an associated 137,240 manholes and 27,486 stormwater catchpits. The stormwater piped networks in the Auckland region generally service the urban catchments.

The maintenance and operation of this significant network is critical to ensure that levels of service are met. For example 39% of these pipes are over 40 years in age and some will require replacement in the foreseeable future. Design standards for stormwater network capacity include primary system capacity for 2-10 year Average Recurrence Interval (ARI) events, and secondary flow, via overland flowpaths and floodplains for 50-100 year ARI events.

The infrastructure to control and convey stormwater within the Auckland region includes:

- Natural assets including streams, wetlands and springs.
- Conveyance structures (pipes, and culverts),
- Treatment Devices (ponds, wetlands and proprietary devices),

- Pumps, grates, traps and grills,
- Stop banks and flood control schemes,
- Manholes, inlets and outlets,
- Overland flow paths and swales.

1.3 STORMWATER TREATMENT AND FLOOD CONTROL

While flooding is still a main focus of stormwater in the Auckland Region, for the last 20 years there has been an increasing focus on stormwater quality impacts on streams and coastal receiving environments. Traditionally the focus has been on larger events with greater hazards, but a lower likelihood of occurring. More recently stormwater has also focussed on the more frequent storms that account for more of the annual water volumes entering the water cycle and define stream health. These storms govern the hydrological regime and are responsible for much of the contaminant loadings on the environment including first flush shock loads as accumulated contaminants are washed from the land into ecological systems.

Construction of stormwater treatment devices has occurred with significant infrastructure investment taking place over the last 20 years in Auckland. The structures and devices which reduce flood risk and improve water quality are shown in Table 1 below.

There are now more than 330 designed wetlands and wet ponds with more being added to the list as they become vested in Council ownership.

Table 1: Stormwater Flood Control and Water Quality Assets

Type	Estimated Totals
Dry Ponds	110
Wet Ponds	280
Wetlands	50
Gross Pollutant Traps (GPTs)	22
Proprietary Devices	120
Soak Holes	2,670
Soakage Systems	16

2 MODEL OBJECTIVES AND RULES

2.1 OBJECTIVES

The overall objectives were to prepare the SWCEM and a supporting Model Development Report to include details of the model development, definitions and structure. A considerable amount of investigation has been necessary to develop the model and this report will include the details, content and shortfalls of this information. The specific project objectives are listed as follows:

- Describe model build development and outline the processes,

- Define model rules and definitions,
- Detail model assumptions and extrapolations,
- List tasks that need to be completed,
- Include some comments about institutional capacity / business capacity to deliver,
- Highlight learning, areas for further focus for the future,
- List model improvements for the future,
- Include model components as appendices.

This is considered Phase 1 of a potentially wider more extensive exercise and project. The objective of this first phase is to provide the direction and structure for the refinement and development of a robust SWCEM that be used on an ongoing basis to support the Stormwater Unit.

2.2 MODEL RULES

To provide focus to the team and avoid `scope creep' the following project objectives and rules were developed:

- Develop the SWCEM in an Excel environment with a clear and simple design,
- Use existing information as available,
- Use data and information that is linked to decoded tables as possible,
- Record any problems/opportunities/issues that may not be critical to the Phase 1 deliverables but are of value,
- Record all assumptions and reasoning,
- Develop database so that former TLA summaries can be extracted.

2.3 SCOPE

The SWCEM includes costs of improvements to multiple stormwater network elements which have been summated under the following stormwater activity classes and corresponding sub classes:

- Flood Alleviation: Flooding of habitable floors, Network upgrades, Network extension, Water detention/Flow Control, Overland Flow Paths.
- Environmental Improvements: Bank Erosion, Outfall Erosion, Stream Protection & Restoration.
- Contaminant Management: Water quality treatment, Transport related treatment, Existing ponds, dams and devices.
- Miscellaneous: Health & safety, coastal outfalls & consent requirements.

2.4 LOW IMPACT DESIGN

Low Impact Design (LID) principles are a component of many existing stormwater projects and guidelines and form a key part of the Stormwater Units vision for integration in all stormwater activities. The council currently adopts a wide range of programmes and management techniques to manage stormwater, many of which are consistent with an LID approach. It was not considered possible to estimate the cost for LID, mainly because it is very dependent on the specific details of how the city will develop and redevelop, and what mechanisms will be used to facilitate the changes. Therefore, no specific cost line items for LID are included in the SWCEM. However a number of the works scenarios, e.g. stream erosion remediation, include LID principles.

In consideration of the above, future modifications / refinements of the SWCEM can include costs more directly related to LID that are within the Stormwater Units area of influence and will be incorporated into future assessments.

2.5 THE TIME SCALE

Typically cost estimations are conducted with a timescale component. However, for Phase 1 of this project it was decided to, as far as practicable, remove 'time' from the equation and simply calculate the total amount for improvements on a "fix it now and do it all" basis. For example the SWCEM identifies the cost of mitigating all flood risk issues that are known or are assumed to exist at present. There is no allowance for additional flood and other risk issues that may be created in the future. The estimated costs have not been discounted.

It is anticipated that future work on the SWCEM would involve a time component and provision has been made for this.

2.6 LIMITATIONS

The development of this SWCEM requires that multiple data sources are used as factors in the associated estimates and calculations. Although it is ideal to have all data to be checked and highly accurate this is not always possible or practical. The following disclaimers briefly put into context the level of expectation and/or confidence in these factors.

2.6.1 SPATIAL AND ASSET DATA

Wherever possible, readily available regional datasets have been used to develop the asset / landuse / geographical databases used in the estimation model. Additionally, former local authorities' datasets have also been used. In some instances this information is considered to be very accurate and in others there is a low level of confidence. In certain instances information sets may not be complete. In general terms the information used is the latest and most up to date available to Council. When there were gaps or low confidence, extrapolation was used based on observations in areas where more accurate data was available.

2.6.2 COSTS

Costs have been derived from the use of available or rationalised unit rates. In some instances these are based on previous cost estimation exercises conducted by Council; unit rates used by Council or other sources as stated in the Assumptions and/or Unit Rates sections. It should be noted that significant assumptions have been made in a number of instances including the use of professional judgement where no costs exist and investigating an accurate rate is not considered practical. It is acknowledged that a substantial body of work is required in the area of accurate and robust unit rate definition.

2.6.3 GROWTH

Although 'Growth' is included in the model it does not include the costs associated with fixing problems which would be created by growth such as increased floor level flooding. The model includes costs for network growth and treatment of contaminants. Growth does not include industrial areas or other landuse development types as this information was unknown at the time of writing. Growth is not based on actual spatial location but the predicted population growth prorated against a unit rate. Renewals, upgrades and network extensions are not considered to be growth within the model structure.

2.7 EXCLUSIONS

The SWCEM development cannot at the Phase 1 stage include all potential costs associated with the stormwater management system. The following have been excluded on that basis:

- Requirements of increasing community expectations (changing Levels of Service).
- Costs associated with rural streams.
- New stormwater issues, i.e. new flood risks or further degraded streams.
- Non-anticipated network consent requirements.
- Asset renewal programme: the Asset Management Team has calculated this separately (including pond desilting).
- Normal asset O&M (business as usual).
- Excludes any data or costs associated with catchpits and pipes associated with Transport related stormwater assets.
- Does not directly include any costs for capital works for remedial works of roading network causative to flooding.
- Costs associated with low impact design (LID).
- Costs to service non-residential growth.

3 METHODOLOGY AND MODEL DEVELOPMENT

This section describes the method and model development for the SWCEM. In particular the intention is to provide sufficient details so that the components and structures of this model are transparent and facilitate discussion and improvement.

3.1 LITERATURE REVIEW

A review of relevant references was carried out to support the development of the SWCEM. This included previous cost estimation exercises and former TA reporting outputs.

- Funding Futures: Funding Three Water- Auckland Region, Hill Young Cooper June 2007. (Project to identify funding gaps between the existing levels of expenditure and possible future three waters infrastructure performance levels).

- Auckland Regional Council Stormwater Action Plan, Auckland Regional Council, September 2004. (Set out a proposal for an expanded stormwater management work programme and discussion around costing).

- Boston Consulting Group: Auckland Regional Stormwater Project, An Action Plan to Deliver Improved Stormwater Outcomes. May, 2004.

- An assessment of the Lengths of Permanent, Intermittent and Ephemeral Streams in the Auckland Region, Auckland d Regional Council TR028, March 2002/9. (Provides details to support the study and assessment of streams across the entire region).

- Auckland Water Industry Annual Performance Review 2006/2007. Auckland Water Group 2007. (Provides an overview from across the key Council stakeholders (Councils and Network Operators) in Auckland on planning, maintenance, customer service, conservation, environment and risk management).

- 2009 / 10 Asset Management Plans for all former Local Authorities. (Includes details of asset numbers, condition and operation and capital costs).

- NSCC Costings Report and Supporting Calculations (2005)

3.2 DATA INVESTIGATION

The project team developed a data requirement list at the beginning of the project and then identified data gaps for further investigation. In some cases it was possible to analyse parent datasets to generate data fit for the SWCEM purpose. The primary focus being:

- Existing costing data (Asset Management Plans),

- Network data (assets e.g. ponds / pipes),

- Assessment data (e.g. habitable floor flooding),

- Other costing projects or studies.

3.3 SWCEM ELEMENTS AND STRUCTURE

The cost estimation model has been developed in a Microsoft Excel workbook and consists of four main components as listed below. Each component contains a range of information which is then factored or linked together as illustrated in Figure 1.

- **Base Data**: This includes catchment data, asset/network data, stream data, regional data and unit costs

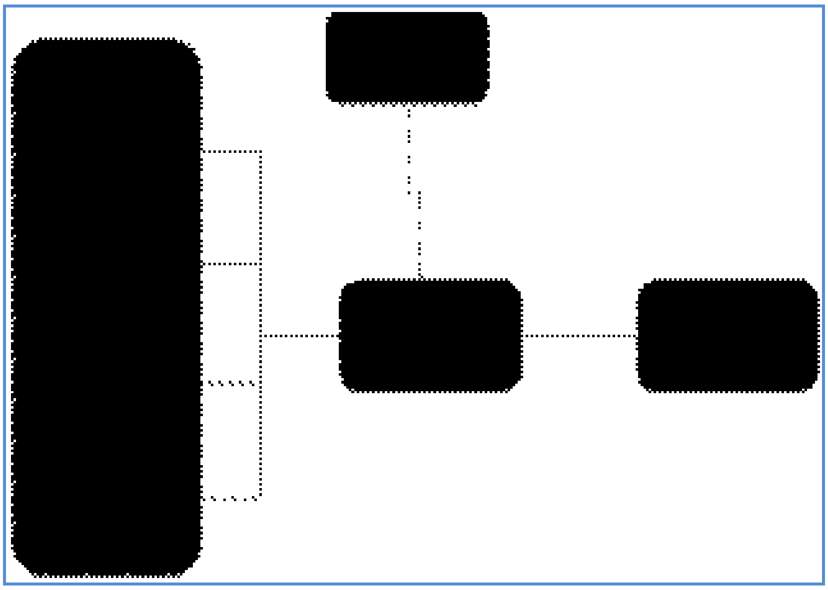
- **Formula Assumptions, Calculations and Option Scenarios**: This includes data assumptions, extrapolations, calculations to define cost of base data factors

- **Growth**: This includes a range of data sources and assumptions on growth based on the most up-to-date information at the time of writing.

- **Report Cards**: The report cards are the reporting output summary of the SWCEM and include details of costs per each activity types and there subclasses including Flood Alleviation, Environmental Improvements, Contaminant

Management, Miscellaneous, Growth (Details about cost report cards are included in Stormwater Improvements: Costing Review, Rev1, August 2011).

Figure 1: SWCEM Model Structure



In practical terms the SWCEM factors asset type against catchment information against a unit rate to generate a cost estimate. Although 'Growth' is included in the model it does not include the costs associated with fixing problems which could be created by growth such as increased floor level flooding but is limited to network growth and treatment of contaminants.

3.4 DATA CONFIDENCE

In order to determine the confidence in the costs attributed to each stormwater activity, we have attributed high, medium or low confidence rating to the components factored in the SWCEM. These include Data, Information, Assumptions and Parameters.

3.5 BASE DATA AND INFORMATION SOURCES

A critical component of being able to develop this SWCEM has been the use of (where available) GIS and asset related. This exercise, while serving the objectives of developing the SWCEM, also provides a base dataset that is recorded under current stormwater catchment area definition that can be used in any future analysis to summarise at a catchment level.

Meetings and correspondence with the Auckland Council GIS Unit resulted in gaps in data to be filled and the development of the datasets compiled within the SWCEM. These data are organised into Catchment, Regional and Stream/Asset related groupings. Data sources include:

- Asset Management Plan data from all legacy councils.
- Stream Walk Surveys to 323km of streams across 4 former councils.
- Data provided on an ad hoc basis from stormwater planning, operations and projects.

- Community LTCCP documents from all legacy councils.
- GIS Regional Data (landuse, parks, streams)
- GIS or Asset Data (roads, buildings, floodplains, pipes)
- Data from other historical studies.

There is significant variability in the quantity and quality of data around the Auckland region. However, this exercise has created a positive opportunity to consolidate data sets from around the Auckland region for the first time. Some observations of the data include:

- There are areas where there is no or poor data and we have had to make broad assumptions in our calculations. These data gaps have been filled on a pro-rata basis from a range of available data covering selected catchments, projects and legacy councils.
- Much of the environmental data is based on significant surveys that cover large parts of the city's urban extent. There is a high degree of confidence in this dataset.
- The hard asset data varies considerably between the legacy councils, though the greatest challenge is to calculate the renewals costs which are outside the scope of this assessment and are covered in the AMP.

3.6 ASSUMPTIONS

The SWCEM has been developed with a number of assumptions around costs, data or development patterns. Typically, there was less confidence in the assumptions and service options for each stormwater activity than the data or supporting information. Examples and discussion around this include:

- **Use of Surrogate Values**: The model uses a simplified approach to estimating costs and does not consider the full range of management responses for each issue. Example: We have assumed treatment ponds to generate a cost for water quality treatment. In reality, there are many ways of providing this treatment. A refinement to this model would be to investigate a broader range of options.
- **Factors Beyond Our Control**: A number of assumptions anticipate decisions that are beyond our control. Example: The timing and location of growth has not been considered in this assessment as it is outside the control and format of the Stormwater Unit.
- **Preferred Management Response**: For stormwater activities where we have identified service options, there is uncertainty as to whether this will reflect the preferred management intervention as set out in a Catchment Management Plan or policy documents. Example: We have assumed that 100% of habitable floors are removed from the 100 year flood plain. In practice, this may be unachievable or undesirable based on economic considerations. There may also be an acceptance that some properties will deal with flood risk through responses such as increased resilience measures.

3.7 STORMWATER ACTIVITY SERVICE LEVEL OPTIONS

For the purposes of the development of the SWCEM stormwater asset service level options have been developed from existing Asset Management Plans, LTCCPs or are assumed levels consistent with current stormwater activities around the Auckland region. These are summarised in Table 2: Stormwater Activity Service Level Option Description and Activity List.

3.8 UNIT RATE COSTS

A unit costs table forms part of the base data for the SWCEM as outlined in SWCEM Elements and Structure. Where possible a low, medium or high cost was provided for each cost unit item. In general the unit cost data has a medium confidence level. Unit costs have been collected from a range of sources and where possible has been compared to contracted rates. Where a cost range was not available and an assumed medium rate was selected, the high and low costs are +/- 25% respectively.

All rates reported are based on the medium rate (referred to as Base Rate in the Report Cards) as the total costs are less sensitive to these data compared to the assumptions and service options. The model has been developed so when more accurate unit costs rates are developed or defined they can be updated and cost outputs can been made. It is acknowledged that a substantial body of work is required in the area of accurate and robust unit rate definition.

Table 2: Stormwater Activity Service Level Option Description and Activity List

Stormwater Activity	**Target Service Level Description**	**Confidence**
Flood Alleviation		
• Flooding of habitable floors	Remove all habitable floors from the 100yr storm event floodplain.	Medium
• Network upgrades	Upgrade pipes and assets as required to prevent flooding from a 10yr storm event.	Low
• Network extension	Extend the stormwater network to properties which are currently without service.	Low
• Overland Flow Paths	Mitigate habitable floor flooding from Overland Flow Paths in a 100yr storm event.	Medium
Environmental Improvements		
• Bank Erosion	Provide mitigation to bank erosion for all urban streams with severe and moderate bank erosion.	Medium
• Outfall Erosion	Provide mitigation to outfall erosion on all urban streams with slight, moderate and severe outfall erosion.	Medium
• Stream Protection & Restoration	Provide riparian planting to all urban streams, develop inanga spawning areas and remove all artificial barriers to fish passage.	Medium

Contaminant Management		
• Water quality treatment	Provide treatment to urban areas. The CEM model assumes that only 25% of this area is actually provided with treatment.	Medium
• Transport related treatment	Treat all roads with greater than 10,000 vehicles per day	Low
• Existing ponds, dams and devices	Improved efficiency for existing wetlands, wet ponds and gross pollutant traps. We have not specified a level of treatment but target guideline to ARC TP10.	Medium
Miscellaneous		
• Health & safety, coastal outfalls & consent requirements	There are a range of stormwater activities with minor costs that have undefined levels of service.	Medium

3.9 REPORT CARDS

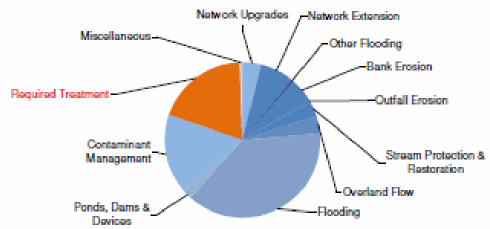
A Report Card has been designed for each sub-activity as part of the SWCEM reporting output. The intention is to summarise key data and information on a stormwater activity basis for dissemination.

They include the catchment / asset / GIS data used in the cost calculator as well as the unit rates they are factored against. Confidence levels, supporting assumptions and a pie chart indicating the relative proportion of the individual activity compared to the total estimated cost are also provided. An example of a Report Card is presented in Figure 2.

Figure 2: Report Card Example

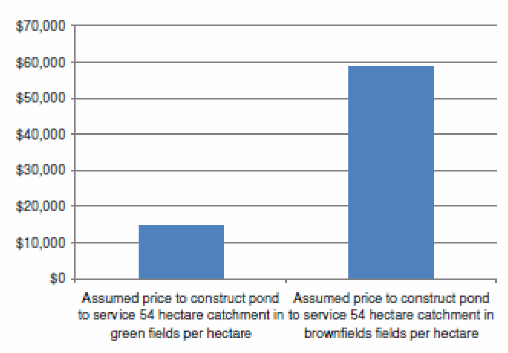
Report Card:

Required Treatment (including source control)



	Service Option Total Treatment Cost to Treat Untreated Areas			Key Assumptions / Calculations
	10% of treatment completed	50% of treatment completed	70% of treatment completed	- Average pond treated area (54ha) based on existing data from NSCC, WCC, RDC, - Average pond size is 0.6ha - Assumes 90% of urban area is Brownfield site - Assumed 50% of all areas drain directly to the coast and/or simply completely unfeasible - Various scenarios reflect that not all treatment is achievable.
Total:	$179,578,000	$897,888,000	$1,257,043,000	

Source Control	Total_Area_of_Roof_m2 (> 1000m2)	Total_Perimeter_of_Roof_m (> 1000m2)	Cost of Source Control	Key Assumptions / Calculations
ACC	7,552,429	716,375	$55,630,383	- Assuming 50% roof area and 30% perimeter require repainting. - Assuming average wall height is 4m.
FDC	732,000	70,555	$5,407,991	
MCC	6,840,837	577,029	$49,354,235	
NSCC	2,227,533	234,433	$16,741,039	
PDC	1,178,524	115,637	$8,736,313	
RDC	701,796	84,929	$5,433,746	
WCC	1,936,218	212,113	$14,671,739	
Total:	21,169,336	2,011,072	$155,975,447	



Data Confidence	LOW	Observations
Notes	- High spatial variation in costs - Land purchase costs vary - Urban area based on MUL	- To fully treat the untreated catchment (the 50%) would require 308 ponds. - This is just the construction and land purchase cost. - Ponds provide flow management. Need to ensure care that we are not double counting the cost of flood risk management

4 CONCLUSIONS

4.1 SWCEM COST OUTPUTS AND SENSITIVITY

For many stormwater activities there are a range of costs depending on the selected service level option. As a guide, the full range of identified costs from the SWCEM is shown below in Table 4: Improvement Cost Summary.

The sensitivity of the model to asset and unit cost variables is minor compared to the sensitivity associated with the activity service level options. For example, Table 3 shows the cost of network upgrades could vary from $205 million to $2,053 million depending on the service level option.

The potential range of Capex costs is from $3.6 billion to $8.1 billion as generated from SWCEM outputs in August 2011. However, a significant portion of the higher estimate is based on the requirement to upgrade all pipes that are currently below their design standard, even though many of these will not be causing any flood issues. It should be noted that these costs exclude Capex costs relating to network renewals.

Table 3: Improvement Cost Summary

Item	**Low ($ million)**	**High ($ million)**	**Base Scenario ($ million)**
Flooding			
Floodplains - Habitable Floors	2,080	2,551	2,080
Overland Flow Paths	51	51	51
Other flooding (dry ponds etc)	209	209	209
Network Upgrades	205	2,053	205
Network Extension	383	383	383
SUB-TOTAL:	2,928	5,247	2,928
Environmental Improvements			
Bank Erosion	253	253	253
Stream Protection & Restoration	167	167	167
Outfall Erosion	22	32	32
SUB-TOTAL:	442	452	452
Contaminant Management			
Required Treatment (source control)	155	155	155
Required Treatment	179	1,257	898
Existing Treatment Devices	105	105	105
Transport Related Treatment	552	903	903
SUB-TOTAL:	991	2,420	2,063
Miscellaneous	32	32	32
TOTAL:	**4,361**	**8,119**	**5,475**

4.2 LEARNINGS AND FUTURE IMPROVEMENTS

Through the development and design of the SWCEM a number of lessons learned and understandings around future improvements have presented themselves. The following list details these.

Flooding Alleviation

- There is currently some uncertainty around flood risk across the region. Although some areas this has been well defined in many other areas further study is required to determine properties in flood plains.

- The SWCEM has the potential to be further refined to show sensitivity to modelling outcomes in monetary terms.

- Further assessment of the cost of property purchases would be of benefit to refine cost model for flood mitigation.

- Associated with purchase of property is the return on reinvestment and sale, this needs to be factored into future models.

- Remedial costs for OLFP works need further refinement as more data presents and is collected as part of current programmes of works.

- Consider introducing flow control (and costs) on lot by lot basis or/and the implementation or WSUD / LID across selected catchments.

Growth

- The SWCEM has been used at the catchment scale to estimate development costs; however this work needs further refinement and would / could report on brown vs green field development areas at a catchment scale rather than the regional lumped estimate currently proposed in version 1 of the SWCEM.

- More detailed information around growth type, locations and densities will be required to improve cost estimation on a catchment basis rather than the regional lumped estimate.

- The SWCEM will need to be calibrated against actual costs and some provision needs to be made for this; an example being costs for Flat Bush and/or NORSGA.

Low Impact Design

- Low Impact Design (LID) options have not been included into the SWCEM directly but the intention is too include LID treatment methods with associated costs.

- Future catchment planning processes have the potential to incorporate LID treatments and in so doing the SWCEM could be updated to reflect these costs.

- A GIS based analysis should be undertaken with defined LID unit rate costs to determine regionwide costs as appropriate.

Transport

- Contaminant treatment costs associated with road network growth were not included. This could be considered in future iterations of the model.

- Catchpit filters were used as a surrogate for all contaminant management in the road reserve. A more realistic mix of options, including potential LID treatments, should be considered.

Maintenance

- The SWCEM does not include "whole of life costings" and this is necessary to support economic assessment and the knock-on costs associated with chosen options.

- Large operational projects such as pond cleanouts which result in optimisation of device function could form a part of any future costs modelling.

Contaminant Management

- The version 1 SWCEM used ponds as a surrogate for all stormwater treatment (other than within road reserves) and a more realistic mix of methods with associated costs needs to be included.

- The extent to which stormwater is, or can be treated (i.e. standards and / or guideline values) has a substantial impact on price so costings should reflect treatment standard scenarios. This would also be incorporated into prioritisation linked to receiving environment values / vulnerability.

Network Costs

- At the phase 1 costings stage a single generic pipe sizing and depth of cover was used to calculate costs and refinements could be made with pipe renewals and network extension costs more reflective of potential sizing. However at the first stage level this was considered sufficient resolution.

- Costings have not included total replacement and this possibly could be considered.

GIS Data

- The survey type data (stream survey, wetland survey etc.) should have QA system to ensure the quality of the data, and the data should be saved under common database.

- Inconsistent asset data format and content makes it difficult to calculate costs on a regional basis with high data confidence. Therefore the SWCEM will be supported by any improvements in updating asset data region wide and setting standards for asset information in the region.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the contribution of many staff from within the Auckland Council Stormwater Unit. We would also like to thank the Auckland Council Geospatial team for their assistance with data collection.

DISCLAIMER

The work presented in this paper was funded by the Auckland Council. Views expressed in this paper are those of the authors and do not necessarily represent policy or position of the Auckland Council.