

COSTING ANALYSIS OF A PUBLIC STORMWATER BMP – A SEVEN YEAR REVIEW

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ABSTRACT

One of the biggest concerns over the use of a stormwater Best Management Practice (BMP's) is the ongoing maintenance cost. As land is developed by private developers stormwater BMP's are often vested in council, and therefore council needs to have a good understanding of what the lifecycle cost of a stormwater BMP is.

A life cycle costing review was performed by Landcare Research and Auckland Council in 2005 on a range of stormwater BMP's. The results from this study were limited as not a lot of maintenance data was available, suggesting that not a lot of maintenance was being performed.

It is vital that decision makers have good, accurate and real data that considers all externalities. Subjective decision making can often leave government organisations with a legacy of cost that often results in the BMP not being maintained.

Stormwater360 has been working closely with various Auckland legacy council asset managers since December 2005 when the first council device (StormFilter) installed in Crows Road in Waitakere required maintenance.

There are presently 108 StormFilters vested under the new Auckland Council and NZTA with a total of 1,685 cartridges installed in these units. This is possibly the largest body of cost data of a single stormwater BMP in the country.

The Auckland Council and NZTA have run numerous Capital Works projects using the StormFilter technology as a standalone stormwater treatment device. These organisations have also established ongoing maintenance contracts to ensure the devices are maintained appropriately.

The following paper will analysis actual costs for the implementation and ongoing operation of the StormFilter over the last 6 years. The paper will also include some specific case studies discussing the factors that can affect the costs of stormwater BMP's.

This paper offers benefit to council asset managers and stormwater design engineers in selecting appropriate technologies for new and existing areas.

KEYWORDS

Life Cycle Costing, Stormwater BMP, Maintenance

PRESENTER PROFILE

Mike Hannah is the Technical Director of Stormwater360. He has had 18 years experience in stormwater infrastructure engineering. Mike has designed, constructed, implemented, monitored and tested numerous stormwater treatment facilities. Mike has also presented some of his research at stormwater conferences in Australia, New Zealand and USA. Co-founder of Enviropod NZ Ltd, Mike has been involved in developing innovative solutions for stormwater management. Stormwater360 is a specialised stormwater engineering company with an extensive research and development program into innovative treatment solutions.

1 INTRODUCTION

The US Environmental Protection Agency (USEPA) definition of a BMP is a technique, process, activity, or structure used to reduce the pollutant content of a stormwater discharge. BMPs include simple, nonstructural methods, such as good housekeeping and preventive maintenance. BMPs may also include sophisticated, structural methods, such as the installation of sediment basins.

The purpose of the paper is to provide a factual cost review of an innovative structural stormwater best management practice; the Stormwater Management StormFilter. The StormFilter is used by Auckland legacy city councils and the Auckland Motorways to remove contaminants from stormwater.

The Stormwater Management StormFilter is an innovative rapid filter for stormwater that has been approved by the ARC since 2003. Stormwater360 New Zealand is the company that holds the New Zealand license and manages all aspects of the life cycle and operation of the Filters over the last 9 years. To date there are over 550 StormFilter installed nationwide with approximately 20% in the ownership with Auckland Council and the Auckland Motorways.

The cost of stormwater treatment and in particular the ongoing maintenance is one of the biggest concerns with stormwater management. There have been numerous attempts both in New Zealand and overseas to evaluate the life cycle costs of stormwater management and low impact design (LID). These studies have often encountered a lack of data or indeed a lack of maintenance being carried out. In order to address this, the Ministry of Science and Innovation funded the COSTnz costing model and website which has been used to assist in the collection and analysis of stormwater cost data. Unfortunately this has had little use since its inception in 2009 (pers. com Christine Harper, Landcare)

Despite all the attempts to quantify the cost of stormwater management, many decision makers in New Zealand (in particular engineers) have a perception that stormwater management is expensive and the most expensive of all forms of stormwater management is manufactured devices. However with no maintenance actually being undertaken or data recorded this perception is purely speculative and based on perception rather than experience.

The purpose of this report is to investigate the real costs associated with the use of the StormFilter in order to assist in either confirming or changing the perception of the use of the StormFilter. There are more factors than cost alone in selection of a stormwater best management practice (BMP), however an accurate evaluation of the cost is essential for decision making.

There are two ways in which this report does this: firstly by determining some input values for a life cycle costing approach and, secondly by undertaking cost comparisons of conventional and low impact design best management practices.

2 STORMFILTER OVERVIEW

2.1 DESCRIPTION

The Stormwater Management StormFilter (StormFilter) is a passive, flow-through stormwater filtration system. It consists of vaults that house rechargeable cartridges filled with a variety of filter media. The filter systems are installed in-line with storm drains. The StormFilter works by passing stormwater through media-filled cartridges that trap particulates and adsorb materials such as dissolved metals and hydrocarbons. After being filtered through the media, the treated stormwater flows into a collection pipe or discharges into an open channel drainage way. StormFilter is offered in three different configurations: cast-in-place, precast and linear. The precast and linear models utilise pre-manufactured vaults. The cast-in-place units are customised for larger flows and may be either covered or uncovered underground units.

Through independent third party studies, it has been demonstrated that the StormFilter is highly effective for the treatment of both first flush flows and design flows during the latter part of a storm. In general, StormFilter's efficiency is highest when pollutant concentrations are highest. The primary target pollutants for removal are sediments (TSS), soluble metals, phosphorus, nitrogen, and oil and grease.

2.2 BASIC FUNCTION

The treated stormwater collects in the centre tube of the cartridge, which is equipped with a self-priming siphon system. Figure 1 illustrates this system. The key component of the system is the plastic float. The float consists of a ball located at the base leading up to a larger portion, which provides increased buoyancy. Initially the ball rests in a seat effectively closing off the port to the drainage manifold. As a result, the filter fills the centre drainage tube until the water level has raised high enough to purge the air from the filter cartridges and displaces the float. At this point the float pulls loose and allows the filtered water to drain out through the manifold. This effectively "primes" a siphon within the drainage tube and spreads the flow across the entire filtration bed. The priming system increases StormFilters ability to be loaded with sediment. A related feature is the cartridge "hood". This hood maintains the siphon effect by preventing air from being drawn into the cartridge until the external water level drops below the bottom of the hood.

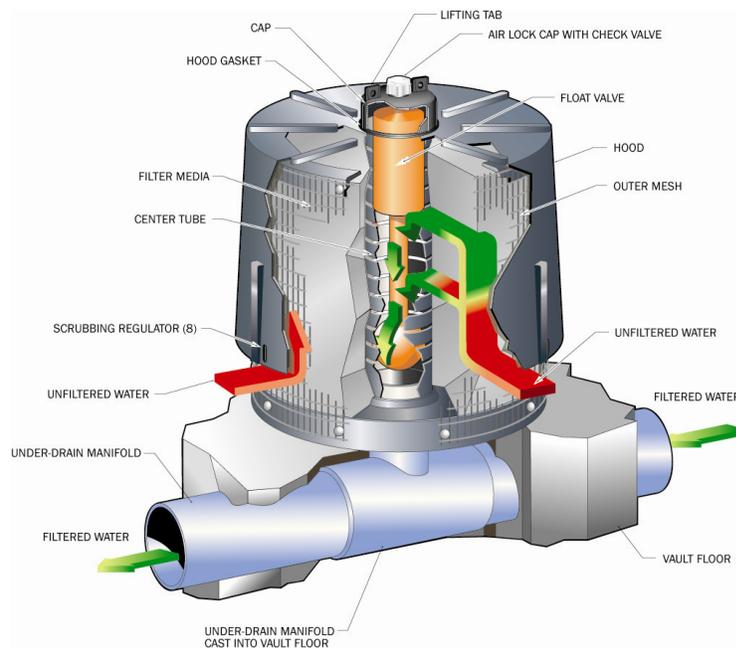


Figure 1: Stormfilter Cartridge

StormFilter is also equipped with flow spreaders that trap floating debris and surface films, even during overflow conditions. Depending on individual site characteristics, some systems are equipped with high and/or low flow bypasses. High flow bypasses are installed when the calculated peak storm event generates a flow that overcomes the overflow capacity of the system. All StormFilter units are designed with an overflow. The overflow operates when the inflow rate is greater than the infiltration capacity of the filter media.

2.2.1 SIZING

The StormFilter is typically sized to treat the peak 80% of the annual runoff within the jurisdiction of the Auckland Regional Council. The number of cartridges required to treat 80% of the annual runoff is determined through a rainfall runoff continuous simulation spreadsheet using actual rainfall from a representative month. The representative month is usually based on the regulatory requirements set by the local stormwater management agency. As the StormFilter is available in different cartridge sizes, the peak design flow for each cartridge is a function of available filter area.

There are a number of design methods used : the solids-based, peak flow and/or detention design method. Solids-based designs utilise the known loading capacity of the StormFilter to size systems in accordance with a desired maintenance interval. Peak flow design is where the StormFilter is sized to treat the peak flow of a water quality design storm as it passes through the filter. The peak flow is determined by calculations based on the contributing watershed hydrology and using a design storm magnitude. The particular size of a StormFilter is determined by the number of filter cartridges (see Figure 1) required to treat the peak stormwater flow. The

detention design method allows the use of fewer cartridges than is required to treat the peak of the water quality design storm as additional detention is provided either upstream or in an oversized vault. The additional detention required is calculated by routing the water quality design storm through the chosen number of cartridges.

2.3 MAINTENANCE OVERVIEW

The primary purpose of the StormFilter is to filter out and prevent pollutants from entering our waterways. Like any effective filtration system, periodically these pollutants must be removed to restore the StormFilter to full efficiency and effectiveness. Maintenance requirements and frequency are dependent on the pollutant load characteristics of each site. To assist the owner with maintenance issues, Stormwater360 provides detailed Operation & Maintenance Guidelines with each unit.

Routine Maintenance of the system involves the following:

- Periodic removal and disposal of sediment and media by standard vacuum truck
- Cleaning, refilling and refurbishment of cartridge
- Record keeping and reporting.

Maintenance considerations have been paramount in the design of the StormFilter. The system has been engineered to have many maintenance features. These are as follows:

- Drain down. The StormFilter contains minimal standing water to minimise the disposal cost. The drain down also prevents the compaction of sediment making it easier to remove.
- Central / Underground. Unlike other forms of stormwater treatment all stormwater contaminates retain in one or a few underground vaults rather than dispersed across a catchment.
- Use of a filter media that has a high load capacity of sediment allowing a long maintenance frequency
- Easy access for inspection and maintenance so that required task can easily be performed
- Repeatable procedures being undertaken by experienced personnel allows for fast maintenance turnaround.

These features help to lower the cost associated with operating the BMP

3 LIFE CYCLE COSTING ANALYSIS

3.1 WHY LIFE CYCLE COSTING

A life cycle costing (LCC) approach has been suggested as an important way to estimate costs associated with stormwater devices. LCC has been used over the last 5 years to justify the use of LID over conventional forms of stormwater management. Likewise it has been chosen to evaluate this manufactured BMP's. LCC is a means of objectively estimating the costs associated with an activity or product.

The Australian/New Zealand Standard 4536 (1999^s) defines LCC as:

“The process of assessing the cost of a product over its life cycle or portion thereof”.

LCC should not be confused with a benefit cost analysis. LID and LIUDD present numerous multiple benefits that enhance different aspects of cultural, physical and natural environments over structural stormwater treatment method. However, stormwater management is complex and a tool box of management options is required to deliver the best (appropriate) outcomes.

The life cycle costing process assesses the acquisition and ownership costs of an asset over its life span: from the planning and design stage, to the construction stage, to the usage and maintenance stage, and finally through to Water New Zealand Stormwater Conference 2012

disposal. 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 (Vesely *et al.*, 2006).

Stormwater360 is a specialist stormwater BMP provider. In delivering its products and services the following aspects of the StormFilter's life cycle is carried out by Stormwater360:

- Research
- Design
- Install
- Maintenance
- Decommissioning
- Development
- Manufacture
- Monitors
- Corrective works

This unique cradle-to-grave ownership or responsibility for the BMP allows for accurate collection of cost data.

3.2 HOW A LIFE CYCLE COSTING ANALYSIS IS CARRIED OUT

Lifecycle costing attempts to calculate a 'present value' of the costs incurred over the life of a technology. 'Present value' is the value now of a sum, or sums of money in the future. The present value metric is important because money now is regarded as worth more than money in the future. This difference in value is because of uncertainty and because money can be invested how to produce a greater sum in the future.

The present value of future money is calculated by 'discounting' it at a rate of interest (or discount rate) equivalent to the rate at which it could be invested. For example, \$105 in a year's time has a present value of \$100 if the interest rate is 5% per annum.

The present value of a sum of money is calculated as:

$$PV = \sum_{i=1}^n \left(\frac{C_i}{(1+r)^i} \right) = \frac{C_1}{(1+r)^1} + \frac{C_2}{(1+r)^2} + \dots + \frac{C_n}{(1+r)^n}$$

Where:

PV = present value

i = year

r = discount rate

C = future cash amount

n = life of project.

3.3 METHOD / APPROACH / DESCRIPTION / PARAMETERS

Life cycle costing can be undertaken using either a statistical or unit cost approach. A statistical approach is based on developing a statistically significant relationship between the size of a practice and its costs. For example dollars per hectare of catchment area (\$/Ha). A unit costing involves identifying individual elements of the acquisition and maintenance phases of a products life cycle, and costing them. For example calculate how much pipe is required for the treatment device and at what rate can it be purchased and installed.

A unit cost approach has been adopted for the COSTnz life cycle costing model by Landcare and Koru Consultants. The COSTnz model is a simple, easy to use and comprehensive life cycle costing model which allows users to quantify the relative costs of stormwater BMP's. The model allows consultants, developers and decision makers to assess the relative performance and cost of different BMP's (COSTnz).

A statistical approach has been adopted for this analysis to review real data collected over the last 7 years. This report suggests give upper and lower quartile values on a \$ per hectare basis for three broad input parameters of the COSTnz model. These are: Total Acquisition Costs (TAC), Routine Maintenance Costs (RMC) and Corrective Maintenance Cost. (CMC)

These parameters can easily be compared with results (outputs) from the COSTnz model for other projects. This report will show an example of this.

3.3.1 TOTAL ACQUISITION COST (TAC)

Includes total cost associated with delivering the product. Included in this evaluation is design and installation. It does not include the costs associated with catchment planning and council supervision.

An example of a couple of projects from legacy councils includes:

Waitakere City Council let a professional services contract for the retrofit design of stormwater quality devices in various locations in Waitakere. The professional services contract was approximately 5% of the supply price and the installation cost was approximately 30% of the supply cost includes enabling works such as bypass manholes, cesspits and pipes. (Pers. com Doherty, Auckland Council)

Another legacy council (Papakura District) retrofitted a large StormFilter to treat approximately 9 hectares of the Papakura Township. The total cost of install the unit and construct an access way and all enabling works was 80% of the supply price of the filter. (Pers. com Chin, SKM),

In this analysis TAC includes design and installation cost for all of the vested StormFilter in this study where installed by the developer at no cost to the council. When installation is part of a new subdivision or development the installation costs for manufacture structural BMP's are usually minimal as works are included in the general drainage contract.

Total acquisition cost includes:

- Intellectual Property
- Design of the treatment device
- Design of access road and enabling works
- Supply of the device and all ancillary components.
- Installation (excavation, crane, connections, compliance)
- Contractors markup
- Freight

3.3.2 ROUTINE MAINTENANCE COST (RMC)

Annual costs associated with routine maintenance. The following activities are included in this analysis and carried out by Stormwater360. Not included are council costs to administer work orders and contracts.

- Inspections
- Removal or sediment
- Disposal of sediment
- Health and safety and compliance
- Establishment
- Media and cartridge filling
- Transport
- Cartridge cleaning
- Report writing
- Record keeping
- Cartridge repairs
- Weigh bridge receipts
- Insurance

3.4 CORRECTIVE MAINTENANCE COSTS (CMC)

This is defined as costs associated with significant alterations to the BMP. In the 7 years of this review over the entire study set no CMC were encountered. Stormwater360 warrant minor 'wear and tear' on the cartridge if a service contract is entered into with the company therefore corrective maintenance of the cartridge is considered routine maintenance.

3.4.1 DECOMMISSIONING COSTS (DC)

Costs associated with the removal of the treatment device at the end of its life span due to redundancy and need of replacement. Decommissioning costs are not considered in this report.

The concrete structure that the StormFilter cartridges are housed has a minimum design life of 50 years. As previously mentioned cartridges are warranted under the maintenance contracted. After 50 years it would be minimal cost to replace the concrete.

Decommissioning costs they have not been included in this study as no decommissioning was undertaken. In a Present Value evaluation, discounting results in decommissioning costs having minimal effect on the life cycle cost.

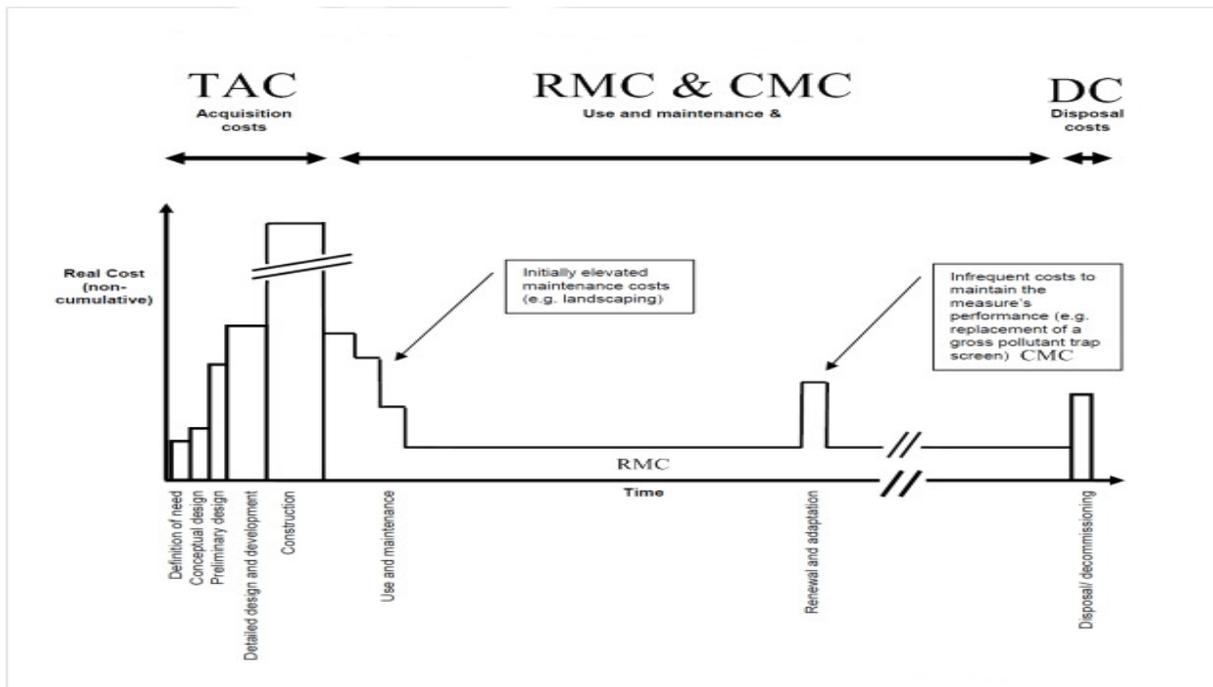


Figure 2:--Phases in the Life Cycle of a Stormwater Best Management Practice

Source: Modified from Taylor

3.5 THE STUDY CATCHMENTS/ DATA SET

At present 106 StormFilter units are owned by the legacy councils of Auckland (Manukau, Waitakere, Rodney, North Shore and Papakura) and Auckland Motorways (NZTA). These treat a total catchment area of 103 hectares of mostly impervious catchment. These government agencies have obtained these units through the following means:

- Vested in council – these units have been purchased and installed by developers as part of infrastructure requirements with subdivision and land development. These units have been installed into urban Water New Zealand Stormwater Conference 2012

Greenfield sites. These systems use perlite filter media and are typically sized as small and where possible StormFilters in this area are often installed before any houses are built and are subject to high sediment loads as a result of small site sediment runoff as houses are being built. Generally these units have been positioned with good access for maintenance. For many of these sites the land take or the topography were influencing factors in the choice to use Stormfilter.

- Purchased and installed by council as part of comprehensive Catchment Management Plan (CMP) enactment. These units have been retrofitted into existing urban environments to target hot spots of stormwater pollution. The StormFilter has been chosen for these sites as the systems can be located underground and have a small footprint requiring no acquisition of land.
- Purchased and installed by councils and NZTA as part of urban infrastructure development (train and bus station carparks). These systems use a mixture of ZPG (busways) and perlite media (train stations) ZPG media is used on the busway car parks as they are in close proximity to the motorway and may have elevated dissolved metal concentrations.
- Purchased by the NZTA as part of the upgrading of the Auckland motorway network. These units have been designed to accommodate the high sediment load derived from motorways. Additional cartridges with low flow rates have been used to minimise the maintenance frequency and traffic management costs. The StormFilter is used on the motorway network on numerous sites these include: Tauhinu Headland, Manukau Causeway, Warmsley Road on-ramp and Victoria Park tunnel.

Government (Auckland City Councils and Auckland Motorways) owned StormFilters were chosen for this study as it was anticipated that there would be a higher degree of maintenance being carried out as well as records of activities being stored. Unfortunately this was not always the case. At the time of writing this report, of the 106 StormFilters installed only 50 of the units has been serviced. There appears to be a few institutional issues around the transfer and ownership of stormwater BMP's that has lead to maintenance not being undertaken. It is not the scope of this paper to comment on this.

4 RESULTS

For this paper the analysis will be limited to the analysis and comparison of the key inputs TAC and RAC. These are the key inputs in the use of the StormFilter. A discount rate of 2.8% was applied to inflate or deflate costs to a 2007 base year. COSTnz uses a 2007 base year for analysis so this will allow easy comparison with outputs from the model.

Table 1 below lists the upper and low quartiles for the TAC and RMC for implementing the Stormwater360 StormFilter as a stormwater BMP.

As expected total TAC costs varied greatly (see Figure 3). A lower estimate value (lower quartile) of \$53,000 \$/Ha/yr to a high estimate (upper quartile) of \$158,000 \$/ha/yr.

	<i>Low Estimate</i>	<i>High Estimate</i>
Stormfilter		
TAC (\$/Ha)	53,000	\$158,000
RMC (\$/Ha/Yr)	\$760	\$1420
CMC (Annualized \$/Ha/Yr)	NA*	NA*

*no corrective maintenance was required over the 7 year period.

Table 1:–Stormwater Management StormFilter Lifecycle costing Parameters

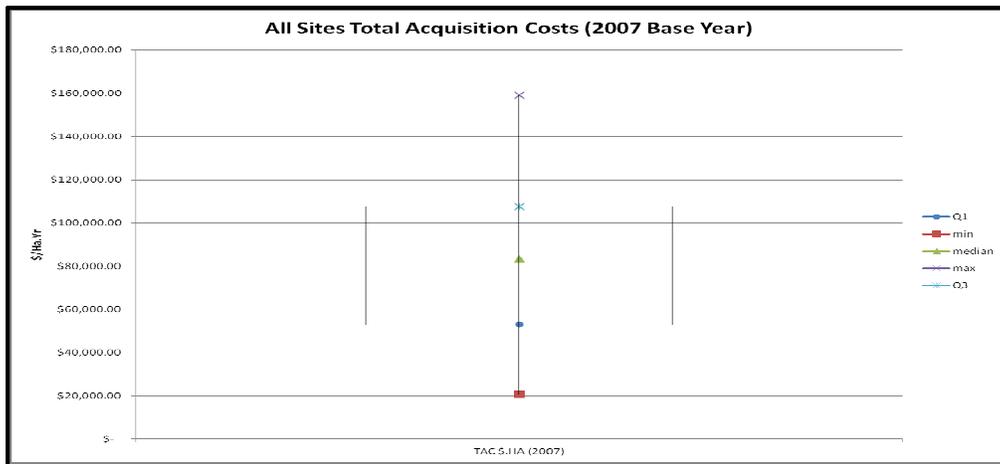


Figure 3:–Box and Whisker Plot of Total Acquisition Costs over all sites

The StormFilter is often used for small impervious catchment areas that cannot be treated with other forms of traditional treatment. The values at the high end were the type of sites where the catchment area for the devices was small.

Figure 4 shows how the TAC equation costs decreases as catchment area increases. Other factors that influence the TAC are as follows:

- Targeted contaminants / Media choice
- Contaminant load and pretreatment costs
- Design methodology
- Retrofit or new development

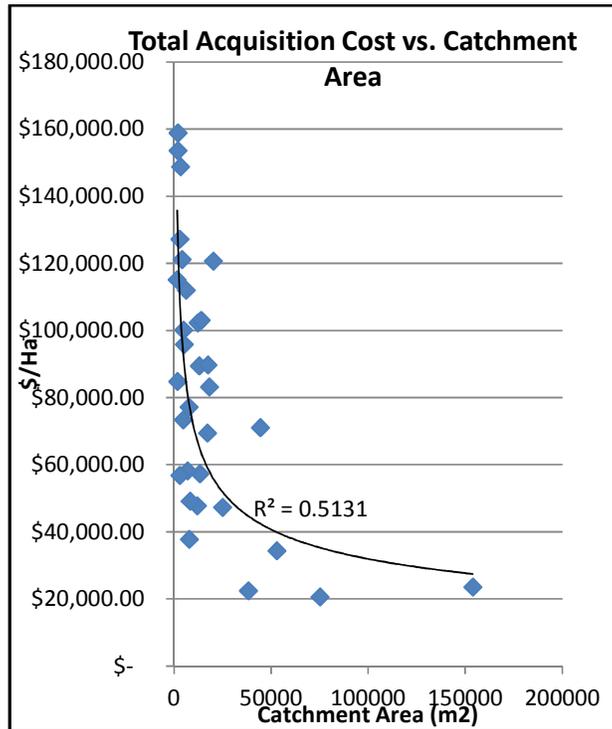


Figure 4:–Total Acquisition Costs vs. Catchment Area

As expected RMC also varied greatly over the studied devices. A lower estimate of \$760 \$/ha/yr to a high estimate of \$1420\$ /ha/yr. should be adopted for a life cycle costing approach. As previously discussed BMP often face elevated routine maintenance costs in the first few years of the life as construction activity and its high contaminant loading. This has been encountered at most sites therefore these values are considered conservative. To place these values in context 1 hectare of residential land can support upto 20 houses or 1 hectare of road is approximately 1km of a 2 lane road. The RMC to each household would be between \$40 and \$70 for the stormwater treatment.

Figure 5 shows that differing land uses had a similar range of cost. Of surprise was the result for high use sites. Devices installed in these sites have been designed for the anticipated high loads. Devices on these sites had higher TAC's however this has resulted in lower RMC through less frequent maintenance activity.

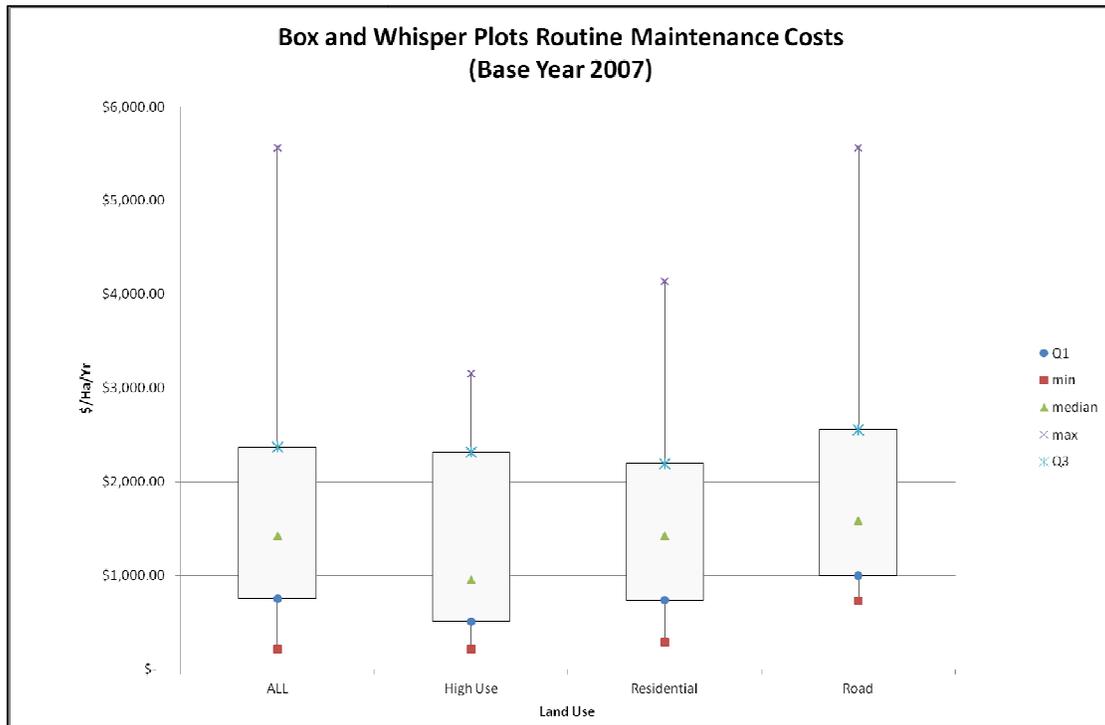


Figure 5:–Box and Whisker Plot of RMC vs. Land use

Figure 6 shows how routine maintenance cost reduces as catchment area increases. The sites with the lowest RMC were clean sites with little activity or integrated pretreatment. The site with the lowest RMC was Albany Busway station. Albany Busway has been in operation for 6 years with only one clean. The catchment is 15.4 hectares of carparks, designed into the drainage lay out is a number of LID pretreatment devices e.g. undersize swales for conveyance. The first clean after the construction phase removed 20 tonnes of contaminants since then the system has not been cleaned. The large catchment area and low level of required cleaning has resulted in low maintenance costs for this device

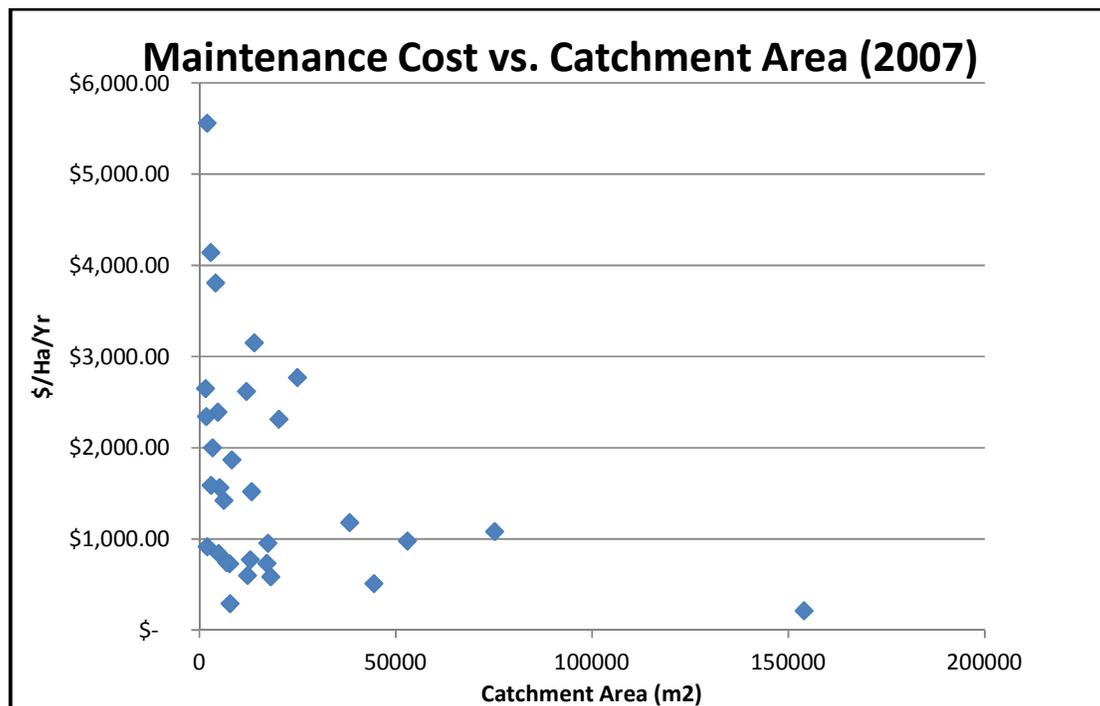


Figure 6:–RMC vs. Catchment Area.

Figure 7 below shows the phases in the life cycle for two example devices with different land uses and design with similar sized catchments. Both systems treat approximately 5 hectares and were installed in 2005. The Lincoln Park StormFilter is an open top StormFilter treating a residential catchment in Massey Auckland. The system was installed as an alternative to converting a natural stream into a treatment wetland. Tauhinu Headland StormFilter is a StormFilter that treats a section of motorway (SH20) just before the Greenhithe Bridge. , Tauhinu had high acquisition cost as the system was designed for the high load of contaminates likely to be encountered on the motorway. The system also used a filter media that targets dissolved metals in addition to suspended sediment.

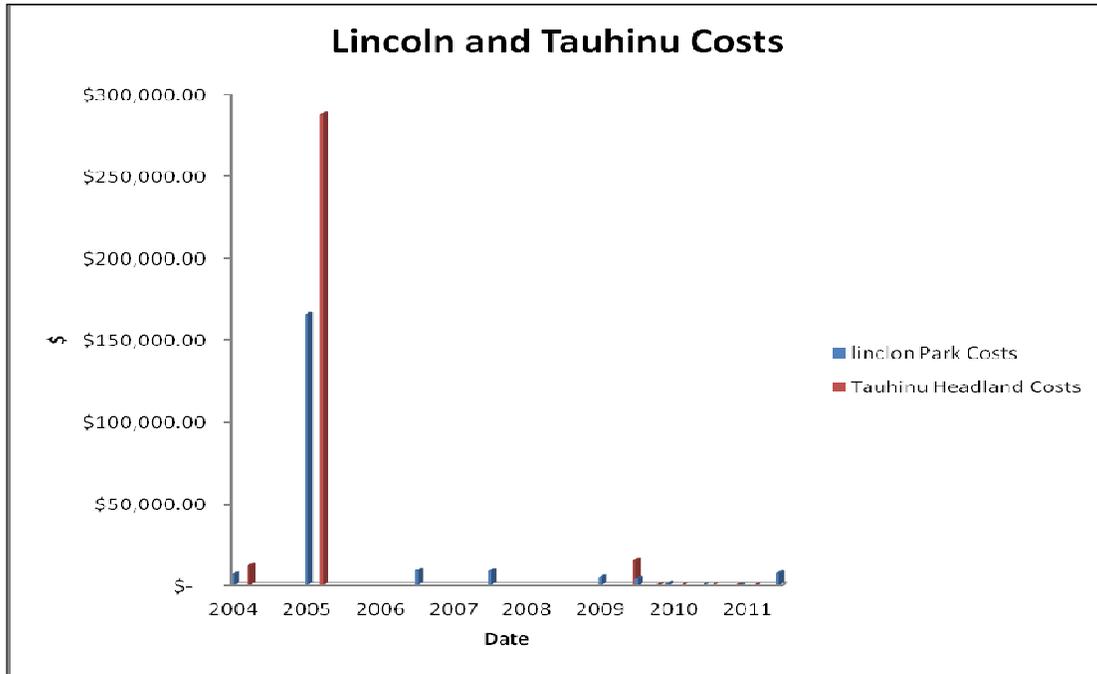


Figure 7:--Lincoln and Tauhinu Cost Time line

The Tauhinu Headland StormFilter was taken over by Auckland Motorway's after all construction had finished. The system had its first clean in 2009 at a cost of \$3900 a hectare, since then the system has been inspected every quarter and has not required cleaning.

The Lincoln Park system was taken over by council before construction of the house lots had been completed. A lack of private site sediment control resulted in the device being maintained 3 times over the first 4 years of its life. Each clean removed between 11 and 15 tonnes of material at a cost of approximately \$2000 a hectare. Since 2009 the site has been inspected every 6 months with maintenance frequencies extending and maintenance cost lowering.

Figure 8 shows the elevated but decreased routine maintenance costs as a result of small site sediment runoff. Councils should look at how they manage on site sediment control and acceptance of stormwater treatment devices vested in council

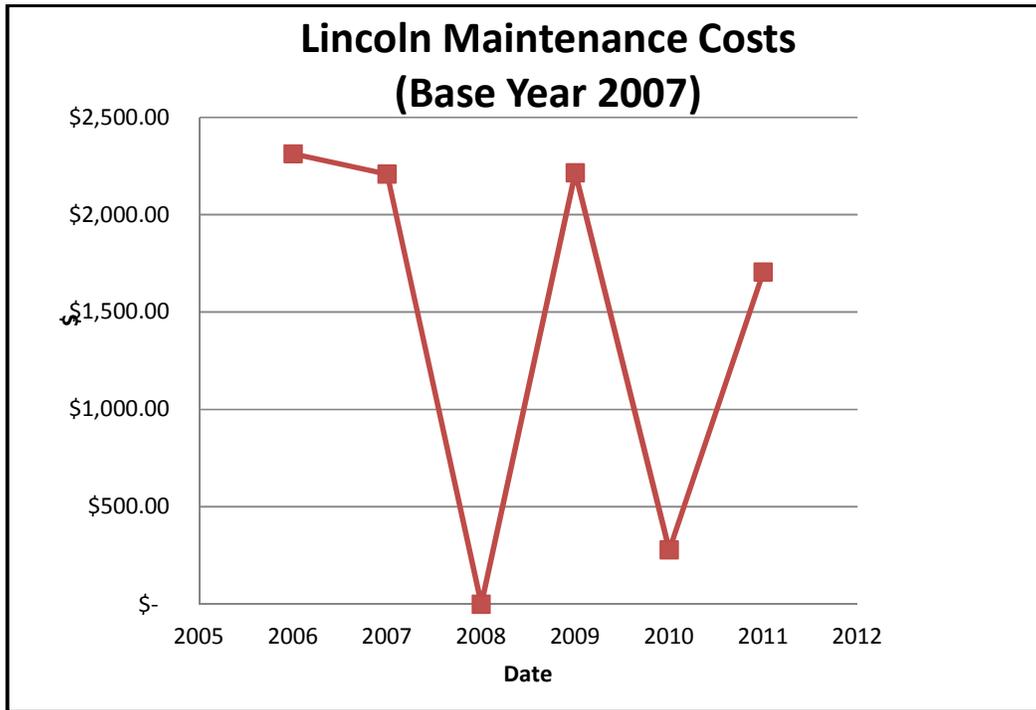


Figure 8:–Lincoln RMC Time Line

5 LIFE CYCLE COSTING COMPARISONS

Many agencies have installed structural measures to improve urban stormwater quality, but have not established management systems that clearly record all of the important life cycle costing details. In researching this report it was found that not all agencies were recording required information to evaluate the life cycle costs of their BMP's. Further to this some government agencies have struggled with the reality of stormwater management and budgets have not been set or income set aside to maintain stormwater BMP's - hence minimal maintenance has been carried out. All of this has led to a lack of little long term real data that is available to compare different BMP's.

In order to draw some comparisons a number of theoretical designs were carried out based on a 3 hectare 70% impervious catchment. The figure (Figure 9) below shows the relative sizes of different BMP's. It was intended to use the COSTnz website to compute the life cycle costs for these designs. Unfortunately at the time of writing the COSTnz website and model was encountering technical difficulties. Therefore the report "Lifecycle Costing – Addison Developments Northern Block" is being used. The Addison report uses a life cycle costing model COSTnz (with a base year of 2006). The results from this were scaled to provide some comparison using the generic sizing developed in the theoretical designs. Table 2 shows an estimate of the main input values in \$/Ha/yr for comparison with this studies results.

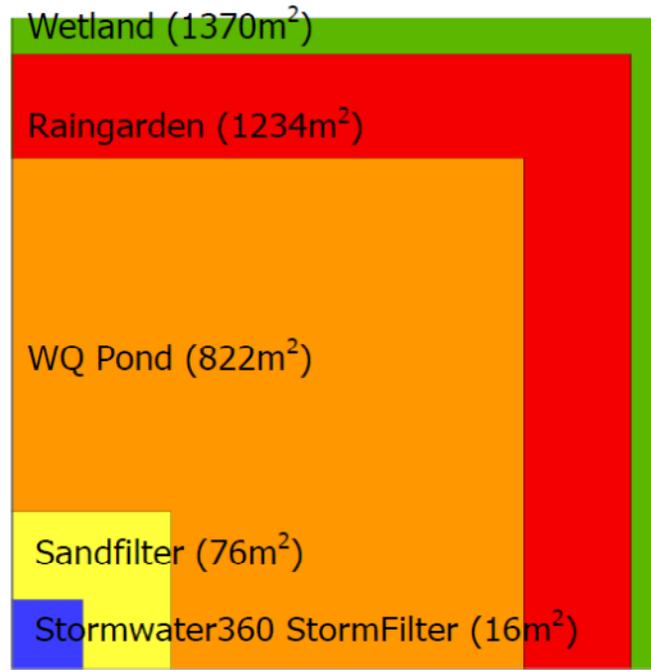


Figure 9: –Relative footprint sizes of Stormwater BMP's

	<i>Low Estimate</i>	<i>High Estimate</i>
Rain Gardens		
TAC (\$/Ha)		\$215,000*
RMC (\$/Ha/Yr)	\$4,100	\$12,000
CMC (Annualized \$/Ha/Yr)	\$5,280	\$8,700
Swales		
TAC (\$/Ha)	\$32,900	\$850,000
RMC (\$/Ha/Yr)	\$5,800	\$37,818
CMC (Annualized \$/Ha/Yr)	\$560	\$1000
Ponds		
TAC (\$/Ha)	\$44,500	\$78,000
RMC(\$/Ha/Yr)	\$1,700	\$3,800
CMC (Annualized \$/Ha/Yr)	\$500	\$850

Table 2: Estimated Life Cycle Costing of the Addison Development Northern Block: –Relative sizes of Stormwater BMP's

*Only one cost estimate was provided in the Addison report.

One item noted in the review of the Addison report is that sediment removal and disposal is considered a corrective maintenance activity and only allows for every 7 to 25 years. With the StormFilter analysis removal and disposal of sediment is a routine activity. The costs associated with routine maintenance of rain gardens, ponds and swales are items such as litter removal, inspections, weed control and vegetation maintenance. These costs are more associated with the ascetic benefit of the LID approach than necessarily the water quality benefit.

Comparing the cost presented in Table 2 with the results of the analysis on the StormFilter(Table 1) TMC (\$43K to \$183K \$/Ha) RMC & CMC (\$760 to \$1420) the results seem comparable.

Two different methods have been used to calculate these results; a unit costing approach for the Addison Development and a statistical review of real cost for the StormFilter. It is possible that all costs have not been realised in the real life review. Further it is very possible that the maintenance being under taken by government agencies is not adequate and more servicing and inspections of the devices may be warranted. To evaluate this the unit costing comparison of a review of evidence presented by Fraser Thomas Engineers (FT) for an environmental court hearing over the proposed Lincoln Road Wetland is discussed. Stormwater360 provided budget theoretical costings and maintenance timings to FT. Below is an extract from the evidence.

'Stormwater 360 have provided budget cost estimates for supply and installation of suitable StormFilter cartridge units to replace wetland D of \$416,000-540,000 respectively, together with corresponding O&M costs of around \$18,000 per year, based on a 12 month maintenance schedule. In contrast, corresponding wetland D construction costs extracted from NZTA costing are \$369,500, Estimated wetland life cycle O&M costs from Landcare are equivalent to \$15,660/yr for the west and east wetlands. The capex costs for the wetlands are therefore slightly less than equivalent StormFilter costs, while O&M costs could be of similar order to the StormFilter O&M costs'.

The TAC assumed in both studies Addison and Lincoln Road Wetland did not consider the land cost associated with the assets. If the land has been designated and set aside for stormwater management this assumption is acceptable. However if the land is required to be purchased the land costs need to be considered in any life cycle costing.

The results of this unit costing approach again show the costs associated with the StormFilter as comparable to other forms of stormwater treatment, and whilst life cycle costing is an important tool in understanding the costs associated with infrastructure development, it is only one parameter in the evaluation process. (Taylor, 2003/5),.

6 CONCLUSIONS

This paper has conducted a life cycle costs analysis of the Stormwater Management StormFilter over 50 locations in the Auckland region over the last 7 years. The paper has suggested input parameters for determining the life cycle costs associated with the use of the StormFilter to remove contaminants from stormwater. In doing so the paper has discussed the influence on the parameters by design, land use and scale.

There were difficulties in obtaining detailed and accurate records of costs for alternative government owned BMP's. Comparisons of the StormFilter total acquisition and corrective maintenance costs with the COSTnz database suggest that the StormFilter is comparable.

Many factors influence the costs of supplying and operating stormwater BMP's, resulting in a large difference between the high and low estimates provided in this study. Some of these factors of influence are as follows

- Catchment area had a great effect on both the total acquisition and maintenance costs of the StormFilter. Larger devices are generally cheaper on a per hectare basis to acquire and operate.
- Land use had an effect on maintenance costs i.e some land uses produce more contaminants. However the study has shown if systems are design to account for the effect of land use, maintenance costs can be controlled.
- Pretreatment and integrated design has an effect in lowering the maintenance costs.
- Elevated maintenance costs are encountered in the first few years of operation of the StormFilter. This is often a result of construction activity. Maintenance cost lower over the first 5 years of operation

- Land cost is not considered in this study but can have a very large affect on the lifecycle costs of implementing a BMP

It is still to be noted life cycle costing is an important tool in understanding the costs associated with infrastructure development, but it is only one parameter in the evaluation process (Taylor, 2003/5), and needs to be considered in the context of social, cultural and environmental goals.

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