THE ECONOMICS OF LOW IMPACT STORMWATER MANAGEMENT IN PRACTICE – GLENCOURT PLACE

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ABSTRACT

North Shore City Council aims to control the impact of stormwater by limiting the ways in which it can be disposed. The focus is on the use of low impact on-site solutions to minimise the amount of run-off and pollution from a site. At Glencourt Place, rainwater tanks are retrofitted to existing properties, gravel trenches are built, and minimal piping is installed instead of reticulating the area with stormwater pipes and increasing the capacity of reticulation downstream. This review of the pilot project compares the performance of the low impact approach with the conventional one based on the criterion of cost minimisation. The analysis reveals higher life cycle costs for the low impact approach; however, with the inclusion of the water saving benefits, the net present value of the two approaches becomes similar. The low impact approach generated increased technical understanding, new policies, organisational systems, revised standards, and increased experience. These changes are expected to reduce the life cycle costs of similar low impact systems in the future. The associated costs can be considered as investments in innovation.

KEYWORDS

stormwater management, eco-innovation, low impact, life cycle cost, raintank, Glencourt Place

1 INTRODUCTION

The detrimental quantity and quality impact of urbanisation on the water environment takes the form of water quality deterioration, stream habitat degradation and increase in flooding (Goonetilleke, 2005). Low impact stormwater management explores changes in urban design and infrastructure that offset these negative impacts by working with nature. Emphasis is placed on avoiding or minimising impervious surfaces to facilitate infiltration and on using vegetation to assist in evapo-transpiration and pollutant and sediment trapping. This translates in maximised stormwater infiltration at source, contaminant containment, and catchment revegetation (Eason et al., 2003).

Low impact stormwater management is a mix of eco-innovations. Eco-innovations are measures that contribute to the reduction of environmental burdens and can be technological, organisational, social or institutional, the different kinds co-evolving with each other (Rennings, 2000). Eco-innovations for stormwater management may take the form of technological measures such as the development of improved filter media for filtration devices; organisational changes that manifest in management instruments such as eco-audits; social innovations expressed in changes of consumer behaviour towards sustainable consumption patterns; or innovative institutional responses to problems of sustainability such as nitrogen emission-trading. Freeman (1992) emphasises the links between the different forms of innovation when arguing that successful action depends on a combination of advances in scientific understanding, appropriate political programs, social reforms and other institutional changes, as well as on the scale and direction of new investments.

The North Shore City Council (NSCC), one of New Zealand's largest cities, incorporated the LIUDD approach in its 2004 Stormwater Strategy, to control the impact of stormwater by limiting the methods of its disposal. As the strategy explains, the focus is on the use of sustainable on-site solutions to minimise the amount of site runoff and pollution. One of the low impact approach pilot projects undertaken by the NSCC involved retrofitting raintanks, gravel trenches and piping at Glencourt Place (Windy Ridge, North Shore City) instead of reticulating the area with a conventional piping system. Findings from this pilot project have been documented by Kettle and Divagam (2002) and Tian et al. (2003). This paper compares the life cycle costs of the low impact approach with that of the conventional approach. Cost entries from the low impact approach are then used to highlight a series of changes in the institutional framework and level of experience that have resulted from this pilot project. A combination of such changes is expected to impact on the future up-take of a low impact approach to stormwater management in the urban environment.

2 BACKGROUND INFORMATION

Glencourt Place is located at the top of a small sub-catchment that drains into the left bank of the Kaipatiki Creek. Here an area of approximately 2.6 ha, roughly bounded by Glencourt Place, Seaview Rd and Stanley Rd, lacked any official stormwater reticulation system, while the existing soakpits were old and often filled with sediment. Earlier developments in this region discharged stormwater mainly to the soakage, and as long as the lower land remained undeveloped the subsequent overland flow and localised flooding on the lower land caused few problems. The later development of Glencourt Place, however, failed to take into account the established drainage condition of the land; as a result stormwater runoff from higher land resulted in serious overland flow problems and flooding during heavy rainfalls (e.g., five properties between 27 and 43 Glencourt Place reported some form of flooding in a 1994 survey (G. W. Tremain, Report to the Glenfield Community Board, 10 September 2001)).

The two approaches considered for managing the stormwater problem at Glencourt Place were:

i.) the conventional approach: reticulating the area with stormwater pipes and/or flowpaths

ii.) or the low impact approach: using an engineered system of ditches, gravel trenches, contoured flowpaths and minimal piping, backed up with rainwater tanks retrofitted to the existing properties.

Raintanks are primarily water-quantity-management devices with minor water quality benefits, which depend on the amount of atmospheric deposition in a given area (Auckland Regional Council, 2003). The water quantity benefits, i.e. peak flow attenuation, are dependent on the spatial distribution of the raintanks in a catchment, detention capacity at the beginning of the storm event, and the timing and intensity of storm flows through the catchment (Hardy et al., 2004). With respect to the water quality benefits, the use of roof runoff for domestic non-potable use will reduce contaminant discharge into receiving waters because some of the runoff will enter wastewater treatment systems or be discharged on to permeable surfaces such as lawns and gardens (Auckland Regional Council, 2003). Coombes et al. (2004) identified a 53% reduction in mains water use as a result of raintank installation at an inner city small house in Newcastle, New South Wales.

3 METHODOLOGY

We compare the life cycle costs of the conventional and low impact approaches and compare our results with the outcomes of previous economic analyses associated with the Glencourt Place project. We use the cost entries identified during our life cycle costing exercise to reveal those aspects that impose higher costs on the low impact approach and consequently inhibit its uptake. In parallel, we highlight changes that resulted from the pilot project that will have implications for the future uptake of the low impact approach.

3.1 LIFE CYCLE COSTING

The Australian and New Zealand Standard (AS/NZS 4536:1999) defines life cycle costing as the process of assessing the cost of a product over its life cycle or portion thereof. Life cycle cost is defined as the sum of acquisition and ownership costs of an asset over its life cycle from design stage through manufacturing, use, maintenance and disposal. To take account of people's time preference, these costs are discountede. The choice of discount rate influences the conversion of future costs to an equivalent present value (Australian National Audit Office, 2001). Identical time horizons must be adopted for assets with differing life expectancies, so that comparisons between alternatives are fair.

We use real costs for our analysis, and the base year is set at 2005 as the construction contracts refer to this year. Using real costs allows current known cost information to be used; a value in real cost is the dollar amount paid if the reason for the cost occurred at the base date and had to be paid for at the base date.

The acquisition cost of the conventional option is calculated for the pipe layout used in 2001 by Tremain (stormwater engineer with NSCC) for the initial engineering costing and new cost data from recent contracts. For the low impact option we estimate the acquisition cost based on cost data from the construction contracts and NSCC's accounting database. Many of the identified acquisition cost elements occurred before 2005, and these have been scaled up by a 2% inflation factor and added to the costs occurring in the base year. The number of raintanks to be installed is 20. The modelling results suggested this number as the minimum to achieve a peak flow that would remain less than the capacity of a pipe one size greater then the existing pipe and therefore not requiring the up-grade of the downstream pipe (Maunsell, 2004; Discharge Summary for the Glencourt Place Stormwater Project). In addition to the raintanks, the low impact option incorporates 120 m of gravel trenches, 50 m of channel, and 235 linear metres of pipes.

With the low impact option, renewal costs are incurred when the pumps and raintanks are replaced every 10 and 25 years respectively; the replacement of the pump is estimated at NZ$600, while the replacement of the raintank is estimated at NZ$2350 (pers. comm. (anon.) 2005).

The yearly operation and maintenance costs associated with pipes are estimated at NZ$ 1/linear m pipe. The operation of the pump is expected to cost the landowner NZ$10/year in additional power bills. The maintenance of the pump and raintank are estimated to cost NZ$20 and $80/year (pers. comm. (anon.) 2005), with no maintenance occurring in those years when the devices are replaced. The maintenance of the raintanks will be the responsibility of NSCC for the first 3 years, after which it will become the responsibility of the landowners. Maintenance associated with the gravel trenches and channel is considered insignificant (pers. comm. (anon.) 2005). From the council's perspective, it is estimated that the inspection of the raintanks and the raintank registry will cost NZ$10/raintank/year.

Decommissioning costs for both the conventional and low impact approaches are excluded from the analysis because they are considered to be part of the replacement contracts. Costs associated with the land up-take of the two options are also excluded from the analysis. The risk costs remain unquantified; we assume that with the proper maintenance of both systems, the remaining risk is insignificant for the design conditions. For the low impact approach, local power failure has been found to happen once or twice a year, and for only 1 to 2 hours; potential water shortage is countered against by allowing top-up from mains for dry periods; the air-gap in the raintank prevents the contamination of mains water supply; while the first flush device, wire screen and leaf guard enhance water quality and ensure continuous operation.

For the present value calculations, we set the time horizon to the longer life and allowed for the replacement costs of the shorter life asset during the study period and for any residual value at the end. If the conventional pipe infrastructure is to be built at Glencourt Place, life expectancy is estimated between 50 and 100 years, this interval determining the time frame of our analysis. To capture the sensitivity of the calculations to the time frame considered and the discount rate applied, we use 50- and 100-year time frames, and 10% and 3.5% real discount rates. The New Zealand Treasury uses a 10% real rate when there is no other agreed sector discount rate, and calculated the social rate of time preference as 3.5% (Young, 2002).

In including the value of the water savings in our analysis, we depart from the guideline of the Australian/New Zealand Standard for life cycle costing that specifically excludes consideration of revenues. Water savings are a consequence of using rainwater for toilet flushing, laundry and gardening, and are estimated annually at between NZ$100 and $150 per household with raintank. The outcome of this calculation is compared with the life cycle cost of the conventional approach that does not generate water saving benefits.

4 RESULTS

4.1 LIFE CYCLE COSTING

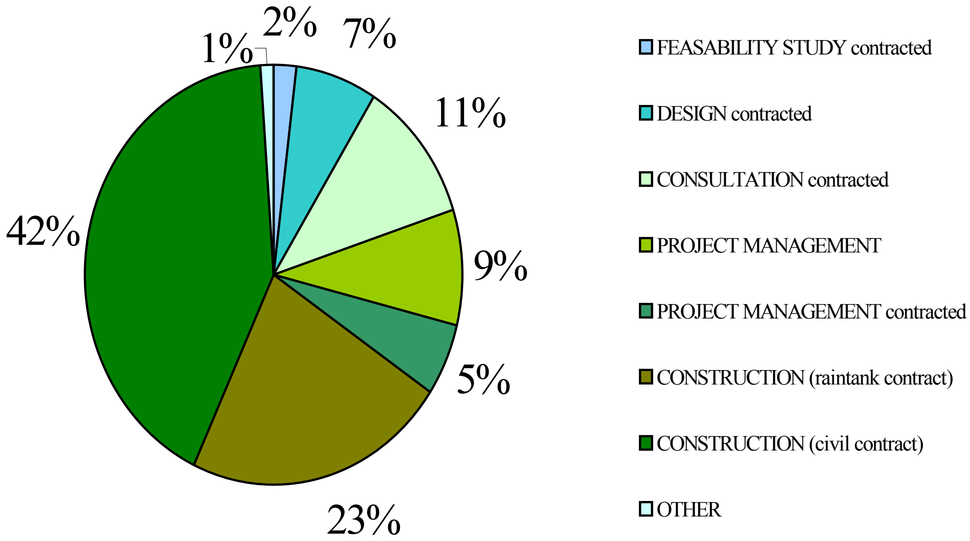
The acquisition cost of the conventional option, based on Tremain's layout and new cost data, is NZ$607,000 (see Table 1).

Table 1: Acquisition cost of the conventional stormwater system for Glencourt Place

Glencourt Place/Conventional Approach/Acquisition Cost				
Description	Quantity (based on Tremain's (2001) layout)	Units	Rate (NZ$/Unit) (updated based on information from NSCC and Maunsell Ltd.)	Cost (NZ$)
1. Provide stormwater pipe reticulation for affected part of glencourt Place, Seaview and Stanley Rds, including 50% subsidy for private connection costs.				462,564
a. 150 diameter pipe	*20*	*lin m*	*140*	*2800*
b. 200 diameter pipe	*390*	*lin m*	*250*	*97,500*
c. 300 diameter pipe	*60*	*lin m*	*436*	*26,160*
d. 375 diameter pipe	*36*	*lin m*	*502*	*18,072*
e. manholes (1050)	*15*	*each*	*3,890*	*58,350*
f. catchpits	*6*	*each*	*973*	*5,838*
g. connection	*32*	*each*	*3,000*	*96,000*
h. contingencies	*20*	*%*		*60944*
i. reinstatement	*10*	*%*		*36566*
j. engineering	*15*	*%*		*60334*
2. Upgrade downstream trunk stormwater mains				144,500 (139–150,000)
TOTAL				607,000

The acquisition cost of the low impact approach amounts to NZ$601,000, with the breakdown of this cost illustrated in Figure 1. Design costs represented 7% of the total acquisition cost, consultation 11%, and project management 14%. With increasing experience in these fields cost savings are expected for similar future projects.

Figure 1: Low impact option – acquisition cost break-down differentiating between the works contracted out by NSCC and the ones undertaken inside the organisation as well as the two different construction contracts involved



The life cycle costing exercise reveals life cycle costs for the conventional approach of between NZ$612,000 and $621,000, and for the low impact approach of between NZ$639,000 and $732,000 dependent on the timeframe and discount rate considered (see Table 2). The inclusion of NZ$125 annual water saving benefit per raintank reduces the present value of the life cycle cost to between NZ$612,000 and $661,000.

The extension of the timeframe from 50 to 100 years makes no difference to the life cycle cost of the conventional approach. For the low impact approach, extending the timeframe from 25 to 50 years increases the life cycle cost by 7%, while a further extension to 100 years results in a further 4% increase if the discount rate is 3.5%. The manipulation of the timeframe does not result in significant difference (around 1%) for the life cycle cost if the discount rate is 10%. The variation of the discount rate has the biggest impact (14% difference) for the low impact approach with the 100-year timeframe.

If one accepts the validity of the assumptions and estimations that have been used for the life cycle costing exercise, the comparison of the low impact and conventional approaches indicates that the low impact approach has a 4–18% higher life cycle cost than the conventional approach; this difference reduces to 0–6% once the water savings associated with the low impact approach are included in the analysis (see Table 2).

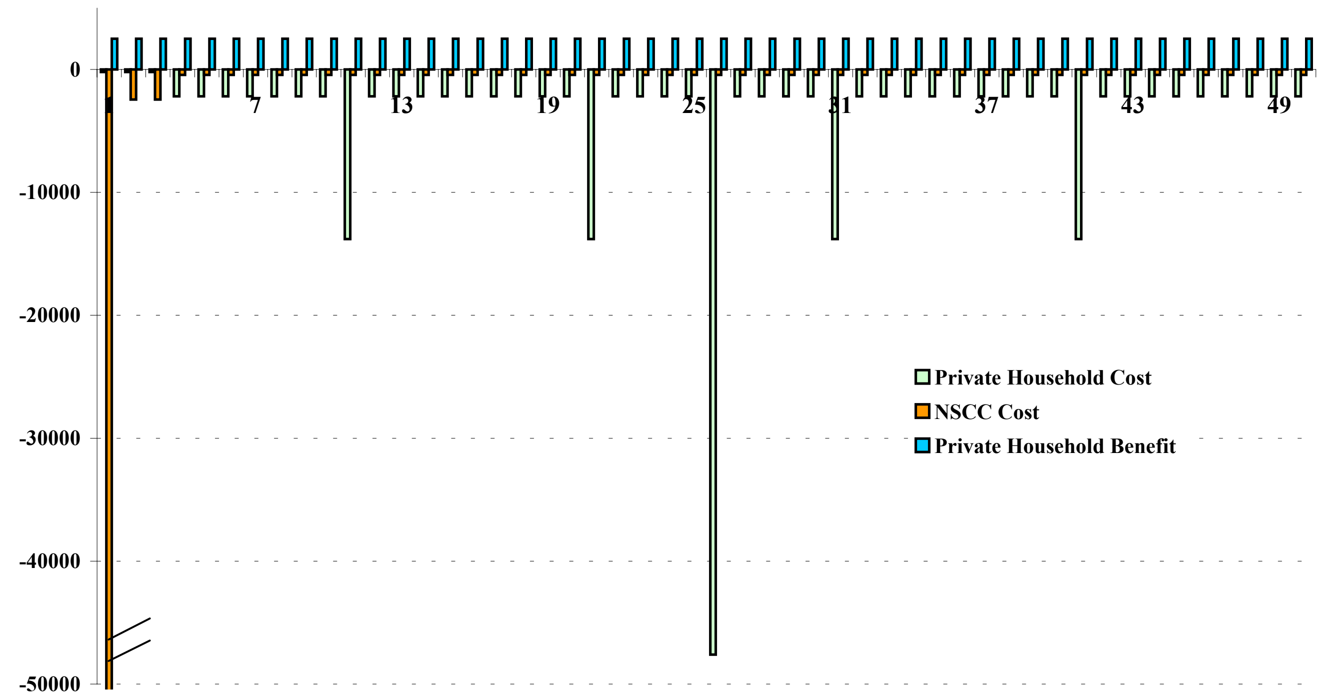
Table 2: Life cycle cost calculations for the conventional and low Impact approaches considering different time frames and applying different real discount rates (the figures have been rounded to the nearest thousand).

Time Frame	25 years		50 years		100 years	
Discount Rate	3.5%	10%	3.5%	10%	3.5%	10%

Conventional (C)			619,000	612,000	621,000	612,000
Low Impact (LI)	655,000	631,000	703,000	639,000	732,000	640,000
Low Impact with water savings (LI_{WS})	613,000	606,000	643,000	612,000	661,000	612,000
Difference (LI-C)			84,000 (+14%)	27,000 (+4%)	111,000 (+18%)	28,000 (+5%)
Difference (LI_{WS}-C)			24,000 (+4%)	0 (+0%)	40,000 (+6%)	0 (+0%)

The temporal occurrence of the real costs and water saving benefits for the 50-year timeframe is illustrated in Figure 2, together with the cost sharing between NSCC and private households (see also Appendix A).

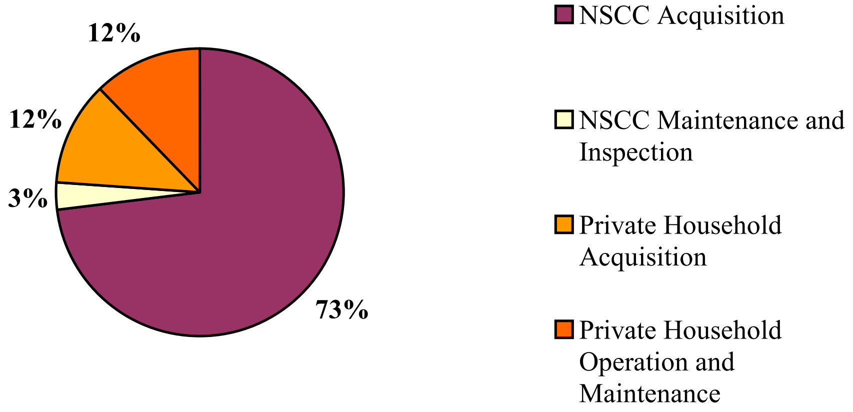
Figure 2: Temporal occurrence of the real costs and water saving benefits for the low impact approach given a 50-year time frame



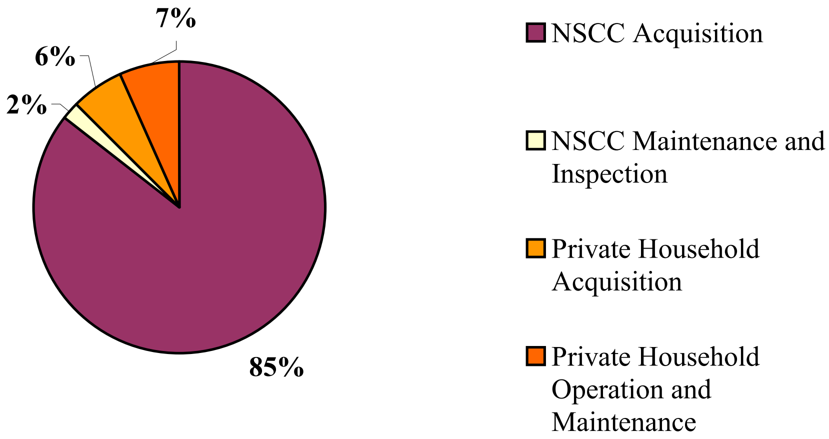
Cost sharing is further explored in Figure 3, based on real and discounted costs. When considering a 50-year timeframe, the total cost estimate for the Glencourt Place project is NZ$823,000 in real cost terms; with 3.5% and 10% discount rates, this estimate changes to NZ$703,000 and $639,000. The proportion of the total cost covered by private households drops from 24% to 13% and 5% as a result of discounting at the two discount rates.

Figure 3: Cost-sharing between NSCC and private households for a 50-year timeframe based on real costs and discounted costs with 3.5% and 10% real discount rates respectively

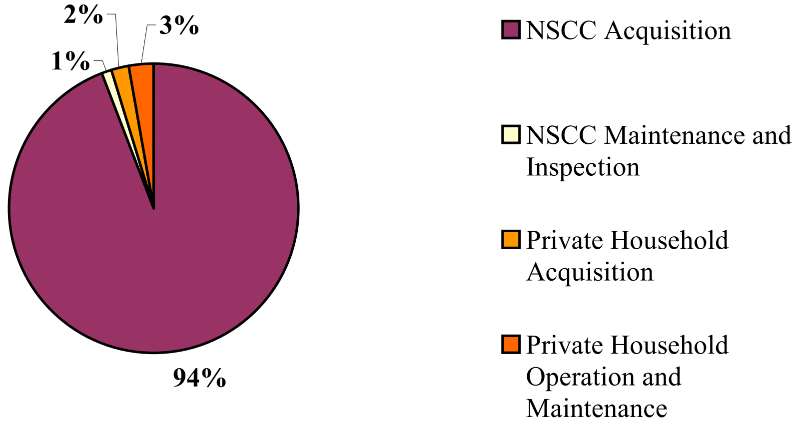
a) life cycle cost (base year 2005, real cost) NZD 823,000



b) life cycle cost (base year 2005, 3.5% real discount rate), NZD 703,000



c) life cycle cost (base year 2005, 10% real discount rate), NZD 639,000



4.2 COST MINIMISATION AS A SELECTION CRITERION

Cost minimisation has been one of the selection criteria that received much attention. The review of the different economic analyses carried out in connection with the Glencourt Place pilot project revealed a series of different approaches, with the scope of analyses varying greatly. The first attempt by G.W. Tremain (Stormwater Engineer, September 2001) to compare the conventional and low impact approaches had an engineering focus and indicated approximately 50% cost saving in favour of the low impact approach. The number of stormwater connections and raintanks considered was 32 at this stage, while the cost of upgrading the downstream trunk stormwater mains, which would not be necessary with the low impact approach, was estimated at NZ$250,000.

At a latter stage the costing has been modified (Meritec Limited, August 2002) to incorporate the technical finding that 40 rain tanks need to be installed in the catchment to solve the flooding problem in combination with a pipeline that would service 11 properties. For these properties, the ratio of paved ground to roof area was greater than the threshold a 9,000-litre raintank can cope. The number of connections for the conventional approach has been also set at 40. Field survey and hydraulic/hydrological modelling results showed that the pipe from Glencourt to Beaudine Ave is slightly undersized and will not need to be enlarged if the low impact approach is chosen. The remaining pipes to the Kaipatiki stream have been found to be significantly undersized, and require upgrading. These findings impacted on the costing of the two approaches, the savings between the two options being diminished from the previous NZ$288,000 to $85,000.

Realising that operation and maintenance costs for the two approaches are different, net present value calculations have been carried out by Maunsell Limited (previously Meritec Limited) and NSCC. Based on rough estimates, Maunsell found the raintank option to have a NPV of NZ$506,100 – NZ$68,500 less than the full reticulation option. NSCC, considering a 25-year time frame and 6% real discount rate, also found the low impact approach to have the lower life cycle cost. The savings associated with the low impact approach have been estimated at NZ$104,000 if the consultation costs were included in the analysis; excluding this cost category increased the savings to NZ$119,000.

Our comparison of the conventional and low impact options using a life cycle costing approach and recent costing data gave the following results:

- The acquisition cost of the conventional approach without the downstream upgrade, estimated by using the pipe layout from the 2001 analysis and revised 2005 cost data for the pipes, manholes and catchpits, was NZ$463,000, NZ$183,000 more than the 2001 estimate. This increase is due to higher pipe costs.

- With the addition of the cost of upgrading the downstream pipe to the capacity of increased flow – upgrade that is avoided by installing raintanks – the acquisition cost of the conventional option becomes NZ$607,000. The acquisition cost of the low impact option with 20 raintanks was estimated at NZ$601,000; this 2005 estimate is 24% higher than the 2002 estimate and is slightly less (1%) than the 2005 estimate of the acquisition cost for the conventional approach.

- The net present value of the two options when the water savings are taken into account are higher than previous estimates and very close to each other (the maximum difference is 6% for the different timeframe and discount rate scenarios).

Table 3: Comparison of outcomes from the different economic analyses carried out in connection with the Glencourt Place project

Conventional (NZ$)		Low Impact (NZ$)	
Acquisition Only			
G.W. Tremain, NSCC Stormwater Engineer, September 2001			
578,000			290,000
		SAVINGS	288,000
Meritec Limited, August 2002			
569,000			484,000
		SAVINGS	85,000
This paper			
607,000			601,000
		SAVINGS	6,000
Life Cycle Costs (water savings included)			
NSCC			
575,000			456,000
		SAVINGS	119,000
NSCC (consultation included)			
575,000			471,000
		SAVINGS	104,000
Meritec Limited, 2003			
575,000			506,000
		SAVINGS	69,000
This paper/minimum difference			
612,000			612,000
NO SAVINGS		NO SAVINGS	
This paper/maximum difference			
621,000			661,000
SAVINGS	40,000		

4.3 OTHER SELECTION CRITERIA

For future low impact projects certain costs are expected to drop due to the lessons learnt from this pilot project and the increase in experience with low impact stormwater management. A summary of the elements that favoured or disadvantaged the selection of the low impact approach at Glencourt Place is provided in Table 4, along with the changes that have been triggered by the pilot project.

Table 4: Summary of elements that acted in the favour (IF) or disadvantaged (DA) adopting a low impact approach to stormwater management at Glencourt Place; the change column lists the impacts of the pilot project, the arrows indicating implications for future selection processes

	IMPACT	CHANGE
Staff interest/Commitment	IF	
Lack of conventional infrastructure in place	IF	
Commitment at strategic level (Stormwater Strategy 2004)	IF	
Funding opportunities (Infrastructure Auckland)	IF	
Expertise and experience with the conventional approach (design, costing, on-going management)	DA	
Lack of expertise and experience with the low impact approach	DA/(IF)	← Experience building up with the low impact approach (design, costing, consultation)
The perception by some residents that the low impact approach is second best to the conventional one	DA	
Technical uncertainties (optimum number, size, spatial distribution of raintanks)	DA/(IF)	← Technical flexibility exposed
Standard restriction (AS/NZS 3500.5, Clause 2.16.2) on water supply for washing	DA/(IF)	← Standard restrictions removed
Lack of legal arrangements (transfer of a publicly funded device to private ownership)	DA/(IF)	← Legal arrangements sorted
High perceived risk associated with assuring continuous operation and maintenance	DA/(IF)	← New policy document: "Stormwater Policy: Responsibilities for Stormwater Infrastructure"

Interest among NSCC staff in trialing low impact approaches to stormwater management and the lack of conventional stormwater infrastructure at Glencourt Place favoured the selection of the low impact approach. If a conventional system had been in place, it would take decades for this to depreciate and allow the consideration of a different system. Commitment at a strategic level to managing stormwater in a more environmentally sensitive way also favours the low impact approach, which is considered superior to the conventional approach from an environmental perspective.

The opportunity to apply for Infrastructure Auckland (IA) funding for the low impact approach resulted in IA funding of NZ$101,000 (less NZ$7,500 for application fees).

The relative novelty of the low impact approach translates into lack of experience with designing, costing, building and maintaining low impact devices. The designation of the Glencourt Place project as a pilot study reflected this situation: pilot projects having learning as a main objective. While expertise and experience are increasing in the low impact approach, the conventional approach has the advantage of earlier experience.

Getting buy-in from the households disadvantaged the low impact approach, as the consultation process was costly and time consuming. As some residents perceived the low impact approach as a second-rate solution, a certain level of trust had to be built up with the involvement of a third party as intermediatory between the two major stakeholders, the residents and the council. Although the low impact approach was easy to relate to at a theoretical, uninvolved level, with legal binding the question became very personal and acceptance for the scheme dropped. The residents could not rely on knowledge and past experience, while the council needed to advise, educate and provide answers to questions that have not been considered before. Consequently, the consultation became an iterative process, and the timing of information collection had a significant impact on the length of the process. As a result of the lessons learnt and the information generated, future low impact projects may be at less of a disadvantage.

The technical flexibility of the low impact approach identified during the design phase of the Glencourt Place stormwater system impacted positively on the consultation process and the size of the life cycle cost. Initially, the modelling outcomes indicated 40 raintanks were necessary in a given area; then the boundaries of the area were extended, which increased the chances of achieving the critical uptake level. Consequent modelling efforts indicated that 20 instead of 40 raintanks would be sufficient. Furthermore, sensitivity analyses carried out for the raintank size showed that tanks even smaller than the proposed 9,000-litre would have the necessary flow amelioration impact, although for contingency reasons the installation of 9,000-litre has been preferred.

Standard restrictions such as the AS/NZS 3500.5, Clause 2.16.2 that stated that only “potable water shall be supplied … for clothes washing” was seen as a disadvantage for the low impact approach, which relied on raintanks for supplying water for clothes washing. Clarifying the standard removed an impediment for future raintank installations.

Legal questions arose over the low impact approach, such as the legality of the transfer of a publicly funded device to private ownership,and the responsibility for renewal, on-going operation and maintenance as well as for inspection and monitoring. Sorting out these questions required the use of specialised service (e.g., legal advise) and staff time (e.g., for the elaboration of the “Stormwater Policy: Responsibilities for Stormwater Infrastructure” document). The conventional approach, on the other hand, is “practice as usual”, with no need for new policies or special legal arrangements. For Glencourt Place the institutional framework advantages the conventional approach. However, once the questions associated with the low impact approach are answered, and new systems and practices are put in place, this differential advantage disappears.

5 DISCUSSION

The Glencourt Place pilot project provided NSCC with the opportunity to experiment with a low impact approach in a retrofitting setting, and this review of the project helped document some of the experiences involved.

The effort put into comparing the costs associated with the conventional and low impact approaches highlighted the importance given to the financial criterion in the selection process. Different analyses resulted in different cost estimates, which indicated sensitivity to the scope and timing of the analysis. Life cycle analysis porvides a thorough coverage of the different cost elements by including, along with acquisition costs, operation, maintenance and disposal costs. Conventional and low impact devices have different life expectancies (e.g., raintanks 25 years; pipes 50 to 100 years), and for comparison the adopted time horizons need to be identical. Due to the long life cycle, the choice of discount rate can influence the present value of future costs. Sensitivity of the estimates to discounting can be exposed by contrasting the real costs with the discounted costs for a number of different discount rates. This becomes even more important when considering the ethical questions associated with discounting costs that would occur to future generations.

We found the acquisition costs dominated the life cycle costs for both the conventional and low impact approaches. The cost of installing the raintanks was similar to the cost of upgrading the downstream pipe, an upgrade that becomes necessary if the conventional approach is taken. For the life cycle costing, the extension of the covered timeframe from 25 to 50 and 100 years resulted in similar magnitude life cycle costs. The variation of the discount rates resulted in some changes; the life cycle cost of the low impact option was higher than the conventional one, with 4–5% if the 10% real discount rate was applied, and 14–18% if the 3.5% real discount rate was used. The inclusion of the water saving benefits diminished the differences, the two options registering no difference in net present value with the 10% discount rate. Difficulties associated with estimating the maintenance and decommissioning costs as well as the cost of land indicate the limitations of this life cycle cost estimates.

When calculating the life cycle cost of the Glencourt Place project, cost elements such as design, project management and consultation registered higher values for the low impact approach due to the novelty of the approach and the lack of both associated experience and support systems. These higher initial costs should not be deterrents; the review identified not only elements that enabled or inhibited the low impact approach but also changes that are attributable to the project. These changes appeared in various forms from revised standard specifications to new stormwater policy on responsibilities for stormwater infrastructure and increased experience with designing and costing low impact devices. Such changes are expected to influence the costs associated with future low impact projects and consequently the likely use of this approach. The costs associated with these changes can therefore be looked at as investments in the distribution phase of innovation.

The externalities associated with both the conventional and low impact approaches remained out of the scope of this economic analysis. As long as markets do not punish environmentally harmful impacts, competition between eco-innovation and non-environmental standard practice is distorted. Exclusive reliance on profitability and market value will favour the conventional approach to stormwater management by disregarding both the negative environmental externalities associated with this approach, and the positive environmental externalities associated with the low impact approach. Even when an attempt is made to include environmental benefits such as water savings, market distortions prevent the true manifestation of the associated impact. New Zealand costs and rates reflect the historically free treatment of water in this country, apart from abstraction and supply costs (Statistics New Zealand, 2004).

Increased data availability for operation and maintenance costs, changing public attitudes with implications for the consultation costs, and increased water pricing, all affect the performance of the low impact approach against the cost minimisation and profitability criteria. Consequently, comparison of low impact and conventional approaches happens in a dynamic framework where both the selection criteria and the performance of the two approaches against these criteria are continually evolving. Experimentation leading to experience through both success and failure becomes critical in shaping this evolution. The Glencourt Place pilot project is such an experiment, and provided insights into the cost implications of the low impact approach in a retrofitting situation while highlighting the potential for future cost reductions.

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APPENDIX A

Glencourt Place Stormwater Project / Low Impact Approach/ Life Cycle Cost (50-year timeframe)

Year	Acquisition NSCC	Operation NSCC	Maint. NSCC	Renewal private	Operation private	Maint. private	Water saving private	TOTAL/Year
2005	-601,338	-200			-200		2500	-599,238
2006		-200	-2235		-200		2500	-135
2007		-200	-2235		-200		2500	-135
2008		-200	-235		-200	-2000	2500	-135
2009		-200	-235		-200	-2000	2500	-135
2010		-200	-235		-200	-2000	2500	-135
2011		-200	-235		-200	-2000	2500	-135
2012		-200	-235		-200	-2000	2500	-135
2013		-200	-235		-200	-2000	2500	-135
2014		-200	-235		-200	-2000	2500	-135
2015		-200	-235	-12000	-200	-1600	2500	-11735
2016		-200	-235		-200	-2000	2500	-135
2017		-200	-235		-200	-2000	2500	-135
2018		-200	-235		-200	-2000	2500	-135
2019		-200	-235		-200	-2000	2500	-135
2020		-200	-235		-200	-2000	2500	-135
2021		-200	-235		-200	-2000	2500	-135
2022		-200	-235		-200	-2000	2500	-135
2023		-200	-235		-200	-2000	2500	-135
2024		-200	-235		-200	-2000	2500	-135
2025		-200	-235	-12000	-200	-1600	2500	-11735
2026		-200	-235		-200	-2000	2500	-135
2027		-200	-235		-200	-2000	2500	-135
2028		-200	-235		-200	-2000	2500	-135
2029		-200	-235		-200	-2000	2500	-135
2030		-200	-235	-47000	-200	-400	2500	-45535
2031		-200	-235		-200	-2000	2500	-135
2032		-200	-235		-200	-2000	2500	-135
2033		-200	-235		-200	-2000	2500	-135

2034		-200	-235		-200	-2000	2500	-135
2035		-200	-235	-12000	-200	-1600	2500	-11735
2036		-200	-235		-200	-2000	2500	-135
2037		-200	-235		-200	-2000	2500	-135
2038		-200	-235		-200	-2000	2500	-135
2039		-200	-235		-200	-2000	2500	-135
2040		-200	-235		-200	-2000	2500	-135
2041		-200	-235		-200	-2000	2500	-135
2042		-200	-235		-200	-2000	2500	-135
2043		-200	-235		-200	-2000	2500	-135
2044		-200	-235		-200	-2000	2500	-135
2045		-200	-235	-12000	-200	-1600	2500	-11735
2046		-200	-235		-200	-2000	2500	-135
2047		-200	-235		-200	-2000	2500	-135
2048		-200	-235		-200	-2000	2500	-135
2049		-200	-235		-200	-2000	2500	-135
2050		-200	-235		-200	-2000	2500	-135
2051		-200	-235		-200	-2000	2500	-135
2052		-200	-235		-200	-2000	2500	-135
2053		-200	-235		-200	-2000	2500	-135
2054		-200	-235		-200	-2000	2500	-135
NPV in 2005 NZ$ with a 10% real discount rate								611,883
NPV in 2005 NZ$ with a 3.5% real discount rate								642,707