The environmental impacts of stormwater in relation to carparking areas.

An assessment of the impacts of stormwater on carparking areas and the structural and legal controls.

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ABSTRACT

The aim of this thesis is to define and expand on what the environmental impacts of stormwater in relation to parking areas are. Also to describe how these impacts are controlled structurally and legally and who is able to compensate for their impacts.

The results of the case studies in this thesis supported the findings of the literature reviewed. There is a better way to design and manage the construction of carparking areas (either impervious or semi-pervious surfaces) in the future urban development environment.

The (long-term ideal) goal is to reduce the environmental impacts from the construction of impervious areas. These adverse impacts are:

- contaminants entering waterways, where they adversely impact aquatic life, and
- flooding from increased runoff rates that causes scouring of stream beds and impact residential and commercial property

These case studies have shown that current practice can and should be modified to have a lower impact on the environment. There is also the possibility of retrofitting existing carparks to mitigate the present effects.

The findings, in seeking to mitigate the adverse effects of carparks on the environment can be broken down into five key areas:

- Any constructed surface or development, whether it be for carparking purposes or roofing should, wherever practicable, have built into its design a treatment and detention facility to mitigate the effects of stormwater on the environment.
- The impacts of any particular project should be looked at in terms of their cumulative long-term impacts.

- Rates relief should be an option for those prepared to upgrade their site to mitigate effects on catchments.
- District plans should provide performance standards with incentives to reduce off-site impacts of stormwater.
- Local authorities should target catchment assessment and design to protect the environment and meet the regional bodies requirements.

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CHAPTER ONE - INTRODUCTION

Adverse Effects of stormwater

Where an impervious surface exists there is the inherit nature of the surface to have flooding and contamination adversely affecting the stormwater systems. Is there a better way to construct and manage the construction of carparking areas (either impervious or semi-pervious surfaces) in the future urban development environment?

The aim of this thesis is to define and expand on what the environmental impacts of stormwater in relation to parking areas are. Also to describe how these impacts are controlled structurally and legally and who is able to compensate for their impacts.

The (long-term ideal) goal is to reduce the environmental impacts from the construction of impervious areas which currently consists of contaminants and flooding, caused by the accumulation of wastes on impervious areas and resulting from the construction of impervious areas. There needs to be a comprehensive system to address the construction and implementation of the methods for mitigating adverse impacts on urban stormwater from carparking areas.

Defining the Issue

The issue this thesis is addressing is that of stormwater pollution, particularly as it relates to carparking areas. This issue starts at every street, every carpark and every driveway - as water trickles down gutters and drains. This stormwater is collecting heavy metals, sediment and nutrient rich materials, then depositing them in the waterways and ecological systems. This causes eutrophication[1] from nutrients, high levels of toxic metals and sediment that is smothering habitats that the community is trying to protect. The real issue is

[1] Eutrophication means the oversupply of nutrients leading to the choking of waterways.

that the accumulating impact of over-enriching the aquatic environment is damaging an environment that has intrinsic values with protection and value to the human community for aesthetics, recreation and health.

The secondary issues are of a similar nature:

- What are the impacts of flooding on the environment as caused by rapid shed of water from impervious surfaces such as carparking areas?
- What methods exist for mitigation to minimise stormwater flooding and contamination on construction or redevelopment of parking areas?
- What engineering design standards for methods exist that could be utilised to encourage best practice in this field?
- There are methods that could be applied or imposed through *Resource Management Act (1991)* (RMA) consent conditions or Regional and District Plans specifically relating to developments that propose to create significant areas of impervious surface.

This requirement of treatment to some degree would improve quality. The impacts and problems of stormwater in the Auckland Region demonstrate that it is a unique location. This is where the Ministry for the Environment (MFE) and the Auckland Regional Council (ARC) have undertaken significant work to develop policies and procedures[2]. Different local government authorities[3] require different standards and safeguarding in their districts.

The third issue that is important in this research has been the issue of financial contributions imposed on development. This is in relation to the impacts for stormwater contribution purposes within district plans under Section 108 of the RMA. This question relates to how Councils undertake their contributions and allocation of these funds. The use of contributions in Auckland by different authorities differs in application and action. There is a lot of responsibility by

[2] MFE & ARC are discussed in detail in the literature review in Chapter Two.
[3] Auckland Region has five Local Authorities and one Regional Body.

councils to ensure that the contribution is applied to the purposes for which it was collected.

The formal research undertaken through the literature available throughout the world and latest conference materials will follow. It is clear from this literature that there is an increasing awareness of these key issues and the actual and potential effects of stormwater contamination and flooding. Chapter Two discusses the literature review, treatment options and the legal and planning criteria and parameters for use of treatment systems. Chapter Three of the research has taken place within the framework of a research project and case study. This research poses a scenario that is common in built up areas in Manukau City especially with the trend in the Auckland Region for intensification of existing built up areas. This reflects the predicted intensification that will grow significantly over the next 50-years. This scenario and its implications will be addressed further in Chapter Four and Five where Manukau and Waitakere City's will have related assessments undertaken on existing operating carparks. Chapter Six will include a summary of the information gained from the research within Waitakere City and Manukau City. Chapter Seven will review the key questions and discuss the results of the research where conclusion and recommendations are compiled in Chapter Eight.

SUMMARY

As has been previously outlined there are more significant global, national, and regional strategies, rules and plans in relation to the effects of a humble carpark than may be contemplated. It is clear that some assessment in terms of the key questions require a detailed analysis in order to provide a tangible result with which we can proceed forward in our design and assessment of the effects of stormwater in carparking areas.

OBJECTIVES – KEY QUESTIONS

- What are the adverse effects of stormwater in car parking areas on the environment?
- What are the best methods for minimising the contaminants entering natural waterways and attenuating flooding?
- What financial measures are used and which financial contribution regime encourages better practice?
- Are there good linkages between statutory practice and district planning, especially at subdivision approval level?
- What are the best planning and legal means for implementing methods?

Table 1.1 Research Methodology

CHAPTER	TITLE	CONTENT	OBJECTIVE
1	INTRODUCTION	PROBLEM	AIM
		OBJECTIVES	
		METHODOLOGY	
2	LITERATURE REVIEW	RELATED LITERATURE	FOUNDATION INFORMATION
3	CASE STUDY ONE - JELLICOE ROAD CARPARK	OVERVIEW	SPECIFIC CASE MATERIAL
		SPECIFIC ISSUES	
		OPTIONS FOR PROBLEM	
		SOLUTION OBTAINED	
4	CASE STUDY TWO - WAITAKERE CITY RECENT CASES	OVERVIEW	GENERAL CASE MATERIAL
		PLANNING AND LEGAL PARAMETERS	
		FINANCIAL METHODS	
		LINKAGES BETWEEN STATUTORY AND DISTRICT PLANNING	
5	CASE STUDY THREE - MANUKAU CITY RECENT CASES	OVERVIEW	GENERAL CASE MATERIAL
		PLANNING AND LEGAL PARAMETERS	
		FINANCIAL METHODS	
		LINKAGES BETWEEN STATUTORY AND DISTRICT PLANNING	
6	COMPARISON OF CASES		DIFFERENT OPTIONS AND EXPERIENCES
7	DISCUSSION	DISCUSSION	PERSPECTIVES ON IMPACTS AND SOLUTIONS
8	RECOMMENDATIONS AND CONCLUSION	RECOMMENDATIONS AND CONCLUSION	RECOMMENDATIONS AND FURTHER RESEARCH TO BE UNDERTAKEN

CHAPTER TWO - LITERATURE REVIEW

INTRODUCTION

The purpose of this literature review is to investigate and answer the key questions outlined in the introduction. Background material will be provided in relation to those five key aspects. These five aspects being:

- The environmental effects of stormwater in carparking areas.
- The methods for minimising the contaminants and flooding.
- The financial instruments used and how to encourage better practice.
- The linkages between statutory practice and district planning at subdivision approval level.
- The best planning and legal methods for implementing the methods.

These questions have been researched from texts and recent conferences and are as outlined following.

WHAT IS STORMWATER?

There are many definitions of stormwater some of those key concepts will be considered. Stormwater is pure rainwater, plus anything it carries. It collects contaminants when it passes over roofs, driveways, roads and through drains. There is usually no treatment prior to it travelling through the stormwater pipes. When the stormwater flows from the street it enters waterways where frogs and other animals and plants live. The polluted water is visible when it merges with clean water because it is mucky and has litter (NSW EPA, 2002).

When there is a heavy rainfall streams usually flood. Historically, stormwater run-off was only of concern as it could cause flooding, impacting property and people downstream. Stormwater shed from impervious surfaces leads to increased peak flow resulting in scouring of the watercourse in streams and damage to habitat (Waitakere City Council, 2003). It is clear that the significant increase in the area of impervious surfaces due to ever intensifying development has combined with waste products from 21st century lifestyle to have a significant detrimental environmental impact. .

TANGATA WHENUA[4]

Within the New Zealand context it is critical to establish the social, economic, legal and cultural environment with which we contend. West (2002) has detailed exactly where the cultural boundaries are within the aquatic environment. This view, as follows, paints a pristine picture of where tangata whenua perspective exists.

West (2002) ascertains that with an ever increasing load on stormwater systems the result will be that Papatuanuku, the earth mother, will show her displeasure by moving her whenua[5]. Instability problems ensue for the roading and stormwater assets. To Maori, the life force essence of receiving waters dies causing stagnant and disease carrying waters generally due to vast modifications to the natural ecosystems. This is where public health can become an issue when people are becoming affected by using this polluted stormwater. An example would be shellfish gathering. It is clear that best practice in the future must provide a more substantial net result for all parties.

Mahinga kai[6], are the traditional food resources reside in the wetlands, lakes, open channels, streams, rivers, and sea. Taonga[7], such as flax, traditional Maori weaving materials, also reside in the same places (West, 2002). These cultural resources are being depleted because of the significant changes that are being undertaken in modifying the waterways in the push for urbanisation.

[4] People of the land: Maori are commonly referred to as the people of the land or area. There are many iwi (tribes) and hapu (subtribes) that may be affected by activities in their locality.
[5] Whenua means Land.
[6] Mahinga Kai, water borne food makes up part of the maori diet. Sea and fresh water environments.
[7] Taonga, treasures to the culture.

Kaitiaki in the *RMA*is quoted as meaning guardianship for the country and its resources. This is guardianship for today and for the future generations of our children and grandchildren. Kaitiaki restores the balance, and with this we see unbalance of matters relating to something as natural as dispersal of rainfall. The last one is the reduced risk to the present population (West, 2002). It is clear that the tangata whenua perspective is reflected in the purposes and principles of the RMA[8]. This is where the action and implementation of this legislation is required to provide for the people and the future of this country.

This has given a snapshot of the cultural background to this literature. The following is detailed research into the current literature that has guided the current best practice and environmental guidelines. This is the establishing literature with which the research, discussion and conclusions stem.

QUESTION 1 - THE ADVERSE EFFECTS OF CARPARKING AREAS

The key environmental issues for stormwater in carparks are based on two main adverse effects. These are the rate of run-off caused by the impervious surface, and the collection of contaminants that flow with the stormwater downstream and adversely affect ecosystems. There is a secondary effect of impervious areas this is the effect of reducing groundwater recharge impacting the major source of continual flow in perennial streams.

Engineers and roading authorities have had the expectation of the stormwater system serving roads to have the following attributes as described by Robinson (2002):

- To ensure the efficient removal of stormwater from the road and protect adjacent property from the run-off from the road.
- To have a system which is safe and easy to maintain.

[8] As outlined in section 7 and 8 *RMA*1991, this can be found in Appendix 1

- In urban areas, the roading stormwater system, principally kerbs and channels, can provide an appropriate disposal point for private property stormwater.
- Trying to accommodate the environmental effect of discharges from the stormwater system need to be environmentally sustainable (only recently).

These factors are commonly considered and with this philosophy behind decision making this is how the current system has been constructed and managed. These methods would be suitable in areas where the carparking areas are small, but in a big city the high proportion of stormwater derived from paved areas flowing into waterways has led to the adverse effects outlined below.

WATER QUALITY AND QUANTITY

Stormwater quality issues predominantly come from road and carparking sources and property immediately adjacent to them. Robinson (2002) has stated that the significant contaminants that one finds in urban stormwater are as tabulated below:

From the table it is clear that there are contaminants in the stormwater. This information covers a wide variety of pollution points and sources. Therefore there is a need to find the adverse effects of carparking areas on the environment. In addition to the table above there are also the consented discharges and illegal discharges contrary to Section 15 of the RMA[9]. For example septic tanks or direct misconnection from waste pipes to the stormwater network.

[9] Section 15 *RMA*can be found in Appendix 2.

***Table 2.1 Contaminants found in stormwater*[10]**

Contaminant	Source
Copper and Zinc	Tyres, roofs and brake linings
hydrocarbons	Oil drips, tyres, bitumen weathering, illegal discharges, spills, vehicle exhaust deposits
Particulate Matter	Grit from frost gritting, wind blown material, debris from trucks, industrial fallout, silt from batters and erosion of water tables, soot from domestic fires
Bacteria	From decaying vegetation, animal deposits, spills from trucks
Organic Matter	From discharges from trucks and from decaying vegetation
Chemicals	Fertilisers and weed sprays (Robinson, 2002).

It is clear that carparking areas are not the only issues however the widespread presence of carparks presents a significant cumulative impact from both water quality and rate of flow. Having provided this picture of contaminants in urban stormwater, in less intensively developed areas, it must be remembered that non point sources (for example: tyre wear) are a major contributor to water quality issues. Dealing with stormwater contamination issues from roads or vehicle use, surfaces alone will not necessarily significantly improve water quality in the receiving waters (Robinson, 2002). There must be holistic catchment projects undertaken to provide for change in use and impacts to ensure that the individual efforts are not fruitless.

The causes of stormwater pollution include litter, cigarette butts, paper, oil, fertiliser, industrial yards, chemicals, detergents, leaves, garden clippings and the like. Everyone is individually and collectively responsible. The volume of rainfall, the period since it last rained and also the cleanliness of the streets can determine the severity of the pollution in general. Stormwater quality affects us

[10] Adapted from report to provide concise table.

in many ways, wherever there are human uses of the water or use on plants and animals. The bacteria level in the water at the beach or in a stream with public access for recreation is an obvious concern (NSW EPA, 2002). The following details from Australia paint a similar picture to that of Robinson above.

> *"Fine particulate matter (FPM) of less than about 20 microns in urban streams often contains high concentrations of chemical contaminants. Zinc concentrations can reach 5000mg/kg. This is trapped in the biofilms grazed by aquatic invertebrates. And the ingestion by those animals can be hazardous. In lab experiments, snails ingested FPM up to 5 microns in size. Sediment settling and filtration devices do not adequately retain FPM. Biofilm trapping in wetlands or shallow macrophyte ponds is an effective mechanism for removing FPM from storm and wastewater" (Timperley, M.H., Golding, L.A., Webber, K. S., 2001).*

Timperley et al. continues to describe the results of increased FPM in streams to be proof of a reduced number of these animals in those streams. With existing treatment devices the range of particulate quality is enhanced downstream due to the intensity of the fine particulate that escapes through the filters. Biofilm trapping in wetlands and shallow macrophyte ponds can remove FPM from waters[11] (Timperley et al, 2001). Thus these impacts are filtering down to the smallest scales not noticeably visible.

STORMWATER FROM ROADS AND CARPARKING AREAS

Stormwater run-off has been shown to contain a range of pollutants, including heavy metals such as lead, cadmium, zinc and copper among others. A principal source of these pollutants has been identified as transport related. The effects of these pollutants on the environment have been recognised as a

[11] Biofilm methods are large pond systems for low flow treatment for reducing the FPM in stormwater. These methods will be detailed further into this report.

significant contributor to the long-term degradation of the quality of our receiving environment. The Auckland Region environment impact was described:

> *"If contaminants continue to be generated at present rates it is predicted that by 2021, 70% (compared to a current level of 50%) of potentially impacted areas will have sediment levels exceeding that where few biota are affected, and 35% will have sediments containing contaminants at levels in excess of levels where most biota are affected (compared with 20% at present)" (Paterson, 2002).*

The sources of contaminants in urban stormwater are reasonably well documented. Road transport is a major source, for example, lead emissions from leaded-fuel vehicles, and copper and zinc from vehicle component wear (predominantly brake linings and engine bearings for copper, and tyres for zinc). Concentrations of polynuclear aromatic hydrocarbons (PAH's) are relatively high in urban run-off and are derived from atmospheric particles from fires or exhausts, abraded bitumen and sump oil (Paterson, 2002).

Roadways within built up areas, such as Auckland Region, can occupy 15 to 20% of the land area. Estimates indicate that vehicle use contributes 40 – 100% of these contaminants in urban stormwater Estimated loading rates to urban waterways for vehicle derived contaminants are as shown in the table below:

Table 2.2 Contaminant loading rate to urban waterways.

Contaminant loading rate to urban waterways	
Lead	6 mg/vehicle km
Zinc	0.7 mg/vehicle km
Copper	0.16 mg/vehicle km
Cadmium	17.6 µg/vehicle km
Nickel	0.045 mg/vehicle km
Chromium	0.1 mg/vehicle km

Total Hydro-carbons	15 mg/vehicle km
PAH	15 µg/vehicle km
(Snelder 1995 in Paterson, 2002)	

AUCKLAND

In Auckland the contamination problem is rapidly growing as the population growth is 70,000 persons per year (NZ Herald, 2003) with more and more persons estimated to be arriving and residing here weekly. The growing network of roads and consumers is perpetuating the issues as can be clearly detailed by these statistics from Paterson.

> *"...9,390 million vehicle kilometers are traveled annually in the Auckland Region. This is 30% of New Zealand's total road usage. Of those 9.4 billion vehicle kilometers traveled (VKT) in the Auckland Region, more than 99% are on sealed roads. About two thirds are on local roads (i.e. not state highways) and one third are on state highways (Transit New Zealand 1996). Not all of those VKT are on roads that contribute to urban stormwater. If it is assumed that the VKT on state highways in the Auckland metropolitan area is at least as great as the VKT on local roads in the Auckland Region but outside the metropolitan area, the above information indicates at least 20% of all the contaminants from road usage in New Zealand are released to the environment in the Auckland metropolitan area (Paterson, 2002).*

From this information concerning the Auckland problem it is interesting to consider other centres and how other parts of New Zealand are monitoring these same trends. The following report from Goff, J., Bolton-Ritchie, L., and Chague-Goff, C. (2002) refers to the Wellington situation.

WELLINGTON

The relevance of this review is the similar nature of the study into Wellington Harbour in comparison to the two harbours within the greater Auckland areas of sheltered low energy receiving environment.

> *"Accumulations of contaminants delivered by stormwater into the receiving waters of Wellington Harbour can be toxic to humans and local biota. It is the sediments underlying these receiving waters that preserve the best record of both contemporary and historical changes in the influx of contaminants. In addition, while the receiving sediments are a sink for contaminants, they also represent a source of resuspended material by either anthropogenic or natural processes. Similarly, under changing environmental conditions, sediment-bound contaminants may be remobilised and enter the water or food chain" (Goff et al., 2002).*

The sediments of the sheltered embayments of the region appear to be susceptible to an accumulation of contaminants. This is common because these low energy regimes are unable to remove excess particulate material because of their low turbidity. There also appears to be a significant contribution of contaminants delivered to the coastal zone by sewer outfalls which is common in a harbour and large catchment system with low water flow rates.

> *"In the case of Moa Point this has been addressed in recent years by the construction of a new sewage treatment facility. However, the abnormally high levels of lead in particular are cause for concern, but with the decline in the use of leaded petrol, concentrations are likely to have declined. A substantial amount of other work has been carried out in Wellington Harbour, and much of the data can be compared if one accepts the pragmatic solutions given above with regards to analytical technique and sediment size. The data reported below relate to individual samples taken at the exit of key storm drains or sewer outfalls in the area. (Goff et al., 2002)*

This data pertains to the following key points. The central harbour still maintains relatively low background levels of pollution and contaminated sediment when taken in the context of sites on the periphery. This concludes that while tidal mixing does occur, these are because of the diluted inputs from the Hutt River and Waiwhetu Stream. All storm drain outlets sites show heavy metal concentrations greater than the threshold effects level. There is a general decrease in contamination away from the Queen's Wharf/Overseas Passenger Terminal (OPT) area towards more peripheral city locations such as Evans Bay and Ngauranga Gorge. While the data provides a poor basis for timeline investigations it does provide enough to prove a continual degradation in these areas. There is on-going research monitoring the spatial and temporal changes in sediment quality at several key storm drain outlets within Wellington City (Goff et al., 2002).

Levels of contamination are high, with all the major storm drains serving light industrial, port, airport, and heavier industrial sources showing significant enrichment. The most likely sources are road and construction-related contaminants, coupled with numerous small industrial enterprises. For specific sites, the Evans Bay East site drains Miramar Peninsula and an area of light industry containing food processing plants, metal workshops and storage areas. Evans Bay West drains parts of Kilbirnie, including the bus depot and an area of small businesses. The OPT and Kaiwharawhara Stream are dealt with separately. (Goff et al., 2002) These points relate clearly to the imperviousness of industrial areas and their impacts, particularly when located close to the water's edge as is common in New Zealand cities.[12]

"An analysis of total metal data from Wellington Harbour indicates that depending upon how you study and analyse the sediment you may or may

[12] These points about industrial areas are linked to and have been detailed in the discussion further in the thesis. This resulting impact of industrial areas is a cause for concern because they are the high use areas with a high rate of pollution. The large industrial operations may be perfect but the small-scale light industrial operation may be the biggest causes of stormwater pollution and lack of responsibility in this field.

not get comparable data. Wellington Harbour has contaminated sediments, most of which are concentrated around the periphery of the basin adjacent to storm drain outlets. The main areas are: Lambton Harbour (inc. OPT), Aotea Quay, Petone foreshore, the Hutt River and Waiwhetu Stream mouth. The most visible contaminants at outlets are derived from road run-off. These include, cigarette butts (e.g. 161 butts in 0.05 m2 at OPT), packaging material (food and drink), and leaves (Goff et al., 2002).

This summary of Wellington's issues is comparable, although more detailed than the summary of Auckland's situation. Waitakere City will be considered next and the points they raise about what is in their water. Waitakere is renowned for being "green" and "eco-friendly" city and they are keen to maintain their high standing.

WAITAKERE

In Waitakere City there is a complex network of 590km of stormwater pipes that carry stormwater to discharge points. The only visible signs of this network are the grates on the side of the road and perhaps the pipes at the local beach. Stormwater is contaminated by motor vehicles through metals such as lead, copper, zinc and oil; all washing off roadways (it is estimated that 70% of stormwater pollution is caused by cars). Rubbish such as plastic bags, bottles and other street litter. Herbicides, garden fertilisers and even rotting lawn clippings. Detergents from car washing and domestic animal faeces are degrading in yards. Illegal and accidental spills that are being dumped into stormwater drains (WCC, 2003).

In the Auckland Region stormwater makes up about 40% of the annual average wastewater flow. During times of heavy rain, stormwater leaks into the wastewater network causing it to overload and overflow. These overflows eventually find their way into the stormwater system and our natural waterways. They add to the toxic cocktail already in stormwater and pose a serious risk to public and environmental health (WCC, 2003). Therefore we need to find environmentally sustainable ways to manage urban stormwater and upgrade the regional stormwater systems. Stormwater management is both a regional and local responsibility. There is no simple solution but by reducing or eliminating the amount of pollutants being washed downstream, the problem becomes more manageable (WCC, 2003).

The impacts, as detailed above, provide clarity as to the impacts of stormwater on carparking and roading areas on the environment. The suitability of impervious surfaces is high from an engineering point of view, although from a holistic environmental viewpoint there must be more taken into consideration. To provide a sustainable future for roading and carparking areas we need to look at the best methods for minimising the adverse effects of, and maintaining these stormwater systems.

QUESTION 2 - THE METHODS FOR MINIMISING THE CONTAMINANTS ENTERING NATURAL WATERWAYS AND ATTENUATING FLOODING.

The best methods for minimising the contaminants from entering the waterways and attenuating flooding can be summarised under the aspects which have been looked into as follows: biofiltration systems, detention ponds for quality and quantity of water, permeable pavements, source controls, infiltration and percolation systems. These will be discussed below and provide interesting methods for providing for the treatment and storage of stormwater.

BIO-FILTRATION SYSTEM

Increased run-off and discharge of polluted stormwater resulting from catchment urbanisation have a negative impact on the aquatic ecosystem of receiving waters. Stormwater drainage solutions include source and in-line solutions[13]. A bio-filtration system is one of the options when considering treating run-off prior to discharging into the receiving environment. Biofiltration systems are a combination of detention, infiltration and collection systems. And generally integrate a vegetated swale as part of the design (Lloyd, S. D., Fletcher, T. D., Wong, T.H.F., Wootton, R.M, 2001).

As part of Lloyd et al's experiment the structure constructed consisted of a 0.8m deep and 0.45m wide trench overlain with grass. The location of the trenches was in the street berm, and passed through the driveways. The experiment consisted of test runs that determined how much treatment was being undertaken and provided for the adequate filtration required prior to the outfall (Lloyd et al. ,2001).

The results showed that bio-filtration can be used as an effective stormwater measure. The treatment time is only sufficient to promote physical treatment

[13] Source solutions are treatment facilities at point source of contaminants, for example the carpark itself. In-line solutions are those within the waterway system.

mechanisms and the high pollutant removal rates achieved for total suspended solids (TSS) and total pollutants (TP) are predominantly the result of enhanced sedimentation, along with absorption of soluble phosphorus into finely graded particles. The result indicated ineffective treatment of soluble nutrients within the bio-filtration system. This is not a serious impediment as a high level of phosphorus and metals are transported in urban stormwater in a particulate form that is trapped. The system could serve as pre-treatment and be followed by treatment in wetlands. Longer detention periods are required for bio-film growth. Therefore an increase in the size of the system is required (Lloyd et al.,2001). This study has shown biofiltration systems can be effective.

In the ARC TP10 (2003) document there is material covered relating to these methods. The use of swales and filter strips are detailed in chapter nine and clarify with similar outcomes these conclusions reached above. The next method to be reviewed is the detail of detention ponds.

DETENTION POND QUALITY

A wet detention pond is a structural measure that has the chance of reducing pollutant effects on the environment and ecosystems. Their size and design is dependent on the size of the catchment and the quantity of the discharge. Wet detention ponds can be used as pollutant traps. There are determining factors for the placement of a pond. The requirements are the volume; depth; variation; the eutrophication; plantation; the establishment of a catchment basin; and the specific pond characteristics. These criteria are recommended when constructing a wet detention pond. The inter-dry period is proposed as the fundamental criterion in order to achieve sufficient residence time for the pollution in a pond. A wet detention pond is an integrated flood and quality control structure (Hvitved-Jacobsen in Torno (Ed.),1989).

ARC TP10 (2003) details ponds and wetlands, generally they are broken down into dry ponds for flood prevention and wet ponds for siltation of particulate sediments. They show that they are effective when used in the right situation and with the provision of measures to inhibit adverse effects during larger storm events. The next method to be detailed is source control, or point source methods.

HYDRAULIC CONTROL

The reasons for the introduction of source control were to avoid flooding, give relief to an overloaded sewer and reduce combined sewer overflows. Environmental awareness has brought about source controls for enhanced water quality. There is a rising cost in maintaining 19th century systems yet the public is not willing to accept the required tax or rates increases needed. A system requires being cheap and efficient systems to mitigate these effects. Detention ponds have been used, although require 0.9m fences. Permeable surfaces have increasingly been used and are mitigating the effects (Niemczynowicz, in Torno (Ed.), 1989).

MAINTENANCE OF STORMWATER QUALITY TREATMENT FACILITIES

Government regulations for quality and maintenance of treatment facilities are becoming more definitive. Public and private both are affected and are required to change with the rising standards. The most likely parties to own and maintain stormwater quality treatment facilities are the local councils. The financial impacts are significant, for the implementation and maintenance. There are concerns about the levels of materials in the residue, yet some have just ignored them (Lenhart and Harbaugh, 2000). This paper describes the different methods of source control, and the relative issues, as tables below:

Table 2.3 Ponds, Wetlands, Swales and Stormfilters

	Advantages	**Disadvantages**
Ponds	Aesthetic value Assimilation of some pollutants	Vegetation disposal Access issues Spill cleanup Large volume of water Invasive species Seasonal characteristics
Swales	Minimum maintenance No confined space Low volume of water	High pollutant loads kill vegetation Vegetation disposal Grass heights Invasive species
Sand filter	Minimal water Defined procedures Minimal downtime	Confined space Large volume of sand and rock Under drain failure Filter maturation period Replacement sand inadequacies
Stormfilter	Easily maintained No biological impact Defined procedure Manufacturer support	Confined space Media disposal Lenhart and Harbaugh (2000)

MAIN CONCERNS FROM STORMWATER

- Rubbish and debris
- Sediments
- Total Petroleum Hydrocarbons (TPH) – eg. fuel, oil
- Heavy metals

- Polycyclic Aromatic Hydrocarbons (PAH) – eg. automobile combustion
- Biological pollutants. (Lenhart and Harbaugh, 2000)

Preventing pollutants entering the system from both private and public sources should always be a key component when considering stormwater. Catchment Management Plans for catchments should be used. These require the public and private users to abide by and take part in the facilities and monitoring of their system and devices (Lenhart and Harbaugh, 2000).

INFILTRATION AND PERCOLATION.

The results from the use of infiltration and pecolation showed that there was no increase in nitrogen and phosphorous in the groundwater downstream from the discharge points. The concentrations of heavy metals were, with the exception of copper, not influenced (Niemczynowicz, in Torno (Ed.), 1989).

Infiltration is a network of systems where stormwater is infiltrated into the ground rather than discharged to the surface water body. For example – ponds, vaults, trenches, dry wells, porous pavements and concrete grids (NCT, 1993). The limitations of infiltration treatment are a loss of infiltrative capacity over time and high maintenance costs in fine soils. Also the risk of ground water contamination.

A point system has been established by North Central Texas(1993) for maintenance of devices –

- Annual, or after extreme events, inspection of facilities is required
- If there is water in the facility 72 hours after an event it requires cleaning.
- Restrictions of disposal of sediment.
- About once every three years.

- The sediment in the bottom layer of a pond should be within toxicity limits specified by regulations.
- Pre-treatment may reduce maintenance costs.
- Porous pavements must be cleaned quarterly by vacuum sweeping and high pressure water.
- Porous asphalt clogs more rapidly than concrete. (NCT, 1993)

Maintenance is detailed throughout the ARC (2003) TP10 document. Each section of the document details what key aspects require maintenance and key aspects to be aware of. The next section to discuss is the structures consisting of permeable surfaces as storage and treatment devices.

PERMEABLE PAVEMENTS

Permeable pavement systems control the stormwater and channel it to existing drains and outfall. There are permeable areas in the urban landscapes that have no impact onto this current method of stormwater networking. At present the rain travels through and into the groundwater table (Pratt, in Torno (Ed.), 1989). The study undertook an assessment of three types of permeable pavements. Grass-concrete; porous asphalt; and permeable block paving. These forms of construction have been shown to retain pollutants, and have had a significant reduction in the total pollutants travelling downstream. The two mechanisms in the enhancement are the sedimentation/filtration and the chemical absorption into materials in the structure. It is critical to choose the right materials at the design stage, specific to the site and pollutants. Designs must ensure future maintenance is taken into account for the life of the system (Pratt, in Torno (Ed.), 1989).

These permeable pavement options are best used over large plain areas, the elimination of surface streams minimises the flow velocity and there are options with what to do with the discharge, these are:

- It may be possible to dispose of stormwater to groundwater on site.

- They may be directed to an adjacent water way
- Discharge to treatment works to ensure quality at times of low flow.
- Water reuse for on site irrigation, as the quantity in storage is available for grey water purposes (Pratt, in Torno (Ed.), 1989).

Sweden has been for 25 years using porous pavement. They have found that it reduces peak flow and reduces pollution on a temporal scale (for example 20 years for porous surface). The question that remains is will the dilution in the groundwater eventually cause other adverse environmental effects. Will this reach a goal of sustainable development? (Niemczynowicz, in Torno (Ed.) (1989).

Porous pavements have been constructed in the same manner as other pavements. They have a geotextile membrane separating the aggregate and the asphalt/concrete. The benefits have been infiltration to the groundwater or storage to avoid peak flow (Niemczynowicz, in Torno (Ed.), 1989). Stormwater enhancement has become a desirable goal for planners and practitioners. This has proved impossible overseas, in Sweden, however, the separation of stormwater and sewer in Sweden is not workable in practice. The total pollutant load from the Swedish city will not be reduced and the risk of toxic effects in heavy rainfall could be increased. The construction of open basins in densely populated areas is unsafe, therefore the use of infiltration and percolation facilities are in common use (Niemczynowicz, in Torno (Ed.) (1989).

Stormwater management involving pervious surfaces requires porous or permeable media. Infiltration practices offer treatment, preserve natural flow, reduce velocity of flow and recharge groundwater. Construction and maintenance of these methods require expertise to ensure minimisation of clogging or blocking of the devices. There are two key systems – vegetative infiltration practices and infiltration structures (USEPA, 1993).

There are key determining factors about the placement of different stormwater management devices. These are soil types, as sandy soils will have a high run-off and low treatment and could lead to pollution in the water table; and depth to rock, septic tanks, wells, foundations or unstable slopes (USEPA, 1993).

Vegetative infiltration practices require well draining soils. Once vegetation is established use of the land must be limited or it may not operate as efficiently. Pre-treatment devices may be required, for example oil or grit separators, if there is the potential for excessive pollution loading (USEPA, 1993).

The infiltration structures are designed to be located in soil so that stormwater run-off can infiltrate to the ground (USEPA, 1993). The key options for infiltration structures are:

- Vegetated filter strips – adjacent to roadways, or stormwater drains, enable wildlife, do not assist in high flow rate areas.
- Grassed swales – vegetated depressions – for low run-off areas – base should be as level as possible. Easy to construct. Cannot control large storms.
- Level spreader – designed to collect storm run-off and create sheet flows over land. Creates a pond and can provide a method of ensuring no scarring or scouring of the landscape. They can easily develop short-circuiting because of erosion or other disturbances.
- Infiltration trenches – for soils with high clay content. Usually a deep, long, narrow trench filled with stone, which allows for temporary storage of stormwater. Remove pollutants effectively, and are good for small sites. Have a short life span due to sedimentation, if not maintained.
- Porous pavement/concrete grids and modular pavements – run-off infiltrates into a reservoir. These provide treatment and reduce the need for kerbing. Can be expensive, easily clogged. May cause ground water contamination (USEPA, 1993).

Point Source Roading Devices

Sumps can be trapped (Robinson, 2002) and this has some significant advantages in terms of maintenance and protection of the stormwater system. Trapped sumps:

- Retain silts at times of low flow, ie act as a small sedimentation tank
- Provide containment for small oil or fuel spills
- It is easier to clean silt from a sump than allowing it to enter the pipe system

Trapped sumps do however have a disadvantage they do concentrate contaminants, particularly heavy metals and oils. While the sump may be reasonably efficient at removing silt and contaminants from the flow prior to discharge to the receiving water, that the material collected in sumps exceeds the concentrations of those materials permitted to be dumped in landfills (Robinson, 2002). As we move more and more toward the removal of contaminants from stormwater, it becomes clear we need to know more about how to dispose of the material collected.

Urban Stormwater Quality

With the increase in impervious area the problem of where the stormwater goes is the key issue. The contaminants present are a direct result of urbanisation, types of land use, vehicle density, and the degree of air pollution prior to a rainfall event (McKergow, undated).

McKergow's study synopsis was to monitor a catchment over a seven year period and discuss the resultant chemical compounds, heavy metal and sedimentation from the flow of the catchment. The results of this study found the following:

- With rain events there were rapid increases in the concentration of nutrients, COD[14], suspended solids and metals.
- Average event mean concentrations of contaminants exceeded acceptable freshwater quality concentrations by USEPA standards[15].
- The relative proportions of contaminant in a particulate or dissolved form affect the ability for contaminants to be removed by settling. All phosphorus was of particulate matter. Heavy metals were divided equally between the dissolved and particulate forms.
- The variation in many contaminants over a storm closely followed suspended solids behaviour. The concentrations of heavy metals and phosphorus generally increased with a decreasing particle size. This can be attributed to the greater area of finer particles for absorption.
- Suspended solids concentrations were reduced by approximately 70% after 32 hours of settling[16].
- Removal of heavy metals, phosphorus and COD was between 10% and 40%, no removal however of nitrate and nitrite.
- Stormwater run-off from residential areas is a significant source of suspended solids, metals and nutrients (McKergow, undated).

WIRI STORMWATER POND

Manukau City has undertaken a program of desilting and dredging the existing pond at Wiri. During this programme the bypass flow of stormwater had to be in accordance with the ARC consent requirements. Therefore MCC defined their project as being to:

- Increase the pond size to provide greater sediment removal efficiency.

[14] COD – Chemical Oxygen Demand.
[15] USEPA – United States Environmental Protection Agency Standards.
[16] This indicates a significant change to the concentrations over a timeframe.

- Construct two new ponds, which act as sediment forebays to improve the sediment removal efficiency of the system.
- Construct a permanent bypass system of channels and pipes to enable stormwater flows to be bypassed when maintenance of the ponds is required and thereby satisfy ARC requirements (Hassan, M., Krpo, Y., Radic-Kljcanin, A, 2002).

This stormwater pond had a positive impact on water quality in the Puhunui Stream and is an integral part of the improvement of the water quality in the Puhunui Stream and the Manukau Harbour. The objective of the proposed works was to provide a practical method of removing the silt both during upgrade and in the future, also providing for the existing stormwater flows into the system and minimising the effect on the environment (Hassan et al, 2002).

Sampling of the captured sediment showed the material, once dried, is within acceptable limits for landfill. A full-scale trial of low-turbidity dredging showed that this technique could be used, with some modification of the equipment, successfully. It may be more effective to use the dredging as a method of periodic maintenance once the pond has been cleared. It also means the build up of silt and debris can be better monitored in the future (Hassan et al, 2002).

ARC initially requested to diverting a storm event by a piped system or open channel. This method was seen to be costly and not feasible due to the large flow rates to be catered for. However subsequent to the dredging trial ARC accepted the use of a lower flow rate comparable to the low flow experienced leading up to the trial dredging. This then made it practical to provide a permanent bypass system at a more acceptable cost (Hassan et al, 2002).

PUHINUI CATCHMENT STORMWATER TREATMENT

The stormwater treatment of the Puhinui catchment was studied as a case in identifying the best options for treatment opportunities. Data was generated to identify the applicability across the region. Ponds were chosen to assess, located in the Puhinui catchment, Manukau (Beca Carter Hollings & Ferner Ltd, 1995).

This scheme removes 64.5% of the sediment from the catchment at a capital cost of $1,547 per ha, a total annual cost of $273 per ha. Therefore the large facilities used are a more cost-effective option. Retrofitting is required in existing catchments to provide similar environmental benefits. The cost of land purchased may be the largest expense. A regional strategy is required for stormwater treatment. The stormwater treatment devices also act as flood detention devices (Beca Carter Hollings & Ferner Ltd, 1995) although these devices can be affected adversely by a flood event.

The planning of a stormwater strategy should be undertaken at the primary stages of catchment development. Treatment should be planned on a catchment wide basis. The costs of treating a catchment under 200 hectares imposes penalties, due to the inefficiencies on a per hectare basis. Costs of ponds are from $1000 to $3000 per ha of a catchment (between 500 and 2000 ha). There are annual costs imposed on maintenance per hectare. In the catchment studied, a new pond near the mouth of the Puhinui stream will provide the most efficient system (Beca Carter Hollings & Ferner Ltd, 1995). This study has shown that pond systems are efficient when a catchment is large enough. Treatment prior to discharge is preferred and the ARC has a preference for off-line ponds.

MODELLING URBAN STORMWATER TREATMENT

This consists of a unified method and model for the treatment and modelling of different systems for the stormwater. The continuously stirred tank reactor model – not simulating actual function and the hydraulic efficiency of ponds and wetlands needs to reflect two basic features in the hydrodynamic process. First is to distribute flow across the detention system, and the second is the amount of mixing necessary and recirculation required (Wong, T.H.F., Fletcher, T., Duncan, H.P., Jenkins, G.A., 2001). The applicability of their study is as follows:

- Ponds and Wetlands – comparing an open unvegetated channel and a densely vegetated channel it is clear that the vegetated channel reduces the quantity of suspended solids quicker and with a lower quantity at the end compared to the open channel.
- Narrow Swales – an experiment was undertaken comparing the swale use, a 40x0.75m with a slope of 0.44% was used. The results showed a reduction in TSS, TP and total nutrients (TN).
- Broad Swales – long shallow trenches with appropriate grass species have shown to treat BOD^5 and suspended solids well.
- Gravel Filters – the particle size, and hence surface area is a significant variable and reduction in turbidity. (Wong et al, 2001).

Grass swales, wetlands, ponds and infiltration systems all form a treatment continuum based on flow attenuation and detention, and on particle sedimentation and filtration (Wong et al, 2001).

The above information provides a detailed review of those systems that are capable of providing for the future of stormwater networks. There is definitely the aspect of sustainability and catchment design philosophy appearing in our policies and legislation. It is clear that one method alone is not going to satisfy the market, but a series of interlinked methods managed on a catchment-wide basis by one body to provide for the long-term goal of reducing all flooding and minimising contaminants in the stormwater system.

QUESTION 3 - FINANCIAL MEASURES USED AND WHICH REGIME ENCOURAGES BETTER PRACTICE

Regional and local councils have recognised the link between stormwater management and desired environmental outcomes sought by their communities. They have subsequently provided and planned for resources to tackle stormwater pollution. As a strong link exists between roading and stormwater pollution, recognition is sought from roading managers to make financial provision for the mitigation of those environmental effects (Paterson, 2002).

SECTION 108, *RMA*(1997)

"(9) In this section, 'financial contribution' means a contribution of –
Money; or
Land, including an esplanade reserve or esplanade strip (other than in relation to a subdivision consent, but excluding Maori land within the meaning of the Maori Land Act 1993 unless that Act provides otherwise; or
A combination of money and land.
(10) A consent authourity must not include a condition in a resource consent requiring a financial contribution unless –
The condition is imposed in accordance with the purpose specified in the plan (including the purpose of ensuring positive effects on the environment to offset any adverse effect); and
The level of contribution is determined in the manner described in the plan." (RMA1991, 1997)

This description of a financial contribution is the justification for the use of contributions within district plans. This clearly states that it must include the purpose of ensuring positive effects, where in the stormwater networks the increase in impervious surfaces and contaminants clearly comprises within this definition.

FINANCIAL CONTRIBUTIONS FOR STORMWATER INFRASTRUCTURE IN MANUKAU CITY

In Manukau City levies are imposed on developers to meet the capital costs of infrastructure required for servicing their development through *RMA*procedures. The requirement can be for the developer to upgrade and contribute to the upgrading or construction of their catchment. There are issues raised when objections are made to the imposition of financial contributions. These main concerns are:

- The cost of physical works based on the estimate for the total catchment upgrade.
- The basis of calculating the financial contribution to properties, and the cost to those further upstream.
- The practicality of upgrading larger size pipes in already developed areas, and whether upgrades of a theoretical basis are feasible in practice

The key point is that it is the development potential that requires the upgrading and the costs are shared between the potential developers (Hassan et al., 2001).

The financial contributions are required in order to upgrade the infrastructure in Manukau. There is a growing need to integrate development with water quality improvements in infill housing areas. The additional cost of water quality improvement is likely to further decrease the economic viability of infill development in many catchments unless other sources of funding are made available, ie Infrastructure Auckland grants (Hassan et al., 2001). These calculations and provisions in Manukau are similar to those in Auckland City.

AUCKLAND CITY STORMWATER FINANCING

In Auckland City the management and maintenance of stormwater infrastructure financing has been obtained from the following sources:

- Levied through rates
- Levies on new development (Financial Contributions)
- Infrastructure Auckland grants
- Borrowing

The key reason for upgrade is that the Regional Growth Strategy requires a further 200,000 persons in central Auckland and the Regional Policy Statement and Regional Plan require higher water quality standards from existing stormwater infrastructure. The upgrade costs have been determined by a contribution of dollars per square metre of impervious surfaces (Paterson, 2001).

Key factors for the current standard in methodology have been derived from the Local Government Amendment Act No 3 1996, and the concern for higher environmental standards by the ARC and the wider community (Paterson, 2001).

WAITAKERE

In Waitakere City, EcoWater Solutions[17] has the responsibility for ensuring that these water related services are designed, constructed, maintained and operated so that residents receive quality, efficient stormwater services via commercially viable and environmentally appropriate systems. The costs involved can be lump sum payments toward the cost of existing or future services known as Developer Contributions, to payments towards the upgrading

[17] A business unit of Waitakere City Council

costs associated with the reconstruction of existing reticulation networks and the provision of new reticulation (WCC, 2003).

The existing City networks were originally placed and sized to facilitate the development of 1000m^2 sections. But the development to densities higher than this have been allowed under the current district plan, causing a necessary upgrading of those systems, thus developers are charged a proportionate share of those costs. The Developer Contributions are set on a catchment basis because in older areas, the networks were not designed for development to the higher densities that apply today. Rather than stop development until the pipe capacity exists, developers are advised of an apportioned cost calculated as follows: On the total cost to upgrade; divided by the total number of properties at maximum probable development to permitted densities. By virtue of the above method, existing houses are not levied, except through general rates, and the Council carries the cost of upgrading for them, while the cost of the new development falls to the developer (WCC, 2003).

When more intense development is proposed than the permitted category, the effects of development will be mitigated, either by agreed works on or off-site, or by contribution to off-site mitigation works. The charges are calculated and documented generally for water, wastewater and stormwater systems within the Asset Management Plans. These plans also contain information on EcoWater's predictions for development rates (for example, the time it will take to recover costs which is an interest component of the charges) and other details as required for the calculation of the charges (WCC, 2003).

NEW SOUTH WALES, AUSTRALIA.

Looking toward our overseas neighbours, they are struggling with the same questions. In New South Wales a lack of funding sources is a major limiting factor for long-term stormwater management programmes. Traditionally, local, state and federal funding is available. Rates are an option although these are capped by the Consumer Price Index (CPI). Some alternatives are available.

At present there are two options - the rating base and development contributions (Chanan, A., Simmons, B., Hunter, G., 2001). These options compiled by Chanan et al are as follows:

- Offset arrangements – stormwater management rather than upgrades.
- Stormwater utilities – a funding utility for stormwater rates – for costs of upgrading.
- Stormwater Revenue Bonds – loans.
- Authority for Stormwater Management - a central co-ordination authority.
- Greater federal involvement – due to the significance of clear and safe environments in their policies.
- Stormwater as a commodity – water shortage, and other uses - harvested urban stormwater can be treated and used for peri-urban areas, parks, sporting facilities, etc.
- Rates Rebate – voluntary conservation agreements, relinquish development rights, or stormwater quality improvements on land in return for rate rebate (Chanan et al., 2001).

SUMMARY

No solution can relinquish all the stormwater funding issues. Traditional funding is of the past, new options must be considered. The question of how local and regional authorities are to manage their infrastructure does require review on an holistic basis. The above examples are clear in their intention for providing a sustainable future for those persons wanting to develop and inhabit these built up areas and combat the ever present stormwater management issues.

QUESTION 4 - LINKAGES BETWEEN STATUTORY PRACTICE AND DISTRICT PLANNING

UNITED KINGDOM

In the United Kingdom (UK) Sustainable Urban Drainage (SUD) requires participation and the recognition that water is a finite resource that needs managing and protecting. Piped systems and the removal of natural waterways with culverts and channels are design legacies of the past. By understanding engineering techniques and combining an holistic approach to SUD, introduces waterways into the built environment, creating wildlife habitats and a community focus. This approach is totally compatible with that promoted by the Parliamentary Commissioner for the Environment in the 'Murky Waters and Ageing Pipes' document (Berry, 2002).

The SUD model from the UK is of value as the techniques and issues are applicable to New Zealand. New Zealand may follow this route as taken by many countries in establishing a more sustainable approach to drainage design. The effects of urbanisation on New Zealand's rivers and coastal waters can not be ignored, and integrated stormwater management strategies are required. Experience from other counties with improved strategies has produced cost savings against conventional drainage systems and significant benefits to the community economically and ecosystems environmentally. As Berry (2002) has concluded "A more creative and innovative approach to the design process is required away from the rigid constrains placed on conventional drainage systems."

The links between statutory practice and district planning are evident in the development control process. These processes are implemented and the last point where district councils are able to enable the regional planning documents. This example above in the UK has shown that sustainable development can be undertaken and provide the desired outcome.

QUESTION 5 - PLANNING AND LEGAL MEANS FOR IMPLEMENTING METHODS

Since World War II the global framework and market is being taken into account. It is important to find where New Zealand fits into this world picture. The recent past and current global and local legislative framework will be reviewed, relating to New Zealand's environmental legislation.

GLOBAL

As the 21st Century has brought about a more global community there have been many defining agreements that New Zealand has been involved in. These agreements aim to ensure a positive result for the global environmental movement. The key multilateral agreements that New Zealand has become a party too are as follows:

- The Framework Convention on Climate Change (1992) ratified 1993
- The Convention on Biological Diversity (1992) ratified 1993
- Convention for the Protection of the Natural Resources and the Environment of the South Pacific Region (1986) ratified 1990.
- Agenda 21 (1992)
- Declaration of Environment and Development (1992)

At the Rio Earth Summit (1992) the Declaration on Environment and Development identified 27 guiding principles for sustainable development. Four of these key principles are:

- intergenerational equity
- precautionary approach
- polluter pays and
- common global responsibilities.

Within this Declaration, Agenda 21 was drafted, as a plan for use by governments to implement the principles of sustainable development. Some of Agenda 21's main themes include *"reforming policies to bring together economic, social and environmental issues; controlling wasteful consumption and production; improving technologies to increase environmental quality standards; and integrating trade and the environment whereby environmental concerns are weighed against sustainable trade barriers".(Agenda 21, 1992)*

The Ministry of the Environment (2002) confirms that the RMA, Biosecurities Act and the Local Government Act are generally in accordance with Agenda 21.

NEW ZEALAND

The Resource Management Act 1991

The *RMA*as implemented in 1991, has taken off from its predecessor the Town & Country Planning Act 1976, its purpose to

"promote the sustainable management of natural and physical resources". (RMA,1991, 5.1)

The fulfillment of the RMA's purpose has been enabled through a series of central and local government departmental and legislation changes. These provide direct reporting for local, regional and central government. This has included the complete and continuing rewriting of the district plans dealing directly with development and land use application to provide succinct objectives, policies and rules at the local government level.

These mechanisms have come about with the full thrust of the *RMA*to promote sustainable use of resources in their entirety. This purpose goes into great detail to describe what sustainable management is:

"a)sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

b) safeguarding the life-supporting capacity of air, water, soil and ecosystems; and *c) avoiding, remedying or mitigating any adverse effects of activities on the environment." (RMA1991, II.5.2)*

This detailed description provides for the basis of New Zealand's central, regional and local government policies and plans to enable the purpose of the Act in its implementation. With this purpose and definition the direct relationship to the land use application in terms of the change in the legislation the local and regional councils were required to undertake and implement the drafting of objectives, policies and rules in their district plans to meet these purposes.

The State of New Zealand's Environment

In 1997 the Ministry for the Environment undertook a study entitled "The State of New Zealand's Environment" some of the key points in relation to the water of the Auckland Region are stated as follows:

"In urban areas, pressures on water come from increasing consumption and from sewage and stormwater discharges... Urban stormwater causes serious problems in some areas (eg. Auckland), polluting estuaries and harbours with sediment and toxic substances (eg. heavy metals and hydrocarbons derived from motor vehicles) and, in some cases, infiltrating and flooding sewerage systems. Stormwater quality is often similar to that of secondary-treated sewage." (MFE, 1997, Chapter 7,p6)

New Zealand Biodiversity Strategy

The New Zealand Biodiversity Strategy (2000) was formulated due to the decline in indigenous biodiversity in New Zealand, as outlined in the state of New Zealand's Environment Report (1997). The Strategy's purpose is to establish a strategic framework for action, to conserve and sustainably use and manage our country's biodiversity. The Strategy in relation to stormwater and waterway ecosystems can be summarised in the following goal "Goal Three:

Halt the decline in New Zealand's indigenous biodiversity." (MfE, 1997) This can be actioned through Theme Two – Freshwater Biodiversity, where the desired outcome for 2020 is that –

> *"land managers and communities continue to be actively involved in protecting and restoring freshwater bodies and habitats of special value to them." (Part III, p45)*

This clarity in statement for action directly relates to the importance emphasised by central government for the minimisation of environmental impacts in relation to the land use activities of carparks.

Auckland Regional Council Technical Publication 10

The Auckland Regional Council (2003) in their latest publication in relation to stormwater treatment devices has included the objectives for managing stormwater is set out under the technical objectives, they are:

> *"The primary water quantity objectives of treatment devised is to match pre-development and post development peak flow rates for the 50%, 10% and 1% Annual Exceedence Probability rainfall events. Where significant aquatic resources are identified in a freshwater receiving environment, additional water quantity requirements may be required." (ARC, 2003)*

This is a clear guideline that provides for the best planning and legal means for implementing methods to fit into the framework as provided by these governing bodies. These bodies are then able to enable the avoidance, mitigation and remedying of the adverse effects of carparking areas on the environment.

CHAPTER THREE - CASE STUDY, JELLICOE ROAD CARPARK, MANUREWA

INTRODUCTION

This case study relates to a carpark for a church in Manurewa. The church had purchased an adjacent lot being zoned Main Residential[18] and applied for an earthworks consent. The processing of the consent led Manukau City Council to impose a stormwater contribution for the upgrade of the catchment for the servicing of the stormwater as caused by the impervious surface being constructed. This contribution condition was then objected to on the premise that they were causing no adverse environmental effects. Section 108 of the *RMA*clearly allows for contributions to be imposed in lieu of works[19]. The objection was heard by the Manukau City Council Hearings Committee who prescribed an alternative solution involving a low impact design option to ensure the effects of the carpark are no more than minor. With the reduction in contribution the applicant was satisfied.

The proposal then went through a lengthy redesign process to find an engineering solution that would both hold the 1:5 year storm capacity for a 24 hour period and also provide some on site treatment. The carpark has been completed and provides for an all weather surface.

The purpose of this assessment and the use of a case study is to determine the relevance and nature of the problem that is existing under the current development directions by regional government. It also highlights the concerns that individuals face when approaching a council for consent to develop. The results show that a conclusion was reached and the carpark has been constructed. The question remains: was there a better way? Could the engineers or Council officers have found an alternative sooner and not had the lengthy process seeking a hearing under objection? These questions will be answered and relevant recommendations given.

[18] As under the Transitional & Proposed District Plans for Manukau City in 2001.
[19] This matter has been detailed as part of the literature review under legislation.

Site Description

The property is located on Jellicoe Road in Manurewa (refer Figure 3.1). Located approximately 3 km from Manukau City Centre and approximately 20 kilometres south of Auckland City centre. The area is generally made up of residential and light commercial premises, and scattered parks and reserves. The nearest waterway is the Puhinui Stream which makes up one of the largest catchments in the urban area for Manukau.

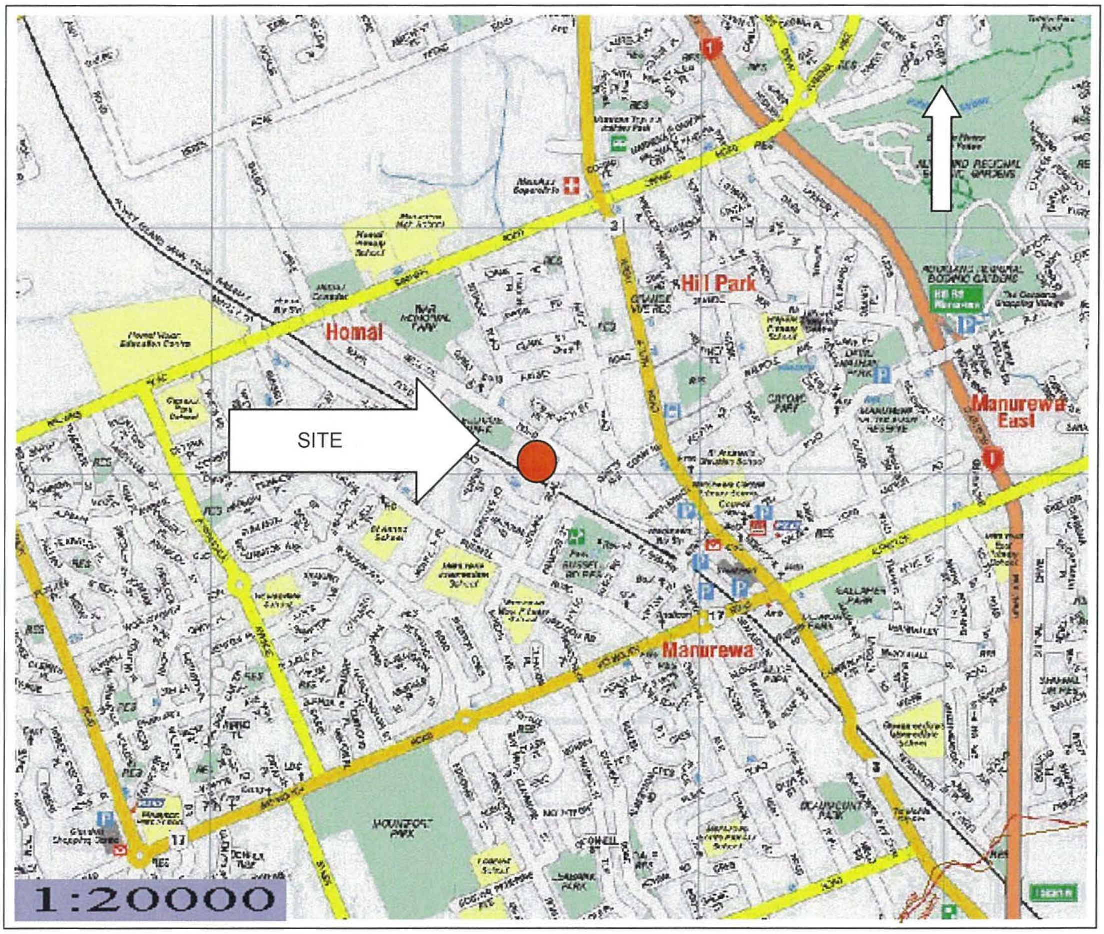


FIGURE 3.1 LOCATION OF SITE: JELLICOE ROAD CARPARK (MCC, 2003)

The site is located on a moderate through road connecting Browns Road to the north with Manurewa town centre to the south east. The North Island railway main truck line is adjacent to the site to the south west. On the site at present is a main church auditorium which was an old warehouse, and a residential dwelling. There are a few scattered trees and some smaller vegetation.

Historically the area has been developed in terms of past standard engineering practice. This practice was to pipe all developments stormwater, to the nearest waterway, discharging what ever went through those pipes. In this area, the compounding factor has been the push for higher density residential dwellings in a catchment that requires significant upgrade to service these higher density developments.

The stormwater catchments, as identified in Figure 3.2 clearly show that the infrastructure maintenance that services each line has been assessed and reflects the actual impact of development in the area.

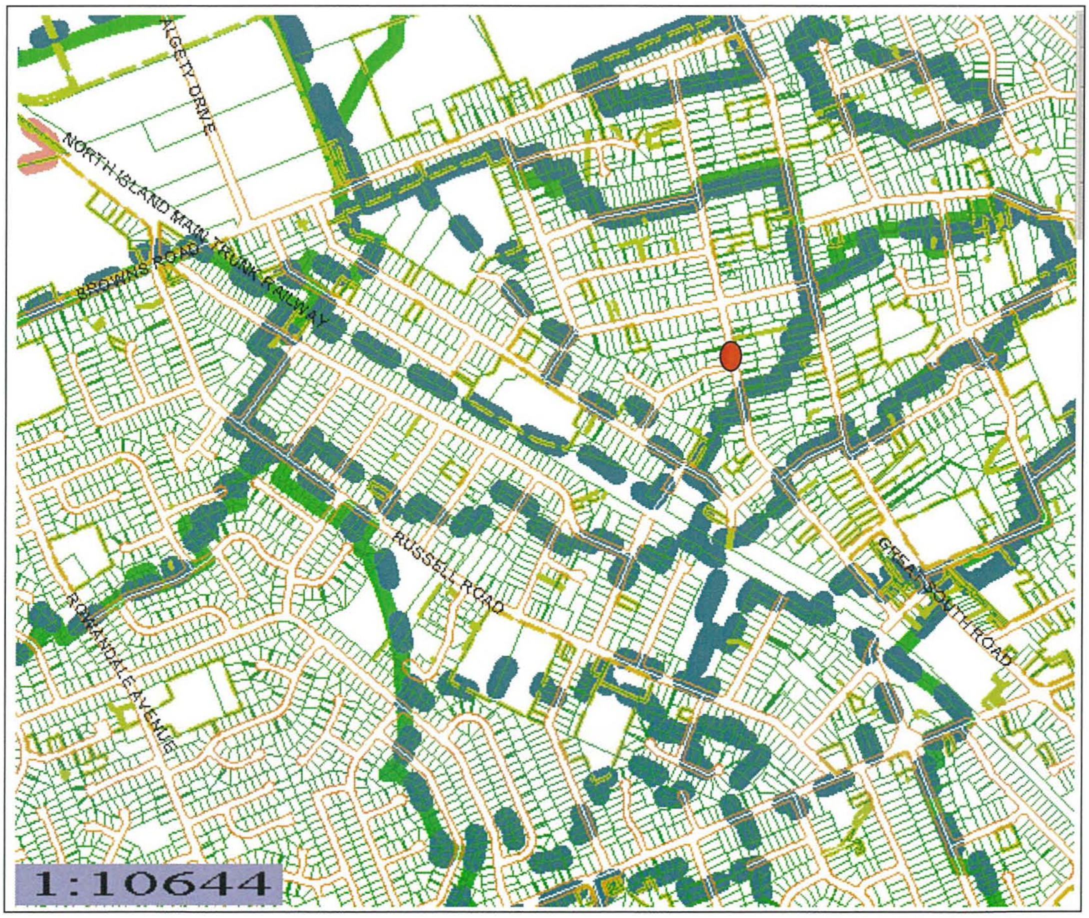


FIGURE 3.2 MANUREWA STORMWATER CATCHMENTS (MCC, 2003)

The existing stormwater services, as shown in Figure 3.3, are of a somewhat ad-hoc nature. The blue dashed lines show that the stormwater servicing does not connect to all lots in the catchment. Nor do these pipes provide satisfactory capacity for the volume of storm water proposed by the greater density proposed in the catchment.

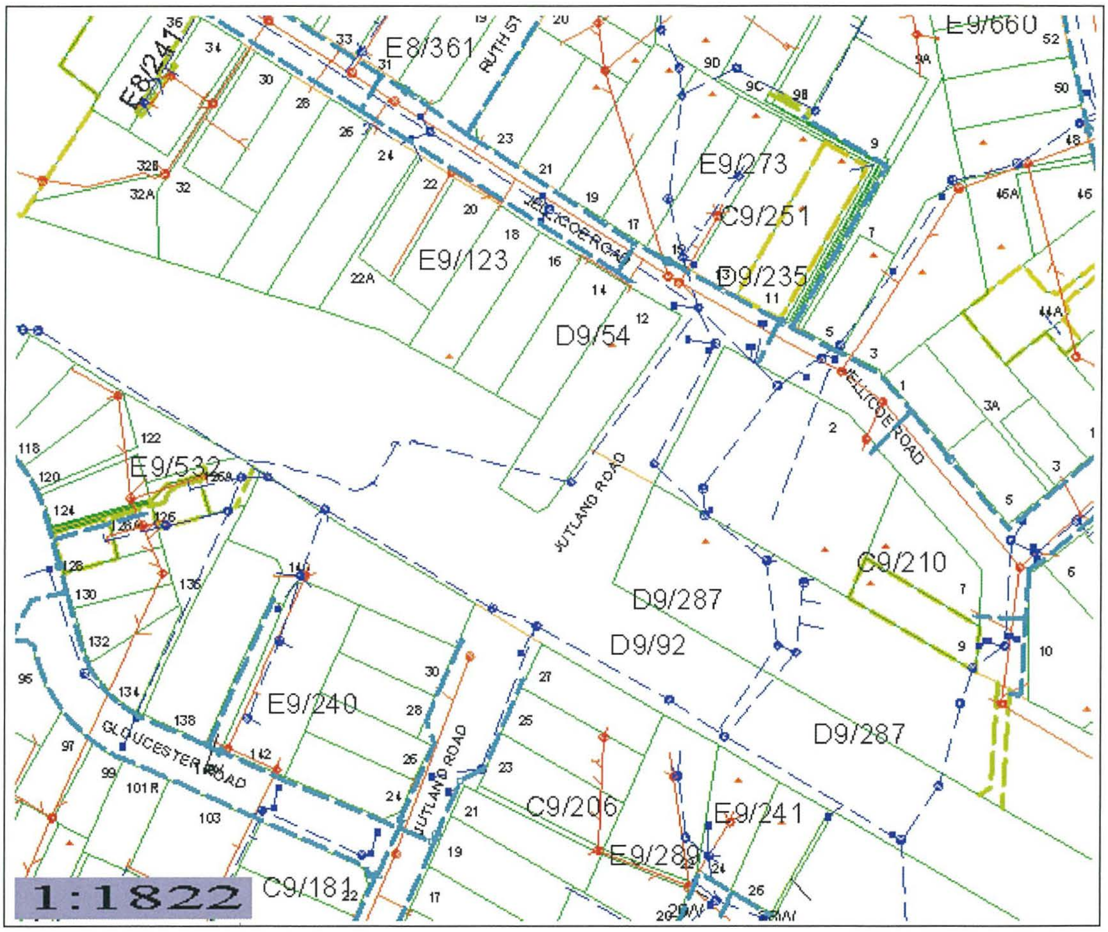


FIGURE 3.3 EXISTING STORMWATER SERVICES IN MANUREWA (MCC, 2003)

FIGURE 3.4 AERIAL PHOTOGRAPH SHOWING THE JELLICOE ROAD SITE (MCC, 2003)

Overview of Case Study

The carpark was required as the church required needed more onsite parking, to suit the District Plan provisions and the growing needs of the congregation. The standard construction design consisted of base course, compacted and seal on top. The church applied for consent, as the District Plan requires consent for onsite carpark and for earthworks over $200m^3$. During the processing it was highlighted that a stormwater financial contribution was required. This was because the downstream catchment capacity required upgrading, due to the increase in impervious surface being constructed. Consent was applied for and granted subject to a financial contribution.

The contribution required for the catchment is based on about $20,000 per additional building site. On a pro rata basis the carpark was to have a contribution of around $50,000. As the church had not accounted for this amount in their construction calculations, and the contribution now amounted to 50% of construction cost, alternatives needed to be considered.

Resource consent process

An objection to the decision to charge for the stormwater contribution was made to Council. Through the process of researching the objection it was found and advised that an alternative method for on site treatment and capacity could reduce the environmental impacts. Therefore the contribution could be amended to take account of any changes to stormwater impacts. The objection was heard by the Council's Hearings Committee, and determined, with advice from Policy Department, that an alternative method could be used. The newly redesigned car park was then constructed.

Stormwater Contribution Calculation

The calculation for stormwater is based on the catchment that feeds a property. This includes the costs associated with upgrading the catchment to a standard capable of maintaining and/or increasing environmental protection and flow capacity. These figures are calculated on a per additional building site basis, where potential developable sites in the catchment are earmarked for contributions. An assumption is made that 70% of the developable sites in the catchment will be developed (so the upgrading is not dependent on the last developed site). The cost to upgrade the catchment is divided by those sites stated above. The final charges are then submitted as condition of the Resource Consent to contribute to the costs.

Carpark Concept

Original proposal

The original carpark design as shown in figure 3.5 details the site, its orientation, the existing building and the area for proposed carpark. Figure 3.6 identifies the area of the existing carpark and the future carpark.

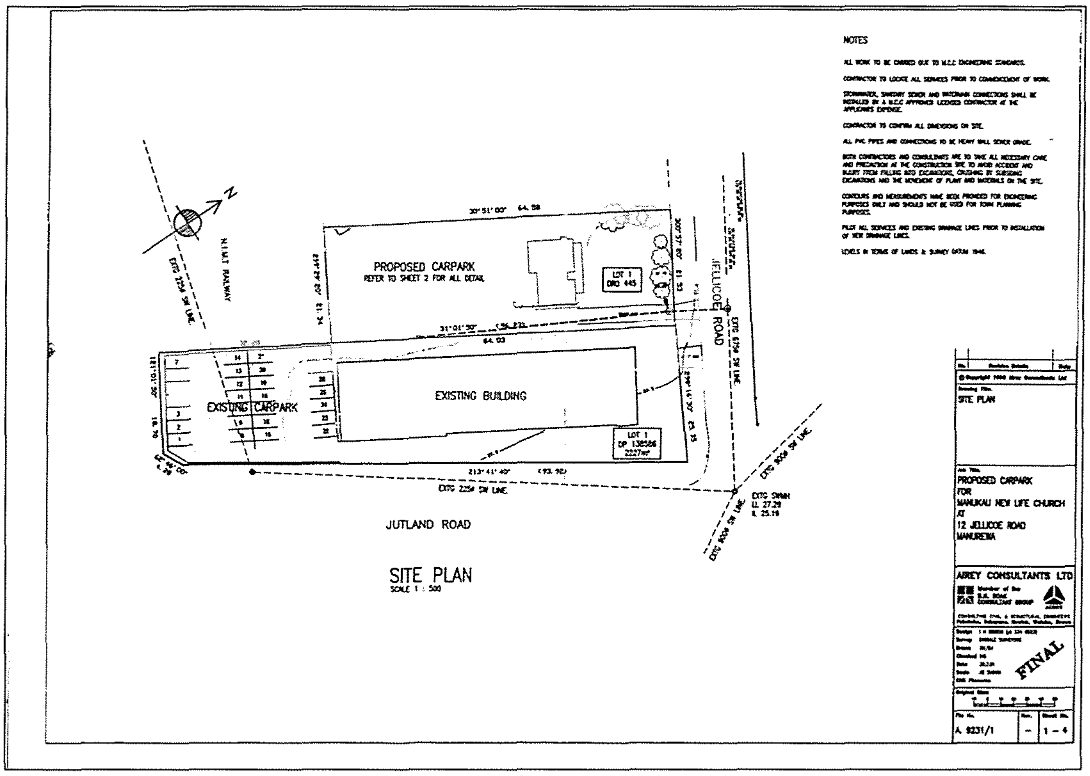


FIGURE 3.5 SITE LAYOUT AND ORIENTATION.

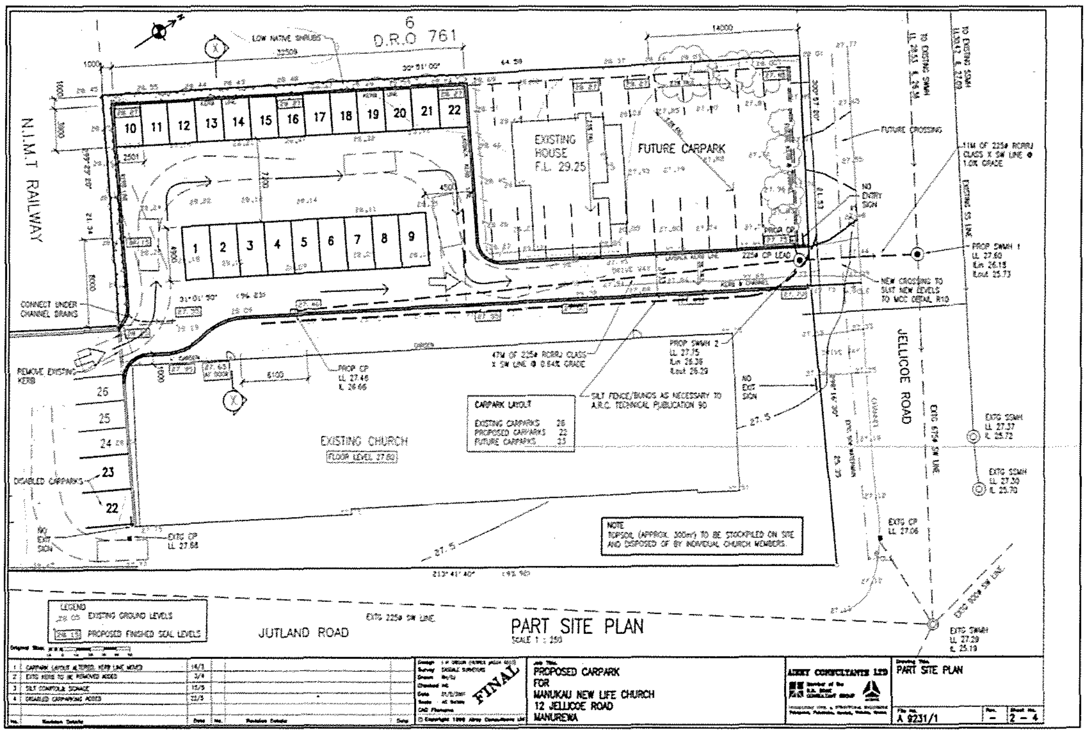


FIGURE 3.6 EXISTING AND FUTURE PARKING AREA

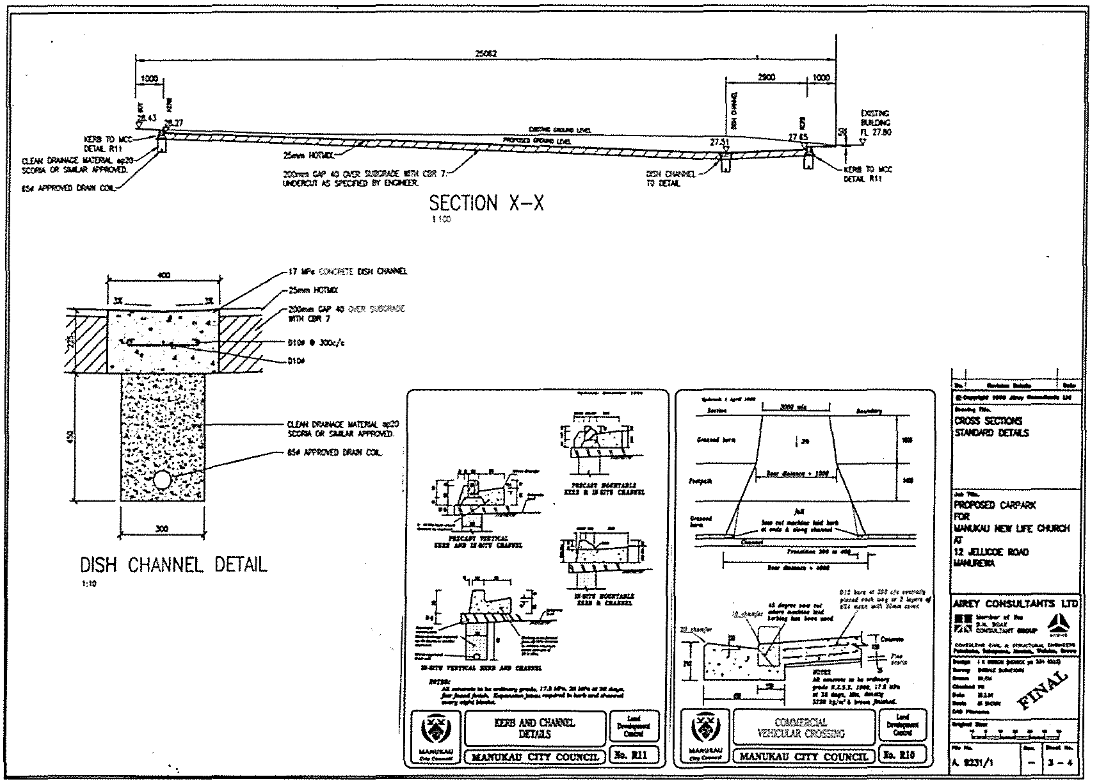


FIGURE 3.7 PROPOSED CROSS SECTION OF PAVEMENT AREA

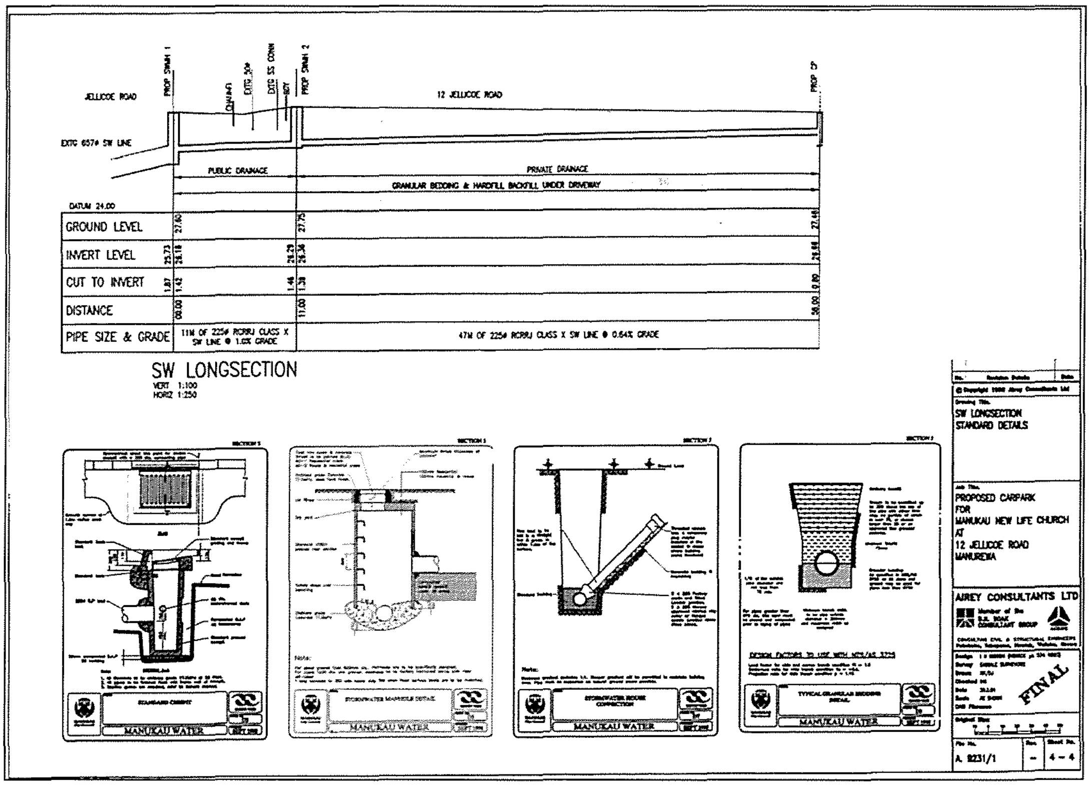


FIGURE 3.8 PROPOSED STORMWATER DRAINAGE CONNECTION

The Design Process

The process for the concept for the carpark was originally based on a no impact baseline. This meant that the proposed carpark was not to create any additional run-off or impact on the environment. This was determined through a consultative process with Manukau City Council stormwater policy engineers. Following are the two sides of the process, Council and the Applicant, detailing the best-fit situations.

The Council

Manukau City Council infrastructure policy engineers determined the following:

- The on site development required the site to be capable of storing water within its construct to minimise the loading on the downstream flow.
- The volume of storage, in practical terms, was to be that of a one in five year storm event which equated to a capacity of approximately ten cubic metres.
- With this volume set out over an area of a 30m x 20m rectangle, it would require a 400-500mm base of course metal.
- The next step involved the surface layer, which was required to be porous to allow for direct infiltration of the stormwater to the sub-base storage area.
- The carpark when finished was required to be safe and able to be used in the fashion any carpark could, with no risk to users.
- That there should be vegetation to assist in the absorption and filtration of the water in its storage environment.

The Applicants

The Applicants had the following constraints within which to proceed with their development on site.

- The current value of the development was $50,000. They were unable to spend more than this amount.
- The design must include the carparks extension in the future.
- There is to be a maintenance free surface (excluding the landscaping area).
- Payment for the stormwater contribution may be required to be split over two years.

Both Council and the Applicant's lists of outcomes and constraints were then put towards the applicant's engineers. Their task was to provide a concise, efficient system to enable both parties to be satisfied with the end result.

THE DESIRED OUTCOME

A hypothetical result if the carpark is designed to fit the aforementioned requirements is shown on the blue line of the graph of figure 3.9. This is representative of the delay of the stormwater as proposed by the storage capacity underground in the carpark. As the existing line shows, the catchment is subject to high volume flows after a storm event. The proposed carpark is required to hold this capacity for a 1:5 year storm and reduce the environmental impacts in comparison with a standard carpark.

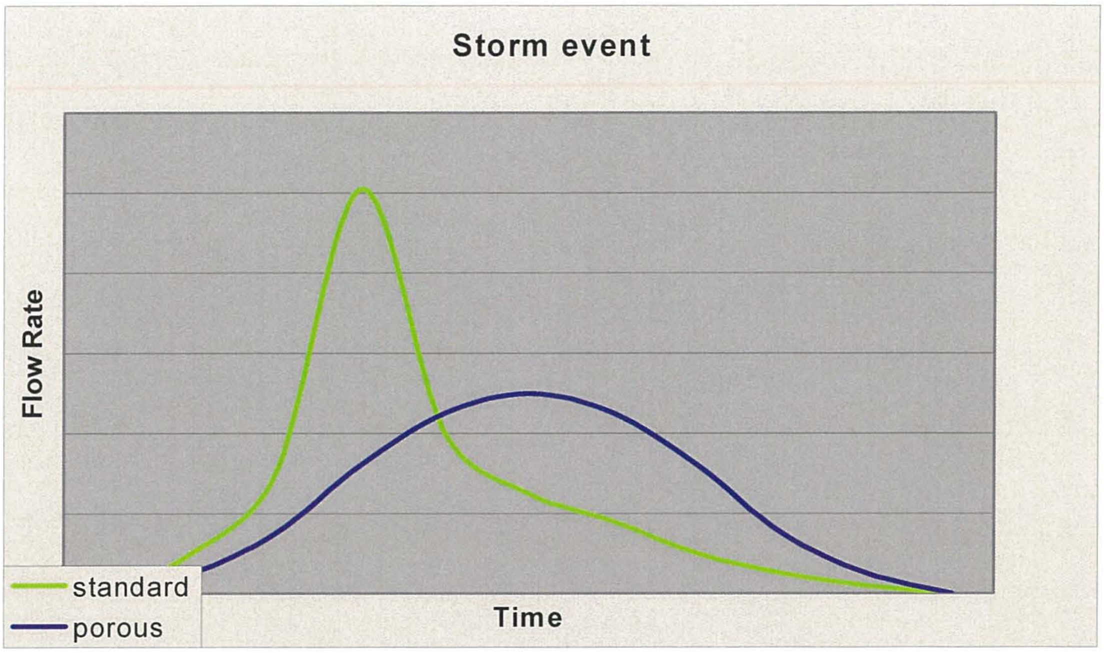


Chart 3.9 desired outcome for catchment

Investigating the Options

An investigation was undertaken to find a concept that had already been successfully used and could provide the desired outcome, as advised from the councils policy department. This was a difficult part of the process due to time constraints for the carpark completion and the cost of construction.

The options put forward to the Engineers acting for the Applicant were based on the Waitakere City stormwater information. They were taken from existing carpark designs. The first place to look for designs that could work for this carpark is within the Auckland Region itself. Waitakere City infrastructure unit, Ecowater, was contacted early on to locate successful projects they had undertaken and which options worked best. The guidelines[20] used were a key

[20] These guidelines can be found in Appendix Three.

component of the original concepts as proposed for a solution to this case study.

DRAFT CONCEPT DESIGN

The draft carpark concept was then put together to provide for all parties' needs. This was drafted by Council officers who then forwarded it onto the applicant's engineers, who were able to design the final carpark.

The proposed layout (figure 3.10) depicts the arrangement as proposed by the Council to the applicant. The key features of this design are that the parking area is to have a central drainage and filtration area. This could have been located in any position on site but here provides for the shortest distance from all the points in the area. The landscaping within the site is to provide amenity and treatment for the anaerobic water within the carpark.

The proposed drainage in the figures (3.10, 3.11 and 3.12) demonstrate the future and proposed areas of treatment, and the capacity within the area for the treatment to be undertaken and provide for both proposed and future areas. Figure 3.12 clearly displays the separation required for the drainage, so as to monitor the carpark's treatment capacity.

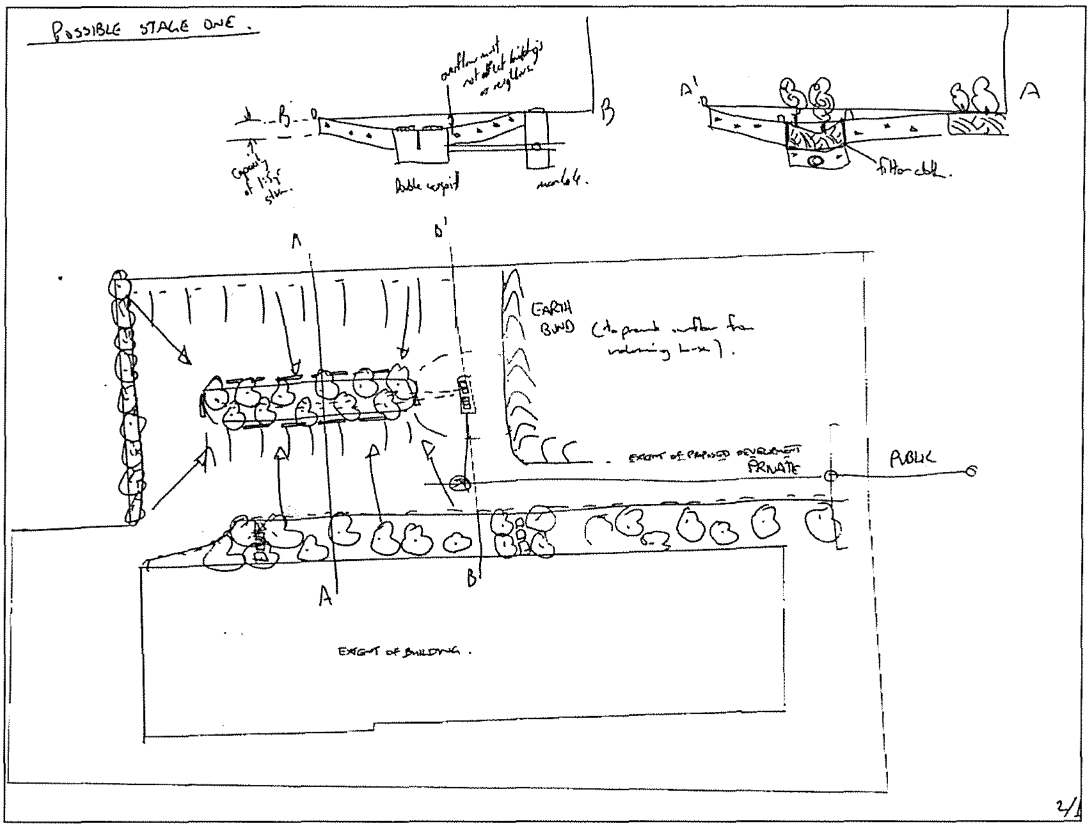


FIGURE 3.10 PROPOSED CARPARKING ARRANGEMENT BY COUNCIL

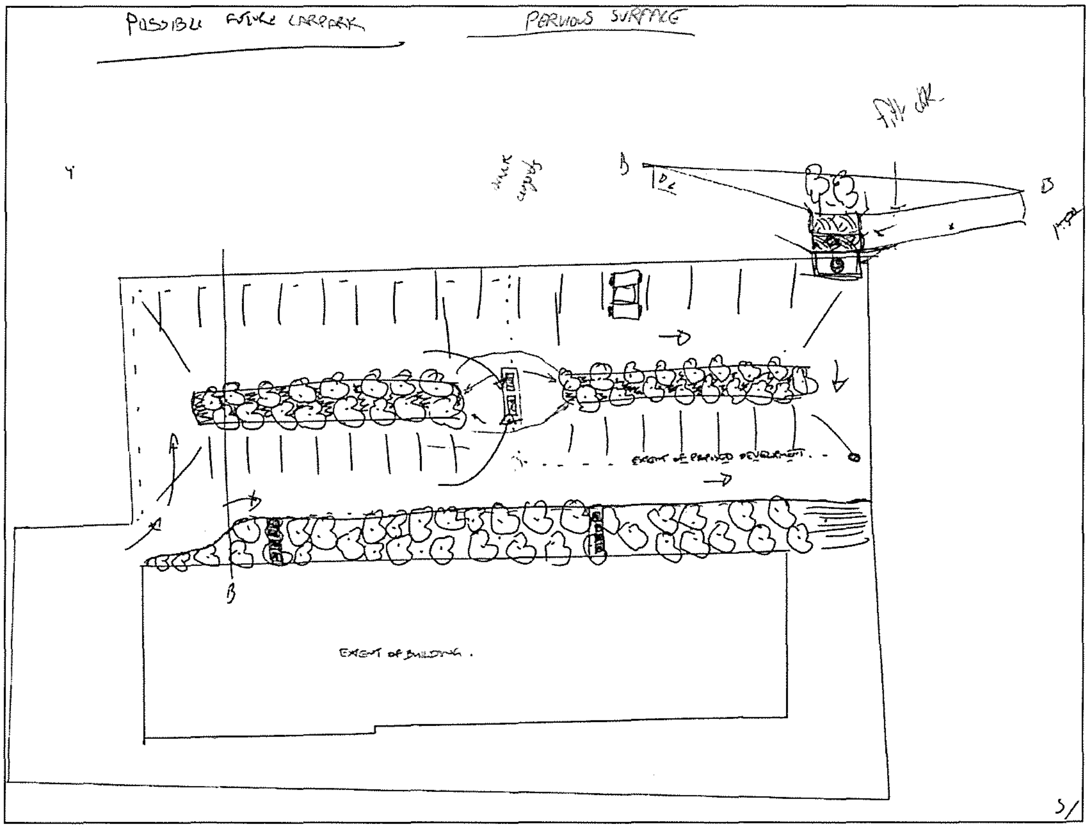


FIGURE 3.11 PROPOSED CARPARK INCLUDING FUTURE CARPARK EXTENSION.

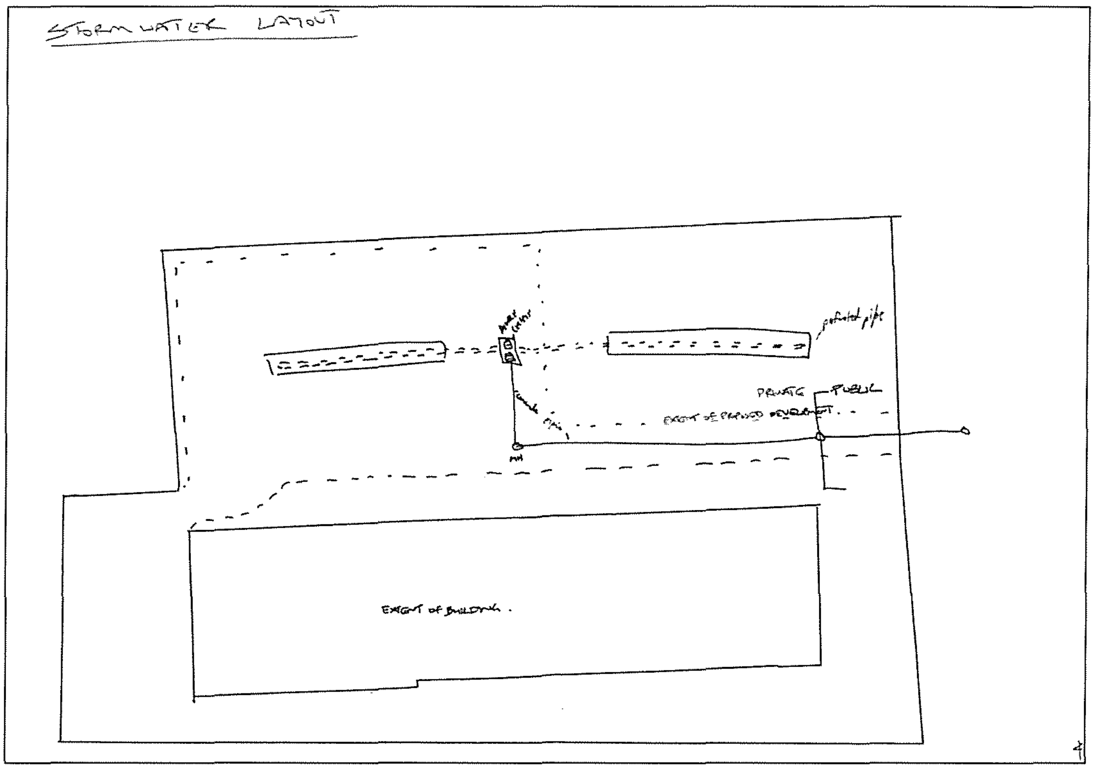


FIGURE 3.12 PROPOSED DRAINAGE

This diagram (figure 3.13) provides for the parking and a method for reducing the instances of vehicles driving onto the filter/planting area. The diagram, in the top right corner, shows the filter cloth and water level designed to treat the water suitably.

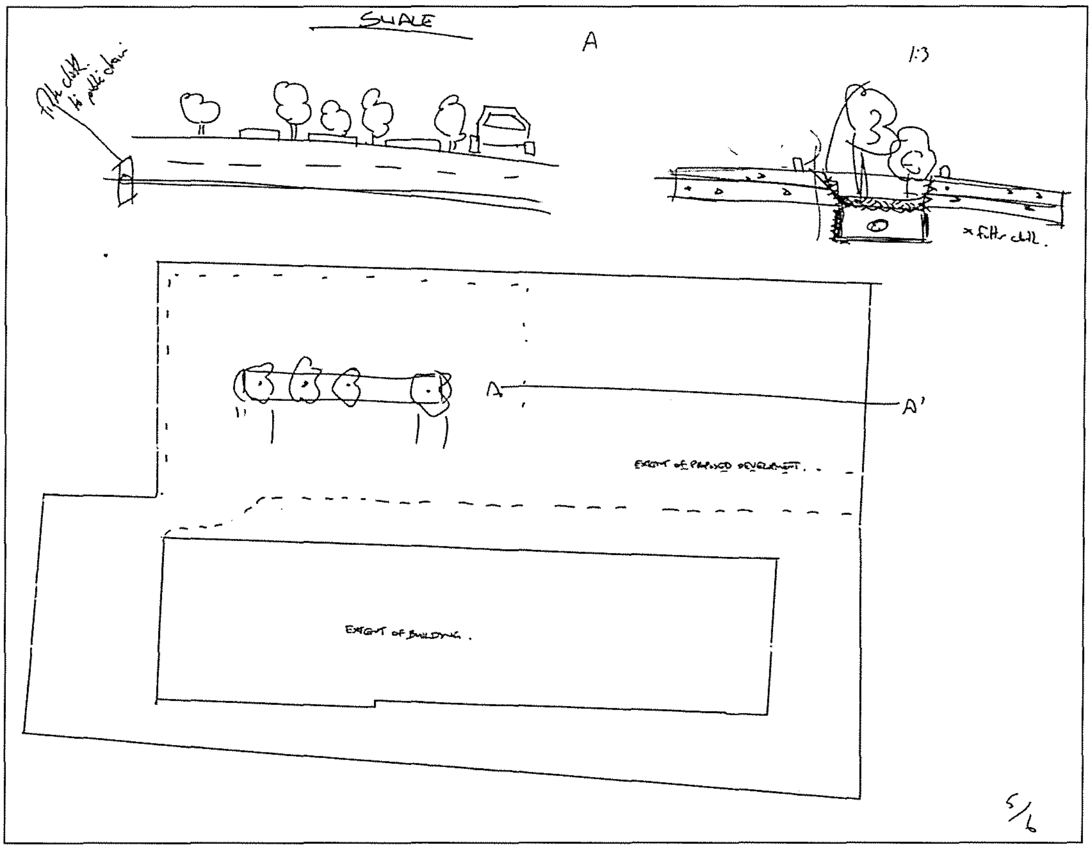


FIGURE 3.13 PROPOSED CROSS SECTION

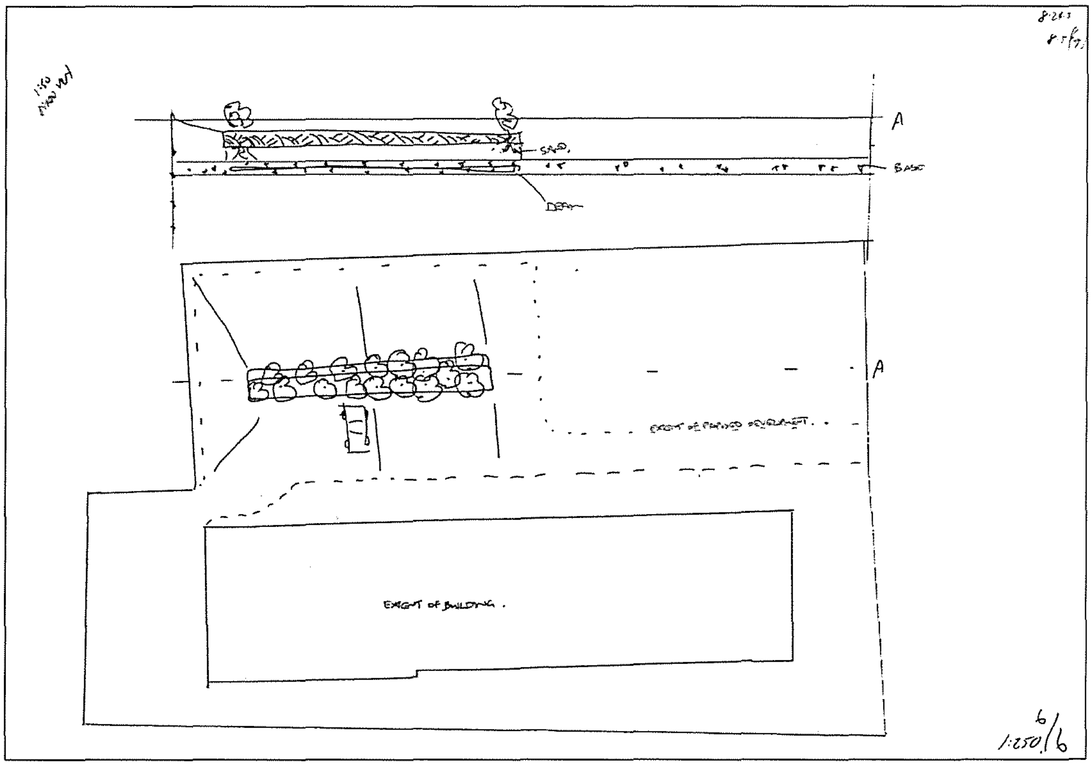


FIGURE 3.14 CONSTRUCTION SECTION

THE ENGINEERS DESIGN

The engineers reporting for the applicant proposed the following method for addressing the issues as outlined. They took consideration of the Waitakere design guide, and the draft as proposed by Council officers.

The design (figure 3.15) was provided by the engineers. This design meet the required criteria while keeping within the applicants budget. The design provided for the landscape treatment strip, the porous surface, and the base coarse provided for a high degree of voids.

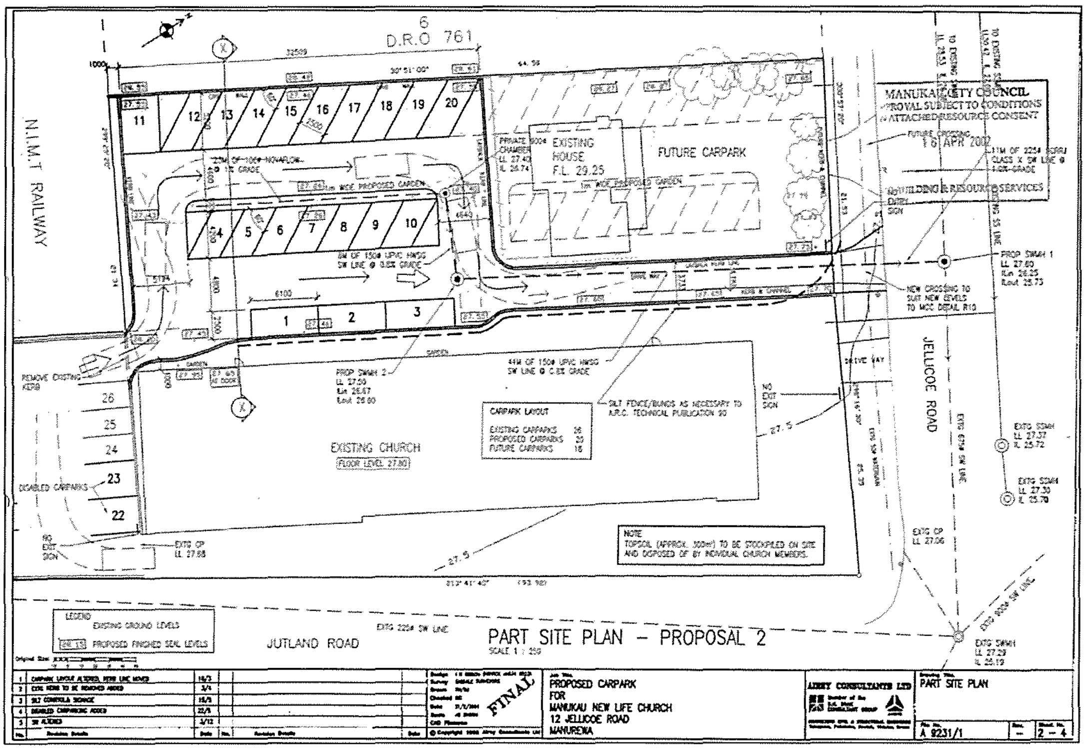


FIGURE 3.15 ENGINEERS PROPOSED LAYOUT/DESIGN

The diagrams (figure 3,15 and 3.16) provide for the Council requirements and show clearly the amount of detail required by the Council prior to approval. The landscaped area detailed provides for the multi-treatment of the run-off from the site.

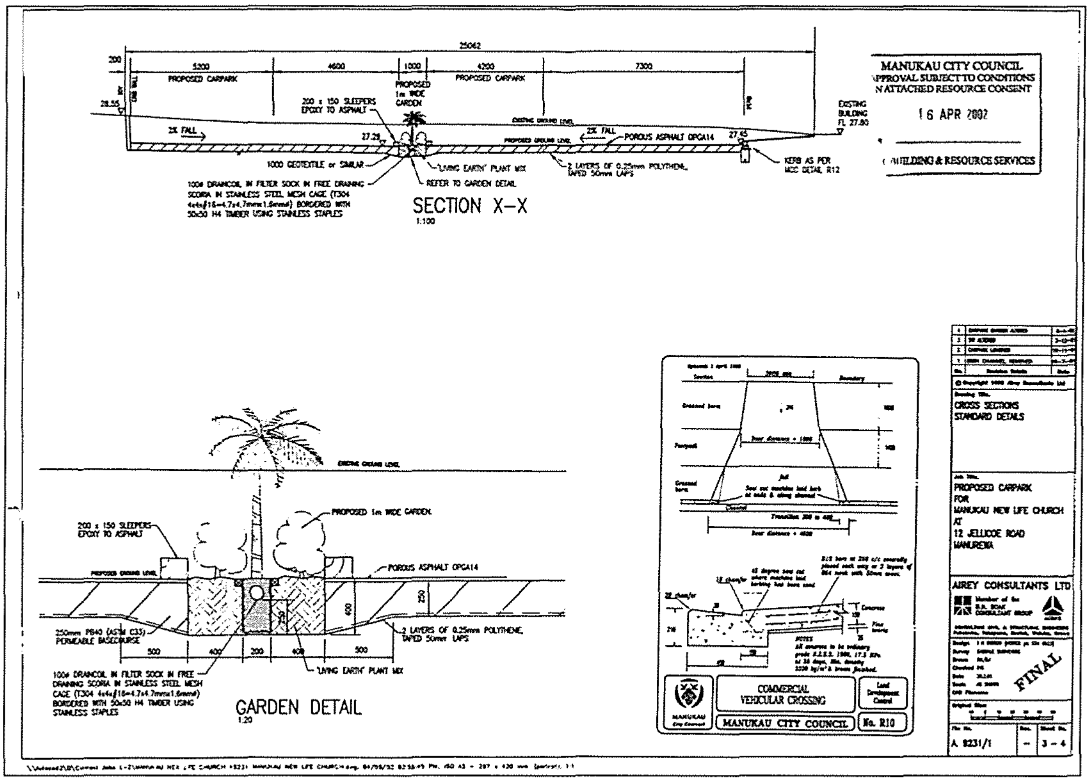


FIGURE 3.16 APPROVED CROSS SECTIONS

FINAL DESIGN

The Council approved the above final design (figure 3.15 and 3.16) as it met all considerations previously outlined. It required a landscape filter strip, aerobic and anaerobic treatment, and permeable asphalt for drainage. All parties agreed that this was a perfect ten out of ten as it satisfied all parties needs.

CHANGES TO THE APPROVED DESIGN

The applicant subsequently made many changes to the original design. MCC were satisfied these changes also met the criteria and so approved them. First, the removal of paving blocks that were key with their gaps for perviousness and the drainage to below the surface for treatment. This was because the applicants did not believe the porous fill would be stable. The amended approval included the use of concrete slabs with steel reinforcing.

A subsequent change was to remove the landscaped garden in the centre. The original approved design was for some vegetation to be situated in the middle to enhance the aesthetic appeal of the car park and to assist in the use of the water and cleaning of the water prior to discharge. However, when the carpark construction was put to tender there were no tenders received, as this type of permeable carpark had not been constructed before. There were issues raised about the asphalt staying consistent, and the sub-base being too coarse to hold together under compaction. A compromise redesign was agreed to by Council. The results can be found as follows in figure 3.17.

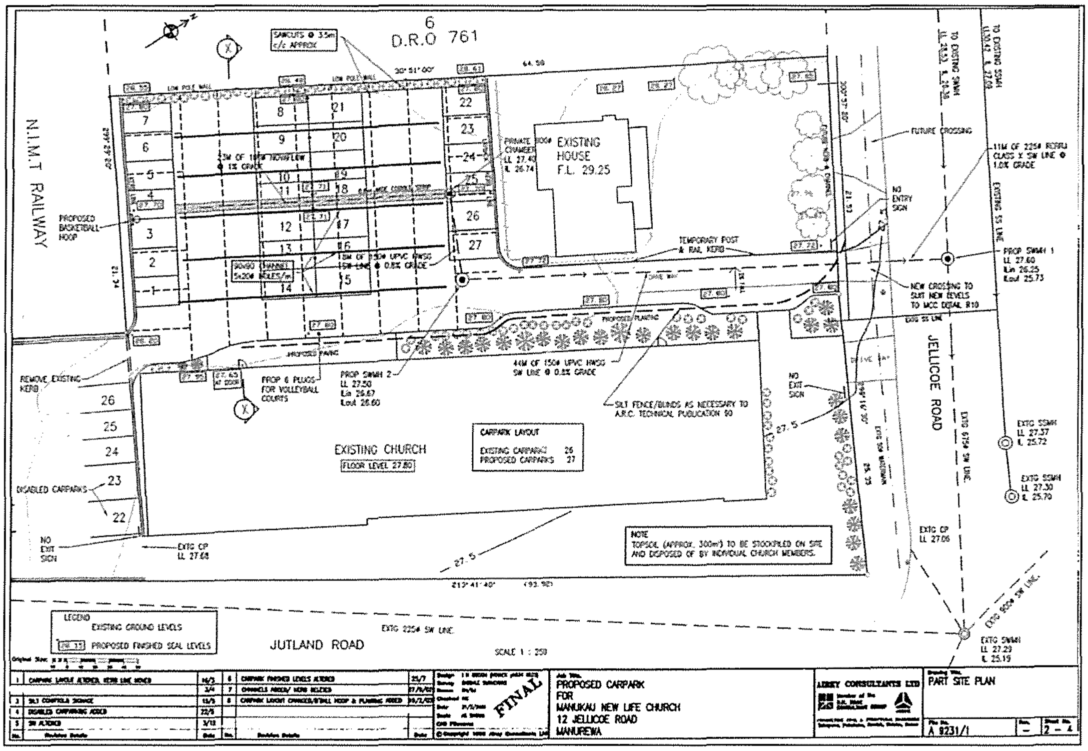


FIGURE 3.17 FINAL AS CONSTRUCTED.

The final layout (figure 3.17) as described previously, details the parking area with an elimination of the porous surface and the central treatment garden facility. The problems with this layout are that,

- There will not be the availability to connect to the future carparking area

- The accessibility of the drainage trench was reduced, requiring lifting of the central area
- The concrete surface with the drainage channels providing a means for run-off and filtration not quite as well as having the entire surface porous.

As can be seen in this design (figure 3.18) the base course storage capacity has remained, however the planted area and asphalt have disappeared.

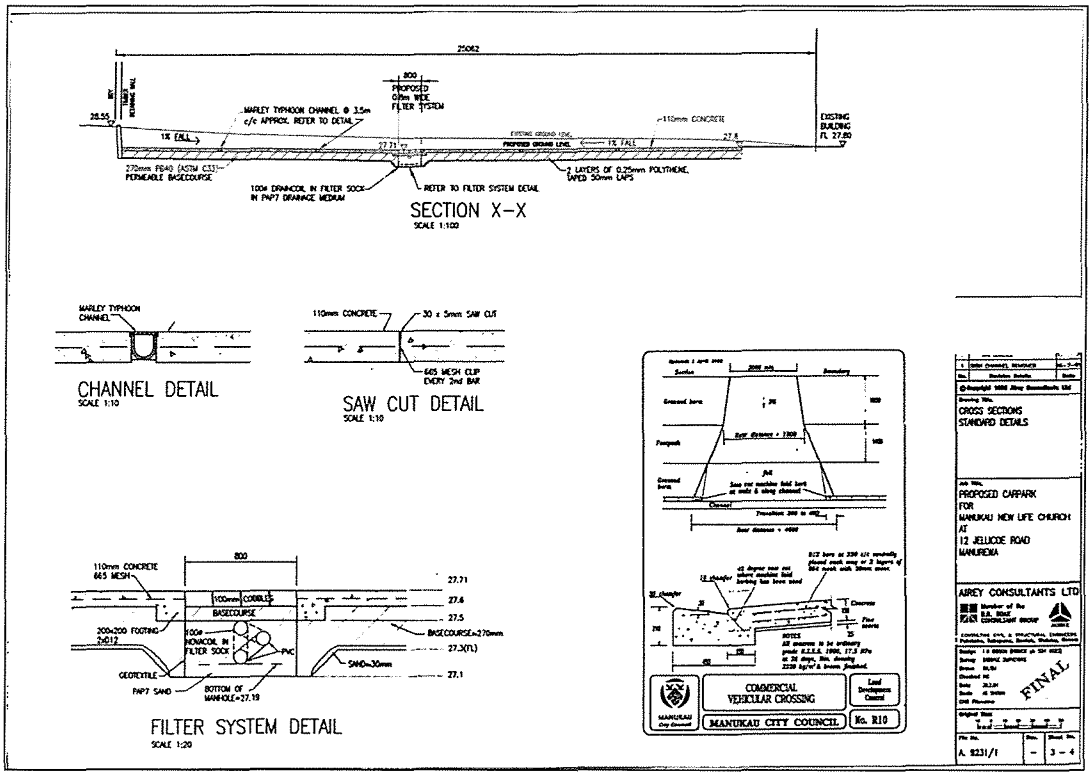


FIGURE 3.18 CROSS SECTION OF FINAL DESIGN

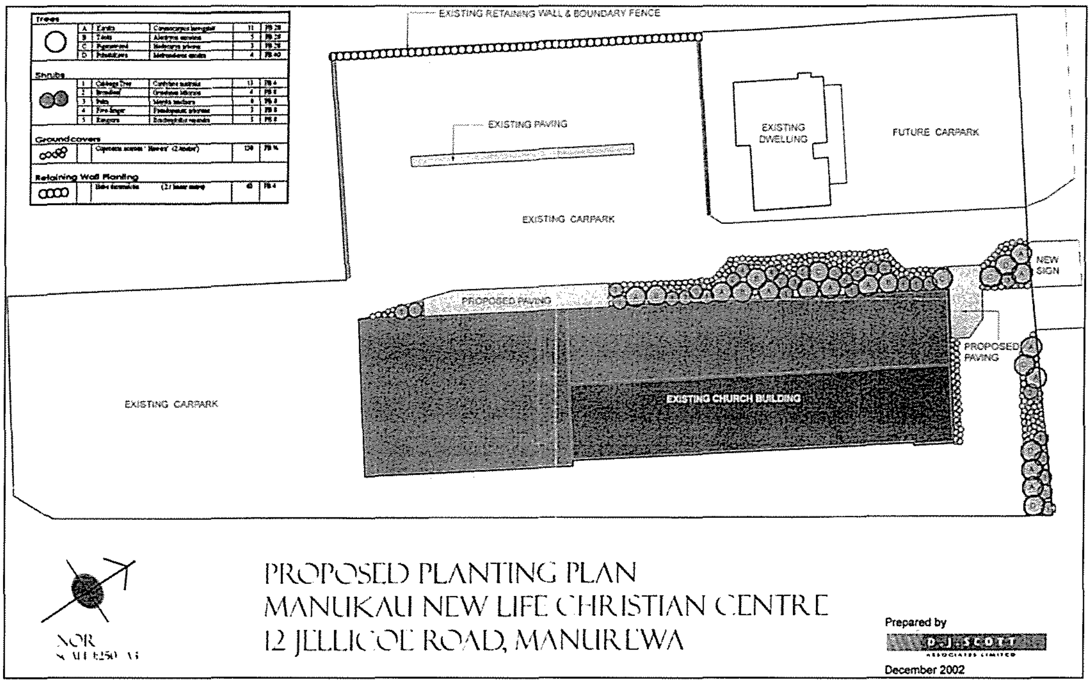


FIGURE 3.19 LANDSCAPE PLAN OOF FINAL DESIGN

CONSTRUCTION

The construction of the carpark was undertaken outside the original schedule, and was completed with the laying of concrete and installation of drains. The progress to completion can be seen in the following photographs (figure 3.20 to 3.25).

FIGURE 3.20 DRIVEWAY AREA BEING CONSTRUCTED.

FIGURE 3.21 DRIVEWAY AREA COMPLETED AND LANDSCAPED

FIGURE 3.22 CENTRAL AREA UNDER CONSTRUCTION

The main carpark area was constructed to enable the storage area for stormwater. These images show that the area was filled with 100-250mm of base coarse to provide the void area with which to hold the one in five year storm event.

FIGURE 3.23 CENTRAL AREA BEING CONSTRUCTED

FIGURE 3.24 CENTRAL AREA COMPLETED.

The central area, in providing for the filter drain and storage area was constructed with maintenance ability. The original concept included a vegetated area, which could easily be dug and maintained. The final constructed carpark has a similar easy maintenance standard, with the paving area being able to be uplifted when required.

FIGURE 3.25 COMPLETED CENTRAL AREA.

CONCLUSION

With this finished carpark the church is able to carry on with their daily and weekly use. The carpark has met most of the requirements as put forward by the Applicant and the Council. The key area that was satisfied was the capacity of storage under the carpark. It has met the Council's requirements to hold the stormwater from a one in five year storm event, which equates to approximately 16m^3 of water.

With the continual push for further intensive housing as outlined in the Auckland Regional Growth Strategy (ARC, 2000), cases such as this one have become common place. The question must be asked – When are the various Council's going to change their policies to provide a 'short-cut' system enabling the regional strategies? It must be hoped that this will happen in the near future. The Jellicoe Road carpark in Manurewa is not a one off happening. These situations are indeed common place within Manukau, and surely the greater isthmus area of Auckland.

RECOMMENDATIONS

The Jellicoe Road case study highlighted many issues with which to identify current practice in terms of catchment redesign and strategy in relating to infill developments. Councils and developers must formulate proactive design guidelines and process systems that can manage and provide a better solution to these problems. Research must be undertaken to guide and provide a best practice model for the Auckland Region where all regional and local councils are able to have a common strategy to confront their catchment capacity problems. Councils should be looking at their entire catchment resources and identifying potential solutions with each new development.

CHAPTERS FOUR & FIVE – CASE STUDIES

INTRODUCTION

The following case studies have been looked at in a concise format in order to assess actual practice in the "real world" as opposed to what seems best in the theoretical world. The two case studies I have chosen are Manukau City and Waitakere City. The examples assessed have been based on the historical developments and the more recent developments around each city area.

Manukau City was chosen, as it is one of the fastest growing cities in the country, with the highest rate of development. Waitakere City was chosen because it has a reputation for being "green" and "eco-friendly", and is associated with future thinking providing integrated developments of world renown.

METHOD OF ASSESSMENT

The method used for locating the following examples was a simple area survey driving around and locating obvious carpark and impervious areas. Sub-catchments or drainage areas were chosen that could have in-line storage or treatment facilities retrofitted.

The method selected for assessment of the chosen carpark examples is based on the following two design documents, and adapted to suit the assessment of these case studies.

Design guide document one is the "Low Impact Design Manual for the Auckland Region"[21] ARC, 2000. This document details the low impact design (LID) approach that is required to provide for a suitable low impact integrated environment for the end users. This report and assessment under chapter four of the technical publication has the purpose of providing:

[21] Technical Publication 124

"a vision for the environment, that is neither pro-development or anti-development. LID is based on the positive notion that environmental balance can be less impacted as new communities are developed through our catchments, if basic principles are followed" (ARC, 2000, p4-3)

The reduction in imperviousness in relation to stormwater management can provide a more sustainable environment. There is not an explicit set of stormwater management criteria in this section. It does however, detail roading areas to be reduce; kerbing to be reduced to limit capacity requirements for the stormwater system; and parking areas to be reduced or include swales or filter strips; to reduce imperviousness and some storage or treatment. Footpath areas and duplication should be reduced and the introduction of vegetation is desired (ARC, 2000).

Design guide number two is the "Stormwater Management Devices: Design Guidelines Manual", ARC, May 2003. This document is a review of the TP10, 1992 that has been in common use in Auckland. This report is very detailed and this complete revision provides for all Auckland stormwater needs. This document has been constructed meticulously and provides a blueprint for what Auckland needs to do to provide for a more sustainable city in the future. Chapter four of the document is entitled 'Choosing stormwater management devices' and has the following general requirements for devices:

Table 4.1 Criteria gained from Chapter Four ' Choosing stormwater management devices'[22]

Water quantity control, source control, physical structure
water quality control, treatment practices
aquatic ecosystem protection, options for treatment
stream channel protection
infiltration or low flow augmentation
site constraints
catchment area, soil type, slopes
contamination generation and removal processes
appropriate practice
device operation and maintenance
(ARC, 2003)

From the above two documents, TP10 and TP124, and their adaptable criteria for assessment, following assessment criteria have been selected. These criteria provide for the assessment of existing carparking systems and their effects on the environment with which they are located.

- Efficient use of area/site for parking/imperviousness
- Proximity to open watercourse/sea
- Adequacy to treat
- Adequacy to store
- Maintenance requirements
- Usability for persons/pedestrians
- Safety
- Approximate volume of traffic – high/low use
- Cost to construct or maintain
- Possibility of upgrade, retrofit to provide treatment/storage

[22] Summary of key points from assessment under Chapter Four of ARC Stormwater Management Devices: Design Guidelines Manual.

This data table below displays the assessment matrix used when undertaking the assessment of carparks. The table defines the criteria in the left-hand side and the right side shows the options. These were initially used however were translated into numbers for construction of graphs for analysis.

Table 4.2 Assessment method data table

Efficiency	Low – Medium – High
Near waterway	Close – Medium – Far
Treatment	Yes, details - Nil
Storage	Yes, details - Nil
Maintenance	Low – Medium – High
Usability	Low – Medium - High
Safety	Low – Medium - High
Traffic volume	Low – Medium – High
Cost	Cheap – Standard – Expensive
Upgradable	Opportunities for modifications, large or small that could provide an improvement to stormwater quality or retention.

CASE STUDY TWO - WAITAKERE CITY

This case study goes through some recent and existing developments that have been undertaken in Waitakere where nothing or little has been done to provide for the contaminant treatment or flow mitigation of stormwater. The discussion will cover the current policy methods and contribution regimes as their recent policies indicate. It should be noted that some parties to mitigate the effects of the proposed development have provided suitable outcomes for the general users and the environment.

PART 1: CASE MATERIAL

The sites chosen were selected from identified business zoned in Waitakere City to cover a cross section of current carparks and treatment facilities in use or constructed. This assessment below was not undertaken to define or overview all Waitakere City carparks but rather obtain sufficient examples to test the criteria chosen for assessing carparks.

In Waitakere the sites that were found were located in public use areas such as Westgate shopping centre, public facilities, schools, business sites and churches.

SITE 1 - WESTRIDGE PARKING AREA

FIGURE 4.1 WESTRIDGE CARPARK

Table 4.3 Westridge Carpark assessment	
Efficiency	Low
Proximity to waterway	Close
Treatment	Nil
Storage	Nil
Maintenance	Low
Usability	High
Safety	High
Traffic volume	Low
Cost	Standard
Upgradable	This facility could be upgraded. Slots could be placed in the lower side of the kerbing and the grass area down hill could be re levelled to allow for overland flow. The drain could be blocked. This would provide primary treatment and reduce the flowrate of the run-off.

SITE 2 – MASSEY HIGH SCHOOL DROP OFF ZONE

FIGURE 4.2 MASSEY HIGH SCHOOL

Table 4.4 Massey High School drop off Zone	
Efficiency	Low
Proximity to waterway	Far
Treatment	Nil
Storage	Nil
Maintenance	Low
Usability	High
Safety	High
Traffic volume	High
Cost	Normal
Upgradable	This could have a treatment facility placed on the down hill side of the area. It is clear from the photo (figure 4.2)

	above that there are gardens and other possible detention and treatment facilities that could be modified with some work. This could provide for ground water infiltration in addition to storage

SITE 3 – MASSEY PUBLIC LIBRARY & COMMUNITY CENTRE

FIGURE 4.3 MASSEY PUBLIC LIBRARY

FIGURE 4.4 MASSEY PUBLIC LIBRARY DRAIN

Table 4.5 Massey Public Library	
Efficiency	Moderate
Proximity to waterway	Close
Treatment	Moderate – The facility is designed with paving on the downhill slope. However in peak flow this will not have any treatability. When the first flush occurs it will sweep the surface silt and contaminants down the stormwater drains as is visible in figure 4.4.
Storage	Low –The storage would occur in the basecoarse of the paving area. This, in low flow rainfall events would let some water seep through to the basecoarse.
Maintenance	Moderate – Low. This facility will have higher than normal maintenance because paving has a shorter life. If however, the paving was laid with perfect accuracy, then the product and design would have the possibility

	to last as long as a standard facility.
Usability	The carpark is very usable. The surface is not perfect, although the change in material from seal to paving is obvious. This allows usability for both parking and walking.
Safety	High – Moderate. This design provides a high safety element. Although if the paving were to be undermined or altered then this could present some problems for pedestrians.
Traffic volume	Moderate
Cost	Normal – high
Upgradable	The facility could be modified to block and pool the water at peak flow to allow drainage through the paving area. This however would cause ponding and may cause erosion. Ponding would provide nuisance to pedestrians or children.

SITE 4 – ST PAULS KINDERGARDEN. WAIMUMU ROAD

FIGURE 4.5 WAIMUMU ROAD CARPARK FOR ST PAULS KINDERGARTEN

Table 4.6 St Pauls Kindergarden Assessment	
Efficiency	Low
Proximity to waterway	Far
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	High
Safety	High
Traffic volume	Low – Moderate
Cost	Normal
Upgradable	With the construction and excavation of soakage gardens for vegetation and primary on site treatment

	the facility could provide a highly attractive outlook and also have a treatment and/or pooling area.

Site 5 – St Pauls School, Don Buck Road

Figure 4.6 St Pauls chool Don Buck Road

FIGURE 4.7 ST PAULS SCHOOL, SWALE

Table 4.7 St Pauls School Carpark assessment	
Efficiency	High
Proximity to waterway	Far
Treatment	High – The use of swales provides a high degree of treatment in accordance with current best practice.
Storage	The swale area provides a low flow environment and thus allows some ponding to store the water flow and limit flow rate.
Maintenance	Low - Moderate. The only maintenance element is the swale area, where regular checking and mowing of the grass to ensure it is catching the water effectively.
Usability	High – no limitations to vehicles and pedestrians
Safety	High

Traffic volume	Low - Moderate
Cost	Low – Normal. Based on the assumption that the carpark was required anyway, and the cost of drainage was reduced by not requiring such a significant network of pipes.
Upgradable	The only recommendation possible is to provide more substantial planting in the swale area that could limit the flow and still have the ability to treat the water..

SITE 6 – MASSEY IN-LINE TREATMENT/STORAGE PONDS

FIGURE 4.8 WESTRIDGE IN-LINE PONDS

FIGURE 4.9 MASSEY IN-LINE PONDS

Table 4.8 Massey in-line at Westgate assessment	
Efficiency	High
Proximity to waterway	Close
Treatment	High – Removal of silt
Storage	High – Designed to limit flow in peak times
Maintenance	Moderate – High. Dependant on monitoring program, may require regular clearing of silt for disposal.
Usability	N/A
Safety	N/A
Traffic volume	N/A
Cost	Costs are substantial and will be proportional to the catchment size
Upgradable	Possibly through other in-line features such as wetlands and by moderation of flows at source in the contributing sub-catchments.

SITE 7 – SHOPPING CENTRE CARPARK BUILDING

FIGURE 4.10 WAITAKERE MALL PARKING BUILDING

Table 4.9 Waitakere Parking Building	
Efficiency	High
Proximity to waterway	Close
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	High
Safety	Moderate
Traffic volume	High
Cost	High
Upgradable	Nil

SITE 8 – WAITAKERE PAK'N'SAVE

FIGURE 4.11 WAITAKERE PAK'N'SAVE

Table 4.10 Waitakere Pak'n'Save	
Efficiency	Low
Proximity to waterway	Close
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	High
Safety	High
Traffic volume	High
Cost	Normal
Upgradable	The construction of the carpark adjacent to a stream

	should have included a filter strip or sand filter built into the carpark. A porous surface would be ideal, but at this stage upgrading could only include ancillary facilities between the carpark and the waterway. Swales could be fitted along the front of parking areas with retrofitting of under drains in swales connected to existing reticulation

SITE 9 – HENDERSON, BEHIND SHOPPING AREA

FIGURE 4.12 HENDERSON SERVICE LANE AND PARKING

Table 4.11 Henderson Service Lane Assessment	
Efficiency	Low
Proximity to	Close

waterway	
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	Medium
Safety	Low
Traffic volume	High
Cost	Low
Upgradable	The site could be sealed to reduce current high levels of silt that will presently be draining into the waterway. With sealing and a filter component in-line would be most the appropriate. The area is high use for commercial activity and therefore a large pond or wetland system would seem inappropriate. Regrading of the parking area and the provision of swales with under drains and overflow devices. Permeable basecoarse for storage with some infiltration to groundwater although the clay soils will limit infiltration rates.

SITE 10 – PLANT RETAIL OUTLET IN THE RURAL AREA

FIGURE 4.13 ENTRY TO PLANT SHOP CARPARK ON RURAL SITE

Table 4.12 Plant Shop Carpark Assessment	
Efficiency	Low
Proximity to waterway	Far
Treatment	Nil
Storage	Nil
Maintenance	Low
Usability	Medium
Safety	Medium
Traffic volume	Low
Cost	Low
Upgradable	With the construction and excavation of soakage

	gardens for vegetation and primary on site treatment the facility could provide a highly attractive outlook is available for a treatment and/or pooling area.

PART 2 : PLANNING AND LEGAL PARAMETERS

COMPREHENSIVE URBAN STORMWATER MANAGEMENT STRATEGY AND ACTION PLAN

The Comprehensive Urban Stormwater Management Strategy and Action Plan (WCC, 2001) sets out the Waitakere City Council's approach to managing the City's stormwater over the next twenty years. It is intended mainly for Council staff for key external stakeholders and for members of the community with an interest in sustainable stormwater management.

The Strategy states that in the past, adverse environmental impacts on the receiving waters and aquatic eco-systems were often overlooked. The management of water quality was centered on controlling industrial discharges without consideration of either pollution from smaller, more diffuse sources such as roads, houses and agriculture or the benefits of good urban design.

Because Waitakere is a rapidly growing city, a major focus of the Strategy is preventing future problems through design of new development and its stormwater management systems. An additional challenge with the limited resources available, is rectifying problems arising from past methods that have proved inadequate.

The integration of best practice catchment management principles, excellence in rural and urban design in both new and established areas, and community and business involvement and education programmes, is stressed as important for the successful management of stormwater needs in the long-term.

This Strategy sets out Waitakere City Council's vision for holistic management of stormwater in conjunction with iwi and the community. The Strategy:

- sets out a vision for sustainable stormwater management
- summarises the issues
- identifies key internal and external stakeholders

- describes the national, regional and local policy and management framework
- sets out goals and objectives
- outlines policies
- establishes priorities
- outlines options and implementation methods
- establishes monitoring measures
- assesses costs and benefits

The Strategy reflects the legislative and strategic context (regionally and nationally), the iwi perspective and the Council's own strategic direction. All point to the need for a more holistic approach to stormwater management recognising the need for total water-cycle management and ensuring that adverse environmental effects are avoided, mitigated or remedied. The support of iwi, key stakeholders and the community is described as being essential to achieving the sustainable objectives.

One of the main aims of the Strategy is to ensure that the Council's diverse areas of expertise continue to be involved in sustainable stormwater management. The Strategy identifies the issues, values and opportunities associated with stormwater quality and quantity. It sets the direction and priorities for implementation that will enable Council to address these issues over the next twenty years. In order to devise appropriate stormwater management this includes:

- The type of issues and community uses in each stormwater management unit
- The classification of the stormwater management units and their coastal receiving environments according to their sensitivity and ecological value.

This information has then been brought together to prioritise the stormwater management units for the purposes of programming comprehensive stormwater catchment management plans and funding allocation for capital works. The information collated includes:

- loss of habitat quality and quantity
- point source contamination of water
- non-point source contamination of water
- flooding
- accelerated erosion and land instability
- land development potential
- altering the natural water balance
- existing stormwater infrastructure
- community use

The Strategy concludes with a detailed summary of objectives, policies, explanations and implementation methods for each of the identified stormwater-related issues. These will then be applied to the catchments in their order of priority.

PART 3 FINANCIAL METHODS

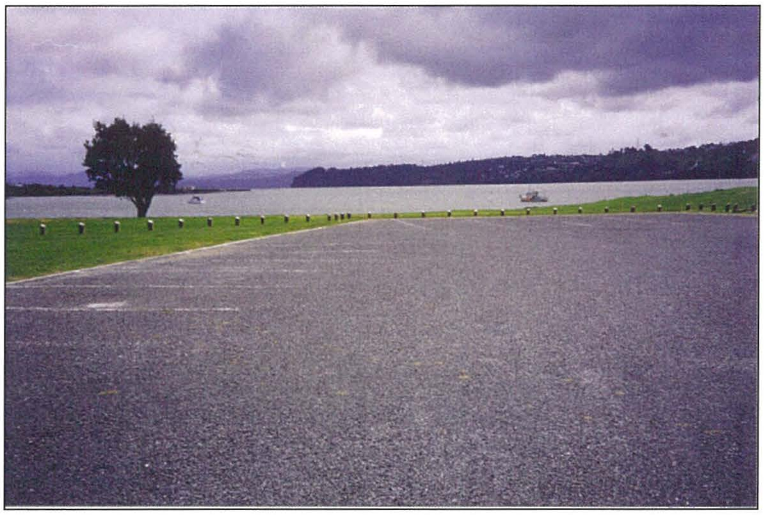
In Waitakere City, EcoWater Solutions has the responsibility for ensuring that these water related services are designed, constructed, maintained and operated so that residents receive quality, efficient stormwater services via commercially viable and environmentally appropriate systems. The costs involved can be lump sum payments toward the cost of existing or future services known as Developer Contributions, to payments towards the upgrading costs associated with the reconstruction of existing reticulation networks and the provision of new reticulation (WCC, 2003).

The existing City networks were originally placed and sized to facilitate the development of $1000m^2$ sections. But the development to densities higher than this have been allowed under the current district plan, causing a necessary upgrading of those systems, thus developers are charged a proportionate share of those costs. The Developer Contributions are set on a catchment basis because in older areas, the networks were not designed for development to the higher densities that apply today.

Rather than stop development until the pipe capacity exists, developers are advised of an apportioned cost calculated as follows: On the total cost to upgrade; divided by the total number of properties at Maximum Probable Development to permitted densities. By virtue of the above method, existing houses are not levied, except through general rates, and the Council carries the cost of upgrading for them, while the cost of the new development falls to the developer (WCC, 2003).

When more intense development is proposed than the permitted category, the effects of development will be mitigated, either by agreed works on or off-site, or by contribution to off-site mitigation works. The charges are calculated and documented generally for water, wastewater and stormwater systems within the Asset Management Plans. These plans also contain information on EcoWater's predictions for development rates (for example, the time it will take to recover costs which is an interest component of the charges) and other details as required for the calculation of the charges (WCC, 2003).

CHAPTER FIVE - CASE STUDY 3 - MANUKAU CITY



This case study goes through some recent and existing developments that have been undertaken in Manukau where nothing has been done to provide for the contaminant treatment or flow mitigation of stormwater. The discussion will cover the current policy methods and contribution regimes as their recent policies indicate.

PART 1: CASE MATERIAL

The chosen sites in Manukau City have been selected from a range of private shopping centre areas, council owned facilities, churches, public open space reserve areas and businesses. These sites have been assessed listing the same criteria as the Waitakere sites.

SITE 11 – CLENDON SHOPPING CENTRE

FIGURE 5.1 CLENDON SHOPPING CENTRE

FIGURE 5.2 CLENDON CARPARK VIEW TO WEST

FIGURE 5.3 CLENDON CARPARK VIEW TO NEW WORLD

Table 5.1 Clendon carpark	
Efficiency	Low
Proximity to waterway	Moderate
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	High
Safety	High
Traffic volume	Moderate – High
Cost	Normal
Upgradable	The carpark could be modified to provide a more substantial facility whereby the drainage is centralised, without the underground drains. The outfall could have a primary treatment facility, a sand filter or rain garden and a discharge to a swale.

SITE 12 – CLENDON RECREATION CENTRE

FIGURE 5.4 CLENDON REC CENTRE

Table 5.2 Clendon Recreation Centre	
Efficiency	Moderate
Proximity to waterway	Moderate
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	High
Safety	High
Traffic volume	Moderate – High
Cost	Normal
Upgradable	This facility could utilise the public open space near by and provide a swale or planted rain garden and

	ponding area to limit contaminant discharge and also store flood volume waters. A simple overflow structure can provide a controlled and direct discharge to reticulation in the event of major storms.

SITE 13 – MANGERE ASSEMBLY OF GOD

FIGURE 5.5 MANGERE ASSEMBLY OF GOD

Table 5.3 Mangere Assembly of God	
Efficiency	Low
Proximity to waterway	Far
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	High

Safety	High
Traffic volume	Low
Cost	Normal
Upgradable	This facility is common for a church, where the requirement of the district plan is such that they must be able to provide for parking at peak demand. Thus the site is dormant for most of the week, except for the occasional meeting or function. This facility could be utilised in a catchment basis for storage and treatment. The problem that it is in private ownership may be overcome through district plans requiring installation in any further developments. Failing this the council should provide for stormwater detention in the reticulation system upgrades.

SITE 14 – MANGERE BOAT CLUB

FIGURE 5.6 MANGERE BOAT CLUB

FIGURE 5.7 MANGERE BOAT CLUB VIEW NORTH

Table 5.4 Mangere Boat Club	
Efficiency	Low
Proximity to waterway	High
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	High
Safety	High
Traffic volume	Moderate – High
Cost	Normal
Upgradable	This facility is located directly adjacent to the sea. The current structure provides for any litter or contaminant to be washed directly into the harbour. Any discharges from the users of the boat carpark can be disposed of

	freely onto the ground and subsequently flowing straight down the boat ramp into the water. The carpark could be regraded to provide for a facility that has a primary discharge area on the grass or in a sand filter to pre-treat the discharges and let the storm water seep into the groundwater.

SITE 15 – MANGERE BRIDGE SERVICE LANE

FIGURE 5.8 MANGERE BRIDGE SERVICE LANE

Table 5.5 Mangere Bridge service lane	
Efficiency	Low
Proximity to waterway	Close
Treatment	Nil
Storage	Nil

Maintenance	Normal
Usability	High
Safety	Moderate - High
Traffic volume	High
Cost	Normal
Upgradable	This facility could have a better design. Although the site area is that of carpark and would require contour changes such as a reduction in parking unless the sandfilter with sub-surface drainage is engineered into the existing dish drains leading to stormwater catchpits.

SITE 16 – KIWI ESPLANADE RESERVE

FIGURE 5.9 KIWI ESPLANADE RESERVE

Table 5.6 Kiwi Esplanade Reserve	
Efficiency	Low – Moderate
Proximity to waterway	Close
Treatment	Moderate – Nil. This style carpark is common amongst carparks on the foreshore. In peak rainfall events the site will discharge onto the grass areas or into the stormwater catchpits.
Storage	Nil
Maintenance	Normal
Usability	High
Safety	High
Traffic volume	Low – Moderate
Cost	Normal
Upgradable	The only provision would be to regrade the carpark so that all surfaces drain to the nearest grass areas. The removal of catchpits and provision of undersurface drains would enable a calm treated site with no direct discharge.

SITE 17 – PAPATOETOE WARD OFFICE, MCC

FIGURE 5.10 PAPATOETOE WARD OFFICE CARPARK

Table 5.7 Papatoetoe Ward Office	
Efficiency	High
Proximity to waterway	Far
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	High
Safety	High
Traffic volume	Moderate – High.
Cost	Normal
Upgradable	This site is located in the busy area of Papatoetoe where many shoppers and visitors use this Council

	owned facility. The carpark is large, and was in moderate use the time the photographed visit. The carpark has sufficient area to provide some treatment and ponding on site in a corner or the grassed area to the north. Or through installing porous surfaces and subsurface drainage along the front of parking spaces. Retrofitting the subsurface drains with sufficient base course could provide storm capacity

SITE 18 – PAPATOETOE TRAIN STATION

FIGURE 5.11 PAPATOETOE "PARK AND RIDE" FACILITY

Table 5.8 Papatoetoe Park and Ride	
Efficiency	Moderate
Proximity to waterway	Far

Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	High
Safety	High
Traffic volume	High
Cost	Normal
Upgradable	This site could be improved by converting the cesspits to storm overflow configuration and regrading the site to normally drain to the surrounding grassed or planted areas.

SITE 19 – PROGRESSIVE ENTERPRISES, FAVONA

FIGURE 5.12 PROGRESSIVE ENTERPRISES ENTRY AREA

FIGURE 5.13 PROGRESSIVE ENTERPRISES TRUCK YARD

Table 5.9 Progressive Enterprises entry and yard	
Efficiency	Moderate
Proximity to waterway	Close
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	High
Safety	High
Traffic volume	High
Cost	Normal
Upgradable	This site is characteristic of industrial sites and could utilise the landscaped areas for storage and treatment.

Sites 20 – 22 General business sites

Figure 5.14 Vehicle Testing Station

Figure 5.15 Pharmacy car park

FIGURE 5.16 AEROVISTA BUSINESS

Table 5.10 General Business sites(Site20 – 22)	
Efficiency	Moderate
Proximity to waterway	Close – Moderate
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	High
Safety	High
Traffic volume	High
Cost	Normal
Upgradable	These facilities all have a common theme whereby they are utilising 100% of their sites for sealed business use for forty plus hours per week. They could utilise any areas for minor ponding or landscaping areas for primary treatment of water prior to discharge.

	In many cases the kerbing prevents dispesal of stormwater run-off into landscaped area. Simple slotting or drilling existing kerbs would allow minor rainfall to recharge groundwater and filter out contaminants on existing unsealed areas.

SITE 23 MARBLE PLACE STREET PARKING

FIGURE 5.17 MARBLE PLACE STREET PARKING

Table 5.11 Marble Place	
Efficiency	Low
Proximity to waterway	Close
Treatment	Nil
Storage	Nil
Maintenance	Normal
Usability	Moderate

Safety	High
Traffic volume	Low- Moderate
Cost	Normal – high
Upgradable	This site is not common but provides an example of over working an area. Here the Council Road Reserve has placed oversized carparks adjacent to a cul-de-sac. When, if ever, it comes time to provide maintenance, the area could be planted. Could install deep base course with under drains and "Gobi" blocks on low use off street parking to provide storage and filtering.

SITE 24 – WIRI IN-LINE TREATMENT PONDS

FIGURE 5.18 WIRI TREATMENT IN-LINE SYSTEM

FIGURE 5.19 WIRI TREATMENT FACILITY, VIEW NORTH

FIGURE 5.20 WIRI TREATMENT FACILITY, VIEW EAST

Table 5.12 Wiri treatment ponds	
Efficiency	High
Proximity to waterway	Close
Treatment	High
Storage	High
Maintenance	Moderate
Usability	N/A
Safety	N/A
Traffic volume	N/A
Cost	Based on a cost per hectare in the catchment
Upgradable	This facility provides an in-line treatment facility to store and treat the entire catchment. This would be less maintenance if primary site treatment facilities were installed, but means contaminants have reached a natural ecosystem which has to be modified. This is the final step in what should be regarded as a treatment train for stormwater quality and volume control. A major improvement would be having off-line ponds that are good for detention.

SITE 25 – AIRPORT TREATMENT PONDS

FIGURE 5.21 AIRPORT TREATMENT, STORAGE

FIGURE 5.22 AIRPORT TREATMENT AND STORAGE SOUTH VIEW

Table 5.13 Airport Treatment Facility	
Efficiency	High
Near waterway	Close
Treatment	High
Storage	High
Maintenance	Moderate
Usability	N/A
Safety	N/A
Traffic volume	N/A
Cost	Moderate
Upgradable	Not required. Offline systems which give maximum protection to the receiving natural waters both from peak flow attenuation and contaminant removal.

PART 2 – PLANNING AND LEGAL PARAMETERS

DISTRICT PLAN— MANUKAU OPERATIVE 2002

In Manukau there is the provision for parking and stormwater issues nestled throughout the plan which can enable use to minimise the impacts.
These can be summarised into residential, business, development and parking sections of the plan.

RESIDENTIAL

Resource Management Issue 13.2.1 states that residential development has the potential to have adverse effects on the quality of the natural environment. This is because it puts stresses and demands on the city's natural resources, for example the coastal environment and freshwater systems. It is stated that business activities contribute most to sediment loadings in stormwater. There is also an overall trend for contaminant loadings to rise with increases in impervious surfaces. Therefore an issue for residential areas is the cumulative effect that increased areas of impervious surfaces associated with residential development may have on the city's receiving waters. An example of this is the degredation of the Tamaki Estuary following development of the East Tamaki Industrial Area and Otara residential subdivision. A number of reports on the decline of the Tamaki Estuary have been produced by the ARC.

Objectives 13.3.1: To protect the natural environment from the adverse effects of development in residential areas and to promote the efficient use and development of the City's resources. And13.3.6: To protect and enhance, unique and representative natural and cultural heritage resources, within the city's residential areas, clarify these statements as outlined above in the Resource Management issue.

The policies that can then be applied are 13.4.1: Residential areas should be developed in a way that avoids, remedies or mitigates adverse effects of activities on the natural environment. This includes the detail that the water quality of the City's harbours, estuaries and natural stream system and the coastal landscape values are required to be protected and enhanced. Policy 13.4.6: "Residential development should include a minimum level of open space" can also provide for areas of treatment and storage of stormwater. Both these policies can be applied through the use of the following rules:

- Zoning
- Site Coverage
- Matters for Control/Discretion
- Coastal Protection Yards
- Tree Protection Rules
- Subdivision and Land Modification Rules
- Information
- Site coverage
- Minimum levels of private open space for multiple household units and residential development on small sites.

BUSINESS

The Resource Management Issue relating to business is 14.2.1. Some business activities have the potential to have an adverse effect on the quality of the natural environment:

> *"Activities in business areas may have the potential to have an adverse effect on water quality... Manukau City's stormwater infrastructure in the business areas of the City has been designed and constructed to accommodate the intensive development which takes place in business areas and to maintain water quality".*

"The ARC's Regional Policy Statement identifies the main causes of stormwater contamination from industrial activities as being unsatisfactory yard practices, accidental spills and lack of awareness of the consequences of pollution". (MCC Operative District Plan, 2002)

This is clearly included in the plan to provide for the protection and enhancement of the business areas of Manukau City.

The relevant objectives for the business area are 14.3.1: To ensure that the quality of the natural environment in and neighbouring business areas is maintained and enhanced. And 14.3.2: To protect the amenity values of residential, rural and public open space areas from the adverse effects of business activities.

These can be enabled through the application of the following policies 14.4.1 Potentially objectionable, noxious or dangerous business activities should be separated from sensitive areas and activities. And 14.4.3 Business areas should be developed and business activities sited and designed in such a way as to avoid, remedy or mitigate adverse effects on air and water quality.
And the following methods are applicable to enable these objectives and policies

- Zoning
- Rules - Activity Table
- Rules - Yards
- Rules - Coastal Protection Yard
- Hazardous Facilities and Substances Rules
- Rules - Activity Table

A special circumstance in Manukau is the provision of the Waiouru Peninsula Special Policy Area - Landscape Design. This has the clear ability to provide for stormwater treatment and storage because it follows the rule that instructs that 20% of any site shall be landscaped.

The general yard rule is relevant because it makes provision for the front yard of a business site to have up to 7.5m planted and landscaped. The yards that adjoin residential or public open space zoned sites must also comply by having a minimum width of 5m. This yard must be fully planted and maintained in grass, trees and shrubs.

The following aerial photos (fig 5.23 and 5.24) detail the differences in imperviousness for the industrial and residential environments. It is clear that the industrial sites are highly developed and almost 100% of each site area is impervious.

FIGURE 5.23 BUSINESS AREA OF EAST TAMAKI (MCC, 2003)

The residential photo (figure 5.24) above details that most areas have at least 30% of the site planted with garden and grass areas.

FIGURE 5.24 RESIDENTIAL AREA OF HOWICK BUCKLANDS BEACH (MCC, 2003)

DEVELOPMENT

The key issues from the development chapter are 9.2.1: The processes of land modification, development and subdivision can cause adverse effects on the environment, such as alteration of natural features and landscape, a deterioration in water quality and destruction or degradation of the amenity values of an area. Land modification, development and subdivision can also adversely affect cultural heritage. Also issue 9.2.2 New subdivisions can lead to piecemeal development where their design is not compatible with the environmental qualities, character and amenity values for the zone in which they occur, having regard to the characteristics of the site upon which the development takes place. And 9.2.5: Flooding can adversely affect human life and property and cause erosion in vulnerable catchments.

The applicable objectives are 9.3.1: To enable land modification, development and subdivision to proceed in a manner that will maintain or enhance the environmental qualities of the environment. And 9.3.2: To ensure new subdivisions have a character which is consistent with the environmental results envisaged for the relevant zone and area, taking into account any heritage sites or features of the land in which development occurs. A further keynote reference is in part 9.3.5:To ensure the provision of an adequate standard of infrastructure and public utility services at the time land is modified, developed or subdivided to avoid, remedy or mitigate any adverse effect on the environment, and to ensure that the cost of providing or upgrading services is borne by those undertaking land modification, development or subdivision to the extent that such works are required to serve, and/or to the extent that such works are necessitated by the proposed activity.

The policies that follow from these objectives are 9.4.1: Land modification, development and subdivision should occur in a way that: (a) maintains or enhances amenity values by retaining, as far as practicable, existing landscape features such as landforms and significant vegetation, and by minimising the adverse effects of site works and construction, such as by dust, noise, and run-off. Also (e) enhances natural processes and features including natural drainage patterns, protected streams and riparian vegetation to avoid, remedy or mitigate adverse effects on water quality, through all phases of the water cycle from waterborne pollutants. The following list is of the key methods for enabling these to be undertaken in relation to these planning methods:

- development and performance standards (district rules)
- engineering performance standards (district rules)
- resource consent procedures (district rules)
- catchment management plans

- public open space standards and reserves contribution (district rules)
- stormwater quality management plans
- promotion of innovative engineering design and construction techniques and solutions (such as 'green engineering')
- streetscaping and street trees
- protection of identified stream systems
- mitigation measures to address the adverse effects of land modification, development and subdivision

TRANSPORTATION

In relation to transportation in chapter eight there are no applicable resource management issues, objectives or policies, the only applicable issues relate to the parking and vehicle circulation section

The matters that do relate to vehicle parking areas (both private and public) form part of the larger road network and influence the use and operation of the road network. 8.16.2: The over-provision or poor design of parking areas can lead to adverse effects. The poor design and management of parking areas can be a deterrent to their use and lead to them being underutilised in favour of other parking. Poorly designed parking areas can impact on traffic and pedestrian safety within a carpark. They can also affect the safe and efficient operation of the adjoining road network by encouraging vehicles to reverse out of sites or to use the adjoining road to circulate between parts of a carpark.

The objectives forthcoming from this issue is 8.17.2 To minimise adverse effects arising from the poor design or overprovision of parking. The policy being 8.18.1 Land use activities should be designed and laid out in a manner that: (a) provision is made for parking and loading for present and future demands generated by the activity; (b) the parking and vehicle circulation provided is designed to ensure its safe and convenient use by the intended users. The method of which has been detailed below under the parking strategy.

Parking Strategy

The strategies anticipated result is that the parking and loading facilities will be provided in conjunction with land use activities in a way that minimises the impact of vehicles accessing those activities. Parking areas will be designed, formed and maintained at a level that maximises the functionality of the transportation system, and landscaped in a manner that enhances the overall amenity of the city.

The rules that flow from this Strategy are summarised as follows:
(e) Design and Construction Details: All public and private parking areas shall comply with the following requirements:

- Except in respect of a site used, or to be used by a single household unit, the parking spaces and access drives and aisles required in respect of the site in question shall, before the commencement of the Permitted Activity of that site, be formed, sealed and permanently marked or laid out in accordance with approved plans to the Councils satisfaction.
- The parking area shall be maintained at all times so as not to create a dust nuisance.
- Stormwater drainage from the parking area shall be constructed to the satisfaction of the Council. This part gives opportunity for council input but does not provide clear guidance or reference to relevant parts of the plan.

(g) Landscape Design of Parking Areas. Parking areas containing 100 or more parking spaces shall be designed with landscaped dividers or islands to provide separate parking bays each containing not more than 100 carparking spaces. The dividers or islands shall be planted with well developed specimen trees capable of growing to a height of approximately 6 metres within 10 years of planting when providing trees and shrubs, safety aspects such as sight distances must not be compromised. This portion clearly gives leverage toward combined use of the landscaped area for stormwater control.

PART 3 : FINANCIAL METHODS

FINANCIAL CONTRIBUTIONS FOR STORMWATER INFRASTRUCTURE IN MANUKAU CITY

Levies on developers are required to meet the capital costs of infrastructure required for servicing their development. The requirement is for the developer to upgrade and contribute to the upgrading of an under capacity catchment drainage system. There are issues raised when objections are made to the imposition of financial contributions. These main concerns are,

- The cost of physical works based on the estimate for the total catchment upgrade.
- The basis of calculating the financial contribution to properties, and the cost to those further upstream
- The practicality of upgrading larger size pipes in already developed areas, and whether upgrades of a theoretical basis are feasible
- The key point is that it is the development potential that requires the upgrading and the costs are shared between the potential developers (Hassan et al., 2001).

Financial contributions are required to upgrade the infrastructure in Manukau. There is a growing need to integrate development with water quality improvements in infill areas. The additional cost of water quality improvement is likely to further decrease the economic viability of infill development in many catchments unless other sources of funding are made available, for example Infrastructure Auckland grants (Hassan et al., 2001).

CHAPTER SIX - COMPARISON OF CASES

INTRODUCTION

This chapter will compare and contrast the case studies that have been researched in the preceding chapters. The sequence of the assessment criteria developed in Chapter Four to assess the sites will be followed. Then the planning and legal parameters will be compared in each area. Subsequently the financial provisions for development discussed, in relation to the two general area case studies: Manukau City and Waitakere City.

ANALYSIS OF SITES

The sites reviewed in Waitakere City were schools, churches, public parking areas, public facilities, and businesses. In Manukau City the similar range was assessed. The key features from the assessed samples were that the sites in Waitakere were of substantially lower impact compared with those in Manukau. This noted it appears that Waitakere is indeed reflecting its "eco-friendly" reputation in reality.

EFFICIENT USE OF AREA/SITE FOR PARKING/IMPERVIOUSNESS

The efficiency of carparks can be described in many ways. This perceived efficiency could pertain to the number of carparks per square metre, or in fact how quickly the users are able to negotiate the carpark. Although these are applicable to some extent, the key criteria for this assessment are based on an overall concept of the carpark being efficient in terms of the use of the area, site and its pervious to impervious ratios.

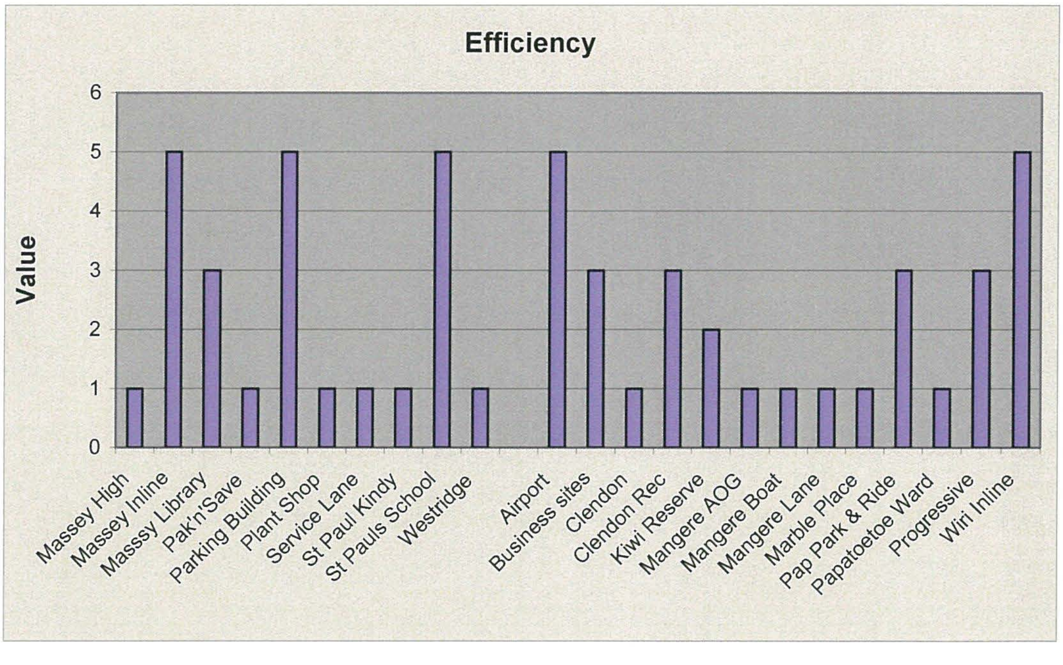


Chart 6.1 Efficient use of area

THE PROXIMITY TO AN OPEN WATERCOURSE OR THE SEA

The proximity to an open watercourse or the sea is an important determining factor because of its impact in a storm event. If a carpark is in close proximity to the sea then there is less potential for the ability to treat or store the run-off water. Being close to the sea or a watercourse is the prime location with which to deal with the water because it will have a direct, high strength impact on the fresh or salt water receiving environment. Discharges direct to water bodies require consent from the Regional Council. Discharges into reticulated stormwater may require consent or may be permitted activities under district or city plans. The Regional Council then imposes conditions on the Territorial Authorities for discharge of the reticulated system to water bodies. There is an increasing control being placed on Territorial Authorities by regional Councils for protection of waterways that are degraded by contamination or high abnormal flows.

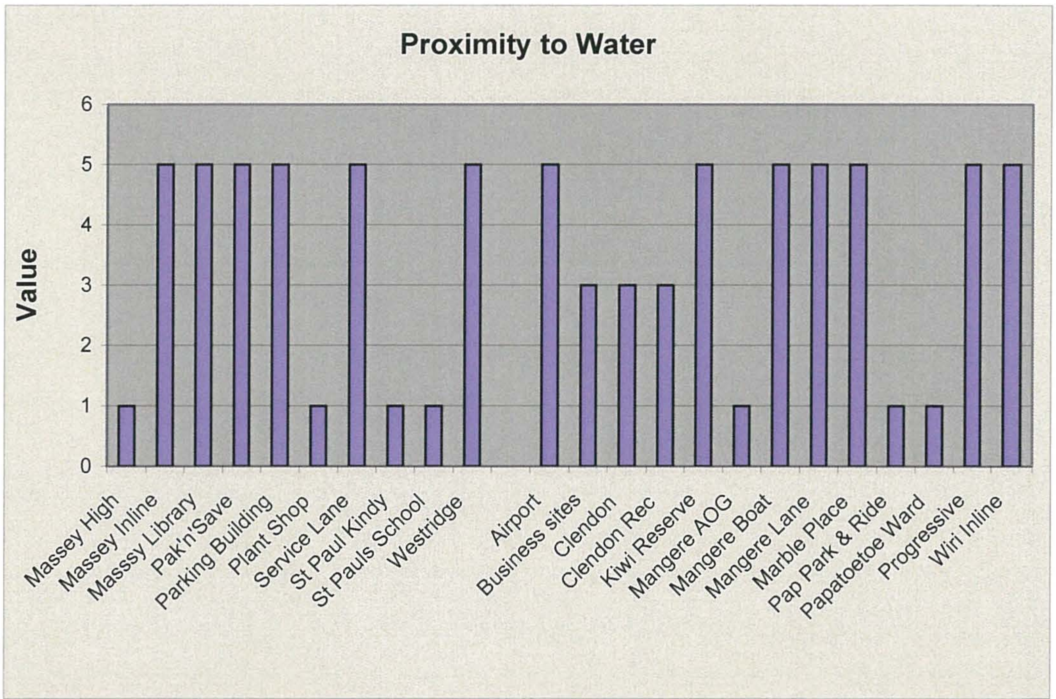


Chart 6.2 Proximity to Water Course or Sea

ADEQUACY TO TREAT

The carparks assessed have inherent abilities to treat stormwater in their design. Traditionally there is no provision for storage or treatment of any sort within a carpark as constructed. The purpose has been to drain the rain, and anything within or on it as fast as possible toward the sea. In the case sites assessed in the preceding chapters there was a wide range of treatment given. The in-line treatment facilities, such as the airport, Wiri pond and West Ridge ponds, are to provide for a large area of developed land and store and treat on a bulk basis while in transit. The facilities and provision for treatment within smaller sealed yards such as a carpark are becoming more common practice.

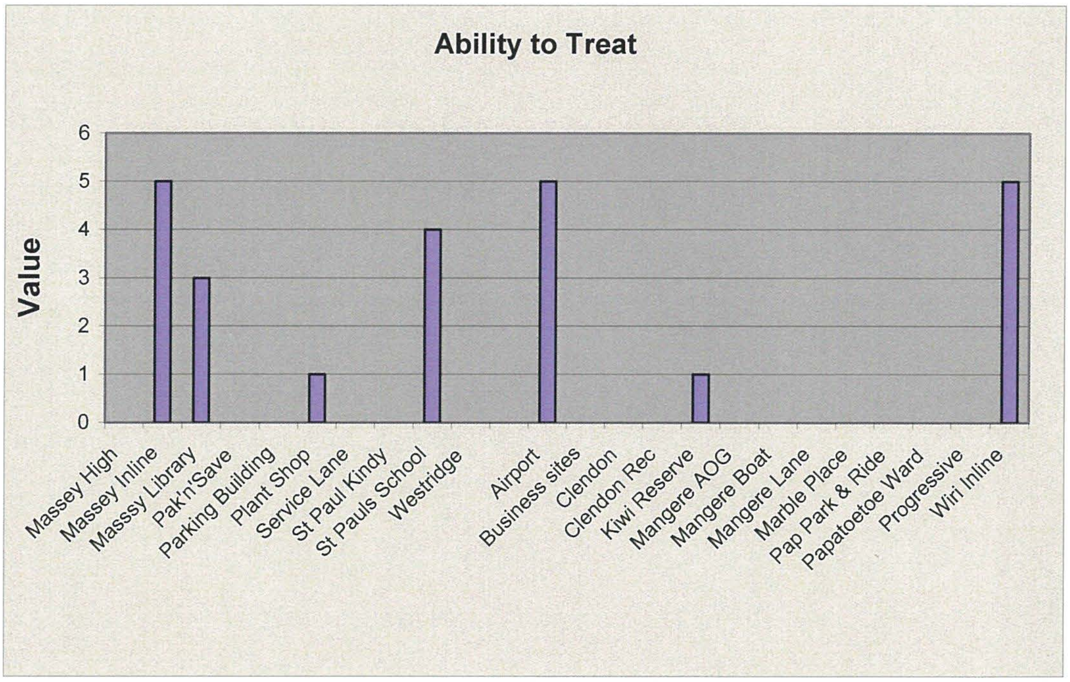


Chart 6.3 Adequacy to Treat

ADEQUACY TO STORE

The capacity of a carpark to store water can enable better management of the catchment and provide for settling of silt or other waterborne substances. This capacity can have adverse effects because of the inherent problems with ponding on a site and the potential hazard for persons or children. The capacity to store can significantly reduce downstream flooding and reduce the requirements to upgrade catchment infrastructure based on the present or forecast trends. Typically in the past increased flows have resulted in local authorities straightening and lining watercourses to turn them into efficient conduits. The impact on aquatic ecosystems was not given any primacy.

Chart 6.4 Adequacy to Store

As is clearly shown by the graph of sites plotted above there are only the three treatment and storage ponds and the swale area at St Pauls School, that have been assessed as having adequate detention of stormwater.

MAINTENANCE REQUIREMENTS

The maintenance of carpark or ponding surfaces is a definite factor when deciding to construct a carpark or pond facility. These costs can be either high or low at the start and then either increase or decrease, depending on a number of factors.

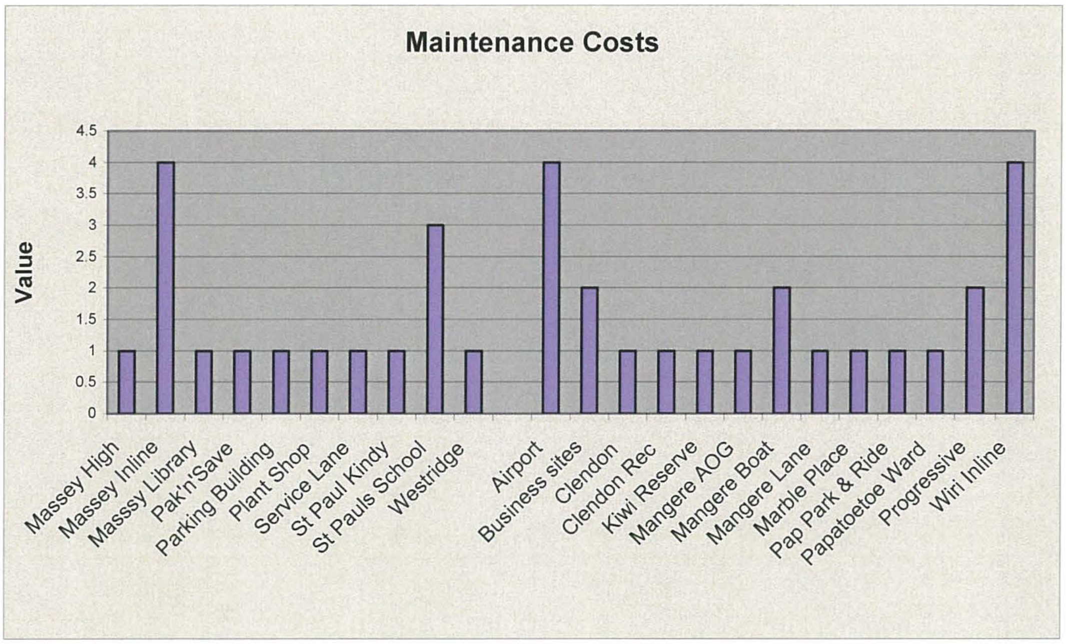


Chart 6.5 Maintenance Requirements

As can be seen from the graph above (chart 6.5) the maintenance costs are higher to maintain the in-line pond systems. These can be the options that developers turn to, to have a low initial cost to maximise profits. This is because of their size and function on a catchment basis. However this requires relating back to a cost per hectare served which should reduce their maintenance on these ponds. The other noticeable result concerning maintenance is the St. Paul's School carpark where the swales exist. These require maintenance to a higher degree due to the swales area for becoming blocked with rubbish and the need to ensure that the grass is of a suitable length to fulfill its purpose.

USABILITY FOR PERSONS/PEDESTRIANS

The purpose of a carpark is not to hinder the users -cars, and their occupants. Therefore the carparks have been assessed to provide a concise view point on their usability.

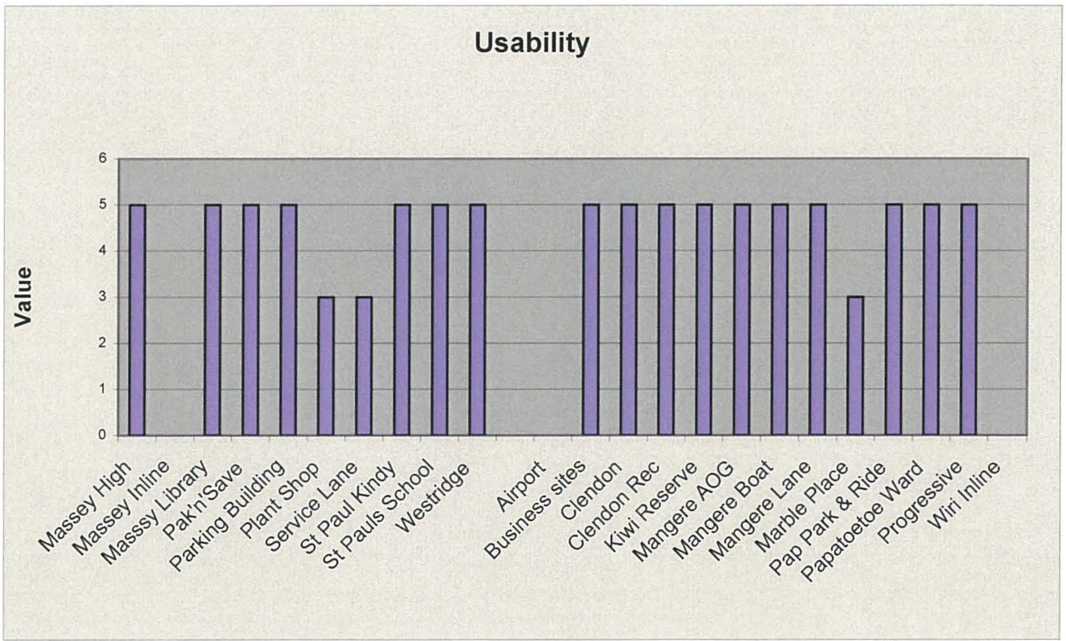


Chart 6.6 Usability for Persons

As is clearly shown on the above chart (chart 6.6) all the carparks viewed were deemed usable for the purpose intended. This included those parks that had been engineered to achieve higher levels of stormwater detention and treatment. Good design can ensure that detention and quality treatment systems do not inconvenience the carparks user.

Safety

The next element in the assessment phase has been the safety in relation to people. This is a key factor in any carpark constructed.

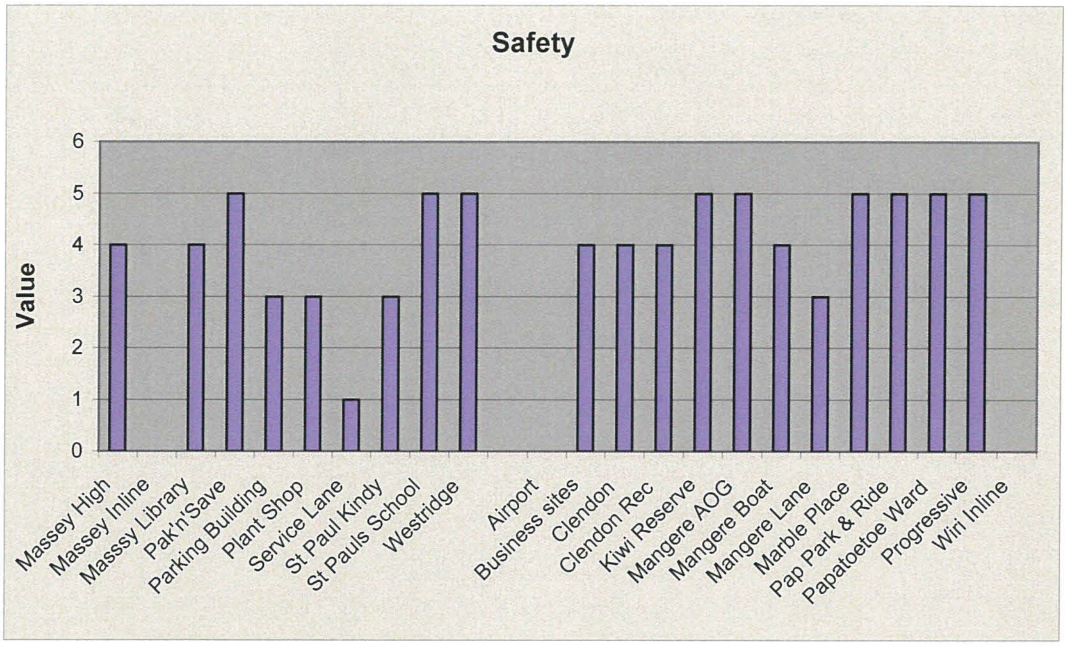


Chart 6.7 Safety

The graph (chart 6.7) shows that its use, layout design and circulation determine the safety of a carpark. Those that scored poorly were because of their lack of islands and markings. Those with stormwater detention and treatment did not compromise safety. It is noted that any significant surface ponding of water would need to be fenced from children and not occur in areas normally used for parking. An exception may be in 100 year rainfall events or similar when the population is exposed to flooding risk.

APPROXIMATE VOLUME OF TRAFFIC – HIGH/LOW USE

The volume of traffic is also a determining factor. The use of a site may require either a high use or low use carpark, and could provide alternative means for the treatment or storage of stormwater within the site, or for a catchment.

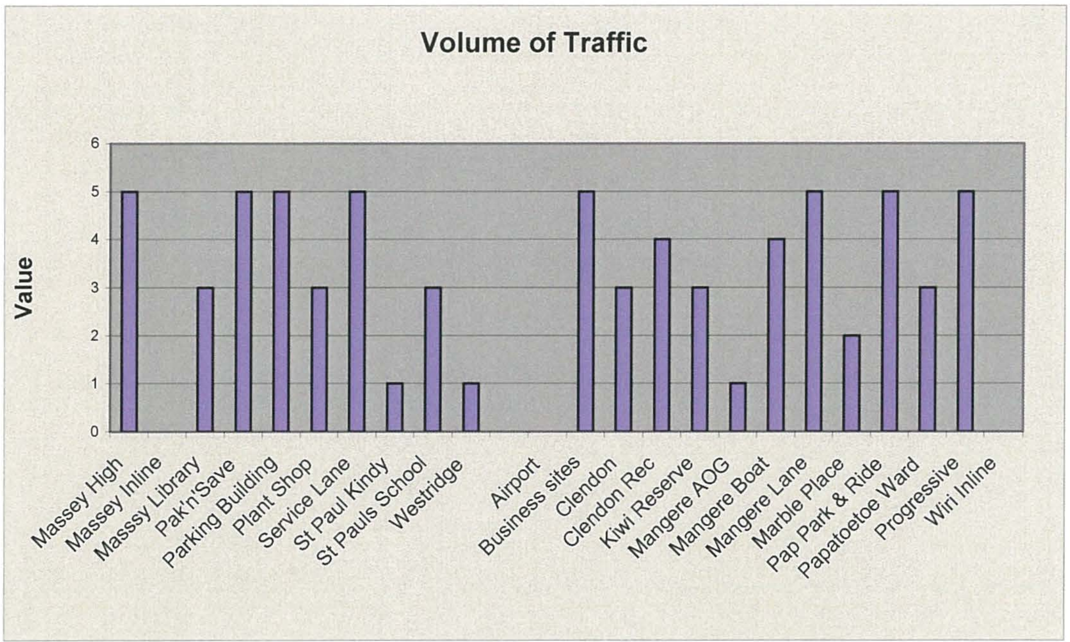


Chart 6.8 Volume of Traffic

The volume of traffic at each location determines the life expectancy of the carpark and also the volume of contaminants that will be present. The above graph (chart 6.8) shows that the high use have direct correlation to business activity where those sites will be used fifty or more hours per week on a constant basis. Whereas those sites with less use, like churches or outlying carparks for shopping complexes, will have less impact and therefore require lesser treatment for contaminants. The stormwater detention issues remain the same.

COST TO CONSTRUCT OR MAINTAIN

The cost to construct and/or maintain a parking area is generally the place where resistance comes to installing stormwater detention and quality measures..

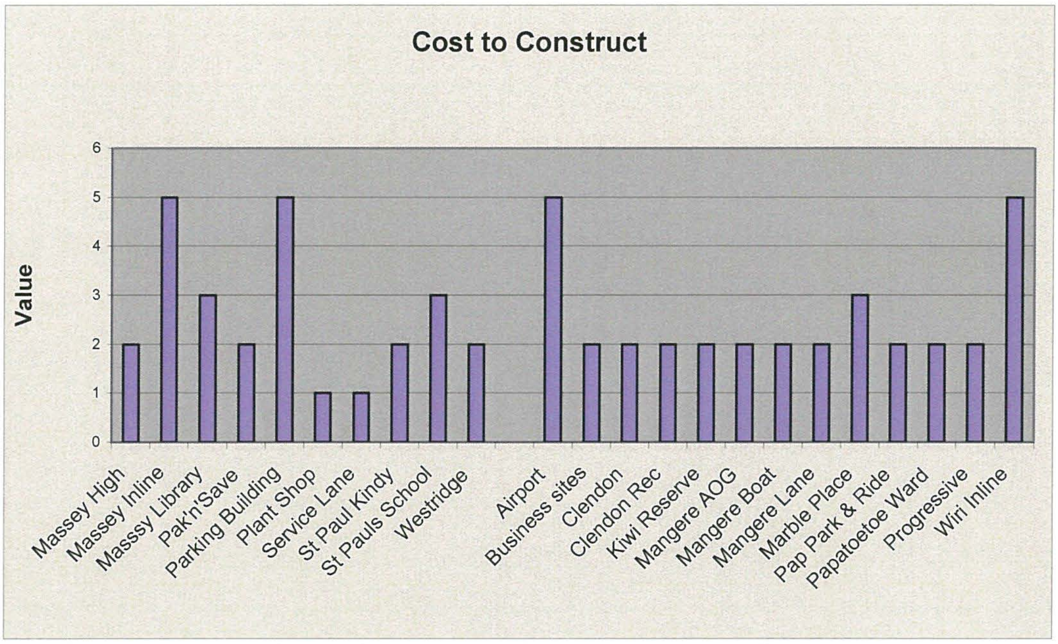


Chart 6.9 Cost to Construct or Maintain

The construction cost needs to be balanced by the long-term maintenance costs while still achieving the necessary abatement of peak flows and reduction in contaminants. Some balance is achievable by Territorial Authorities carefully apportioning costs to developers for those sites designed in ways that require additional stormwater reticulation treatment and controls. Similarly through rebating those costs when adequate systems are installed.

THE POSSIBILITY OF UPGRADE, RETROFIT TO PROVIDE TREATMENT/STORAGE

Seeing the potential in existing carparking facilities can make all the difference to the provision of future developments and catchment design and assessment. Those sites with potential for significant upgrading in control have been identified and their site summaries in the previous chapters detail potential methods for their modification options. The fact that those modifications proposed have not had a detailed cost analysis.

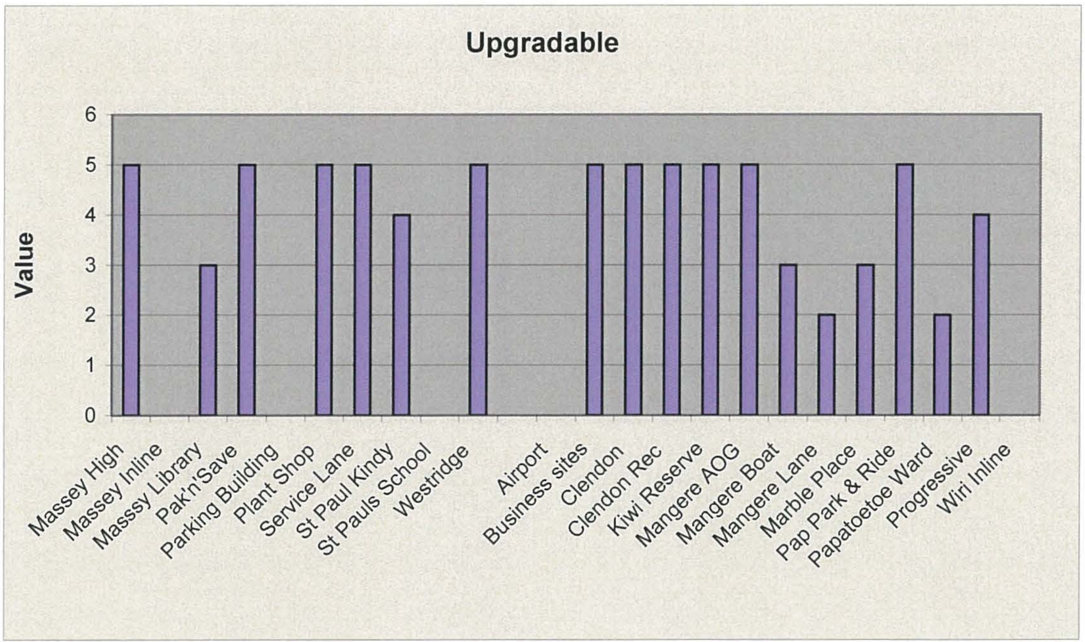


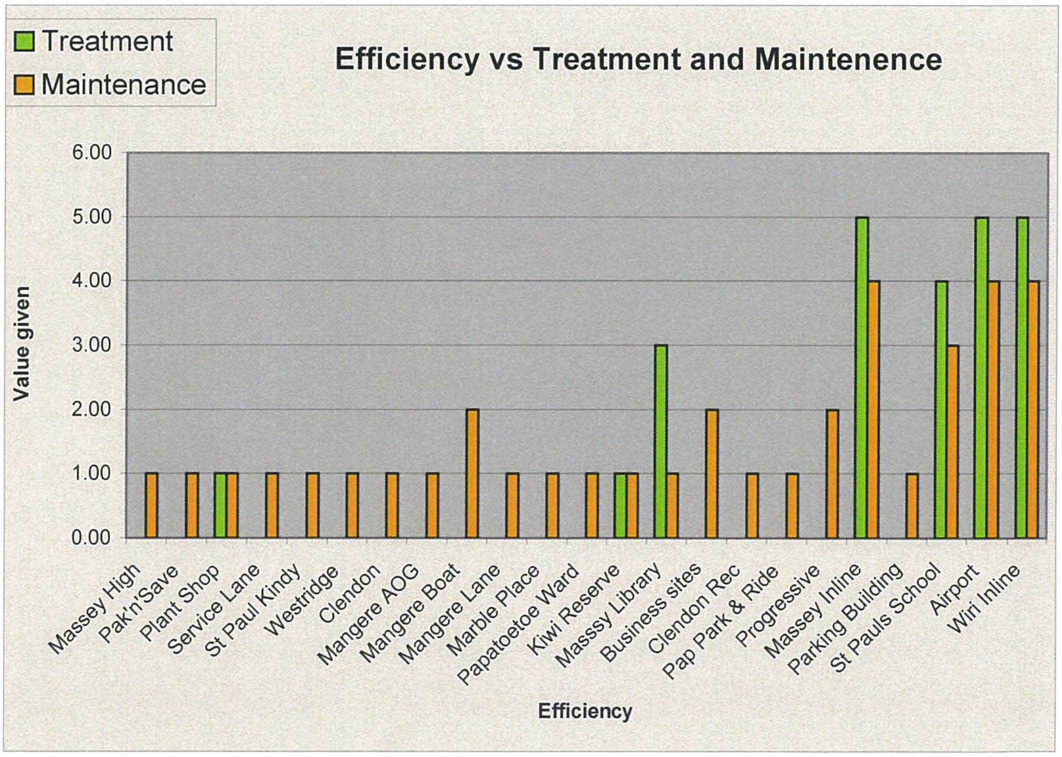
Chart 6.10 Upgrading potential

Overall it is more effective and equitable for sites generating effects to contain those effects. A simple example may be a fast food outlet carpark with a stormwater system that prevents contaminants entering the stormwater. The cost of disposal of the contaminant is not borne by the receiving streams.

SUMMARY

A comparative assessment of a sample of carparking facilities around Manukau and Waitakere Cities has been completed. These assessments have highlighted the following key points required to make a complete usable efficient carpark.

People base the efficient use of an area for parking and imperviousness on the usability. This usability provides for an area's use in all weather conditions and for the design life of the carpark. That life being a minimum of 20 years and up to 50 years matching the design life of most buildings. The case study carparks have all shown that they are sufficiently usable although the carparks, when constructed with a less durable method could have a further reduced life expectancy.



<u>Chart 6.11 Efficiency vs Treatment and Maintenence</u>

Chart 6.11 shows the relationships between the group of sampled sites graded by their efficiency in comparison to the treatment and maintenance scales. The results show that the relationships are almost direct in those cases. The efficiency of a carpark is directly proportional to the treatment it can undertake and the maintenance costs associated from them. Therefore the theory would be that the higher the costs the more efficient the carpark would become in relation to the methods undertaken in this study.

The impacts from a carpark in close proximity to an open watercourse or the sea have a reduced potential for treatment. In the Auckland area the sea and waterways are a significant part of the landscape. The carparks that are close to a waterway or the sea do not allow off-site flow attenuation or contamination reduction in reticulated local authority drainage systems. Those sites directly adjacent to the sea should not have any direct discharges and should have onsite treatment and storage to ensure that reasonable removal of contaminants is undertaken to mitigate those effects. This principle can be said to apply to any developed area in close proximity to a body of water. It should be noted that a direct discharge from any site to a water body requires consent from the Regional Council. In Auckland it is expected that ARC TP10 would be applied.

From the case study carparks the means used to treat the contaminated water were the same as some of the methods previously discussed in the literature review. Generally, around the Auckland Region there is minimal treatment and storage facilities involved in carpark construction or design. This is increasing, but not at the rate that will be able to eliminate for need for development contributions or other government initiated methods for control.

The adequacy to store that is involved in the sites identified is minimal. The only real storage capacity has been in relation to Case Study One and the in-line stormwater ponding systems usually initiated by local bodies, or larger organisations or developers. The ponds used are effective, although they have ongoing costs for dredging and maintenance. They are efficient at removing sediment and usually the dredged material can be safely disposed of at a land fill. In-line ponds require special consideration of fish passage and design for bypass during maintenance.

The cost factor for maintenance requirements of a carpark, and in particular, a treatment system, are key determinants when evaluating the system related to cost factors. The maintenance requirements and costs for a carpark are increased where litter and contaminants are trapped for disposal by maintenance crews. Stormwater detention devices generally add to the capital costs. And the cost of maintaining landscaping areas which would be required for other purposes should be excluded even though they may serve the purpose of stormwater treatment and detention.

The usability for persons clearly demonstrates that all carparks can be significantly useful and the construction objectives have not brought significant shortcomings. The safety aspects also are quite clear, carparks are presently safe for use by vehicles and persons.

The Volume of traffic varies from site to site and this could be a dermining factor in how councils determine parking demand. The problems are that the shop owners want carparks for all their customers, they do not want to pay for them, and they only use peak demand at Christmas

The cost to construct and maintain carparks is borne firstly by the developers, and then by the owners. These costs assessed vary significantly due to the type of surface and issues associated with them. The research example being the shops behind Henderson is clearly a low cost to construct carpark, although the owners could have compliance costs in relation to the ARC regional plan.

There was a clear sign from assessing the carparks that there is always room for improvement. Any carpark could be upgraded and retrofitted to provide for stormwater treatment and attenuation.

WAITAKERE CITY CASE STUDY SITES

The Waitakere City sites performed well, as can be seen on the overall graph (Chart 6.12). There were moderate treatability of the sites, and very high usability of the carparks.

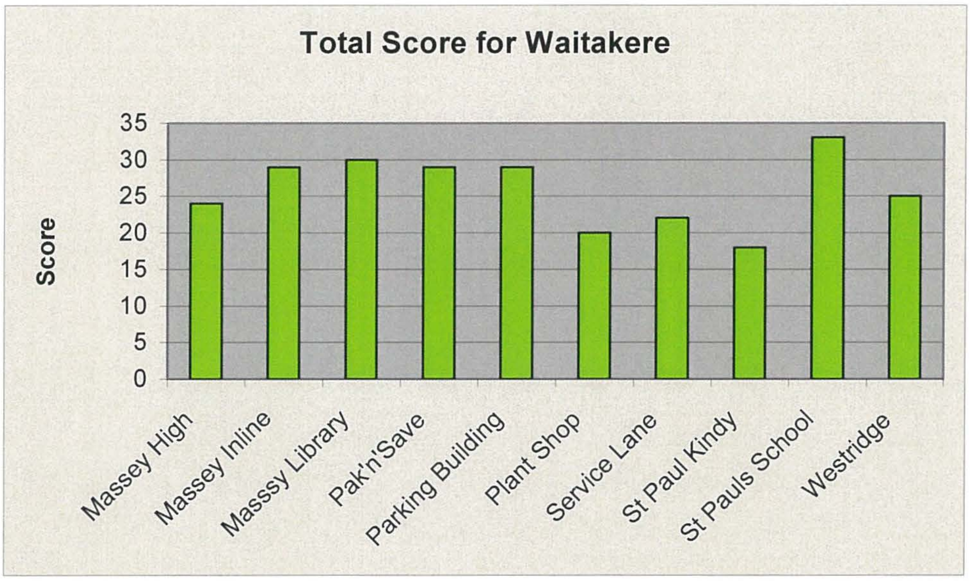


Chart 6.12 Waitakere sites

The scores were calculated as the sum total of values obtained from the site research undertaken in Chapter Four. Overall the total scores for each site are not dramatically different. The sites that scored poorly were those with an impervious surface designed and graded to discharge contaminants and existing silt into the stormwater system, that being in close proximity to a waterway. Those scoring well were those with their own treatment facility and storage capacity for peak flows.

The cumulative graph below defines in a more pictorial way, the accumulation of the aggregations for the sites in Waitakere City. The graph shows that the Waitakere sites were generally of good quality, constructed well, and safe, and were usually large carparks with high traffic volume. The graph also indicates that the quantity of treatment and storage at the carparks was low overall and only by a minority of the carparks in the study had any capacity for storage[23].

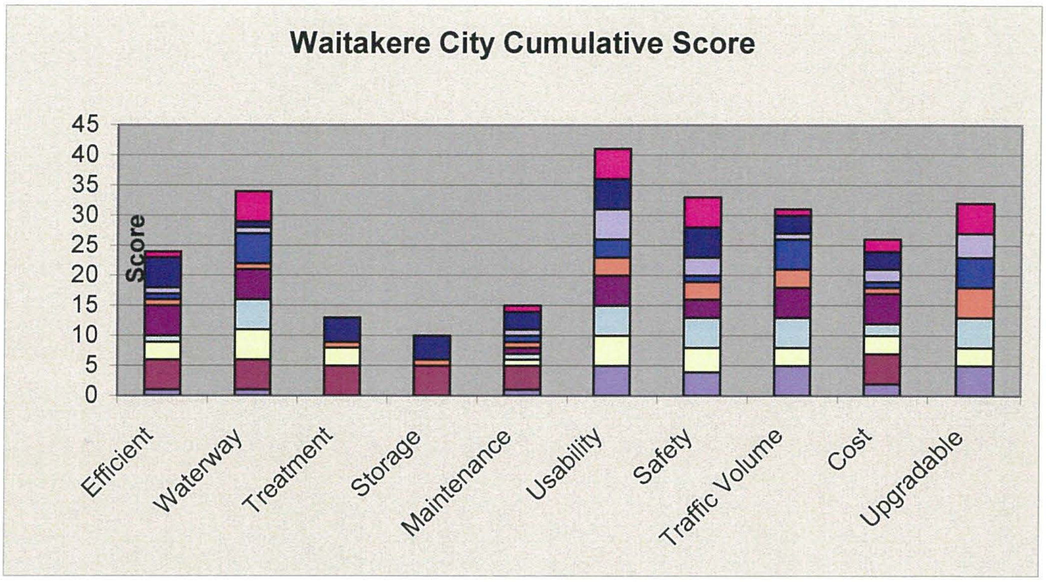


Chart 6.13 Waitakere Cumulative Scores

It can be seen that generally the Waitakere sites scored poorly for treatment and storage. Although there were treatment and storage facilities on some sites it is currently insufficient in terms of meeting the future demands on the City's resources.

23 If a comprehensive study was undertaken of all carparks this rate would be even lower. The sample included those that were known to have a positive environmental rating compared to others.

MANUKAU CITY SITES

The Manukau City sites demonstrated a different approach. There was almost no treatment currently on site. All the carparks, however, have the potential to be modified to provide a substantially more suitable surface and design overall that would help the treatment and storage of stormwater.

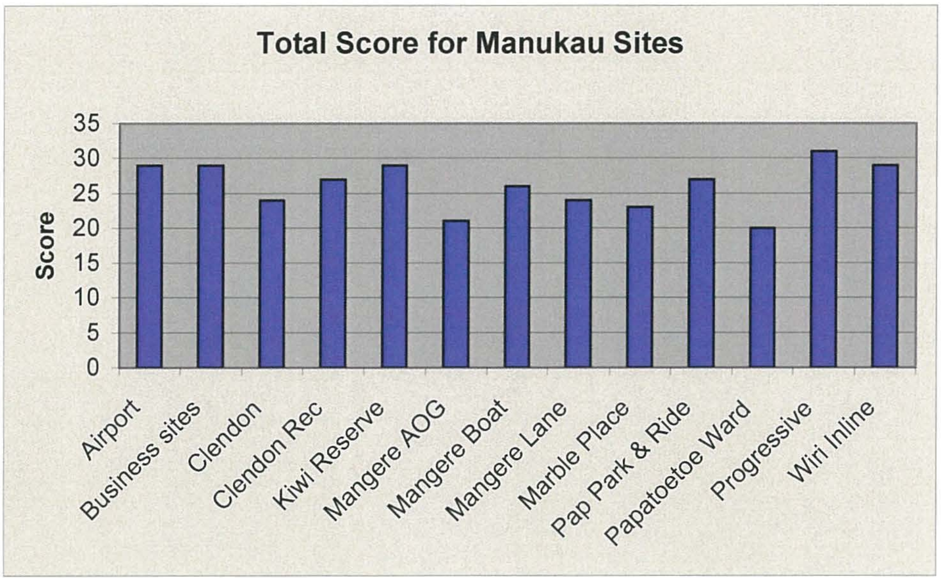


Chart 6.14 Manukau Results

The scores for sites in Manukau were generally lower. The lowest score went to the Papatoetoe Ward Centre and the Manukau AOG, where the carparks were totally impervious and provided no treatment. This imperviousness combined with the high amount of use provides for a poorly performing carparking area having greater impact for the use provided.

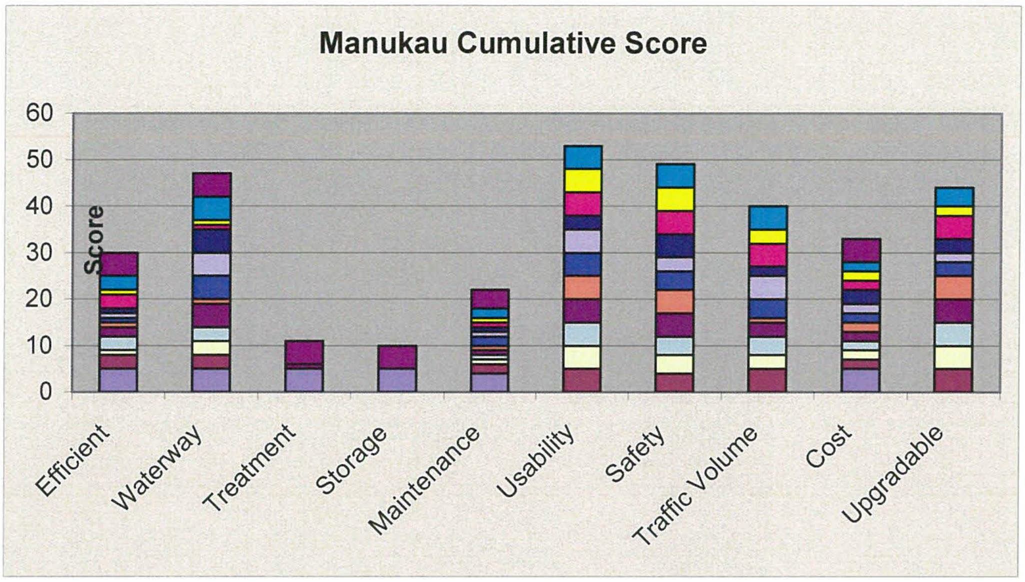


Chart 6.15 Manukau Cumulative

This cumulative graph shows a similar trend with the Waitakere graph. It depicts the minimal storage and treatment in the Manukau situations and also clearly shows that all the carparks were usable and safe.

SUMMARY

In comparing the overall averages (shown in Chart 6.16) for both Waitakere and Manukau Cities, similar results are shown. The only clear differences are in the safety ratings and the treatment and storage ratings. The higher safety rating of the Manukau carparks is due to the higher quality samples chosen whereas in Waitakere the sample was of a greater range and included some semi-pervious surfaces that were unsealed.

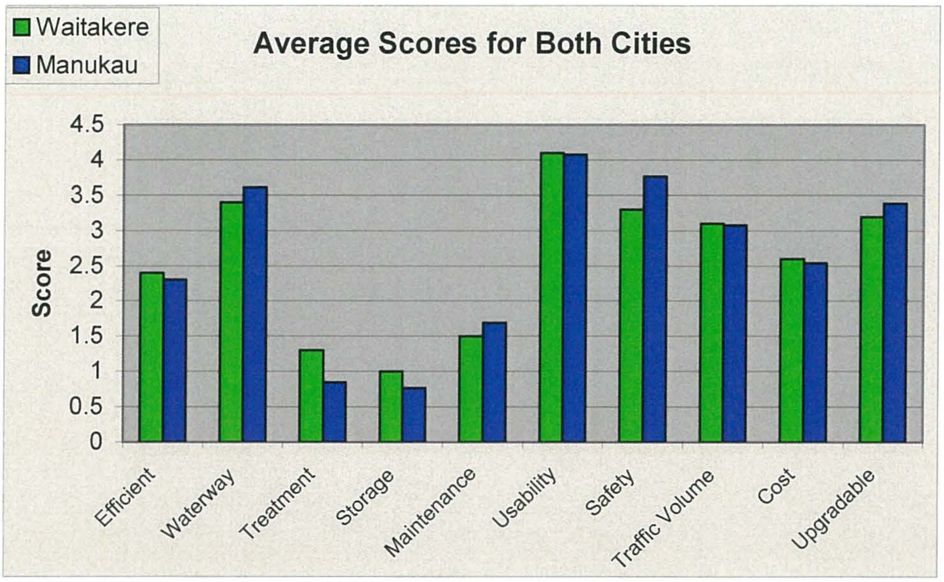


Chart 6.16 Comparison of Both Cities

The treatment component of the study has highlighted Waitakere's stronger emphasis on treatment, although both cities are required to meet the ARC standards for discharges. It is clear that a significant amount of work is needed before the current unsatisfactory rate of impact on the environment is eliminated. The improvement, however, is moving considerably slowly. It may be time for Territorial Authorities to adapt their governing policies and employ suitable instruments to encourage property owners to upgrade their on site facilities. Perhaps benefits could be granted to those that choose to comply and upgrade. As yet, no city council has settled on a decisive approach.

CHAPTER SEVEN - DISCUSSION

INTRODUCTION

This chapter will reiterate answers that have been researched. It will also cover the literature outlined previously and discuss the case studies in detail.

There are many definitions of stormwater some of those key concepts will be considered. Stormwater is pure rainwater, plus anything it carries. It collects contaminants when it passes over roofs, driveways, roads and through drains. There is usually no treatment prior to it travelling through the stormwater pipes. When the stormwater flows from the street it enters waterways where frogs and other animals and plants live. The polluted water is visible when it merges with clean water because it is mucky and has litter (NSW EPA, 2002)

When there is a heavy rainfall streams usually flood. Historically, stormwater run-off was only of concern as it could cause flooding, impacting property and people downstream. Stormwater contamination is now recognised that impervious surfaces lead to increased peak flow resulting in scouring of watercourse in streams and damage to habitat (Waitakere City Council, 2003).

Stormwater is a derivative of having to deal with increasing rain events with high peak flows. This causes instability problems for the roading and stormwater assets (West, 2002).

KEY QUESTION - WHAT ARE THE ADVERSE EFFECTS OF CAR PARKING AREAS ON THE ENVIRONMENT?

The environmental issues for stormwater in carparks are based on two main adverse effects. These are the rate of run-off caused by the impervious surface, and the collection of contaminants that flow with the stormwater downstream and adversely affect ecosystems. There is a secondary effect of impervious areas this is the effect of reducing groundwater recharge impacting the major source of continual flow in perennial streams

AQUATIC IMPACTS AND POLLUTION

The rate of run-off caused by the impervious surface and damages this cause, for example scouring, flooding and habitat destruction. The contaminants that flow with the stormwater downstream adversely affect ecosystems.

It is clear that carparking areas are not the only contributors. Dealing with stormwater contamination issues from roads or vehicle use surfaces alone will not necessarily restore water quality in the receiving waters. (Robinson, 2002) There must be holistic catchment projects to be undertaken to provide for this modification in use and ensure that the efforts are not fruitless.

The causes of stormwater pollution include litter, cigarette butts, paper, oil, fertiliser, industrial yards, chemicals, detergents, leaves, garden clippings and the like. Everyone is individually and collectively responsible. The volume of rainfall, the period since it last rained and also the cleanliness of the streets can determine the severity of the pollution in general. Stormwater quality affects us in many ways, wherever there are human uses of the water or use on plants and animals. The bacteria level in the water at the beach or in a stream with public access for recreation is an obvious concern (NSW EPA, 2002). Fine particulate matter (FPM) of less than about 20 microns in urban streams often contains high concentrations of chemical contaminants. Zinc concentrations can reach 5000mg/kg. This is trapped in the biofilms grazed by aquatic invertebrates. And the ingestion by those animals can be hazardous. In lab experiments, snails ingested FPM up to 5 microns in size. Sediment settling and filtration devices do not adequately retain FPM. Biofilm trapping in wetlands or shallow macrophyte ponds is an effective mechanism for removing FPM from storm and wastewater." (Timperley,et al., 2001) This description details that the fine material does affect adversely the aquatic habitats in the environments.

Stormwater run-off has been shown to contain a range of pollutants, including metals with aquatic toxicity such as lead, cadmium, zinc and copper, among others. A principal source of these pollutants has been identified as transport related. The effects of these pollutants on the environment have been recognised as a significant contributor to the long-term degradation of the quality of our receiving environment.

The sources of contaminants in urban stormwater are reasonably well documented. Road transport is a major source, for example, lead emissions from leaded-fuel vehicles, and copper and zinc from vehicle component wear (predominantly brake linings and engine bearings for copper, and tyres for zinc). Concentrations of polynuclear aromatic hydrocarbons (PAH's) are relatively high in urban run-off and are derived from atmospheric particles from fires or exhausts, abraded bitumen and sump oil (Paterson, 2002). These detailed descriptions of the contaminants give some concern to what may be entering other receiving environments around Auckland. This is why treatment methods should be implemented and councils should be enabling research and development of methods to ensure these contaminants do not enter our waterways.

Roadways within built up areas, such as Auckland Region, can occupy 15 to 20% of the land area. Estimates indicate that vehicle use contributes 40 – 100% of these contaminants in urban stormwater. Stormwater is contaminated by motor vehicles through metals such as lead, copper, zinc and oil; all washing off roadways (it is estimated that 70% of stormwater pollution is caused by cars). Rubbish such as plastic bags, bottles and other street litter. Herbicides, garden fertilisers and even rotting lawn clippings. Detergents from car washing and domestic animal faeces are degrading in yards. Illegal and accidental spills are being dumped into stormwater drains. These being daily, weekly, every person products are causing and adding to the cumulative problems that we have defined above in the results of testing.

FLOODING

In the Auckland Region stormwater makes up about 40% of the annual average wastewater flow. The contributions can be much higher and up to 600% of the wastewater flow at peak flow. During times of heavy rain, stormwater leaks into the wastewater network causing it to overload and overflow. These overflows eventually find their way into the stormwater system and our natural waterways. They add to the toxic cocktail already in stormwater and pose a risk to public and environmental health (WCC, 2003).

Engineers and roading authorities have always had the expectation of the stormwater system serving roads to have the following attributes and described by Robinson (2002). To ensure the efficient removal of stormwater from the road and protect adjacent property from the run-off from the road. To have a system which is safe and easy to maintain where in urban areas, the roading stormwater system, principally kerbs and channels, can provide an appropriate disposal point for private property stormwater; and the effect of discharges from the stormwater system need to be environmentally sustainable. These factors are common and with this philosophy behind decision-makers this is how the current system has been constructed and managed. These methods would be suitable in small areas where the areas are small, but in a big city the continual blocking and filling of waterways has led to the adverse effects as outlined below. Stormwater quality issues from sources of the road itself and property immediately adjacent to it.

SUMMARY

The impacts, as are detailed above, provide clarity as to the impacts of stormwater on carparking and roading areas on the environment. The suitability of impervious surfaces is high from an engineering point of view, although from a holistic environmental viewpoint there must be more taken into consideration. To provide a sustainable future for roading and carparking areas we need to look at the best methods for minimising the adverse effects of, and maintaining these stormwater systems.

The adverse effects of parking areas on the environment in relation to these case studies have shown that the capacity of the storm water network, due to its age and the increasing infilling in housing, provides no capacity for the increasing rate of run-off. The major impacts of carparking on the environment are that of flooding due to run-off rates from impervious surfaces, and secondly the collection of contaminants (heavy metals, oils, dusts) and litter from associated land use activities and the parking of vehicles.

KEY QUESTION - WHAT ARE THE BEST METHODS FOR MINIMISING THE QUANTITIES OF CONTAMINANTS ENTERING NATURAL WATERWAYS AND FOR ATTENUATING FLOODING?

The best methods for minimising the quantities of contaminants entering the waterways and for attenuating flooding can be summarised in the aspects which have been looked into as follows: biofiltration systems, detention ponds for quality and quantity of water, permeable pavements, source controls, infiltration and percolation systems. These will be discussed below and provide interesting international methods for providing for the treatment and storage of stormwater

Catchment based assessments are required. These assessments should be undertaken and appropriate areas of land and landscaping be designated for stormwater treatment and storage purposes. This basis has been reiterated throughout the literature reviewed and has been captured in summary following.

There is a rising cost in maintaining 19^{th} century systems yet the public is not willing to accept the required tax or rates increases needed. A system requires being cheap and efficient systems to mitigate these effects. Detention ponds have been used, although require 0.9m fences. Permeable surfaces have increasingly been used and are mitigating the effects (Niemczynowicz, in Torno (Ed.), 1989). Catchment Management Plans should be used. These require the public and private users to abide by and take part in the facilities and monitoring of their system and devices. (Lenhart and Harbaugh, 2000)

Stormwater drainage solutions include source and in-line solutions. A bio-filtration system is one of the options when considering treating run-off prior to discharging into the receiving environment. Biofiltration systems are a combination of detention, infiltration and collection systems. They generally integrate a vegetated swale as part of the design. (Lloyd et al.,2001).

A wet detention pond is a structural measure that has the chance of reducing pollutant effects on the environment and ecosystems. The usefulness is dependent on the size of the catchment and the quality of the discharge. (Hvitved-Jacobsen in Torno (ed),1989)

Infiltration is a network of systems where stormwater is infiltrated into the ground rather than discharged to the surface water body. For example – ponds, vaults, trenches, dry wells, porous pavements, concrete grids. The limitations are a loss of infiltrative capacity over time and high maintenance costs in fine soils. Risk of ground water contamination. A major benefit is a higher backflow maintained in streams during dry weather because of the restoration of the natural water table.

The vegetated waterway reduces the quantity of suspended solids quicker and with a lower quantity at the end compared to the open channel. (Wong et al ,2001). Narrow Swales have a reduction in TSS, TP and TN. Where broad swales, long shallow trenches with appropriate grass species, have shown to treat BOD5 and Suspended solids well. Gravel filters the particle size, and hence surface area is a significant variable. Reacts well in-line with reduction in turbidity. From these points it is clear that grass swales, wetlands, ponds and infiltration systems all form a treatment continuum based of flow attenuation, and detention, and on particle sedimentation and filtration.

There are existing permeable areas in the urban landscape that provide no impact onto this current method of stormwater network. At present the rain travels through and into the groundwater table. (Pratt, in Torno (ed) (1989)

The use of porous pavement in Sweden has been for 25 years it reduces peak flow, reduces pollution on a temporal scale (for example 20 years for porous surface). The question that remains is will the dilution in the groundwater eventually cause other adverse environmental effects. Will this reach a goal of sustainable development? (Niemczynowicz, in Torno (Ed.) (1989).

Level spreaders are designed to collect storm run-off and create sheet flows over land. If a pond is created it can ensure no scarring or scouring of the landscape. They can easily develop short-circuiting because of erosion or other disturbances. (USEPA,1993). These devices have been used to perform a key function. These can be used more and may provide for significant positive overland flow solutions in large park areas.

SUMMARY

The previously discussed information provides a detailed review of those systems that are capable of catering to the future of stormwater networks. There is a definite aspect of sustainability and catchment design philosophy coming through departmental policy changes. It is clear that any one method alone is not going to solve all the issues. A series of interlinked methods managed on a catchment by catchment basis, by one body is needed. This will support the long-term goal of reducing all flooding and contaminants levels in the stormwater system.

The various methods reviewed provide alternatives that can be used in both proposed and existing situations. Then can be undertaken as a retrofit, to upgrade a catchment or to provide for an increase in amenity.

KEY QUESTION - WHAT FINANCIAL MEASURES ARE USED AND WHICH FINANCIAL CONTRIBUTION REGIME ENCOURAGES BETTER PRACTICE?

As can be seen in the study and the method undertaken in case study one, the current situation is not the best method. There should be some freedom for the consumer, developer, or ratepayer to choose the best option for their requirements. There are many different options that will be discussed in detail further in the discussion. However the cost of those decisions should be borne by the beneficiaries and not the environment or down stream communities.

This situation in case study one offered no alternatives or flexibility at the consent level. The policy set out that a contribution should be paid, and this was calculated by the Council's current formula.

THE MAIN REASONS FOR FUNDING

Regional and local councils have recognised the link between stormwater management and desired environmental outcomes sought by their communities. They have subsequently provided and planned for resources to tackle stormwater pollution. As a strong link exists between roading and stormwater pollution, recognition is sought from roading managers to make financial provision for the mitigation of those environmental effects (Paterson, 2002). These reasons are justifiable, the councils have a duty to protect and enable land use.

The key reason for upgrade is that the Regional Growth Strategy requires a further 200,000 persons be accommodated in central Auckland. The upgrade cost has been equated to a contribution of the cost per square meter of impervious surfaces (Paterson, 2001). This does provide a fair and equitable cost calculation, although should the cost be borne in the first place.

Looking toward our overseas neighbours, they are struggling with the same questions. In New South Wales a lack of funding sources is a major limiting factor for long-term stormwater management programmes. Traditionally, local, state and federal funding is available. Rates are an option although these are capped by the Consumer Price Index (CPI). Some alternatives are available. At present there are two options - the rating base and development contributions (Chanan et al.,2001). This issue will always be of concern. Governments will always have to find more money than they will have.

The existing City networks were originally placed and sized to facilitate the development of $1000m^2$ sections. But the development to densities higher than this have been allowed under the current district plan, causing a necessary upgrading of those systems, thus developers are charged a proportionate share of those costs (WCC 2003).

Levies on developers are required to meet the capital costs of infrastructure required for servicing their development. The requirement is for the developer to upgrade and contribute to the upgrading of an under capacity catchment. There are issues raised when objections are made to the imposition of financial contributions.

PURPOSE OF FUNDS WHEN ACQUIRED

These main concerns are the cost of physical works based on the estimate for the total catchment upgrade. The basis of calculating the financial contribution to properties, and the cost to those further upstream. The practicality of upgrading larger size pipes in already developed areas, and whether upgrades on a theoretical basis are feasible (Hassan et al., 2001). Again the provision of these services and upgrading is required on a continual basis, monitoring systems and construction costs will always be present.

The financial contributions are required in order to upgrade the infrastructure in Manukau. There is a growing need to integrate development with water quality improvements in infill housing areas. The additional cost of water quality improvement is likely to further decrease the economic viability of infill development in many catchments unless other sources of funding are made available, for example Infrastructure Auckland grants (Hassan et al., 2001).

How funding is obtained

The income for the infrastructure upgrades comes from the following sources lump sum payments toward the cost of existing or future services known as Developer Contributions, to payments towards the upgrading costs associated with the reconstruction of existing reticulation networks and the provision of new reticulation (WCC, 2003). These options compiled by Chanan et al from Australia provide very similar views and requirements, they are as follows:

- Offset arrangements – stormwater management rather than upgrades.
- Stormwater utilities – a funding utility for stormwater rates – for costs of upgrading.
- Stormwater Revenue Bonds – loans.
- Authority for Stormwater Management - a central co-ordination authority.
- Greater Central Government involvement– due to the significance of clear and safe environments in their policies.
- Stormwater as a commodity – water shortage, and other uses - harvested urban stormwater can be treated and used for peri-urban areas, parks, sporting facilities, etc.
- Rates Rebate – voluntary conservation agreements, relinquish development rights, or stormwater quality improvements on land in return for rate rebate (Chanan et al.,2001).

Summary

The assessments of the different Local Authorities methods and purposes give a clear picture as to where they see themselves within the big picture. It is clear that the regional and central government bodies are imposing more stringent limits on pollution and discharges. These new standards then cause the local bodies to react, and interpret them as they see fit for their respective situations and targets set.

The better practice issues arise from the roles of the developer – council interactions. Better practice arises from the leadership that is applied from above regulatory methods used to meet the standards. It is clear that there are choices: increase rates, borrowing, or commit to charge the developers, who incur as part of development cost. It is clear that from above that there is a political consequence and component in the decision making.

KEY QUESTION - ARE THERE GOOD LINKAGES BETWEEN STATUTORY PRACTICE AND DISTRICT PLANNING, ESPECIALLY AT SUBDIVISION APPROVAL LEVEL?

From case study one, it is clear that the linkages are poor. For councils to impose conditions of consent that requires that an objection be made each time for that financial contribution to be reduced shows that there are flaws in the current system[24]. Where the answers lie is within the local bodies themselves. A catchment analysis and resource analysis should be made to determine the allocation of resources. This will provide the best results to satisfy all parties.

Reviews have been undertaken for both Manukau City and Waitakere City situations. These reviews have provided a snapshot into each of the Local Authorities' drive and views, when considering the stormwater situation in a more holistic way.

WAITAKERE CITY

Waitakere City has set a good precedent by having a Comprehensive Urban Stormwater Management Strategy and Action Plan that sets out the City's approach to managing its stormwater. The Strategy's main focus is to mitigate the adverse effects of stormwater including the protection of the aquatic habitats and the attenuation of flooding. Another important aspect of the strategy is preventing future problems by designing an adequate stormwater management system. The Council also has the goal of remedying the problems arising from past inadequate design.

[24] How many sites in the city are contributions applicable to? How many times will this issue come up in the future? How much time will be spent defending and hearing these cases individually? Should something be done now to ensure that something can help all those persons, a common solution? Is this solution what the Council will want? Will it assist the planning and regulation of the city?

Best practice catchment management principles in both new and established areas, community and business involvement and education programmes are stressed as important for the management of stormwater needs in the long-term.

The Strategy reflects the legislative and strategic context (regionally and nationally), the iwi perspective and the Council's own strategic direction. All point to the need for a more holistic approach to stormwater management, recognising the need for total water-cycle management and ensuring that adverse environmental effects are avoided, mitigated or remedied.

The Strategy is interpreted to accurately assess the actual requirements needed infrastructurally. Waitakere has a supportive objective, policy and rules that are enforceable through their district plan, giving more supportive effects based planning regime. Waitakere has a concise philosophy about the forward thought required to implement and sustainably manage their resources. There is still much to be done, however, to ensure this sustainable future is achieved.

MANUKAU CITY

Manukau City has provisions for parking and stormwater issues nestled throughout their district plan, enabling use to minimise the impacts of stormwater. There are key enforceable objectives, policies and rules that are used daily by the City's development control department. The nature of the objectives and rules provides for any activity. But there is a flaw, in that the default option for developers is to construct in accordance with the Council's Manual of Engineering Quality Standards, rather than to pursue best practice management and design more suitable catchment options for their developments.

Residential development has the potential to have adverse effects on the quality of the natural environment. An issue for residential areas is that of the cumulative effect of increased areas of impervious surfaces associated with residential development pertaining to the effects on the City's receiving waters.

The business zone development rules are based on quantity of flow and only now Council is starting to review the quality impacts. Most business areas are close to the coastline and discharge almost uninhibited and without treatment. The stormwater infrastructure in the business areas of the City has been designed and constructed to accommodate the intensive development that takes place in business areas. The infrastructure is only designed to maintain water quality but not improve or enable aquatic life to be re-established. There is a need, however, for concise rules and methods in relation to stormwater management for the protection and enhancement of the business areas of Manukau. The Proposed Auckland Regional Plan, Air Land Water, institutes rules for stormwater discharge protection from industrial sites and requires consents for a schedule of industries.

SUMMARY

The development of a city can cause adverse effects on the environment by a subsequent deterioration in water quality. Flooding can adversely affect human life and property and cause erosion in vulnerable catchments. The issues connected to flooding are clearly addressed in the Manukau Plan and provide for the suitable development and mitigation of effects.

It may also be noted, that, depending on the zoning requirements of an area, the total amount of carparking area may not be sufficient to cater for needs or may be unnecessarily excessive. If a parking area is too small it may result in higher use of public transport, or that an alternative business area that is easier to park is found. If there is over-provision in a parking area it will be underutilised and may lead to nuisance activities.

KEY QUESTION - WHAT ARE THE BEST PLANNING AND LEGAL MEANS FOR IMPLEMENTING METHODS?

In specific terms the planning method that has been considered in relation to the Jellicoe Road, Manurewa, case study has been that of imposing a contribution to pay for the upgrading of the catchment. In retrospect it can be seen through the consent process that there was indeed a better solution than Council's imposed conditions. The decision of the Hearings committee the consent requirements, reflects a change to fit with ARC policy to improve environmental standards

In general planning and legal means for implementing methods of mitigating adverse environmental effects of carparks all have varying levels of cost. These are through rating, loans, and contributions on development and others. The best planning and legal means to implement methods are through the development control elements of the regional and district plans. These are legislative documents and enforceable as provided for under the RMA.

From assessment in Chapter Five it has been shown that the business areas of a city have a higher impervious surface ratio. Also these areas have a greater use of resources and levels of contaminants than that of the residential areas. This increased the problems of contaminants entering the stormwater system and environment. These areas require a greater level of treatment and flood mitigation devices.

This is in stark contrast to residential areas where a minimum of 30% of the sites are vegetated and gardens and significantly lower use by contaminating activities. The Industrial environment can be remedied with the imposition of stormwater treatment methodology that can be undertaken under the Waitakere and Manukau Operative District Plan. This should provide any landscaped area as a treatment facility for contaminants and storage. This could comprise of retrofitting systems on redevelopment and on new developments in the city.

Summary

The local bodies should integrate these actions to comply with the regional council's thresholds. The recommendation from this discussion is that a holistic catchment study is required to provide for the reduction of the traditional pipe construction method for stormwater control. We must work towards the sustainability promoted by the Resource Management Act.

The way forward is to take a number of steps. Firstly take a catchment that requires a significant amount of upgrading and study all the matters that relate to the stormwater impacts. Secondly review the catchment existing resources including carparks and other open areas. Thirdly identify the contaminants or contaminating factors of the catchment and isolate and identify each one. When the catchment is looked at from a resource basis rather than a single source there are an abundant number of options that could be employed to rectify and restore the catchment.

CHAPTER EIGHT – CONCLUSIONS & RECOMMENDATIONS

This chapter draws conclusions from the case study undertaken. It will first revisit the aims and objectives initially made, in relation to each of the three case studies – Jellicoe Road Carpark, Manukau City, and Waitakere City. Finally recommendations for best practice will be given, along with suggestions for further research.

REVISITING THE AIMS

This study was undertaken to investigate the adverse environmental impacts of stormwater in carparking areas.

The issue of stormwater pollution in relation to carparking has remained a central theme in this thesis. There has been evidence provided by way of the literature review (refer Chapter Two) that stormwater pollution starts with every street, every carpark and every driveway. The stormwater run-off collects heavy metal, sediment, and nutrients and deposits them in the waterways and ecological systems that we are trying to protect. These cumulative impacts are poisoning and over-enriching the aquatic environment with toxic material and nutrients respectively. This will have immediate impacts as well as reduce the amenity value for future generations.

The second theme is high rainfall events and subsequent water shed from impervious surfaces causing flooding. Flooding is an increasing problem while rainfall patterns remain much the same. As the face of the land changes from the original dense forestation to highly commercialised and impervious landscape, stormwater is collected and redirected into the waterways. There are many methods that exist for mitigation or minimisation of stormwater flooding and peak discharges through hydraulic controls. There are design standards such as ARC TP10 (2003) existing globally that can be utilised to encourage best practice in this field.

To implement stormwater management methods, legislation such as the *RMA*with consequent regulation through district plans, rules, policies and conditions on developments can be utilised. Where new developments are proposing to create areas of impervious surface, they require counterbalancing controls.

Auckland Region has long-term and continuing stormwater issues. The various local authorities' viewpoints pertaining to the same environmental issues have resulted in a diversity of strategies to resolve the issues.

One strategy is the financial contributions imposed on developers relating to the effects their development will have on stormwater run-off. The contributions are a key tool for ensuring that upgrading has adequate funding. Auckland Region's local authorities are justified in levying developers, however, options should be given to developers to offset their contribution to the extent that they are able to mitigate the adverse effects by various means. The councils, in return for receiving the financial contributions, have the responsibility of ensuring the allocated funding is correctly applied to remedy the problems caused by the increased impervious area and the pollutant discharges associated with the use of the impervious area.

The literature review undertaken has shown that there is increasing awareness of the key issues involved in and the actual and potential adverse effects of stormwater on the environment.

THE ADVERSE EFFECTS OF CAR PARKING AREAS ON THE ENVIRONMENT.

Carparking areas have significant impact on the rate of stormwater run-off and the quantities of contaminants entering waterways. The impacts of areas for carparking are more than minor. Engineers need to be seeking to design carparks that will contain the flooding, treat the contaminants, and control the adverse impacts of parking areas on the environment.

The impact of each carparks impervious surface needs to be viewed on a larger scale. Every carparking area adds to the cumulative impact on the environment of peak stormwater discharge rates, sediment and vehicle related pollutants.

The suitability of carpark impervious surfaces to cater for the primary purpose is high from an engineering point of view, although from a holistic environmental viewpoint there must be more taken into consideration. To provide a sustainable future for roading and carparking areas we need to look at the best methods for minimising the adverse effects of, and maintaining these stormwater systems.

The "down stream" adverse effects of parking areas on the environment in relation to these case studies have shown that the capacity of the storm water network, due to its age and the increasing infilling in housing, provides no capacity for the increasing rate of run-off. The major impacts of carparking on the environment are those of flooding due to run-off rates from impervious surfaces and scouring of stream beds resulting in adverse habitat effects. And second the discharge of contaminants (heavy metals, oils, dusts) and litter from associated land use activities and the parking of vehicles again with adverse effects on biota and habitats.

THE BEST METHODS FOR MINIMISING THE CONTAMINANTS ENTERING NATURAL WATERWAYS AND ATTENUATING FLOODING.

There are many suitable methods for minimising the contaminants entering the natural waterways and for attenuating flooding. However, not every method is suitable for every location. Flexible catchment plans are required to provide for those options so that overall there are an improvement in the system. There are numerous case studies and detailed engineering research into the impacts and different designs to provide for a range of engineering solutions. The major methods are filtration, infiltration, permeable pavements, detention ponds (online and offline), settling ponds and wetlands.

Stormwater treatment and detention systems are capable of catering to the future of stormwater networks. There is a strong sustainability and catchment design philosophy coming through regional and local government departmental policy changes. It is clear that any one method alone is not going to solve all the issues. A series of interlinking methods managed on a catchment by catchment basis is needed. In many ways a treatment train can be used, for example with filtering on site followed by off-site stormwater peak flow storage and release. This will support the long-term goal of reducing all flooding and contaminants levels in the stormwater system.

The various methods reviewed provide alternatives that can be used in both proposed and existing situations. Then can be undertaken as a retrofit, to upgrade a catchment or to provide for an increase in amenity.

THE FINANCIAL MEASURES USED AND WHICH FINANCIAL CONTRIBUTION REGIME ENCOURAGES BETTER PRACTICE.

Asset managers should assess as many options as possible to provide for the provision of the upgrading of catchments. Financial instruments used should cover the additional infrastructure costs associated with any development effect not fully mitigated. This will drive the use of efficient, sustainable methods.

The different Local Authorities methods and purposes give a clear picture as to where they see themselves within the big picture. It is clear that the regional and central government bodies are imposing more stringent limits on pollution and discharges. These limits cause the local bodies to react, and interpret them as they see fit for their respective situations and targets set. There is some consistency, although not completely. Some duplication of work is being undertaken based on the individual city.

The better practice issues arise from the roles of interactions between developer and council. Better practice arises from the leadership that is applied from above regulatory methods used to meet the standards. It is clear that there are choices: increased rates, borrowing (deferred increased rates), or commitment to charge the developers, who then undertake development effect mitigation as part of development cost. It is clear that from above that there is a political consequence and component in the decision making.

THERE ARE GOOD LINKAGES BETWEEN STATUTORY PRACTICE AND DISTRICT PLANNING, ESPECIALLY AT SUBDIVISION APPROVAL LEVEL.

District plans do follow the regional plans and policies. At present there are new design policies although they are underutilised. Through the subdivision approval stages of development there is too much emphasis on past practices, rather than designs that follow the new policies. Developers and engineers appear stuck in a cost and design rut, whereas if they developed strategies they could find better solutions for their clients.

The development of Auckland Region has caused significant adverse effects on the environment by a subsequent deterioration in water quality. Flooding has adversely affected residential and commercial property and caused erosion in vulnerable catchments. The issues connected to flooding are clearly addressed in the Manukau Plan and provide for the suitable development and mitigation of effects. The past practices of straightening and concreting streams to make them efficient flood conduits with severely reduced habitat values are no longer acceptable.

It may also be noted, that, depending on the zoning requirements of an area, the total amount of carparking area either may not be sufficient to cater for needs or may exceed requirements. If a parking area is too small it may result in higher use of public transport, or customers driving to alternative business areas that are easier to park in. If a parking area is underutilised it may lead to higher than necessary peak water flows and control measures. If parking areas are oversized and underutilised they lead to higher than necessary peak water flows and control costs.

THE BEST PLANNING AND LEGAL MEANS FOR IMPLEMENTING METHODS.

District Plans under the *RMA*are required to have effects based performance standards rather than approved construction standards. This should flow through the planning regime and be easily understood by any person.

The local bodies are required to integrate planning and effects based standards to comply with the Regional Plans. Holistic catchment studies are required to provide for the reduction of the traditional pipe construction method for stormwater control. Territorial authorities must work towards the sustainability promoted by the Resource Management Act.

A number of steps forward are required. Firstly consider each catchment that requires a significant amount of upgrading and study all the matters that relate to the stormwater impacts. Secondly review the catchment existing resources including carparks and other open areas. Thirdly identify the contaminants or contaminating factors of the catchment and isolate and identify each one. When the catchment is looked at from a resource basis rather than a single source there are an abundant number of options that could be employed to rectify and restore the catchment.

RECOMMENDATIONS

Any constructed surface or development, whether it be for carparking purposes or roofing should, wherever practicable, have built into its design a treatment and detention facility to mitigate the effects of stormwater on the environment.

It is clear that structural obstacles can be overcome in relation to treatment and storage of stormwater. The continued development and research to improve practices should be promoted as we seek to provide for future generations

The impacts of any particular project should be looked at in relation to the catchment it is within and the cumulative impacts of these areas. It should not only be up to the Councils to control, but for the developers and engineers to provide more rigorous assessment of their projects.

Financial contribution and catchment plans should include provision for rates relief for those prepared to upgrade their site to mitigate effects on catchments as preferable to action against those who are unable or unwilling to upgrade.

District plans should provide performance standards not standard designs for the provision of onsite maximisation with incentives to reduce off-site impacts of stormwater.

Site assessment should enable councils to levy existing properties as to their direct impact and provide for options of upgrading, rather than take a default option of upgrading the stormwater system to a pipe constructed method only.

The methods for mitigation of impacts should be undertaken on a holistic catchment basis. Catchment assessment is where the local authorities should targeted to ensure catchment design and controls protect the environment and meet the regional bodies requirements.

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LIST OF APPENDICES

APPENDIX 1 –

RESOURCE MANAGEMENT ACT (1991) PART II SECTION SEVEN AND EIGHT

7. Other Matters – In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall have particular regard to –

(a) Kaitiakitanga:
(b) The efficient use and development of natural and physical resources:
(c) The maintenance and enhancement of amenity values:
(d) Intrinsic values of ecosystems:
(e) Recognition and protection of the heritage values of sites, buildings, places, or areas:
(f) Maintenance and enhancement of the quality of the environment:
(g) Any finite characteristics of natural and physical resources:
(h) The protection of the habitat of trout and salmon.

8. Treaty of Waitangi – in achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall take into account the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).

APPENDIX 2 –

RESOURCE MANAGEMENT ACT (1991) PART II SECTION 15

15. Discharge of contaminants into environment –

(1) No person may discharge any –

(a) Contaminant or water into water; or

(b) Contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water, or;

(c) Contaminant from any industrial or trade premises into air; or

(d) Contaminant from any industrial or trade premises onto or into land –

Unless the discharge is expressly allowed by a rule [in a regional plan and in any relevant proposed regional plan], a resource consent, or regulations.

(2) No person may discharge any contaminant into the air, or into or onto land, from –

(a) Any place; or

(b) Any other source, whether moveable or not, -

In a manner that contravenes a rule in a regional plan or proposed regional plan unless the discharge is expressly allowed by a resource consent or allowed by section 20 (certain existing lawful activities allowed).

APPENDIX 3:

WAITAKERE DESIGN GUIDELINES

C2.1: Porous asphalt and concrete pavement

Description

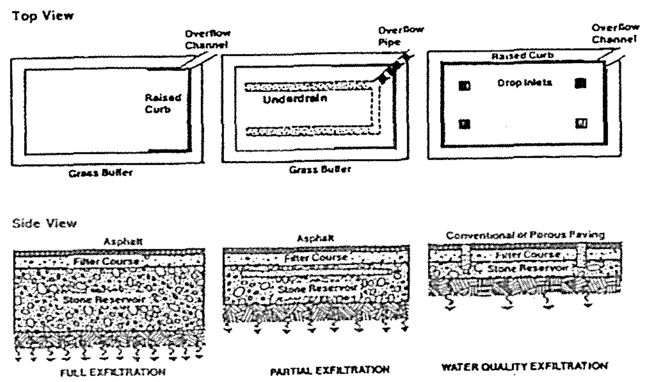
Porous asphalt and concrete paving materials consist of an open graded coarse aggregate cemented together by bitumen or cement into a coherent mass, with sufficient interconnected voids to provide a high rate of permeability into a high void basecourse/sub-base.

Porous concrete consists of specially formulated mixtures of cement, and uniform open graded coarse aggregate. This material may be combined with certain water reducing and air entraining admixtures. When properly handled and placed, pervious concrete has a high percentage of voids which allows rapid percolation through to the sub-base.

Purpose

- Promote water balance by reducing runoff and promoting infiltration and detention;
- Reduce volumes and peak rates of runoff and maintain groundwater recharge by providing detention and infiltration of stormwater; and
- Improve water quality by filtration and bacterial action.

Diagram



(Source : Schueler, 1987)

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FIGURE A1.1 WAITAKERE POROUS PAVING GUIDELINE

C2.2: Modular paving

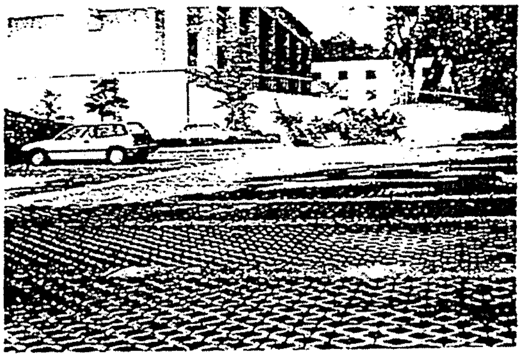
Description

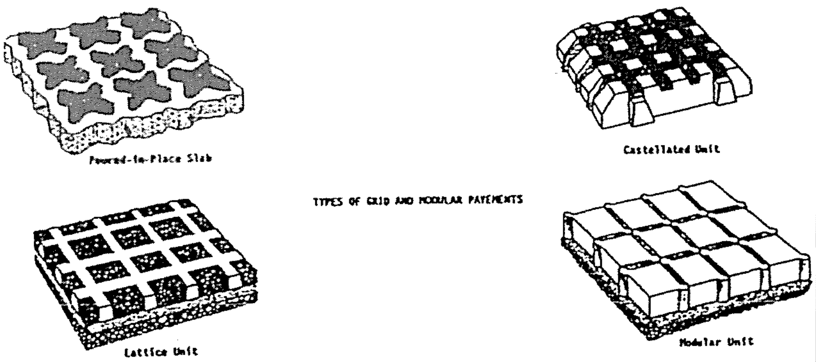
Modular paving is best incorporated into the design stage of new developments, to reduce runoff. Modular pavers are available in various brick and concrete pre-forms which, if laid on a permeable base, will allow water to infiltrate, either through joints or perforations.

Purpose

- promote water balance by reducing runoff and promoting infiltration and detention;
- reduce volumes and peak rates of runoff by providing infiltration of runoff;
  improve water quality by filtration and bacterial action; and
- maintain groundwater recharge.
-

Diagram





(Source : Florida Development Manual, 1992)

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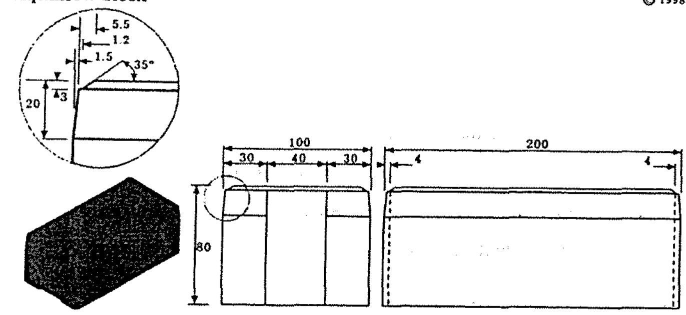
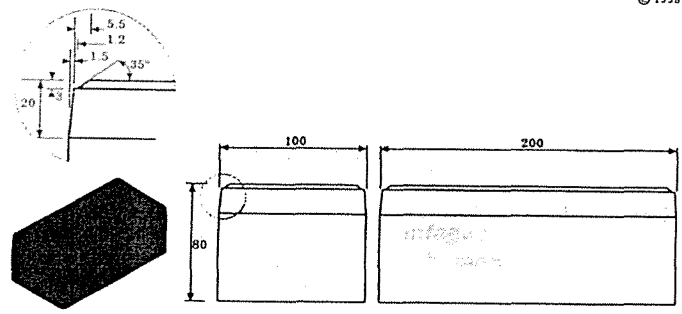
FIGURE A1.2 WAITAKERE POROUS PAVING GUIDELINE

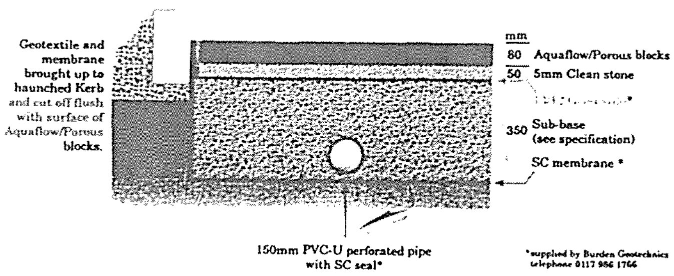
Aquaflow block © 1998



Porous block © 1998



Typical Lined System Section © 1998



Typical Infiltration System Section © 1998

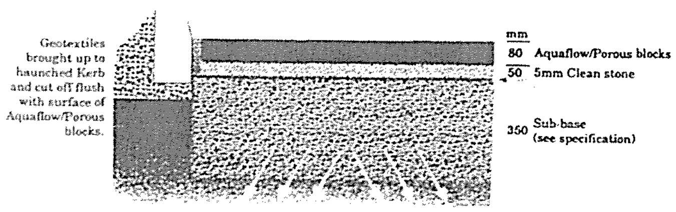


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FIGURE A1.3 WAITAKERE POROUS PAVING GUIDELINE

APPENDIX 4:

DATA FROM SITE ASSESSMENTS

DATA TABLE

	Efficient	Waterway	Treatment	Storage	Maintenance	Usability	Safety	Traffic Volume	Cost	Upgradable
Airport	5.00	5.00	5.00	5.00	4.00	0.00	0.00	0.00	5.00	0.00
Business sites	3.00	3.00	0.00	0.00	2.00	5.00	4.00	5.00	2.00	5.00
Clendon	1.00	3.00	0.00	0.00	1.00	5.00	4.00	3.00	2.00	5.00
Clendon Rec	3.00	3.00	0.00	0.00	1.00	5.00	4.00	4.00	2.00	5.00
Kiwi Reserve	2.00	5.00	1.00	0.00	1.00	5.00	5.00	3.00	2.00	5.00
Mangere AOG	1.00	1.00	0.00	0.00	1.00	5.00	5.00	1.00	2.00	5.00
Mangere Boat	1.00	5.00	0.00	0.00	2.00	5.00	4.00	4.00	2.00	3.00
Mangere Lane	1.00	5.00	0.00	0.00	1.00	5.00	3.00	5.00	2.00	2.00
Marble Place	1.00	5.00	0.00	0.00	1.00	3.00	5.00	2.00	3.00	3.00
Massey High	1.00	1.00	0.00	0.00	1.00	5.00	4.00	5.00	2.00	5.00
Massey Inline	5.00	5.00	5.00	5.00	4.00	0.00	0.00	0.00	5.00	0.00
Masssy Library	3.00	5.00	3.00	0.00	1.00	5.00	4.00	3.00	3.00	3.00
Pak'n'Save	1.00	5.00	0.00	0.00	1.00	5.00	5.00	5.00	2.00	5.00
Pap Park & Ride	3.00	1.00	0.00	0.00	1.00	5.00	5.00	5.00	2.00	5.00
Papatoetoe Ward	1.00	1.00	0.00	0.00	1.00	5.00	5.00	3.00	2.00	2.00
Parking Building	5.00	5.00	0.00	0.00	1.00	5.00	3.00	5.00	5.00	0.00
Plant Shop	1.00	1.00	1.00	1.00	1.00	3.00	3.00	3.00	1.00	5.00
Progressive	3.00	5.00	0.00	0.00	2.00	5.00	5.00	5.00	2.00	4.00
Service Lane	1.00	5.00	0.00	0.00	1.00	3.00	1.00	5.00	1.00	5.00
St Paul Kindy	1.00	1.00	0.00	0.00	1.00	5.00	3.00	1.00	2.00	4.00
St Pauls School	5.00	1.00	4.00	4.00	3.00	5.00	5.00	3.00	3.00	0.00
Westridge	1.00	5.00	0.00	0.00	1.00	5.00	5.00	1.00	2.00	5.00
Wiri Inline	5.00	5.00	5.00	5.00	4.00	0.00	0.00	0.00	5.00	0.00

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