DOWN WITH THE DRAIN:
LOOKING AFTER OUR URBAN RUNOFF AND WATERWAYS IN THE ERA OF SUSTAINABLE MANAGEMENT

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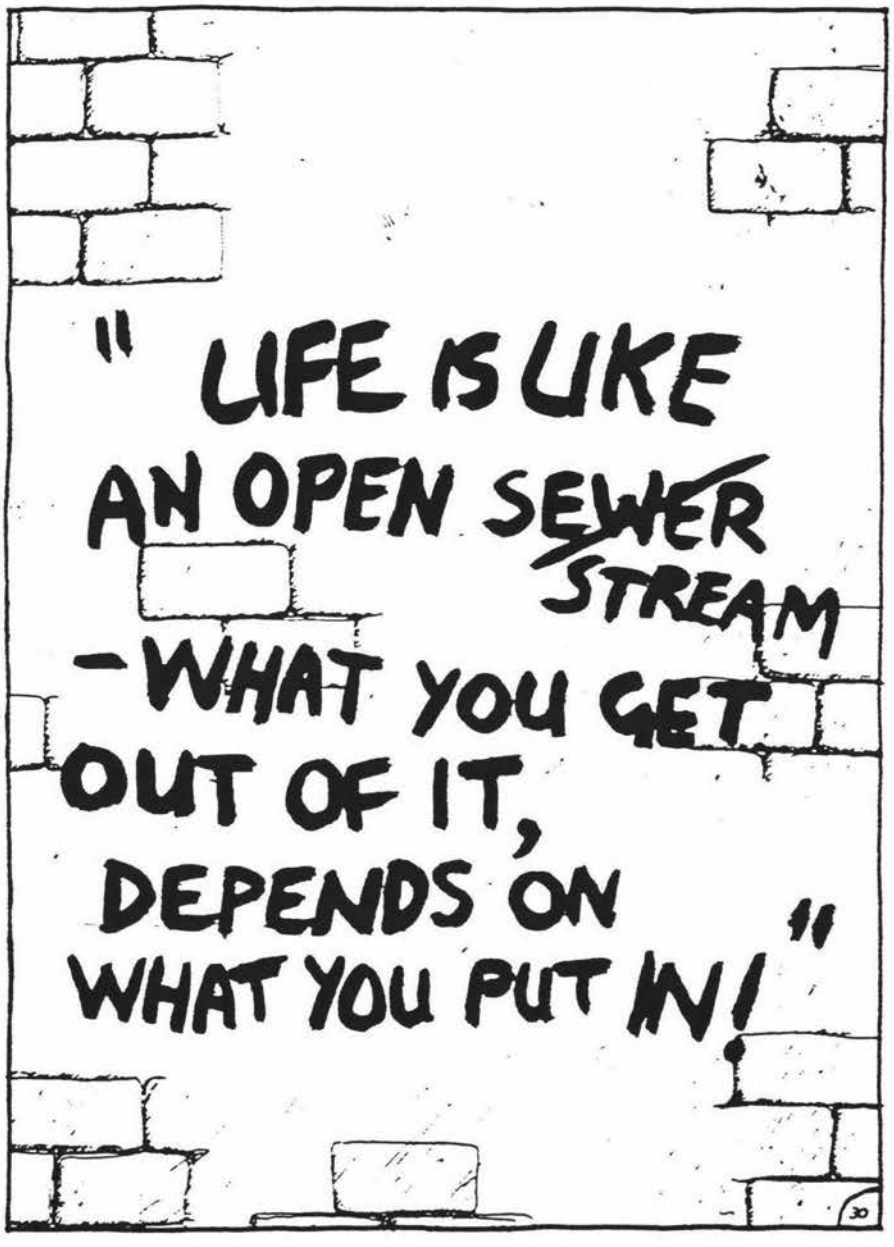
And it shall come to pass that... "Swarms of living creatures will live wherever the river flows. There will be large numbers of fish, because this water flows there...

But the swamps and marshes will not be fresh; they will be left for salt. Fruit trees of all kinds will grow on both banks of the river. Their leaves will not wither, nor will their fruit fail. Every month they will bear because the water from the sanctuary flows to them. Their fruit will serve for food and their leaves for healing."

Ezekiel 47: 9-12



Source: Auckland Regional Authority (1980)

ABSTRACT

Recent reforms of environmental and local government legislation have radically changed the nature of environmental management in New Zealand. There is a new mandate for the "sustainable management" of natural and physical resources. This thesis examines how environmental considerations are currently being incorporated into the management of urban runoff and waterways in New Zealand.

Three case studies of urban councils were conducted. Two main data collection methods were employed. Interviews were conducted with the relevant council staff and this information was supplemented by an analysis of regional policy statements, regional plans and district plans that employed a method of plan coding. This sought to establish what policies and programmes the councils were involved in, whether this was different from the late 1980s, and the extent to which they were carrying out various types of innovative solutions to environmental problems.

The research findings suggest that councils vary considerably in their approach to urban runoff and waterways. It showed that urban streams in New Zealand have suffered levels of degradation including pollution and channel modification that are consistent with many urban areas overseas. Recently, elements of a new philosophy have been applied to their management, which has coincided with the introduction of the Resource Management Act (RMA). Following overseas trends, there has been a recognition by managers of our waterways and stormwater systems that former practices in managing urban runoff have neglected environmental issues and natural resource conservation. This research suggests that stormwater management practices are taking on board the considerations of water quality, quantity and biodiversity to a greater extent than that which happened in the past. The extent to which this is happening in any particular area depends on the scale of the issues, the sensitivity and utility of affected resources, and the level of commitment by both community and council to changing traditional practices.

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GLOSSARY

Best Management Practices (BMP): "Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters..." (Dennison, 1996, 367). BMPs can be used at any stage of the pollution cycle, for instance to prevent or treat pollution, and include both structural and non-structural controls.

Biodiversity "is the variety of the world's organisms, including their genetic diversity and the assemblages they form...The breadth of the concept reflects the interrelatedness of genes, species and ecosystems" (Reid and Millar, 1989 in Gaston, ed., 1996).

BOD: Biological Oxygen Demand: the removal of dissolved oxygen in water by decaying matter.

Catchment: "The total area from which a single river collects surface runoff." Otherwise known as the "watershed" or "drainage area" (Whittow, 1984, 88).

Design Storm, flood: "The storm or flood which is used as the basis for design, i.e., against which the structure is designed to provide a stated degree of protection or other specified result" (Whipple et al., 1983, 220).

Drain: means a sewerage drain or stormwater drain, usually in the form of a pipe laid underground.

First flush: "Commonly observed phenomenon in which the concentration of pollutants is higher in the earlier stages of a storm event" (Whipple et al., 1983, 221).

Greywater: the water and waste products from sinks, showers and baths (Bell, 1994).

Mulch: "A natural or artificial layer of plant residue or other material covering the land surface". It is useful in retarding runoff, conserving moisture and preventing soil erosion (Dennison, 1996, 375).

PAH: polynuclear aromatic hydrocarbon- a particular type of contaminant often found in urban runoff.

Ponding: There are several types. "Detention basins" are described by Ferguson and Debo (1990) as slowing the passage of runoff as it moves towards the receiving waters thereby suppressing flood peaks. The most common of detention basin is the "dry pond" which, as the name suggests, holds water temporarily (ASCE, 1992). As dry

ponds hold water only for a short space of time they are not effective at improving the water quality. Improving water quality requires the use of "retention basins" that are designed to hold runoff for a longer time period than detention ponds. They require a storage capacity larger than the expected volume of runoff and are therefore bigger and consequently more expensive than detention basins (ASCE, 1992). The ponds are normally "wet ponds" where water is held permanently. Removal is accomplished by a number of physical, chemical and biological processes. Particulate pollutants are removed by gravitational settling. Pollutants such as BOD and pathogenic bacteria can be removed by the use of aquatic plants and other micro-organisms.

Porous pavement: Porous pavement is pavement that allows for the infiltration of surface runoff due to a higher porosity than a similar impervious asphalt or concrete mixture. Another variation is concrete grid pavements where modular, interlocking blocks with openings of permeable cover in-between are used to allow water to seep through to the subsoil (Urbonas and Roesner, 1993).

Retrofit: Upgrading or adding on to the existing stormwater system which is exclusively referring to the addition of treatment devices for improving water quality (Dennison, 1996).

Rivers: "means a continually or intermittently flowing body of fresh water; and includes a stream and modified watercourse; but does not include any artificial watercourse (including an irrigation canal, water supply race,...farm drainage canal)" (s2 RMA). For the purposes of this thesis it includes all urban waterways.

Source controls: The preventative means whereby pollution and contaminants are kept separate from rainfall/ and or stormwater (Urbonas and Rosner, 1993). For examples of the various techniques used see Table 2.3.

Stormwater: The water that runs off the ground surface of a catchment. The main cause of stormwater is the inability of rainwater to infiltrate the surface.

Stormwater system: Programs which deal with conveying urban runoff downstream. It can include everything from roof top drains through to outfall channels. There are always two parts- primary and secondary paths. The primary path is that which is intended to most often carry the flow and consists of pipes and open channels. The secondary path is the route that the runoff takes when the primary path can

no longer contain the flow due to either blockages or a exceedance of the hydraulic capacity.

Street sump: A chamber which is installed in the drain and incorporates features to intercept and retain silt, gravel and other debris" (Building Industry Authority, 1992, viii).

Swales: These are channels, typically lined with grass or other vegetation that are constructed to convey runoff. The vegetation retards the flow velocity and can act as a partial treatment mechanism (ARC, 1992).

Urban runoff: For the purposes of this research it can be interpreted as being equivalent to stormwater. It is the stormwater that runs off an urban catchment and also the non-point sources of pollution that accompany it.

CHAPTER ONE

INTRODUCTION

BACKGROUND

The management of urban runoff is concerned with what to do with rainwater that appears in a part of the urban environment where it is undesirable (Eberhard and Bernstein, 1984). Urbanisation results in a drastic change to the natural hydrological processes of a catchment. This requires the installation of a stormwater system to replace the existing natural drainage pattern of the area to protect property and transportation routes from flooding. The design of the stormwater system has traditionally been based on getting rid of urban runoff as fast and as efficiently as possible. The result has been an artificial drainage pattern that contributes little to the environmental health or amenity value of the urban landscape.

As urban centres have expanded in size, a whole range of environmental problems have been observed in many areas around the world associated with the design and management of stormwater infrastructure. The most obvious problems have been flooding and erosion. After a rainstorm in a "natural" forested catchment most water is either held by vegetation or seeps into the ground. In an urban area, asphalt and concrete replace soil, buildings replace trees and most of the rainwater becomes surface runoff leading to downstream flooding, erosion of river banks, beds and the loss of aquatic habitat. This necessitates the construction of costly downstream structures to mitigate the problems.

Urban waterways have been almost synonymous with a polluted appearance. They have too often been used as cheap and convenient sewers. Mann (1973, 13) described them as *"the most intensively used and most often abused resource on Earth"*. As environmental values have received higher priority in the post war period, the traditional disposal of industrial wastes and domestic sewage into rivers and coasts has either been reversed or it has been treated to a much higher standard. As this has occurred, the relative importance of urban runoff (stormwater) as a source of contamination has been observed in the urban environment.

All urban surfaces from rooftops to roadways are deposited with contaminates from urban activities that are washed into waterways and other aquatic receiving environments every time it rains (Hough, 1989). The impact of these contaminants, depending on the dynamics of the receiving environment, can be severe on the long term health of aquatic species and ecosystems. However, recognising the connection between urban runoff and the resulting degradation in the water quality of areas, with no other evident polluting discharges, has often been slow.

As a result of these environmental problems and a shift in community values caused by the environmental movement, the traditional way of managing stormwater has come under question. Since the Brundtland Report (1987) the concept of sustainability has shaped much of the present debate on environmental issues and this has left its mark when stormwater quality and quantity are discussed. In 1991, New Zealand became the first country to draw from this concept by incorporating the principle of sustainable management into the Resource Management Act (RMA). The RMA, radical by international standards, revamped most of the fragmented environmental legislation that existed previously and sought the single purpose of promoting the sustainable management of natural and physical resources.

This thesis seeks to address the extent to which councils are incorporating the principle of sustainable management into urban runoff and waterway management. The following chapter outlines the research objectives, questions and the structure of the thesis.

THESIS AIMS, OBJECTIVES AND RESEARCH QUESTIONS

OVERALL AIM

The main objective of this thesis is to answer the following question:

> How have environmental considerations been incorporated into the management of urban runoff and waterways in the era of sustainable management?

Environmental considerations examined in this thesis include aspects such as flooding, pollution, and the health of the ecosystem. Management is the process of planning, organising and controlling (Koontz and O'Donnell, 1972). The era of sustainable management refers to the period since local government and resource management reforms took place in the 1980s.

THESIS OBJECTIVES

Objective One: *Describe the extent to which environmental considerations been incorporated into the management of urban runoff and waterways*

Research questions:

- What are the theoretical approaches to stormwater management?
- What theoretical approach is most akin to the sustainable management of urban runoff and waterways?

One of the main aims of this research is to ascertain how the approach taken by councils compares with the theoretical models and the criteria that is developed in Chapter Two.

Objective Two: *Identify how councils are incorporating environmental considerations into urban runoff and waterways.*

Research questions:

- What type of approach and characteristics have councils adopted?
- What goals, objectives and policies are the councils pursuing?
- What programmes are the councils implementing?
- What source controls, retrofitting and other requirements are being used to mitigate adverse effects of urban runoff?

These questions seek to identify each council's general strategy in protecting urban waterways and runoff from flooding, pollution and other environmental problems. These include structural, non-structural or semi-structural activities. They can be in the form of regulations, resource consent conditions, economic instruments, education/ advocacy and construction of treatment devices.

Objective Three: *Determine whether stormwater practices are different now from what occurred before the era of sustainable management.*

Research questions:

- What were the past and present institutional arrangements for the environmental protection of urban runoff and waterways in New Zealand?
- How does the RMA influence councils in the consideration of environmental aspects when they are managing urban runoff and waterways?
- Are practices different under the new institutional context than they were before?

Objective Three clarifies what changes the "era" of sustainable management means for the management of urban runoff and waterways. In particular, it examines whether the change of institutional arrangements that has occurred in New Zealand has led to a change in management philosophy and the way practices are being carried out.

DEVELOPMENT OF URBAN RUNOFF MANAGEMENT

Maori were the original users of the waterways and had developed their own distinct management approach. They had great respect for water resources because of their reliance upon them for food and materials, transportation, ceremony and spiritual healing (Gelfund, 1991). Contemporary urban waterway managers have until recently ignored Maori values and the environmental principles that went with them.

Colonisation of the country brought with it the desire to expand economic growth and transform New Zealand into a "modern nation". Legislation was enacted during this period, to provide the institutional basis with which developers could rapidly exploit natural resources. There was little willingness during this period of rampant development for New Zealand's legislature to consider values associated with resource conservation (Hearn, 1982).

Based on this development ethos, it is little surprise that New Zealand's urban waterways have always been exploited for their convenience. As cities have developed there has been a need for drainage to make land suitable for production and settlement (Roche, 1994). This has led to progressive dredging, piping, canalisation and clearance of vegetation on urban waterways. Over time the general community has come to perceive them as being: *"the source of floods, smells or dangers to small children, or as disposal systems for stormwater, sewerage or rubbish"* (Roper-Lindsay, 1994, 125).

Over the years various pieces of legislation have been passed dealing with the management of urban runoff and waterways. The first laws related to giving local government agencies the power to construct and manage drainage systems and the ability to utilise watercourses for the discharge of stormwater. Over the years, New Zealand's environmental legislation has been consolidated. This have led to changes in the way waterways have been managed. For instance, as a response to public health concerns the worst excesses of industrial discharges to waterways have been cleaned up.

Since the post war period in New Zealand, public concern about the environmental state of urban waterways has developed (Wilson, 1989). Problems of erosion, sedimentation and flooding have also became noticeable in urban waterways and receiving waters. As the causes

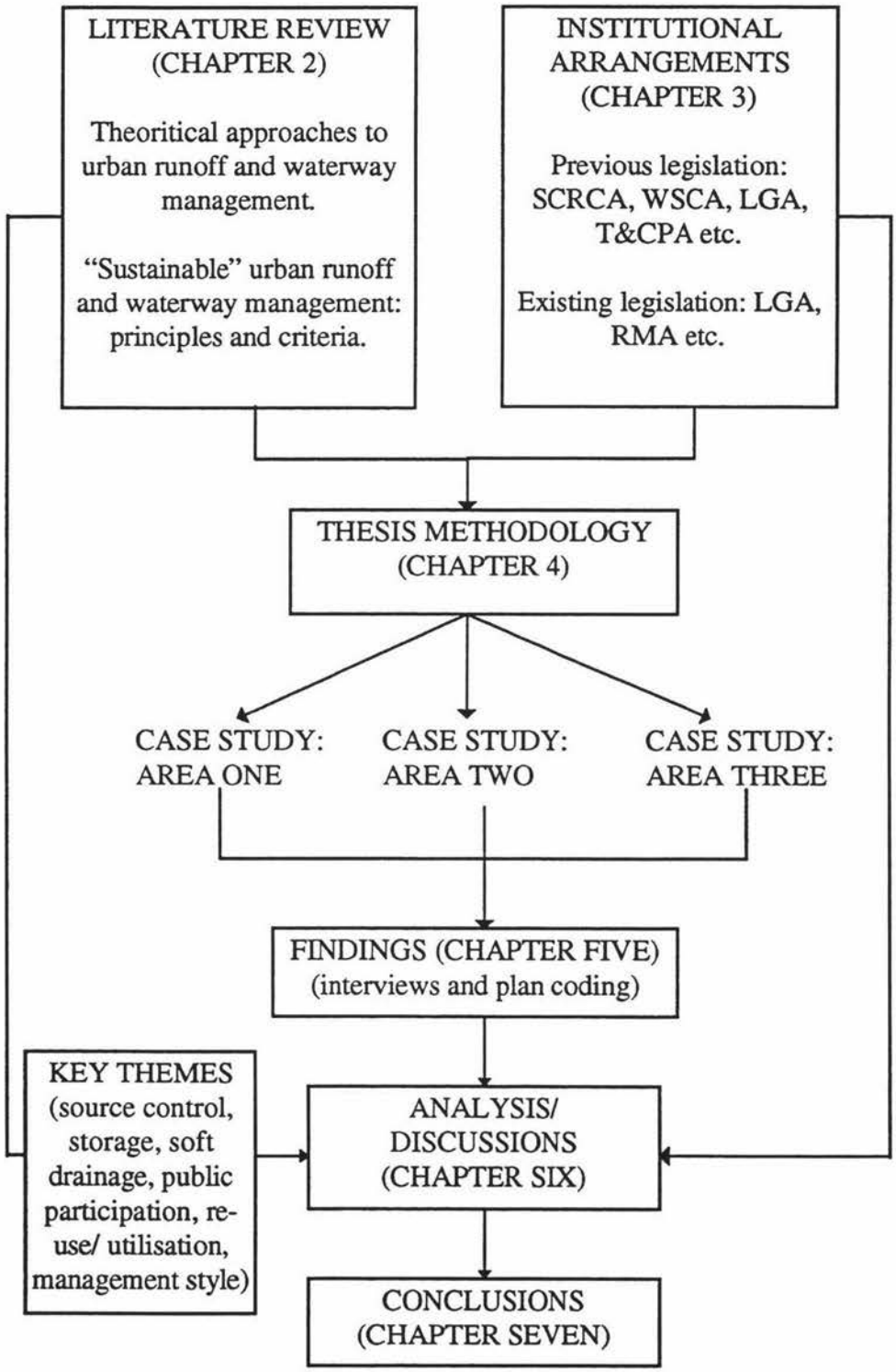
of these problems became obvious, government agencies took existing legislation originally targeted at the rural sector, and applied them to the urban setting as best they could. These statutes, developed on an incremental basis over many years, were not only fragmented but were administered by an increasingly complicated bureaucratic system. This situation was eventually overhauled in the years 1989 and 1991. The RMA did more than integrate existing legislation. Up until the introduction of the RMA, the disposal of urban runoff was not generally thought of in the context of "sustainability" (White, 1992). Stormwater, which had in general been regarded as being "clean", could no longer be seen as such. The RMA also provided an integrated framework to effectively deal with complicated environmental issues. This removed a major institutional impediment under previous legislation to allow for a land-use planning approach to mitigate the effects of urban development on waterways and the coastal environment.

THESIS STRUCTURE AND CHAPTER OUTLINE

The structure of this research is outlined in Figure 1.1. The task for chapter two is to set up the framework for determining the extent that environmental considerations have been incorporated into the management of urban runoff and waterways. The broad approaches of managing stormwater in the literature are identified and their development and differences are explained. The approaches are then discussed with respect to the concept of sustainability. Finally, a set of characteristics or criteria are derived that allow the research findings to be analysed and the extent to which environmental considerations have been incorporated into the management of urban runoff and waterways to be described.

A review of New Zealand's institutional arrangements is undertaken in the third chapter. The changes local government reform (1989) and the Resource Management Act (1991) have brought are discussed. It outlines the powers local authorities had previously when managing urban runoff and waterways, the environmental considerations they were obliged to comply with and the changes the RMA and local government reform have brought.

Figure 1.1: Thesis Structure



The fourth chapter outlines the research design and methods used to address the aim, objectives and questions to be examined. There is a discussion on the selection of three case study areas and the main methods used to obtain information. Each area was selected on the basis of obtaining a range of councils in different operating environments. The main sources of information are from interviews with selected participants, form plans, and from other literature either produced by councils or written by external sources.

Findings from the plan analysis and interviews are presented in chapter five. The plan analysis identifies how urban runoff and waterways have been considered in plans and policy statements prepared by councils. The interview findings are summarised results from a series of interviews conducted with council staff. Chapter Six discusses the key issues which emerged from the research results. The main task is to use the criteria worked out in Chapter Two to analyse the research findings. The chapter is divided up into sections based on these criteria. The driving force behind council actions is explored. The profile of urban runoff, waterways and environmental programmes within the councils is assessed and the degree to which councils are managing urban runoff and waterways sustainably is discussed.

The final chapter evaluates the research findings in terms of the aims and objectives outlined in this chapter. Recommendations are made concerning how environmental considerations should be incorporated into stormwater management in the future. The research design is also reflected upon and suggestions are put forward for future research on this topic.

CHAPTER TWO

LITERATURE REVIEW

This chapter explores two themes. First, it explores the development of theoretical approaches to managing stormwater runoff in the urban environment and the environmental benefits or problems associated with each approach. Second, it describes what the concept of "sustainable management" of urban runoff and waterways means in theoretical terms. A set of principles and characteristics are developed as part of this. These need to be considered when evaluating the extent to which environmental considerations have been incorporated into urban runoff and waterways.

URBANISATION AND THE RUNOFF PROCESS

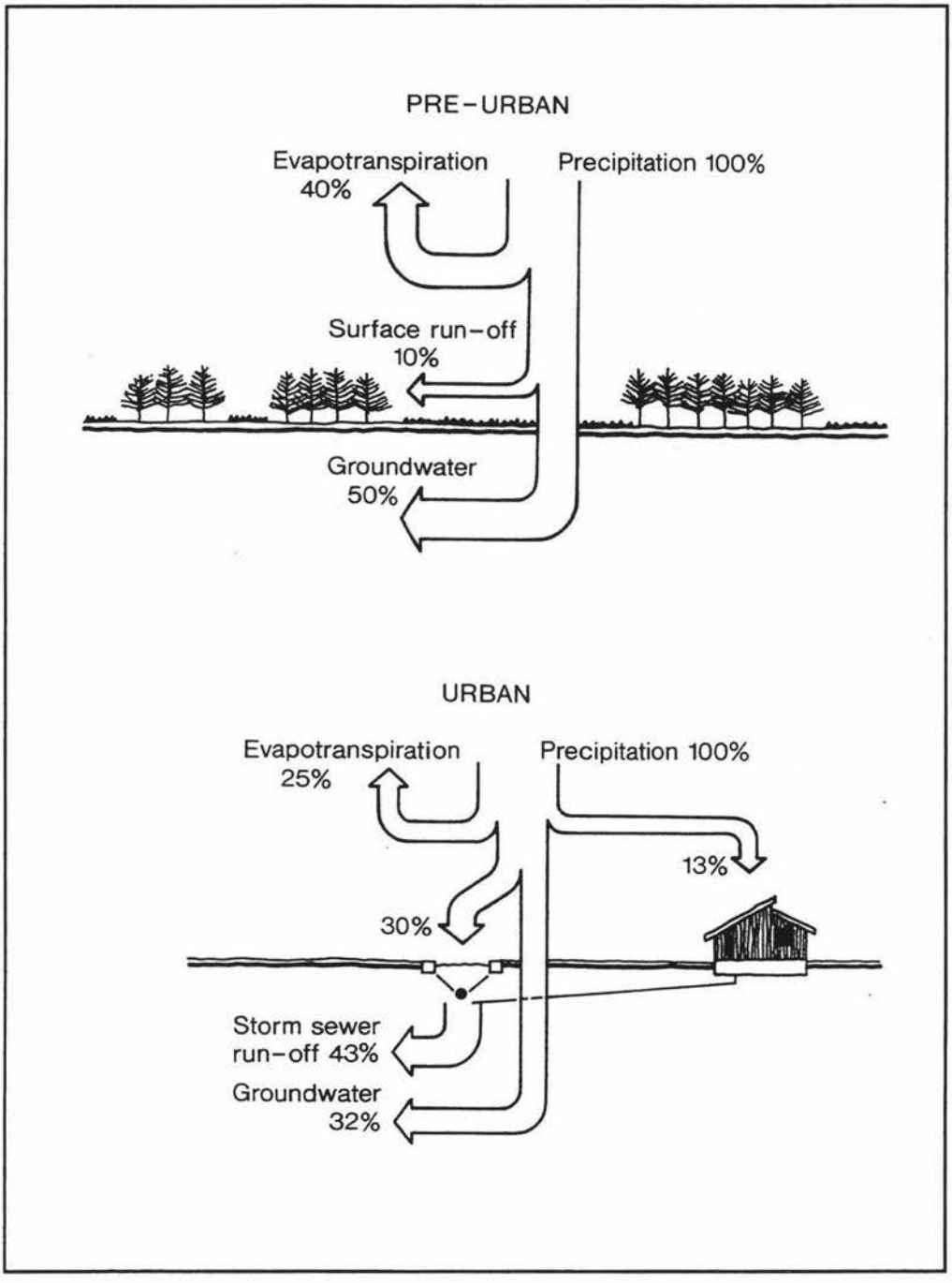
Urbanisation results in a much greater volume of surface runoff being produced than under natural conditions. The causes of this phenomenon have been well established. They are associated with the drastic change in land use that results by turning a pervious catchment into an impervious one (Urbonas and Roesner, 1993). Figure 2.1 illustrates this change in land use by showing the contrast between the different hydrological properties of a forested catchment and that of a "typical" urbanised area and its regime of asphalt and concrete. The lack of infiltration capacity in the urban area means that most of all the rainfall that would previously have soaked into the ground can no longer do so and consequently becomes surface runoff.

A stormwater system is designed to remove this excess surface runoff (i.e., the storm sewer runoff in Figure 2.1). It serves several vital community functions. It removes stormwater from the streets thereby allowing transportation to function during bad weather and it prevents any hazard to local residents or damage to property (Urbonas and Roesner, 1993). Stormwater infrastructure has an obvious economic and social role in the community. As part of the general urban infrastructure it can be analysed in terms of being a supporting mechanism for economic development (Bamberger et al., 1985) or a result of socio/political relationships in a

capitalist society (Walker, 1981). Most authors though, have focused on its environmental role in the modification of the hydrological cycle.

Figure 2.1: Hydrological changes resulting from urbanisation

(Source: Ministry of the Environment, Ontario, 1978 in Hough, 1989).



APPROACHES TO MANAGING URBAN STORMWATER

Four approaches to manage urban runoff are identified in Table 2.1. and a range of characteristics are given for each one. Rather than give an exhaustive account of the development of the different approaches, the aim of this chapter will be to portray to the reader the differences inherent in each of them.

THE TRADITIONAL ENGINEERING APPROACH

The traditional engineering approach for managing urban runoff is summarised in Table 2.1. It is based on conveying urban runoff from its many points of origin in the urban environment to the outfall in the most economical manner. The collection system is often based around a system of buried pipes which are constructed with a capacity to manage a specific peak flow of runoff or "design storm".

The style of management for this approach is exclusively engineering in its nature. It is heavily technocentric, with a single focus to protect urban development and transportation (Ferguson and Debo, 1990). As shown in Table 2.1 it relies upon "hard drainage" features that emphasise the efficiency of conveyance (American Society of Civil Engineers, 1992). Often the surface runoff goes into the same system as the sewer. This type of system is referred to as a storm-sewer or combined sewer system.

The conveyance approach was first applied well before the advent of the motor car. Originally its purpose was to remove water and horse manure from the city streets as it posed a nuisance, aesthetic and public health problem. (Ferguson and Debo, 1990). The functions of conveyance continue to be needed to remove water from roads so vehicles can travel safely or land drainage can be carried out.

Problems of the traditional engineering approach

Over the last 30 years there has been a slow build up of knowledge regarding the problems of urbanisation and drainage based around conveyance (American Society of Civil Engineers, 1992). The traditional engineering approach never considered factors external to the system such as wider environmental considerations (Ferguson and Debo, 1990). A range of common

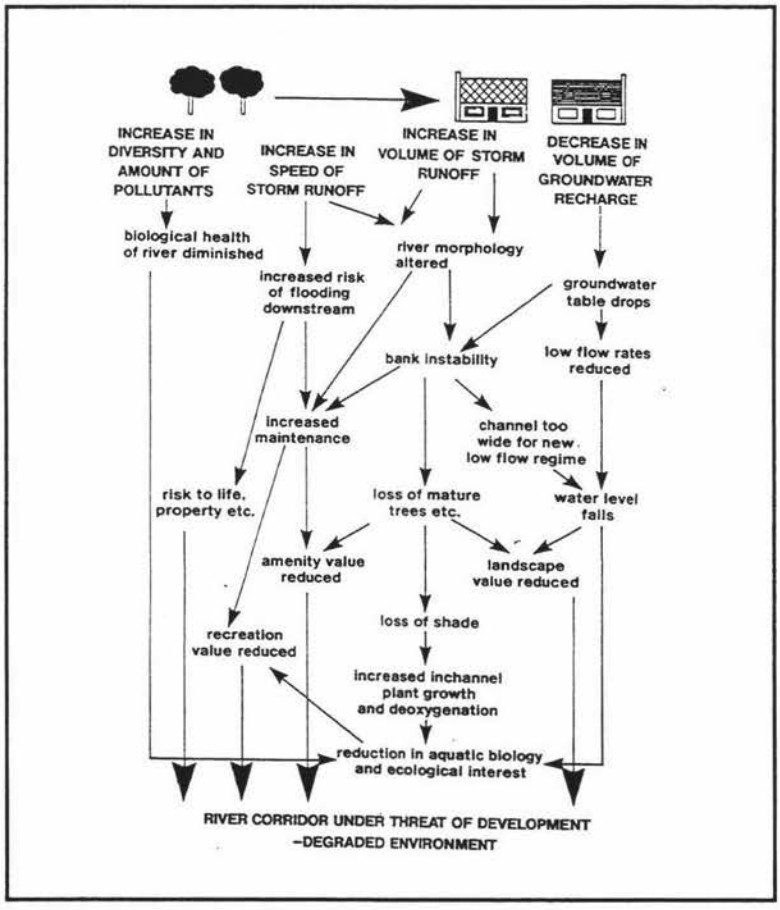
Table 2.1: Theoretical approaches to managing urban runoff and waterways

	Traditional engineering	Stormwater management	Ecological design	Integrated stormwater
Human/ nature relationship	Very strong technocentric	Strong technocentric	Utilitarian	Utilitarian/ ecocentric
Waterway perception	Dominant use	Multiple use	Conservation and creative use	sustainable use
Stormwater perception	Strong negativistic view	Negativistic view	Utilitarian	Modified anthropocentric (ecocentric)
Issues and concerns	Flooding	Flooding, minimum water quality standards, aesthetic/ recreation aspects	Restore hydrological balance, minimise environmental impacts, maximise benefits of natural resources	Maintain ecological carrying capacity, Balance economic, social and environmental goals
Management style	Scientific/ domination of nature	Technical scientific	Multi-faceted design	Holistic management
Disciplinary involvement	Mono-disciplinary-engineering	Predominantly engineering	Multi-disciplinary	Multi-disciplinary
Private/ public focus	Public sector	Public sector	Public sector and developers	Partnerships between authorities, community and business
Environmental techniques/ strategies	Hard drainage dominant i.e., pipes, drains and pumps	Hard drainage predominant, storage ponds for detention and retention. Ad-hoc source controls.	Focus on passive systems i.e., natural channels, swales Detention, retention, porous pavements, rooftop collection Guidelines for appropriate land-use	Integrated hard drainage and passive systems Integrated use of structural and non-structural controls detention, retention, re-use of runoff

environmental problems have been observed in numerous urban areas around the world and have been reviewed by a large number of authors. A summary of potential problems are presented in Figure 2.2. It shows that from an increased impervious land area and a conveyance based stormwater system (that increases the speed of runoff) a wide and complex range of adverse environmental effects are produced. These problems can be classified as being either of a hydrological, ecological or infrastructural nature.

Figure 2.2: Possible impacts of urbanisation via hydrological change

(Source: Woolhouse, 1989).



Hydrological problems relate back to the modification of the water cycle induced by urbanisation. The classic problem associated with the effects of urbanisation has been downstream flooding. In general, floods develop faster, are of greater magnitude and peak flow, and run off more rapidly than before. The last aspect means that urban waterways are often left with minimal flows in-between storm events (Whipple et al., 1983).

As alluded to, the cause of urban flooding is partly the impervious nature of the catchment created during urbanisation. Also to blame is the stormwater system created under the traditional engineering approach. The conveyance approach is designed to provide a minimum of impedance thereby concentrating water to specific discharge points very quickly. This results in higher discharge velocities than in natural conditions and a accumulation of runoff further downstream with the increased potential of flooding.

The traditional engineering response to flooding in the city brought on by the modification of the urban hydrological cycle has been to increase the hydraulic conveyance of the flow channels. That means that either greater downstream flood control structures are needed or the stormwater system capacity needs to be increased i.e., larger culverts, larger diameter pipes or stabilisation of channel banks to prevent erosion and so on. (Beale, 1992). These modifications are difficult and expensive to construct and maintain (Lyle, 1994). There is a growing recognition in the literature that drainage problems are becoming too expensive to solve by the traditional engineering approach (Beale, 1992; Lyle, 1994).

The traditional engineering approach increases the capacity of the stormwater system by modifying natural channels in the catchment through straightening (to shorten the river length), deepening (increase channel capacity) or lining (to increase hydraulic efficiency). This is carried out with little consideration for aquatic life and their habitat's protection. The result has been engineering structures that have replaced natural habitats with "sterile, concrete lined, box-shaped channels" (Penning-Rowsell et al., 1986, 124). Various authors, summarised by Swales (1982), have identified that modifications of natural channels eliminate instream cover, pool-riffle patterns, bank vegetation (having an adverse effect on the shade, water temperature, nutrient dynamics and wildlife habitat) and change the substrate characteristics, modifying flow regimes and changing in-stream water chemistry.

The natural characteristics of waterways are required by aquatic life for shelter. Their removal reduces available cover and results in an overall decline in fish stocks (Bulkley et al., 1977; Congdon, 1971; Gibson and Power, 1975). Overall, studies reveal that works to increase hydraulic efficiency adversely affect fish habitats and result in a reduction to fish and

invertebrate density, biomass and diversity (Bulkely et al., 1977; Golden and Twillery, 1976; Hansen and Muncy, 1971; Peters and Alvord, 1964).

The traditional engineering approach has generally not considered water quality issues (Commonwealth Environmental Protection Agency, 1993; Niemczynowicz, 1993). Poor water quality has direct consequences for aquatic life (Figure 2.2). The higher the level of pollution, the greater is the environmental stress on aquatic life (Millar, 1993). Perceived water quality issues have changed over time as new information has come to light. Up until relatively recently the nature and quantity of contaminants from stormwater was considered insignificant when compared with the more important sources such as sewage or industrial discharges (Whipple, 1977). In the New Zealand context, managers in the area of Auckland have been the first to realise that given no other apparent source of pollution, stormwater quality was destroying or significantly reducing natural plant and animal habitats (Melville, 1991).

The nature of contaminants associated with urban runoff has become better understood. McGriff (1972), in a article summarising the existing state of knowledge, stated that there were four main effects of urbanisation on receiving water quality. First, urbanisation led to higher volumes of surface runoff and increases in the sediment load of streams. The groundwater recharge was often minimised reducing low flow levels and hence dilution potential. There was also an increase in nutrient levels which cause eutrophication. Finally, a change in stream temperatures was shown to be produced which increases the temperature in summer and decreases it in winter. This adversely affects the dissolved oxygen content and in summer months has a deleterious effect on water quality. It was only in 1974, that research by the Environmental Protection Agency expressed concern over toxic substances being present (Shaheen, 1975). The main pollutant types associated with contaminated urban runoff as they are understood now are shown in Table 2.2.

The process for contaminants entering waterways was also becoming more widely appreciated during this time (Moore, 1989). Most pollution is a result of people deliberately or accidentally using stormwater grates for the disposal of wastes, or through poor management practices on industrial sites using contaminated materials (Auckland Regional

Council, 1995). The recognition of the importance of diffuse sources of pollution has only come about slowly over the last few decades. Also it has been recognised that the majority of contaminants are washed out directly following rainfall in what is termed the "first flush" (Whipple et al., 1983).

Table 2.2: The main groups of contaminants found in Auckland stormwater

(Source: Williamson, 1986, in ARC, 1995)

CONTAMINANT	EXAMPLES	SOURCES
Suspended solids		Soil, road material, corrosion products
Nutrients	Nitrogen	Nitrate, ammonia, organic nitrogen
	Phosphorous	Phosphates
	Oxygen consuming organic material	Plant material, oil and grease, sewerage, industrial organic chemicals
Toxic Substances	Heavy metals	Lead, zinc, copper (sometimes nickel, cadmium, chromium, mercury)
	Petroleum hydrocarbons	PAH
	Biocides	Chlordane, DDT, PCB, lindane, dieldrin
Human Pathogens	Micro-organisms	Bacteria Viruses

The general change in approach to urban runoff

While traditional engineering principles have continued to be needed for such things as land drainage and flood control, within the last 30 years numerous authors have been critical of the environmental consequences. They highlighted the lack of knowledge about the issues, an indifference to the consequences of intruding upon processes in the natural environment and the institutional obstacles in taking the needed preventive or corrective measures (Secretary General for the United Nations, 1971 in UNESCO, 1974). Shifts to incorporate environmental considerations into urban runoff and waterway management have been slow.

The basic principles of conveyance are ingrained and there is consequently a lack of willingness by professionals to change practices (ASCE, 1992).

THE STORMWATER MANAGEMENT APPROACH

Smith et al. (1993, 247) defines stormwater management as the *"planning, analysis, collection, storage and controlled discharge of stormwater"*. It was developed in the mid 1960s and the early 1970s and is still widely used. As Table 2.1 suggests, it takes the environment into greater consideration by incorporating many of the lessons learned from the traditional engineering approach. Smith et al. (1993, 247) defines the goal of stormwater management to be: *"minimising the environmental impacts of urbanisation while providing for safety and convenience in land development"*. The process of management involves identifying environmental limitations, predicting the effects of urban development and establishing the means to mitigate against these potentially adverse effects Smith et al. (1993).

The stormwater management approach accepts the complexity of urban water problems and makes use of a range of techniques (Smith et al., 1993). For instance, there is the recognition of the need to adopt risk-based decision making rather than rely on fixed, arbitrary design standards such as a design storm (ASCE, 1992). In stormwater management, risk analysis is a process where different means to reduce risk are evaluated and acceptable levels of risk, both up-stream and downstream, are made (Wiggins, 1978). This not only improves the decision making process but limits the liability of managers and protects the public's welfare.

The stormwater management philosophy accepts that a different approach is needed to that of conveyance when mitigating the adverse effects associated with flooding. Rather than increasing the capacity of the drainage system, the flows may be attenuated through ponding. This has resulted in a proliferation of stormwater detention and retention ponds being constructed in urban environments over the last several decades in the United States (ASCE, 1992). Despite this more enlightened approach to environmental problems, solutions are engineering based and represent "end-of-pipe" controls.

THE ECOLOGICAL DESIGN APPROACH

The ecological design approach is a conglomerate term for a range of ideas that have been put forward by disciplines such as urban ecology, landscape ecology and ecological planning whose greatest influence was in the 1970s and early 1980s. In comparison with stormwater management, it represents a fundamental change in the value to which urban runoff and waterways are perceived (Table 2.1). This has consequently led to a departure away from "hard drainage", prevalent in the previous approaches, to "passive" or "soft" systems.

McHarg, from the ecological planning school, epitomised the philosophy of the approach with his 1969 book title *"Design with Nature"*. McHarg was concerned with finding the best land-uses when developing an area. His method was one of the first to consider ecological and natural principles, developed from scientific disciplines, to manage the environment. This offered landscape architects a more appropriate method of design to the purely aesthetic and architectural approach that dominated thinking at the time (Koh, 1982).

In essence, the ecological design approach is based on the belief that the long term environmental costs of land development will be reduced they are based on sound ecological and geomorphologic principles. The approach can be seen as an intellectual reaction against the technocentric thinking of the industrial era. It is therefore critical of the traditional engineering approach under which the extensive storm-sewer infrastructure in the United States has been designed and built. Simonds (1978), one of the authors of the ecological design approach, stated that it would only have been necessary to construct 5% of the present system had "sound" landscape planning been carried out in the first place.

In using passive systems, adherents to the ecological design approach take full advantage of landforms to guide and absorb the flow of urban runoff (in preference to pipes and concrete channels). Storage of urban runoff is encouraged but in comparison to stormwater management it focuses on restoring the nature hydrological balance by allowing water to infiltrate back into groundwater supplies. There is also a shift to focus on controlling the water at the source of the problem rather than dealing with its effects in the actual stormwater system. For instance, in new developments the goal is to achieve a rate of water run-off that is equivalent to pre-development levels (Simons, 1978; Hough, 1989). This marks a radical

departure away from the "end-of-pipe" controls used in the stormwater management approach.

Perhaps the strongest influence of the ecological design approach has been in encouraging the use of streams in their natural form rather than as pipes or the highly modified "open channels" of the traditional engineering approach (ASCE, 1992). The value given to urban runoff and waterways under the ecological design approach is that of a resource. Simons (1978) views streams as the best conductors of urban runoff. They are hydraulically superior as they are able to generally carry a greater flow than a pipe. They also have the potential to be aesthetically pleasing when vegetated.

Despite the consideration given to natural processes, ecological designers are characterised by viewing nature in a utilitarian manner. This is due to the influence of the founding schools of thought which are anthropocentric by nature (Koh, 1982).

THE INTEGRATED STORMWATER MANAGEMENT APPROACH

The fourth approach discussed for the management of urban runoff and waterways is what Niemczynowicz (1993) and Lawrence and Reynolds (1995) describe as the integrated stormwater management approach (Table 2.1). It represents the most contemporary approach to stormwater management having been developed with all the benefits of a better understanding of the nature of environmental problems. In many ways it is an extension of some of the ideas and techniques from the all three previous approaches.

Urban runoff and the stormwater system is viewed as being part of the total urban water resource system. For instance, Lawrence and Reynolds (1995) emphasise the benefits of integrating the management of water supply, waste disposal, flood control and urban runoff. They stress the need to design and construct stormwater infrastructure in co-ordination with planning for land-use, open spaces and transportation at all scales i.e., "street block", "precinct" and "urban corridor". Aspects that are taken into consideration in this include retarding runoff, conserving stormwater, re-using treated greywater, growing vegetation and making use of swales, wetlands and storage basins to intercept and filter urban runoff pollutants (Lawrence and Reynolds, 1995).

Integrated stormwater management reflects the seriousness with which urban runoff is now viewed as an environmental issue. It takes a "prevention is better than cure" approach. There is an emphasis on source controls to eliminate non-stormwater discharges rather than treatment in the stormwater system. The nature of the source controls include a range of measures that are of a structural, semi-structural, and non-structural nature (Niemczynowicz, 1993).

One of the most important differences is that adherents to the integrated stormwater management approach take on a much broader or holistic perspective referred to as an "ecosystem approach". The ecosystem approach integrates ideas from a wide variety of concepts and movements and holds, in particular, that environmental, economic and social sectors are interrelated and interdependent. This belief is founded on the principle that we and everything else on the planet are all inextricably bound together (Boulding, 1966). A decision made in one area is taken as likely to affect others. This necessitates a "multi-disciplinary", "multi-jurisdictional" and "multi-stakeholder" approach to effectively link together all related agencies and organisations in the management of resources like urban runoff (Royal Commission on the Future of the Toronto Waterfront, 1992).

An ecosystem approach stresses the importance of ecosystems and the interactions between the organic and inorganic parts of an area. It therefore puts an emphasis on incorporating environmental objectives into development projects. Stormwater facilities can be designed to provide such things as urban aquatic ecosystems, places for recreation and educational pursuits, and the enhancement of aesthetic quality (Smith et al., 1993). As such, full use is made of passive systems wherever possible (Table 2.1).

SUSTAINABLE URBAN RUNOFF MANAGEMENT

The concept of sustainability has evolved out of the conservation and development debate of the 1960s and 1970s. It has important implications for how environmental concerns are incorporated into the management of all natural resources (Lele, 1991). From the discussion on approaches to urban runoff and waterway management it has been environmental concerns

that have driven changes to practices rather than the economic or political motivations of Bamberger et al. (1985) or Walker, (1981). It is therefore necessary to explore the concept of sustainability and the implications that this has for urban runoff and waterway management as New Zealand has incorporated the term "sustainable management" into the RMA. It is also a signatory to a number of international treaties relating to sustainable development including Agenda 21 and the two conventions on climate change and biodiversity at the Rio Earth Summit (1992).

SUSTAINABLE DEVELOPMENT

The concept of sustainability has many guises in the literature. The most important term is sustainable development (Lele, 1991). The notion of sustainable development is a reaction against the technocentric attitudes of exploiting and dominating the natural environment, and viewing economic development as the paramount goal (Reid, 1995). The Club of Rome's report (1972), for instance, took a pessimistic "neo-Malthusian" view of environmental prospects at a global scale. The view was that the resources on which society depends, such as fossil fuels, were limited and the global economy was close to reaching those limits. This was going to result in a crisis of resource depletion, pollution, damage to natural ecosystems, erosion and associated environmental degradation (Reid, 1995). Various other reports around this time and later concluded that present human activities were unsustainable (Blakely, 1995).

It was from the need to reconcile conservation and development in the natural environment that the concept of sustainable development was coined. The use of the term sustainable development dated back to 1980 when the World Conservation Strategy was published. However, it was only through the Brundtland report (1987) where the concept of sustainability became a global paradigm of central importance in the environmental debate. It was based on the premise that conservation and development are "mutually dependent" rather than antithetically opposed. The success of conservation initiatives ensures that the social and economic objectives of human development will continue (Reid, 1995).

The Brundtland Report (World Commission on Environment and Development, 1987, 8) defines sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*.

The Brundtland Report's definition was intrinsically tied up with considerations of equity both for the needs of present and future generations (Lele, 1991). It is open to a vast range of different interpretations (Lele, 1991; Reid, 1995). Documents like the World Conservation Strategy (1980), Brundtland (1987) and Agenda 21 (1991) have attempted to put their respective definitions into practice by drawing up a range of operational objectives to address environmental issues at the global scale. They have stressed the importance of maintaining the life supporting capacity of the planet, maximising environmental assets in cities, promoting technology that is ecologically sound and achieving a balanced response to the economic, social and environmental aspirations of the community. However, there is a general lack of information in the literature about what a sustainable future means for various contexts such as stormwater management. Smith et al. (1993, 253), one of few authors to tackle this problem, states that an indication of whether sustainability is being achieved in a particular area is the *"co-existence of ecological diversity and urban development"*.

ECOLOGICAL SUSTAINABILITY

Sustainability is underpinned by the concept that the ecological basis of human life is to be sustained (Lele, 1991). This requires maintaining the integrity of natural life-support systems. These include the bio-geochemical cycles that purify air and water, recycle key minerals, produce and renew soil and in general provide for the sustenance of life on Earth (IUCN et al., 1991). It has been expressed in many different contexts. Petts, in Smith et al. (1993, 244-5) states that to be sustainable, water resources need to be managed in the most appropriate manner to meet societies demands without degrading the water's sustaining base". Urban runoff and waterways are part of the hydrological cycle and therefore need to contribute to this goal if they are to be sustainable (Smith et al., 1993).

Managing natural life-support systems demands a change in the underlying attitudes towards nature as expressed by the technocentic paradigms. Human activities must incorporate a greater respect for nature. Protecting the sustaining base of water requires the promotion of

such measures as protecting catchments, controlling runoff, reducing water extraction and diversions thereby maintaining an acceptable water quality (Lyle, 1994). The concept of "ecological sustainablity" benefits greatly from an ecosystem approach to the management of the environment in contrast to the fragmented and ad-hoc manner in which many previous environmental management regimes have operated (Grumbine, 1993). For instance, both adherents to sustainability and the ecological approach view the "catchment" as the best level to provide for the link between land-use and downstream water quality and quantity (Grumbine, 1994; IUCN et al., 1991).

The ecosystem approach has been heavily incorporated into the integrated stormwater management approach (Lawrence and Reynolds, 1995). There are many characteristics and principles of this approach as shown in the management style section in Table 2.3. The ecosystem approach is comprehensive in that decision makers consider all human activities that maybe affecting water quantity, flow and quality. This is in contrast to the narrow focus of the stormwater management approach which concentrated solely on point source discharges without recognition of diffuse sources of pollution.

In the ecosystem approach the goal for managers is to develop more effective policies (Szaro et al., 1996). Managers must monitor the consequences of their actions so that progress towards stated objectives may be evaluated quantitatively and adjustments made. Where data availability and expertise is lacking the precautionary principle should be applied. This recognises that full scientific certainty on an issue is rare and should therefore not be a reason for delaying measures to prevent environment degradation (Sitarz, 1994).

The concept of sustainability also focuses on protecting the environment by anticipating and preventing damage rather than by remedying it (IUCN et al., 1991; Reid, 1995). This principle is as relevant to urban runoff and waterway management in the form of source controls, as it is to other areas of resource management as shown in Table 2.3. Source controls are preferable to the end-of-pipe approach. It is less expensive to reduce stormwater volumes at the source than construct huge conduits downstream. By increasing the capacity for infiltration, through either reducing impervious surfaces to a minimum or minimising directly connected impervious areas, the natural hydrological

Table 2.3: Criteria for the sustainable management of urban runoff and waterways

MANAGEMENT STYLE

Principles

- Apply an integrated catchment based approach.
- Anticipatory environmental management is better than reactionary management.
- Make certain that relevant agencies are co-operating with each other.
- Monitoring is essential role in the management process.

Techniques

Development of a watershed management plan that describes existing patterns of environmental quality and community life in a watershed and recommends goals and policies to manage future development to minimise impacts on water resources. Agencies in the strongest position to attack urban stormwater issues are (a) whole catchment based, (b) ensure co-operation of the main players in the catchment and (c) focus entirely on stormwater. Planning time frames should be around 50 years. Monitoring should evaluate the environmental conditions and the effects of management practices. Integrated management combines the stormwater system with natural areas. In this way "greenways" may be employed.

SOURCE CONTROL/ LAND MANAGEMENT

Principles:

- Minimise impervious surfaces.
- Prevent non-stormwater materials being discharged i.e., wastes, litter, rubbish, and sediment.
- Reduce directly connected impervious surfaces to a minimum.
- Prevent pollution from arising at the source rather than treating its effects downstream.

Techniques

public education, building codes, floodplain management, green-space preservation, zoning incentives, alternative landuse, impact taxes, tax credits, construction permit process, enforcement program, animal control, vegetation programs, porous pavements, lawn aeration, street sweeping/ cleaning, soakage basins, silt traps, oil interceptors, riparian zone management, national regulations i.e., motor vehicle emissions

SOFT DRAINAGE

Principles:

- Natural waterways provide the best means to convey surface runoff.
- Water from urban runoff is best treated by biological systems.

Techniques

Natural lining of waterways, use of artificial wetlands and swales. For small volumes of urban runoff- green landscape i.e., vegetation filter strips and swales. For larger volumes- bulrushes and reeds i.e., wetland environments

Table 2.3 continued...

STORAGE

Principle

- maximise the retention of urban runoff and treat it to the best possible extent.

Techniques

detention (dry) basins, retention (wet) basins, infiltration basins

RE-USE AND UTILISATION

Principles

- Reduce the use of high quality imported water by using treated urban runoff or rainwater.
- Integrate urban waterways and runoff into open space irrigation, landscape and recreation.

Techniques

rooftop storage

communal collection i.e., using as greywater from ponds etc

PUBLIC PARTICIPATION

Principles

- Involve the general public in determining environmental end results.
- Give the public ownership of problems and the choices in respect to difficult trade-offs.

Techniques

Various techniques are available but all interested parties should be represented in decisions.

cycle can be restored. This will reduce the amount of surface runoff volume entering the stormwater system (ASCE, 1992; Yu and Nawang, 1993). This can be achieved through techniques such as vegetation programs, porous pavements and effective site designs.

Source controls need also be applied to prevent pollution. It is more effective and cheaper to prevent pollution instead of reacting to damages by treating the effects downstream. It is also fairer as it places the responsibility on the developer to provide the solution (Niemczynowicz, 1993). There are a range of structural and non-structural approaches available as outlined in Table 2.3. Each one must be carefully applied on a case-by-case basis.

SUSTAINABILITY AND THE URBAN ENVIRONMENT

The urban environment puts great stress on the functioning of natural processes and represents a major contributor to environmental and ecological degradation (Hough, 1989; IUCN et al., 1991). Tied into the concept of "urban sustainability" is the need to maximise urban environmental assets and preserve biodiversity (Rookwood, 1993). On a global scale it is important to protect natural biodiversity because of its potential benefit to humans for providing resources such as fuel, fibre, food crops and pharmaceutical supplies and improving biotechnological processes (Solbrig, 1992).

Preserving biodiversity is normally associated with non-urban environments. Some have argued that urbanisation has meant such a drastic modification to the natural environment, that what remains is ecologically insignificant. Therefore, nature in cities may not be needed in the strict sense to achieve global sustainability (Hengeveld and Vocht, ed., 1982). Another perspective is offered by Hondius (1976). Hondius views the inclusion of nature in cities as representing a reaction to development in and after the industrial revolution. It represents more of a socio-political ideology than a desire for protecting the natural environment.

However, on the global scale there are few purely "natural" or semi-natural habitats left. It is argued that this increases the relative importance of human modified landscapes, such as cities, and their associated biodiversity (Heywood, 1996). By providing for wildlife and their habitats in the urban environment an additional threat to the survival of species and ecosystems is reduced (Laurie, 1979).

Maximising natural areas in the city can also improve the local environmental quality. For instance, natural areas can act as "green lungs" and improve the urban climate. They can provide positive benefits in reducing temperature, filtering particulate matter, and absorbing pollutants such as carbon dioxide and sulphur dioxide (Hough, 1989). Plants have a similar role in aquatic environments. For instance marshlands promote the uptake of nitrogen and phosphates and other toxins. Biodiversity also has aesthetic and social importance. Various writers such as Bernatzky (1975) state that nature areas are therapeutic to the physical, mental and spiritual health of city inhabitants. Others, such as Reduron (1996), argue that increasing biodiversity in cities promotes changes in awareness and attitudes to urban

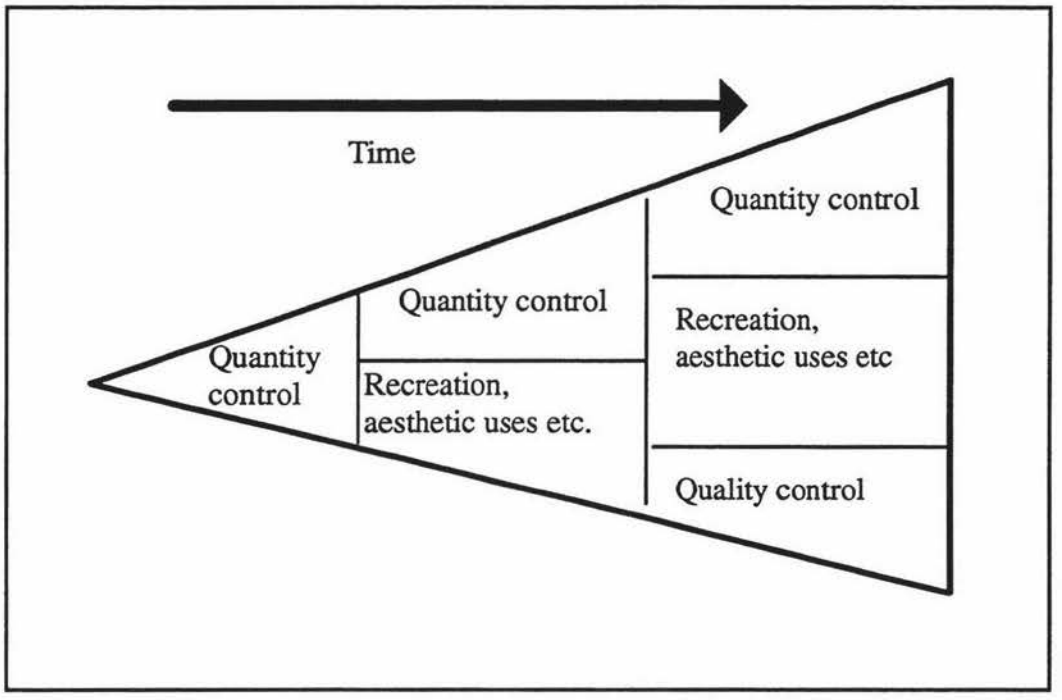
environmental issues. They can promote a reduction in the negative environmental aspects of urban life and sensitise future generations to the benefits of living in a city which has achieved a harmony between the built environment and natural areas.

Urban sustainability is enhanced when urban waterways and the stormwater system are incorporated into natural areas, such as parks and reserves where elements of natural ecosystems remain. Adherents to the integrated stormwater management approach emphasis this (Lawrence and Reynolds, 1995). Managers operating under this approach may, for instance, attempt to link up existing parks and reserves throughout the city and beyond with urban waterways in what becomes long corridors or "greenways". Greenways increase the value of natural assets within the urban area by connecting wildlife habitats to each other allowing movement of animal species, humans and the transfer of energy and matter across the city (Royal Commission on the Future of the Toronto Waterfront, 1992).

Another means of integrating the stormwater system into natural areas is in the use of artificial ponding. Storing water in a catchment for a time before discharging it can have great environmental benefits (Lyle, 1994). Ferguson and Debo (1990) outline a range of storage approaches that represent a continuum between those which provide only limited environmental benefit (quantity control) to those having significant environmental, social, and economic benefit (quantity, recreation, and quality functions). The provision of these functions has developed over time as shown by Figure 2.3. Ponding can also improve surrounding amenity, aesthetic and possibly recreational values.

Maximising urban environmental assets can also extent to utilising urban runoff. Utilising stormwater represents a shift from disposing stormwater to turning it into a useful resource. This is consistent with the concept that cities should become producers rather than solely consumers of natural resources (Hough, 1989). The potential benefits depend on what is done. Several principles for its use are listed in Table 2.3. Stormwater can be used after treatment as a communal supply source reducing the need for using high quality imported water. Rainwater can be collected on an individual basis through rooftop collection. This reduces the volumes of surface runoff at the source, and is in keeping with concept of shifting from total reliance on network based supply to greater

Figure 2.3: The storage approach (source: CEPA, 1993)



self sustainability on the individual block. Additionally, greywater can be re-used through the irrigation of plants therefore deferring the need for expensive sewage system augmentation.

SUSTAINABILITY AND TECHNOLOGY

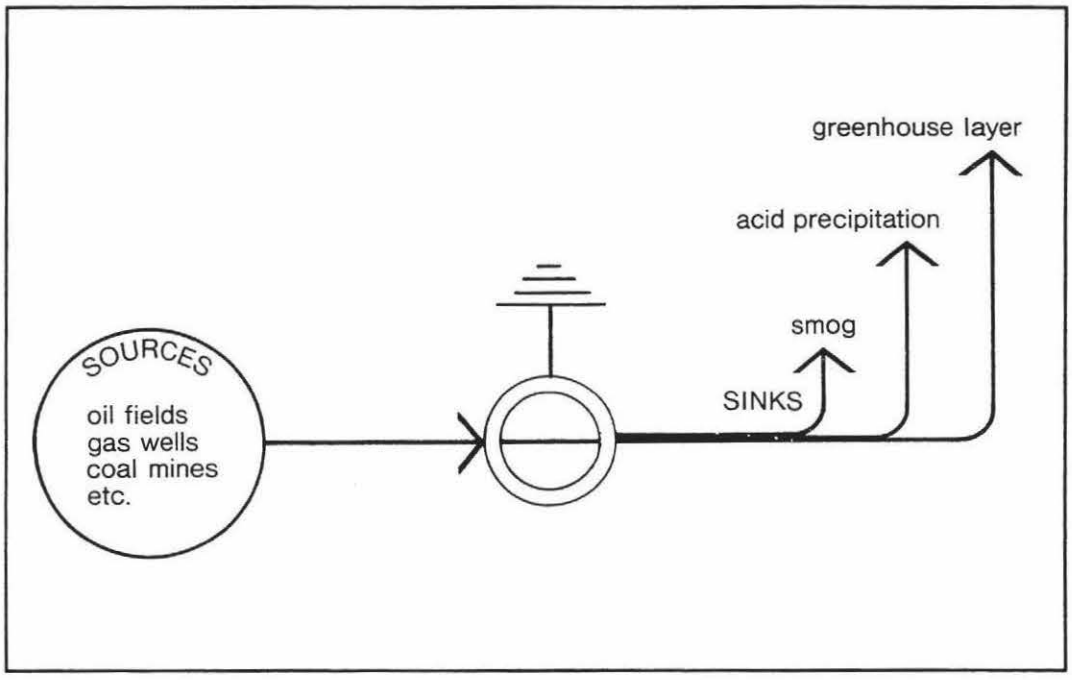
When advocating sustainable development there have often been calls to develop "alternative" or "appropriate" technology (WECD, 1987; IUCN et al., 1991). These terms coined by Schumacher (1973, in Teich (ed.) 1986) stress a need to re-orientate more traditional "industrial" forms of technology with those that are either compatible, supportive of, or subservient to natural processes.

Traditional "industrial" technology is characterised by being resource intensive, complex and requiring the use of non-renewable forms of energy. It is often expensive to construct and maintain, and requires a centralised managerial structure to operate it. Conceptually this type of technology is represented in Figure 2.4. Based around a linear system it is considered unsustainable because it inevitably destroys the environment on which it depends. Either

sources become depleted as in the case of fossil fuels or the sinks (air, soil and water) eventually become overloaded beyond their ability to operate.

Figure 2.4: Technology based on "Linear Systems"

(Source: Lyle, 1994)



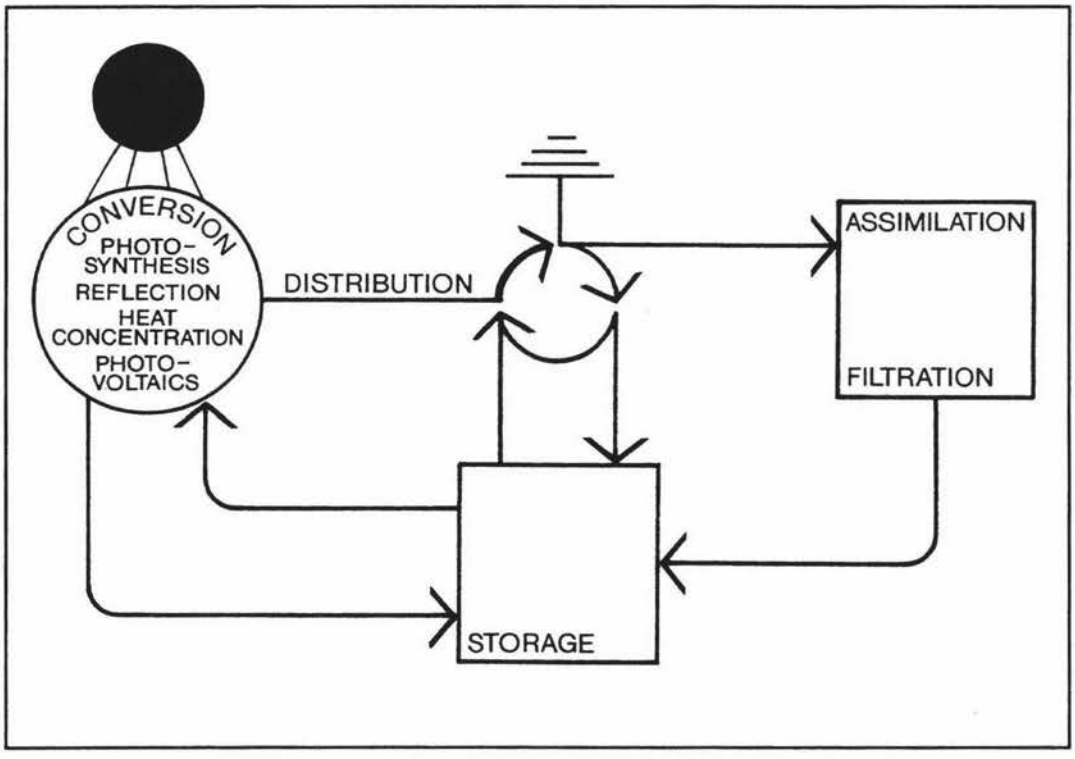
Generally, in the past stormwater systems have been based on either the traditional engineering or stormwater management approach. Both these approaches have a deposition towards industrial technology as they create stormwater systems based on "hard drainage", i.e., pipes, concrete drains and pumps, as described in Table 2.1. This type of stormwater system does not provide for the co-existence of ecological diversity and urban development. Rather, the result is often the destruction of the natural flow patterns of waterways and an increase in the diversity and amount of contaminants in the runoff and a consequent degradation of the life supporting capacity of the receiving waters.

Appropriate technology (Figure 2.5) is quite different in concept and basic operation to that of linear based "rational technology" (Elms, 1995; Lyle, 1994). It is designed to protect the environment by needing less resource inputs, polluting less, and recycling waste products. Other attributes of appropriate technology include being ecologically sound, simple, self

reliant, durable, low energy input, labour intensive rather than capital intensive, compatible with local customs, and waste reducing or recycling (Winner, 1986; Teich, ed., 1986). A particular type of appropriate technology is "soft" or "passive" technology. In managing urban runoff, it is characterised by relying on land-form, soil, plants and biological processes rather than pipes, drains, pumps, and mechanical systems that treat urban runoff (Lyle, 1994).

Figure 2.5: Appropriate Technology: Systems that are "regenerative"

(Source: Lyle, 1994)



Managing urban runoff and waterways in a more "sustainable" way requires using technology in a manner that has greater consideration for natural processes than that which occurred in the past. From Table 2.1 the ecological design and integrated stormwater management approaches provide for this. Various techniques and principles are listed in the "Soft Drainage" section of Table 2.3. The use of ponding through detention and retention basins promotes a more natural hydrological process of runoff (Lyle, 1994). Other more innovative techniques such as artificial wetlands and natural channels seek to minimise the dysfunction of the stormwater system with various bio-geochemical cycles. Artificial wetlands provide a process that is close to the natural cycles where water is stored, chemical and physical

pollutants assimilated and recycled as shown in Figure 2.5 (Lyle, 1994; Niemczynowicz, 1993). In the processing phase these wetlands turn waste water into a resource by creating products such as wood, paper, and chemicals. As such artificial wetlands are described by Niemczynowicz (1993) as "sustainable ecological solutions" that are in "peace with nature".

Similarly, natural channels provide refuge for wildlife and allow terrestrial ecosystems to flourish on either side. They have many other advantages over piping including being less expensive, having greater aesthetic appeal, and in general carrying a larger flow than a pipe. They also do not require continual replacement at regular intervals as a piped system does.

SUSTAINABILITY AND PARTNERSHIPS

The concept of sustainability is an ethical issue. Trade-offs among and within competing groups in the community must be able to be negotiated (Petts, in Smith et al., 1993). In urban runoff and waterway management various conflicting interests arise that require a political response. Examples provided by CEPA (1993) include the protection, planning and restoration of natural vegetation and waterways versus the right to go beyond the public jurisdictions and into private property, waterway recreational values versus the need to remove upstream litter and pollution, and funding of downstream flood control structures by charging distant upstream properties. Also the environmental problems associated with urban runoff and waterways cannot be solved through a traditional "command-and-control" style regulatory approach as previous reliance on it has often not worked in practice (Burby and Paterson, 1993). It is therefore essential that the public are aware of local issues and can debate and make decisions about them through the political process (Rockwood, 1993).

In being consistent with an "ecosystem approach" to management, only the integrated stormwater management approach is characterised by requiring ongoing community support and awareness (Table 2.1). There are two main indicators to assess if the level of community participation is increasing. The first is the reduction in the number of decisions affecting the local environment that are taken without the active involvement of those whose living conditions are affected. This is concerned with assessing how power

has been devolved from higher level authorities down to the public in affected areas. It examines the extent to which the public have been allowed to participate in the development of policies and practices. The second indicator is an increasing of the number of local initiatives by government, business and community groups to achieve sustainability objectives (Rookwood, 1993). There are various ways in which public participation can be increased. Community groups can participate by serving as watchdogs in the reporting of spills and vandalism of natural areas. The public can provide local knowledge of environmental conditions where previous monitoring has been lacking. Other initiatives include partnership arrangements between local government, schools, community groups and business and so on.

From the previous discussion the integrated stormwater management approach is considered the most likely approach in Table 2.1 to be able to achieve sustainable urban runoff and waterway management. It is more ecocentric in outlook, makes use of passive systems and has a ecosystem approach to management. Table 2.3 outlines a number of principles or criteria that are associated with this approach. By listing them, the different case study areas can be compared against a standard of how urban runoff and waterways should be managed in a sustainable manner. The extent and ease with which these principles and techniques can been incorporated into an area depends to a large degree on the existing institutional arrangements within the area. The institutional arrangements that exist in New Zealand are discussed in the next chapter.

CHAPTER THREE

INSTITUTIONAL ARRANGEMENTS

The management, protection and use of urban runoff and waterways occurs in New Zealand, as elsewhere, within a particular set of institutional arrangements. These arrangements have been progressively modified over the last century. Therefore there is a need in this chapter to examine the previous institutional arrangements for managing New Zealand's urban runoff and waterways and the mechanisms for protecting them from environmental degradation. This sets up the background to compare the changes that local government reforms and the RMA have had on New Zealand's environmental regime and the significance this has for urban runoff and waterway management.

PAST INSTITUTIONAL ARRANGEMENTS

The institutional arrangements for the management of urban runoff and waterways in New Zealand developed over the preceding century. Before local government reform and the RMA in the early nineties, they had become highly complex with a multiplicity of relevant agencies and acts.

THE POWER TO MANAGE

Until 1989 the power to manage urban runoff and waterways was vested through either special purpose drainage boards or the engineering and parks departments of territorial authorities and catchment boards. In all cases they were largely managed for functional purposes. The 1908 Land Drainage Act (LDA) was one of the first pieces of legislation dealing with urban runoff and waterways. It gave Drainage Boards the power to maintain, upgrade or construct drains and watercourses and, in the absence of any environmental legislative requirements, basically allowed for the disposal of stormwater as they saw fit (Wilson, 1989).

The functions of the Land Drainage Act were replaced by the Local Government Act (LGA) (1974). Under this law, a territorial authority was required to provide and maintain all drainage works necessary for the efficient drainage of the district. Drainage included both sewerage and stormwater drains, pipes, pumping and treatment works and buildings. Section 509 gave general powers to make, maintain, alter, enlarge, or extend any drainage channel or land drainage works. Section 448 gave authorities the power to utilise any stream within the district for the discharge of stormwater. The Local Government Act also established that a council could construct surface drains for road stormwater, dams and holding reservoirs (ss 449, 450) (Palmer, 1993).

In Auckland and Christchurch, the institutional arrangements of drainage were different to that of much of the rest of the country. In Christchurch, the drainage administration was carried out by the Christchurch Drainage Board under the Christchurch Drainage Act 1951. The Christchurch Drainage Act was similar in scope to the LGA. Until 1992, the Auckland Regional Council undertook regional drainage in Auckland City under the Auckland Metropolitan Drainage Act 1960.

THE SOIL CONSERVATION AND RIVERS CONTROL ACT (1941)

The Soil Conservation and Rivers Control Act (hereafter SCRCA) dealt with the problems of flooding, erosion and soil conservation. The legislation was largely a response to the problems resulting from the significant clearance of forest from rural catchments (Roche, 1994). Certain functions associated with flood and erosion control are still retained under the SCRCA 1941 (Harding, 1996). However, nothing in this Act can derogate from the powers and functions of the councils under the RMA (Campbell and Dixon, 1993).

Although its emphasis was on controlling land-use activities in rural catchments, the SCRCA did set up the national organisational structure for flood control in New Zealand. At the regional level, catchment boards (ad-hoc local authorities) were established. They were responsible, for instance, for controlling drainage board activities and works associated with watercourses with respect to the functions of the SCRCA.

The SCRCA recognised the link between land-use and downstream flooding by giving catchment boards the power to make by-laws and land-use controls to carry out their functions. Section 34 of the 1959 SCRCA Amendment Act, for instance, gave catchment boards the ability to identify activities that were likely to contribute to soil erosion, flooding or cause deposition in streams. It such circumstances property owners had to gain consent and take appropriate measures. This would be of later significance to urban development as it provided a mechanism to mitigate soil erosion and subsequent sedimentation in watercourses from residential subdivision and associated earthworks.

EARLY LEGISLATION TO MANAGE WATER POLLUTION

Water pollution was the last environmental issue in land and water management to attract notice from legislators (Roche, 1994). Institutional arrangements were mainly targeted at public health and the protection of fisheries. Two examples were the Water Pollution Act (1953) and the Health Act (1956). The former did not set up regulations but created the Pollution Advisory Committee which, as the name suggests, was restricted to an advisory role, thus relying on the co-operation of industry. In practice it was largely impotent in bringing about any significant changes (Roche, 1994; Wilson, 1989). The Health Act gave local authorities the duty to control any nuisance or condition existing that was likely to be offensive or injurious to health. This allowed measures to be taken concerning any watercourse, stream or lake. It also provided the councils with various matters which local authorities could make by-laws for, including the collection and disposal of sewage and conditions to be observed in the construction of drains. Various trades, considered offensive, were required to gain prior consent before establishing in a given area. This gave local authorities the power to situate them elsewhere or set conditions that would minimise any adverse effects they might have on waterways.

By the post war period these early legislative mechanisms for water pollution had become ineffective. Strong economic growth around the country brought with it a range of new issues that included urbanisation, increased manufacturing and the intensification of agriculture. These issues resulted in conflicts over the allocation of water between competing rural, urban, industrial, domestic and subsequently recreational and scenic users. In response to these pressures the Water and Soil Conservation Act (1967) was introduced (Roche, 1994).

THE WATER AND SOIL CONSERVATION ACT (1967)

The WSCA (1967) legislation operated along side the existing SCRCA. The effect of both statutes was to set up for the first time a comprehensive framework to plan and administer water allocation, water pollution, flood control and soil and water conservation. The WSCA (1967) also set up new authorities to oversee the various new responsibilities embodied in the legislation. At a national level, the National Water and Soil Conservation Authority (NWASCA) was established to co-ordinate issues, while Regional Water Boards (RWB) were set up at the regional level.

The powers that councils and drainage boards had in relation to stormwater were subject to both the SCRCA and WSCA. The WSCA shifted the approach of water managers from the "dominant use" of hydrological resources to "multiple use". It meant that no competing user of a water resource had the legislative mandate to over-ride other users (Fenemor, 1992). Urban waterways could not therefore be given over entirely to a single purpose. The rationale according to Roche (1994) was to stop waterways and rivers being turned into "de facto sewers". However, the concept of "multiple use" proved unsatisfactory in practice as it was awkward to apply and realised neither the goals of developers or conservators (Organisation for Economic Co-operation and Development, 1995).

Water managers were given a variety of mechanisms under the WSCA (1967) to carry out the functions of the Act. These included an ability to authorise activities in or near rivers through a permit system, an ability to fix the acceptable flow and standard of quality for any river, and "General Authorisations" (s22) to permit a range of environmentally insignificant activities such as the discharge of stormwater into receiving environments.

While these policy mechanisms could effectively control point sources of pollution, non-point sources of water contamination were not dealt with in any comprehensive manner under the WSCA (Williams, 1980). What was also apparent was that the approach to stormwater flood control in this period was still very much centred on modifying rivers through such means as straightening, widening and constructing stopbanks (Roche, 1994). It was only in the early 1980s that the NWASCA formally altered its river control policy affecting urban areas to one

which encouraged territorial authorities to consider alternative means such as land-use planning (Ericksen, 1986; NWASCA, 1982).

LINKS BETWEEN LAND-USE CONTROL AND WATER MANAGEMENT

Institutional arrangements connecting catchment land-use planning and water management issues were first established in the SCRCA (1941) and consolidated by both the Local Government Act (LGA) and Town and Country Planning Act (TCPA). Territorial authorities were responsible for administering the provisions of the LGA (1974) and the Town and Country Planning Act (1977). Over time the management of various aspects of urban runoff and waterways either began to fall within the scope of the TCPA or were strengthened despite the Act's primary orientation towards controlling urban development and the rural environment.

The TCPA (1977) provided regional, maritime and, to some extent, local planning authorities the power to plan for aspects which water managers considered relevant including the need to protect land with wildlife, scenic and recreational values (Ericksen, 1990). For instance, there was mandatory catchment authority representation on regional and maritime planning committees. The ARA (1983c) proposed that ecological and amenity values associated with urban waterways should be promoted, if desired, by territorial councils through the district scheme.

The main concern in this period was restricting development, such as housing and associated earthworks, from taking place in areas where it was not suitable. This was in regard to flooding or downstream sedimentation. The Town and Country Planning regulations of 1960 allowed for such measures to be incorporated into district planning schemes. In 1979 the LGA Amendment Act (1979) required local authorities to refuse building permits in hazardous areas unless protective measures were taken. It was also made mandatory for local authorities to control subdivision through the scheme plan in areas where natural hazards, such as flooding, would make the land unsuitable for development or where they would aggravate such hazards (Ericksen, 1990).

Despite their advocacy (Ericksen, 1971; 1975; 1982; 1986) land management or source controls were weakly adopted in comparison with structural solutions. The reasons for this situation were complex. One reason proposed by Ericksen (1990) was a failure by local authorities to work with catchment boards and a resistance to being regulated on urban flood issues. Another reason was that water engineers seldom promoted them. Ignorance also played its part as few decision makers seemed to appreciate that structural solutions increased the probability of disaster by encouraging development in the protected areas that were perceived by the public as being safer than before (Ericksen, 1990).

By the early 1980s, with the trend of urbanisation showing no sign of slowing down, it was becoming very apparent to local authorities that developers had for too long ignored the need of land subdivisions to meet general expectations with respect to stormwater runoff. The ARA (1983a) summed up this whole situation as being very unsatisfactory. For instance, they expressed genuine concern about the issue of development occurring in secondary (overland) flow paths. Developers had often overlooked the fact that the on-site stormwater system or primary flow path, was usually only built to account for a five to ten year design storm. This meant that sooner or later the flooding of property would occur when the primary path become overloaded or blocked during flooding.

Comprehensive planning for stormwater management

Given the nature of the problems, which included both water quantity and quality issues, a more sophisticated approach to manage urban runoff was needed from local authorities. This led to the emergence of comprehensive stormwater management planning. It was clearly of national concern at this time. This was recognised by the NWASCA when it produced a guidance manual to assist territorial authorities on how best to approach the issue of flooding (NWASCA, 1982).

While concern in the 1980s with comprehensive planning centred on flooding, instability and public safety, there was now more attention focused on wider environmental considerations such as the need to protect certain streams and waterways in the urban area. This led to the ARA's (1983b) "Land and water management plan" being produced. Developed in the

trouble-prone Auckland region, it provided the most creative example of comprehensive catchment planning that was put into practice in New Zealand (Ericksen, 1990).

Barriers to comprehensive water and land planning

Despite the ARA's "Land and water management plan", the development of an integrated and comprehensive approach to catchment management was never completely achieved (Ericksen, 1990). The few innovative councils which tried to implement such planning found that they were hampered by the following institutional problems including:

- The plethora of environmental laws and regulations that had emerged in an incremental and ad hoc fashion over about 80 years. This had created a enormously complicated system (Cocklin, 1989; OECD, 1981). Pollution management was controlled by a wide number of statutes creating legal content that was considered "unnecessary and inefficient" (ARA, 1983b). Further, there was little provision made to deal with non-point sources of pollution.

- the lack of integration between land-use planning and water management i.e., the need for the TCPA to incorporate more principles and objectives from the two Water Acts. In particular, there was a need to strengthen the provisions of Section 4(3) which provided all too casually that "regard shall be had to the principles and objectives" of the two Water Acts (ARA, 1983b).

- Following on from the second point was the need for greater legislative emphasis on co-ordination between the different local authority agencies. In the Auckland region, the need for co-ordination fell between the various agencies involved (regional and local authorities, regional water boards, harbour boards, and maritime planning authorities) (ARA, 1983b).

- The need for land and water management plans to have statutory force. While the NWASCA and RWBs were given extensive powers to plan in respect to issues associated with water quality, quantity and wildlife, they were greatly constrained as the plans could not be formally recognised under the WSCA. Those authorities which produced "Land and Water" management plans assumed that the various agencies could be effectively co-

ordinated so that policies would be progressively incorporated into regional or district schemes (ARA, 1983b). Often this did not occur in practice and it was recognised that water managers needed to be given their own legislative basis for planning (ARA, 1983b).

Overcoming these problems was not an easy task. The complex nature of the stormwater problem meant that the only way forward lay in a more integrated approach.

LOCAL GOVERNMENT REFORM

The legislation discussed so far came out of a period that was characterised by a strong development ethos and bureaucratic, coercive government control (Roche, 1994). This lasted until 1984 when a new political and economic environment was created by the incoming Labour government. This ensured a period (1985- 1991) of fundamental restructuring to the whole state sector including that of environmental management in New Zealand (Buhrs and Bartlett, 1993). The key themes were to:

- "downsize" the state through shifting business activities into the private sector
- promote economic liberalism in which the market place was considered the most efficient and most effective means of realising individual and community preferences
- promote individual community responsibility i.e., "user pays" and devolution of power

The many existing agencies of government with a role in environmental management, e.g. the NWASCA, embodied the idea of "inefficient" centralised control. These agencies were also unpopular with environmental groups, who saw them as having potentially conflicting mandates (the development and protection of natural resources). In the process of government reform, they were either closed down or substantially reformed (Buhrs and Bartlett, 1993; Roche, 1994).

INSTITUTIONAL REFORM

At the national level the Ministry of the Environment was formed to replace the former government agencies involved in environmental issues. Its role was to overview and monitor local authorities. Under the RMA it can determine policy by setting national environmental standards, i.e., National Policy Statements, to guide and direct local authorities. It can also

call in any application for a resource consent in order to make a decision at a national level. However, it has been distinguished by a lack of funding and few real powers to alter local authority activities (Buhrs and Bartlett, 1993). The Department of Conservation (DOC) was another national department of relevance established with special responsibilities in respect to national parks and coastal management.

There were several principles of reform underpinning local government. An emphasis was placed on separating regulatory and policy functions from service delivery. A greater degree of council accountability and transparency of operations was also required. Councils were expected to be highly accountable to their ratepayers in terms of their performance. Councils were expected to become more "business-like" to improve efficiency and the quality of work they carried out. There were also limitations placed on the size and functions of government. In particular, there was a substantial reduction in the number of local authorities. Before the reform there were 625 units of local government. There are now just 12 regional councils and 74 territorial authorities (including 4 unitary authorities). The decrease in the number of local authorities was designed to improve the delivery of their services and policy (Buhrs and Bartlett, 1993). Another aspect of significance was that the new regional councils were given boundaries that roughly followed those of catchments. Also, by setting up the basic organisational structures and processes, local government reform had considerable influence on how the RMA would be implemented (Buhrs and Bartlett, 1993).

THE RESOURCE MANAGEMENT ACT

The long awaited overhaul of environmental legislation was realised in 1991 with the introduction of the Resource Management Act (RMA). This single piece of legislation integrated the administration of land, air, water, the coastal zone and pollution with the goal of sustainable management. The vision of sustainable management was that future generations were to have adequate resources to meet all foreseeable needs and to protect the life supporting capacity of the environment. Thus through Section 5 of the RMA, New Zealand put its own modified definition of sustainability into its legislative framework (Smith, 1993).

ORGANISATIONAL RESPONSIBILITIES

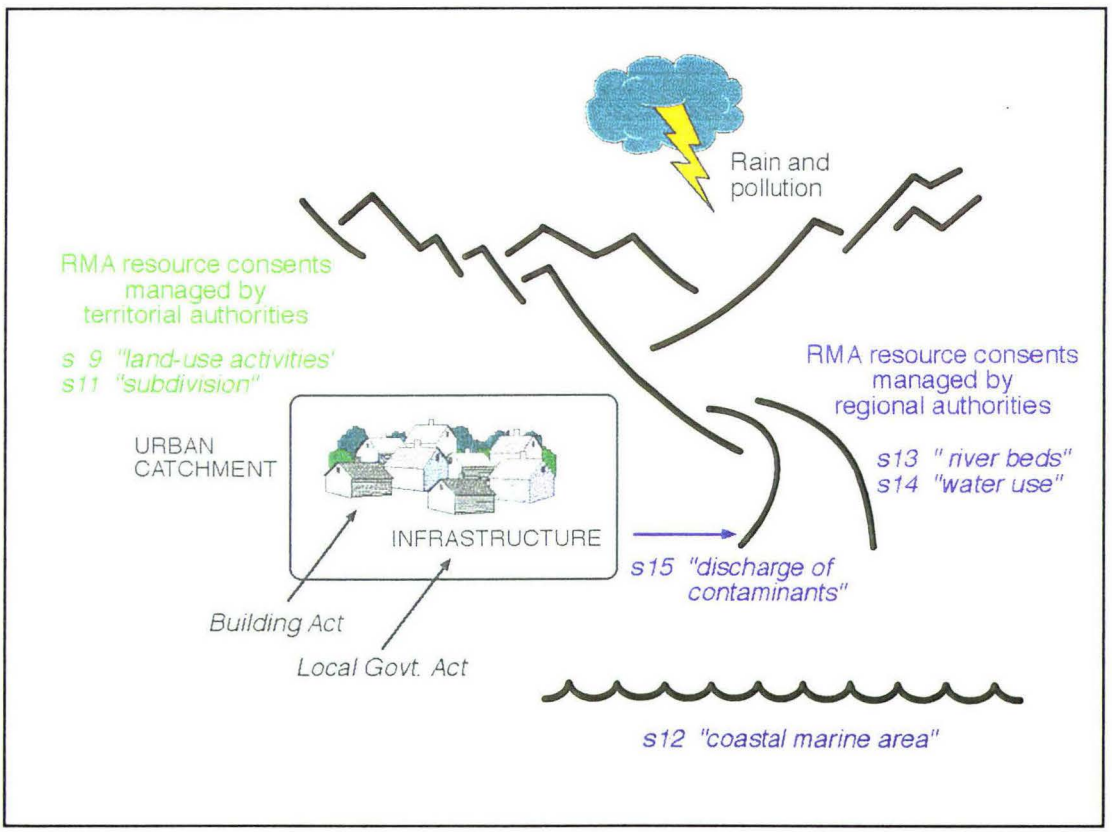
Under the RMA both regional councils and territorial authorities have a role in environmental management. Regional councils have most of the responsibilities for water management. They effectively took over the functions of the NWASCA, water boards and catchment authorities. Their responsibilities include administering the modification of river beds and banks and water quality and quantity. Under Section 30(c)(4) of the RMA regional councils have the specific function of controlling land-use to avoid and mitigate natural hazards. Regional Council's also have the responsibility for controlling catchment land-use activities for the *"maintenance and enhancement of the quality of water in water bodies and coastal water"* (sec30c). Territorial authorities have a similar function to regional councils: *"The control of any actual or potential effects of the use, development, or protection of land..."* including avoiding or mitigating any natural hazards. Territorial authorities also have powers to restrict subdivisions where land or structures are likely to suffer or accelerate and worsen *"damage from inundation from any source"* (s106(1)(a) & (b)).

The institutional arrangements for urban waterways and runoff are shown in Figure 3.1. The functions of regions and districts under the RMA together with the functions under the LGA provide the framework for integrated management. In practice, the potential is there for the management of stormwater to become far more integrated than that which previously occurred under previous legislation (White, 1992). To be effective, the control of stormwater requires co-ordination of regional and district planning so that conflicts over what level of local authority is responsible for particular aspects of land use planning are prevented (White, 1992).

Under the LGA (1989) the territorial authority retains its service delivery role. It still provides and maintains all works necessary for the efficient drainage of the district as shown in Figure 3.1. Drainage includes both sewerage and stormwater drains, pipes, pumping, treatment works and buildings. The regional drainage function has been abolished so that in areas such as Auckland either the territorial authority or local authority trading enterprises has had to continue with the role.

The Building Act, shown in Figure 3.1, is also relevant as it controls how buildings are constructed. The Building Act sets up the framework for the Building Code, which administered by territorial authorities, sets minimum performance standards that buildings must comply with. The Building Code (Building Industry Authority, 1992, piii) states that water *"which is collected or concentrated by buildings or sitework must be disposed of in a way that avoids the likelihood of damage or nuisance to other property"*. It is the responsibility of the property owner to meet this standard by providing, to the council's satisfaction, an "acceptable solution".

Figure 3.1: The relationship of legislation to the urban runoff system



Local authorities still face strong legal and community pressure to avoid natural hazards. In the case of the need for protection of property from the effects of surface water the RMA (s.68(2)& 76(2a) allows regional and district plans to set performance criteria in addition to, or more restrictive than that specified in the Building Code (the Building Act 1991 specifies a protection standard of 50 years for minimum floor levels).

CHANGE OF ETHOS IN THE RMA

The RMA has put into legislation many new duties and explicit principles and requirements. While the Town and Country Planning Act contained some broad principles, the WSCA (1967) provided only very limited guidelines with respect to water management. The values of the RMA are embodied in Part II which sets out a hierarchical set of principles and considerations to guide the management of natural and physical resources. These principles affect the consideration of all policy, planning and resource consent applications.

Focus on ecological values

Compared to previous legislation the RMA has given greater priority to environmental values. It is perhaps a recognition by legislators that natural and physical resources are a necessary condition of a sustainable future. In the allocation of water, the RMA provides for the requirements of commercial and community interests (i.e., the need to remove stormwater from the urban environment), but also takes into consideration the protection and enhancement of ecological, scientific and intrinsic values (Young, 1991). Under the old water regime for instance, benefits and detriments were traded off (Fenemor, 1992). In contrast the RMA, as expressed in Part II, stresses the need to maintain a "bottom line" through the safeguarding of the life-supporting capacity of air, water, soil and ecosystems (s5b). The level of environmental protection given to a particular resource must be weighed up with the range of principles and priorities in Part II.

Part II places a high priority on protecting water bodies. For instance section 6(a) makes *"the preservation of the natural character of the coastal environment..., wetlands and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use and development"* a matter of national importance. Given the highly modified extent of most urban waterways it is unlikely that this section will be applicable in many urban areas.

The provisions contained in Section 7, of lesser importance than section 6, are perhaps more relevant to stormwater managers in that they require particular regard to be made for:

- *"the maintenance and enhancement of amenity values"* (s7c)
- *"intrinsic values of ecosystems"* (s7d)
- *"maintaining and enhancing the quality of the environment"* (s7f)

- *"any finite characteristics of natural and physical resources"* (s7g).

The differences in legislative intent should be borne out when managers of waterways are considering the intended environmental results of policies. Under the old regime the ARA (1983a), one of few councils with a strongly developed policy on stormwater, indicated that given "wise" land use practices urban streams could provide for recreational pursuits such as fishing or even swimming. In contrast, the environmental ethic of the RMA emphasises the preservation of the aquatic resources and enhancement of their value as a desired future state.

While the RMA has an "ecological focus" it is neutral with respect to reconciling competition between economic and environmental goals (Memon and Gleeson, 1994). It is up to private developers to utilise natural resources, as opposed to the state. This fits in with the government's philosophy of economic liberalism. The role of local authorities is to control unwanted "market externalities". This represents a change from the Town and Country Planning Act where land-use planning was an essential tool for promoting development and regulating its adverse effects. The RMA lacks procedural means to integrate environmental values into the key policy areas such as economic policy or transportation. The notion of social equity has also been avoided.

Focus on environmental effects

The RMA also gives councils the duty to avoid, remedy or mitigate adverse effects that might affect environmental quality (s17). This applies as much to natural hazards as to pollution. Compared with previous legislation, the RMA focuses on controlling adverse environmental effects rather than specific activities. Engineers and practitioners thus have a "moral obligation" to control the manner in which they interfere with the environment (Buckeridge, 1992). For instance, the Section 17 term "avoid" suggests the prevention of damage. In the case of urban runoff this equates with the application of source controls. The term "remedy" suggests either curing or controlling the symptoms. This could be seen to support the drive for the restoration of wetlands which have the capacity to mitigate adverse effects and restore natural character. The term "mitigate" implies reducing adverse effects i.e., providing treatment options such as detention and retention ponds and wetlands. Local authorities have to choose which of these options to pursue.

Focus on cultural concerns

Maori concerns and values are now an integral part of the decision making process thereby representing a shift away from the "monocultural" nature of previous legislation such as the WSCA (1967). Maori have a particularly high regard for water resources both in the physical sense and also the spiritual as they consider it to possess a life force or mauri (Fenemor, 1992). Part II contains explicit requirements to take into account the principles of the Treaty of Waitangi (s8), such as the need to actively consult, and to recognise and provide for Maori cultural relationships with water and other resources (s6e). Environmental managers also need to have regard to the concept of kaitiakitanga or guardianship of natural resources (s7a).

THE DEVOLUTION OF POWER

The RMA provides more opportunities for public participation, consultation, alternative disputes resolution and accentuation on Maori concerns than previous environmental legislation. Throughout the RMA is the assumption that the public will be consulted and agreement reached over goals for acceptable levels of environmental quality.

The intent of the RMA is to place responsibility for the management of resources with the community most directly affected by changes to it and as such has devolved power out to the local authorities. The RMA represents a shift from a coercive style of regime to a more co-operative form of government mandate (Buhrs and Bartlett, 1993). For instance, regional councils have little or no effective national co-ordination (Kopp, 1991). There are now few central controls on water pollution (Young, 1991) and local government has been given more responsibility with regard to flooding and other natural hazards (Campbell and Dixon, 1993).

WATER QUALITY STANDARDS

With the introduction of the RMA, the standards and guidelines developed under the previous environmental regime have been discarded (Memon and Gleeson, 1994). New standards must therefore be developed by local authorities. The RMA does, however, introduce statutory minimum water quality standards. These qualitative standards, listed in Appendix 3.1, apply to all fresh water and restricted coastal discharges throughout the country. If desired, a regional plan may set higher standards preferentially by the use of the classes specified in the third schedule of the RMA (s.69(1)&(2)).

The RMA's jurisdiction over urban runoff quality begins when water enters the receiving environment such as a river or the coastal environment. The definition of water in the RMA does not include water in any pipe, tank or cistern (s2). Thus residential properties do not have to apply for a discharge permit when discharging into the stormwater system unless it is a direct discharge to a river. All discharges of contaminants into receiving waters require a permit unless allowed for in a regional plan. This gives regional councils the discretion to control the pollution coming out of the stormwater system by forcing territorial authorities who administer the drainage network to adopt treatment measures.

IMPLEMENTATION OF POLICY

A major tool for resource management under the RMA is the regional and district plan. In theory resource planning involves identifying existing or potential resource issues and determining what to do about them. The RMA framework establishes that issues must link into objectives, policies and rules. Rules represent one of the principal regulatory means for resource management allowing activities to be "prohibited, regulated or allowed". Any rules under the RMA have the power of a regulation and are to be interpreted in accordance to other regulations put into effect under the RMA (Palmer, 1993).

Planning can occur at national, regional and local levels. With respect to urban waterways and runoff, the regional and local levels are the main levels of concern. Planning at the regional level employs two types of policy instrument; the Regional Policy Statement (RPS) and the Regional Plan (RP). It is compulsory for regional councils to prepare a Regional Policy Statement (RPS) (s60). These provide an overview of resource management issues in the region and the policies and methods necessary to achieve the integrated management of the natural and physical resources. Plans both at the regional and district levels must not be inconsistent with the RPS.

Regional Plans

These are specific plans relating to resource management issues (Fenemor, 1992). They have given regional councils a statutory basis for water resource planning although there is no general obligations to prepare them. Due to the cost to prepare and administer a plan they will only be produced where there is a problem, or one is likely to develop. Regional plans may be

used to set minimum flows, lake levels and standards of water quality or permit minor activities as a "general authorisation" did under the WSCA (1967). They can be also used to control land-use activities that may impact on water quality.

District Plans

District plans (equivalent to district schemes under the Town and Country Planning Act) are mandatory. The purpose of a district plan is to assist territorial authorities to carry out their functions in order to achieve the purpose of the RMA (s72 RMA 1991). District plans are accompanied by district rules which like the rules in regional plans prohibit, regulate or allow land use activities. Activities cannot be controlled unless they are causing adverse effects on the environment. As under the WSCA, regional councils can make submissions when district plans are prepared. These could state, for instance, that potentially polluting land-uses and stores of hazardous wastes are sited away from water or operated so as to minimise risk.

The RMA planning process for policy statements and plans is based on adaptive management (Buhrs and Bartlett, 1993). This provides greater potential for an effective ecosystem approach to environmental management (Szaro et al., 1996). Under the RMA framework issues are planned for by setting objectives, policies and methods to promote desired changes which can be monitored. There is a much bigger emphasis on monitoring in general. The RMA requires local authorities to monitor the operation of their plans with the intention of providing feedback on the efficiency and effectiveness of methods that are being implemented.

There is also a new obligation to consider alternative methods, the reasons for and against adopting particular courses of action, and the extent to which particular courses of action are necessary before adopting any objective, policy, rule or method. There is the option of local authorities not intervening in a situation if the costs of doing so would outweigh the benefits.

RESOURCE CONSENTS

The RMA recognises five main types of resource consent as shown in Table 3.1. Water management in the RMA is very restrictive given the definitions in Table 3.1. This was the same with the WSCA (1967). Any type of activity involving the disturbance of a river bed or

taking, damming, diverting water or discharging contaminants into water is restricted by the need to gain a resource consent.

Table 3.1: Restrictions on activities as set up by the RMA:

land-use consent	no person may use any land in any manner that contravenes a rule in a district plan or proposed district plan unless allowed by a resource consent
subdivision consent	no person may subdivide land unless allowed by a rule in a district plan or a resource consent
coastal permit	restrictions related to the coastal marine area are contained in section 12, 14 (related to use of water) and 15 (related to the discharge of contaminants). In essence no person may interfere in the coastal marine area without a resource consent.
water permit	no person may take, use, dam, or divert any water and other matters listed under s14 unless allowed by a rule in a regional plan or have a resource consent.
discharge permit	no person may discharge any contaminant or water into water or contaminant onto or into land in circumstances which may result in the contaminant entering water etc unless allowed by a rule in a district plan or a resource consent (s15).

The system of granting permits or "resource consents" has changed compared with previous legislation. All applications are dealt with in exactly the same way as other activities having a similar effect on the environment. Any type of activity requiring a "resource consent" may according to definitions and provisions contained in the regional or district plan and rules fall under the specific categories shown in Table 3.2.

Decisions on resource consent applications are subject to criteria such as the resource management objectives (Part II of the RMA), consent of persons affected and the assessment of the effects of activities on the environment (Fourth Schedule). The assessment of environmental impacts is of primary importance in considering resource consent applications such as stormwater discharges (i.e., s15 see Figure 3.1) or river bed modifications such as canalisation or dredging (i.e., s13 see Figure 3.1). This contrasts with "water rights" under the previous regime in that the conditions that must be considered are now made explicit. The

primary focus is on outcomes or environmental bio-physical effects. The meaning of the term "effects" is wide ranging and includes cumulative effects.

Table 3.2: Restrictions on classes of activities as set up through plans (RMA s2)

Permitted Activities	Allowed by a regional or district plan; no consent is required
Controlled activities	Specified in a plan as such A consent is required with some conditions.
Discretionary activities	Specified in a plan as such, a consent is required. Consent can be granted or refused, if its granted conditions can be imposed.
Non-complying activities	These are not allowed by a rule in a plan but are not prohibited activities. A resource consent is required. A consent authority should be satisfied that the environmental effects are minor or that the activity will not be contrary to the objectives and policies of the plan. A consent can be granted or refused. If granted conditions may be imposed.
Prohibited activities	If these are specified in a plan the activity is not permitted and a resource consent can't be granted.

The RMA allows local authorities to require the adoption of the best practicable option in a discharge permit for treatment and discharge (s108). Before this condition is placed on the consent, the regional council needs to be satisfied that the condition is the most efficient and effective means of preventing or minimising any actual or likely adverse effect. In doing so they must have regard to the nature of the discharge, receiving environment and other alternative methods.

ECONOMIC INSTRUMENTS

The RMA has little provision for the use of economic instruments. Water cannot be priced either to encourage conservation or to provide for the externalities of its use (OCED, 1995). Of the few economic instruments available to water managers, Section 36, allows local authorities to recover some of their costs associated with the administration of their resource management functions. Such charges can be either specific amounts or varying amounts, depending on the amount of work carried out by local authorities. Another example is that the

Ministry for the Environment may make grants or loans on appropriate conditions to any person to assist in achieving the purpose of the RMA.

EVALUATION OF THE RMA

Environmental values are a primary concern in the resource planning process. Notably they are now provided for mostly at the local and regional government levels. It has only been with the introduction of the RMA that regard for adverse environmental impacts is mandatory in all resource management decisions. As such they have a much better chance of being identified and incorporated in the management process compared to the pre-reform situation (Buhrs and Bartlett, 1993).

However, as Buhrs and Bartlett (1993) have indicated certain aspects of environmental management are still inadequately dealt with in the RMA. The first is the advocacy of environmental values related to the control of pollution. Buhrs and Bartlett (1993) suggest that it is too heavily weighted at the local and regional levels. The result is a lack of focus on either contaminant sources or substances. Regional and local levels of government are severely constrained by legal barriers and by their ability to interfere with economic decisions in the private sector. Second, the continued and largely uncontrolled urban growth and quality of life (social issues) are inadequately covered. The RMA is severely limited in its ability to regulate economic, social and cultural matters. Finally, co-ordination between government agencies on issues remains as potentially weak as it has under previous legislation. Given its very nature, all of these "gaps" in the RMA are relevant to the management of urban stormwater and runoff.

This chapter sets the scene for subsequent analysis of how councils in the case study areas have responded to both the advantages of the RMA's integrated "ecosystem approach", to the management of air, land and water, and the potential legislative "inadequacies". The means through which this is done is explained in the fourth chapter on Methodology.

CHAPTER FOUR

METHODOLOGY

This chapter outlines the research design and methodology used to evaluate how environmental considerations have been incorporated into the management of urban waterways and runoff. Three case study areas have been selected for this research. The method of selection and the nature and characteristics of each area are examined in turn. This is followed by a discussion of the two main methods that were used to gather information. The first is a form of "plan analysis" or "plan coding" and the second is interviews with relevant council staff.

INFORMATION GATHERING

Information from this thesis was gathered from a range of sources and analysed using a mixture of quantitative and qualitative methods. This provided an inter-method triangulation approach to answering the thesis aim, where two or more methods of different methodological origin are used to assess the same issue(s) (Sarantakos, 1993). Together they provide a means to show any gaps between the public policies and methods of the organisations, as represented in the plans, and what has actually been implemented by those organisations, as revealed through the interviews.

DOCUMENTS

Documents (such as council material, academic research, journal articles and newspaper reports) were read and considered in the early stages of thesis development to aid in the construction of the research design. Many of these documents were revisited, along with new ones, once the interviews were carried out. This process added to the information gathered from the interviews and provided an aid to their analysis.

Catchment management plans and Annual Plans

As a guide in fulfilling their responsibilities under the LGA (1974) councils may prepare catchment management plans (CMP) for the provision of drainage services. These usually

identify a range of potential structural works. The allocation of funding for the provision of drainage services is dealt with through the Annual Plan process.

It was decided not to systematically analyse catchment management plans as these documents are of an essentially technical nature. Catchment plans outline specific works which are not necessarily comparable from area to area. They do, however, provide a useful source of information on what facilities, such as detention ponds, councils have in place or are planning to construct in the future.

Miscellaneous documents

Various miscellaneous material was also examined. The basis for selecting material was whatever was available and relevant. Such information produced by councils was on their own initiative rather than that necessarily required by statute. Strategic plans, for instance, have become popular at the district level in New Zealand (McAlister, 1993). These were available in some of the case study areas and outline long term social and economic goals, e.g., stormwater infrastructure, that are unable to be examined in the District Plan with its 10 year time range and strictly environmental focus. Other material provided by councils included council by-laws, general authorisations, s32 documents prepared for plans and information packages on programmes put in place by the council.

Policy documents

Policy statements and plans were gathered from the appropriate councils in the case study areas. These were prepared to meet the council's responsibilities under the RMA. They include documents such as regional policy statements and regional and district plans (as outlined in Chapter Three).

The policy statements and plans covering each area represent the most obvious "institutional" outline of how urban waterways and runoff are protected from such problems as flooding and pollution. Their objectives contain the council's aspirations for the improvement in the environmental quality of urban waterways and aquatic receiving environments. The district plan, through its control of land-use activities through regulations, can have a major effect on the water quality of urban runoff.

CASE STUDY SELECTION

The district level represented the most appropriate scale for answering the research aim and objectives as most administration of the drainage network is carried out at this level. Not only do territorial authorities manage the stormwater system in New Zealand but the district is the smallest political entity that has the power to produce environmental regulations across its boundaries. Also, environmental issues associated with stormwater are seen in most areas as being local rather than regional in nature.

Political boundaries were used in preference to physical boundaries to define the spatial extent of the case study areas because research focused on the managerial approach in each case study area. Analysis on a catchment basis was rejected because the research would quickly become centred on differences in the infrastructure between catchments rather than the general managerial approach that underlies them. Structural facilities, such as detention ponds, are constructed on a case-by-case basis and so comparison between catchments is difficult and beyond the scope of this thesis.

Once the scale of case study areas had been selected a preliminary scan of the existing stormwater literature in New Zealand was made. From this preliminary scan three districts were chosen for case study areas for this thesis. Choosing three case study areas was necessary to provide a manageable research problem given the constraints of this thesis. Such a sample can not be considered to be of a sufficient size to achieve a national representativeness. There are 12 regional councils and 74 territorial authorities including 4 unitary authorities in New Zealand to choose from (Statistics N.Z., 1996), although the number of districts that had appropriately sized urban areas for the purposes of this thesis were far fewer than this total.

The case study areas are Auckland City Council (isthmus only), Christchurch City Council and Palmerston North Council. The researcher chose the case study areas on the basis of relevancy to the thesis topic as described by Sarantakos (1993) as purposive sampling. The result is therefore a selection of what may be described as "highlight areas" in New Zealand. These areas are all characterised by having important issues in relation to urban runoff and waterways yet have a diversity in the type of response they have taken to their operating

environments. Their individual operating environment means that they may have different catchment characteristics, size of population and managerial arrangements. The researcher's intention is to find common themes that existed between the councils despite the differences in operating environment.

CASE STUDY ONE: AUCKLAND CITY ISTHMUS

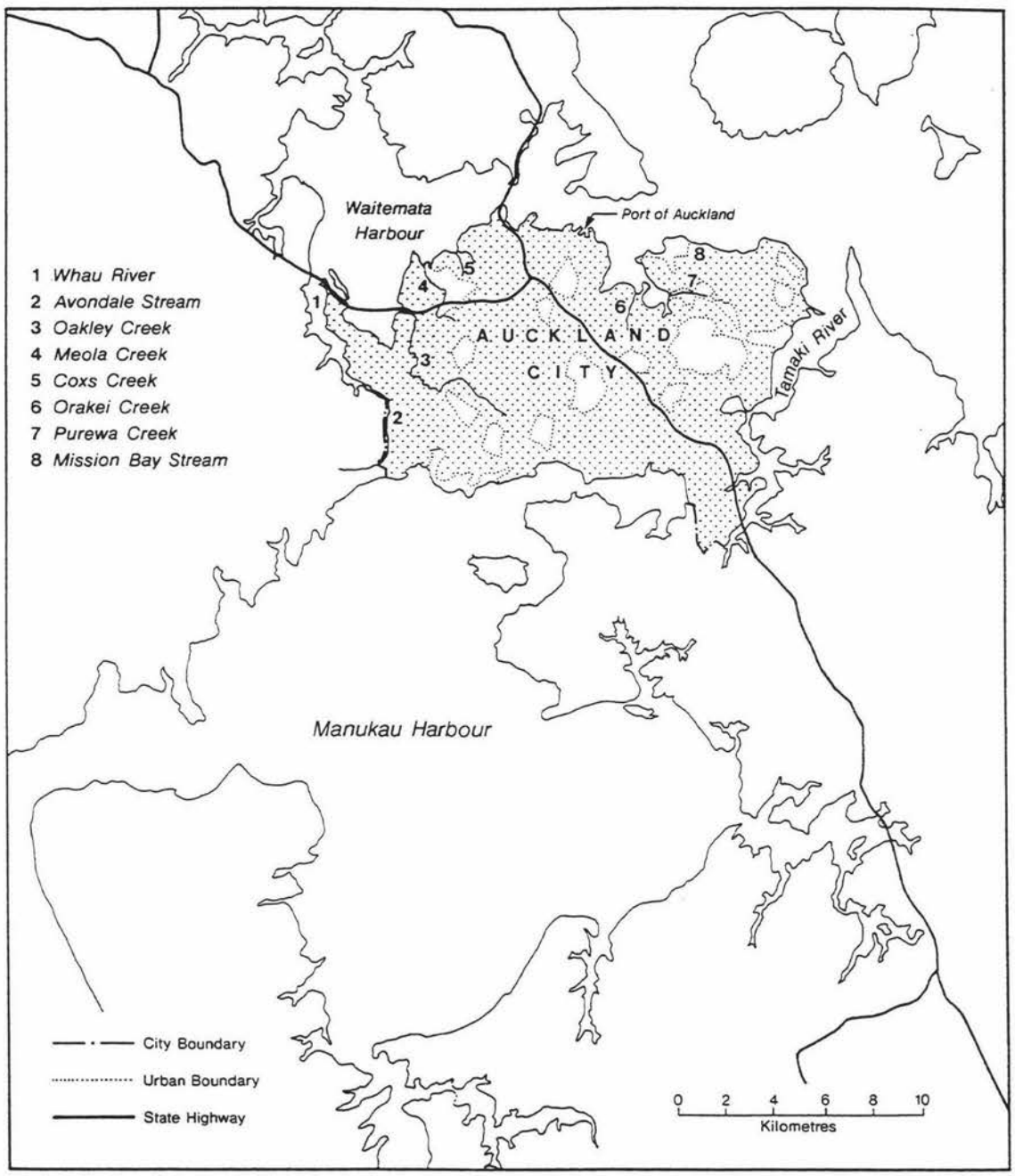
A case study in the region of Auckland was an obvious candidate for selection. Stormwater quality has been a regional issue in Auckland and most of the New Zealand literature and research on the adverse effects of stormwater has come out of this area. The Auckland Regional Council (1995) have stated that the adverse ecological effects from stormwater-borne contaminants found in Auckland is proportional to those found in other major cities around the world. The city of Auckland had a number of councils operating in it. The territorial authority that was chosen was Auckland City Council (isthmus area) shown in Map 4.1. The catchments in this district were fully urbanised and represented one of the few areas in New Zealand whose catchments do not contain any rural land. Problems such as pollution and flooding were related entirely to urban activities making it a better choice than other districts in the Auckland region.

Out of all the Auckland metropolitan districts, the Auckland City isthmus represents the most heavily urbanised area with 19.6 people per hectare. The area is characterised by heavy infilling and an extensive impervious area. Auckland City, generally, has shorter, steeper catchments than the other two case study areas which mean that the flooding problems are relatively isolated compared with the other case study areas. Flooding is still considered a problem in the district. The rainfall average is the highest of the case study areas at around 1105mm per year (Statistics N.Z., 1996). The stormwater system is different from Palmerston North and Christchurch in that it comprises a mixture of separated and combined drainage systems. The piping system is supposed to have capacity up to the 10 year flood. Houses are protected up to the 100 year flood.

Urban waterway quality

There are numerous streams in the Auckland City isthmus area. Their quality is often poor. The ARC (1995) recognise that, because the catchments are fully urbanised, these

Map 4.1: Auckland City Isthmus



streams have low base flows in dry seasons and stormwater contaminants are poorly diluted (ARC, 1995). Most concern with the water quality of streams has centered on

sewer overflows. Sewer overflows are common in Auckland City and this significantly reduces the water quality in waterways such as Meola and Cox's Creek among others.

Some waterways e.g., Mission Bay Stream have been highly modified in that for much of their length they are channeled underground. Others retain some ecological significance. As sections of the upper catchments of Avondale and Purewa Creek are vegetated they provide likely habitats for species of native fish e.g., banded kokopu. The larger watercourses in the city area such as the Whau, Oakley and Orakei Creeks are used for recreation. The Orakei Creek, in particular, flows into the Orakei Basin where important sporting activities take place (ACC, 1992).

Receiving water environment

The ARC (1992b) carried out an economic evaluation of Auckland's harbours and estuaries and estimated the resource to be worth over $440 million annually. This included the role of the harbours for commercial fishing, recreation values, shellfish harvesting and amenity values. There are also intangible benefits including intrinsic, aesthetic, cultural and spiritual values. Both the Waitamata and Manakau estuaries have important ecological values. The Manukau Harbour is considered an internationally important sanctuary for many species of bird (ARC, 1995).

Most concern over the quality of stormwater in Auckland is focused on the Manakau and Waitamata estuaries and related to the cumulative build-up of sediment contamination levels. Auckland estuaries are characterised as being low-energy and poorly flushed. In particular, the upper reaches of estuaries are regarded as being highly sensitive to stormwater contamination, because they act as "retention zones" where suspended solids are deposited, and where contaminants continually accumulate. The highest buildup of contaminants is found near stormwater discharge points (ARC, 1995).

The contamination problem is widespread with nearly 3500ha of marine area considered likely to receive the majority of contaminant loads from urban stormwater runoff. Out of this area 50% is predicted to currently have concentrations of heavy metals of lead, zinc and copper at levels which are likely to produce undesirable biological impacts. If

contaminants continue to be generated at present day rates, the rate of sediment contamination will accelerate with concentrations becoming higher. Predictions suggest that by 2021, 70% of potentially impacted areas will have sediment contaminant levels above the level of producing undesirable biological impacts (ARC, 1995).

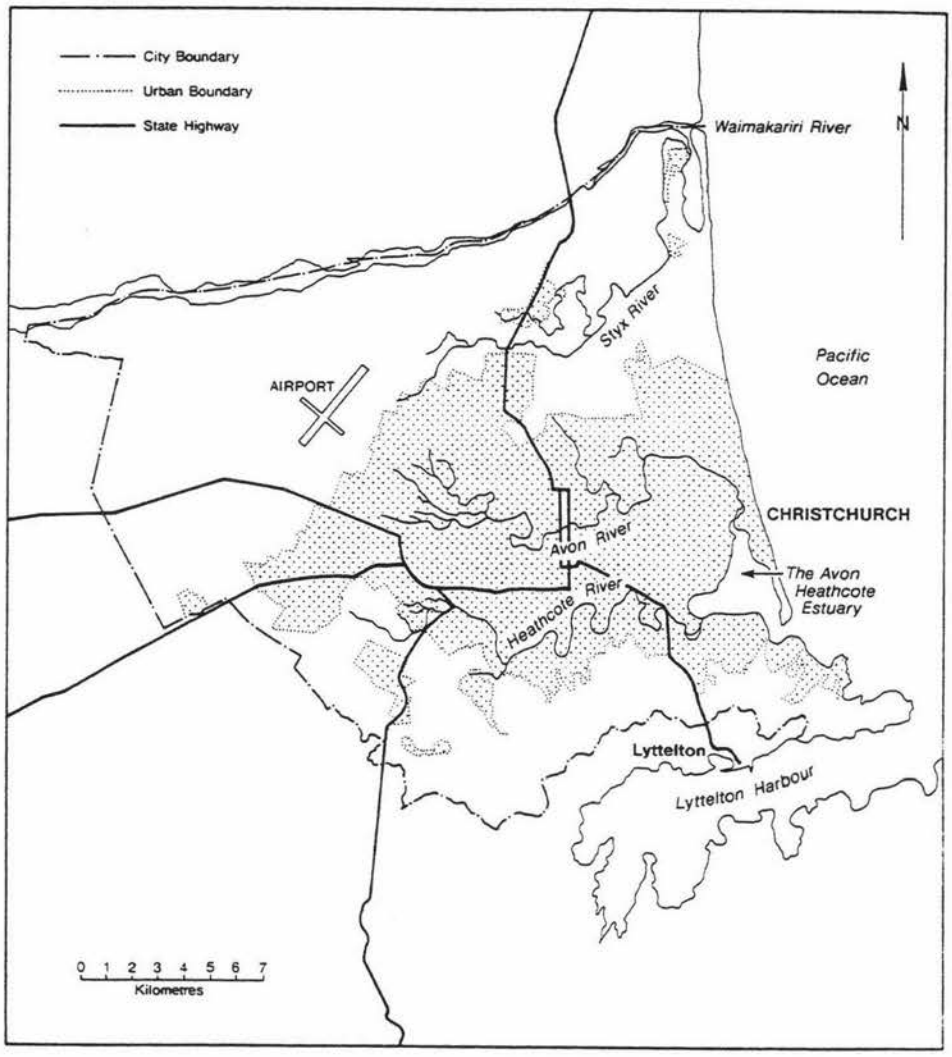
CASE STUDY TWO: CHRISTCHURCH CITY

One of the main distinguishing characteristics about Christchurch is that its waterways are a central focus in the city identity. Christchurch City, shown in Map 4.2, has been chosen on the basis that the managerial approach with respect to urban waterways represents one of the most innovative in the country and the closest to that of the integrated stormwater management approach. Unlike Auckland, Christchurch has always been serviced by a fully separated stormwater system (Wilson, 1989).

The majority of Christchurch is drained by the Avon and Heathcote Rivers which flow into an estuary system. Both these two small rivers are primarily spring fed. Christchurch has the lowest average rainfall of any of the case study areas (645mm, Statistics N.Z., 1996) and its catchments are quite flat. The high amenity value of Christchurch's waterways comes in part from introduced plants, such as weeping willows, along the banks. The first concern for the management of the river landscape has been the visual impact (Roper-Lindsay, 1994).

The Avon-Heathcote Catchment has become highly urbanised since the beginnings of European settlement in the 1850s although parts of the Heathcote still contain rural areas. Before settlement Christchurch was a swamp area. Stephenson (1980) describes the pre-settlement vegetation as comprising flax, raupo, tussock grass, fern and patches of swamp forest. This swamp land was progressively drained by an underground stormwater and sewerage system from about 1878 as managed by the Christchurch Drainage Board (Stephenson, 1980; Wilson, 1989). Modification of the drainage pattern was accompanied by the removal of native vegetation. There is now little native vegetation along the waterways (Roper-Lindsay, 1989).

Map 4.2: Christchurch City



Avon-Heathcote estuary

The Avon-Heathcote catchment drains into an estuary which is unmatched among New Zealand estuaries in sustaining wildlife population, as large and diverse as it is, within such a heavily urbanised area. The area is internationally important for the wide number of species of birds (111 species of bird have been recorded). Historically the rivers and estuary have supported various types of fish and shellfish although contamination of the shellfish restricts human consumption now.

Recreation

The Avon-Heathcote estuary is highly valued for the range of recreational activities it provides i.e., boating, fishing and windsurfing. In general, faecal coliform numbers levels are low enough in the estuary to allow contact recreation (CRC et al., 1992).The Avon and Heathcote rivers in Christchurch are also used occasionally for recreation i.e., bathing and canoeing.

Heathcote River

In the early years of the 20th century the Heathcote River had the notorious reputation of reputedly running red on occasion. This was a result of receiving mostly untreated effluent from factories in the most heavily industrialised area in New Zealand. It was only by 1971 that this situation had been mitigated by stopping the last of the industrial discharges into the Heathcote River (Stephenson, 1980).

The CRC et al. (1992) described the Heathcote River as a "flood prone rogue" compared with the Avon and Styx Rivers in the context of Christchurch. Extensive flooding in the 1970s led to engineering works, the "Woolston Cut", to mitigate the problem but this resulted in undesirable environmental consequences. Salt water extended further up the river and this killed off vegetation and caused erosion (Gelfund, 1991).

The main water quality issue in the Heathcote River is considered to be sediment from Port Hill catchments. An important source of this sediment is from the erosion of material from hillslope subdivisions.

Heavy Metals

In general there remains a lack of information on the effects that heavy metals are having in the river. A study conducted by Elliot (1996) reported that both the Avon and Heathcote river's sediment contain certain "hot spots" of heavy metal which are linked to industrial sites. Zinc is the primary contaminant in the industrial catchments although lead and zinc also exceed relevant sediment quality guidelines. The lower reaches of both rivers are of most concern. However, surveys of invertebrates and fisheries suggest the

main limiting factor is not pollution but the physical habitat i.e., base flow and sediment texture.

Both Elliot and a CRC (1994) study found that in general, lead levels are low in relation to water quality criteria and copper levels are marginal. None of the contaminants measured in the CRC study in residential areas contained high concentrations.

The study by Elliot (1996) produced the surprise finding that it was the rivers and not the estuary that are more likely to exceed relevant sediment quality criteria. The relatively unpolluted nature of the Avon-Heathcote estuary is likely to be the result of a better flushed system than Auckland estuaries.

Avon River

From a wildlife point of view the Avon is different from many urban streams, such as the Heathcote River, in that it supports a growing brown trout population. Although the Avon does not normally suffer from flooding, the amount of development along the side of the river means that there is more potential for flood damage than the other urban rivers in Christchurch. The main threat is from tidal flooding in the lower reaches.

One problem that is becoming more apparent is that springs are becoming more intermittent in their flow. This has resulted in the observation that many headwater tributaries are dry or carry negligible flow during the summer and autumn months. Periodic studies have indicated an overall deterioration in the health and diversity of the aquatic environment associated with the reduction in base flow levels (CRC et al., 1992).

The main water quality issue for the Avon is its microbiological status which is poor by WSCA (1967) standards even very close to headwaters. In the central city the faecal coliform level is five times higher than the recommended level for contact recreation (CRC et al., 1992). The main source of this pollution is from the duck population in the river and also bird and dog droppings in the catchment.

CASE STUDY THREE: PALMERSTON NORTH CITY

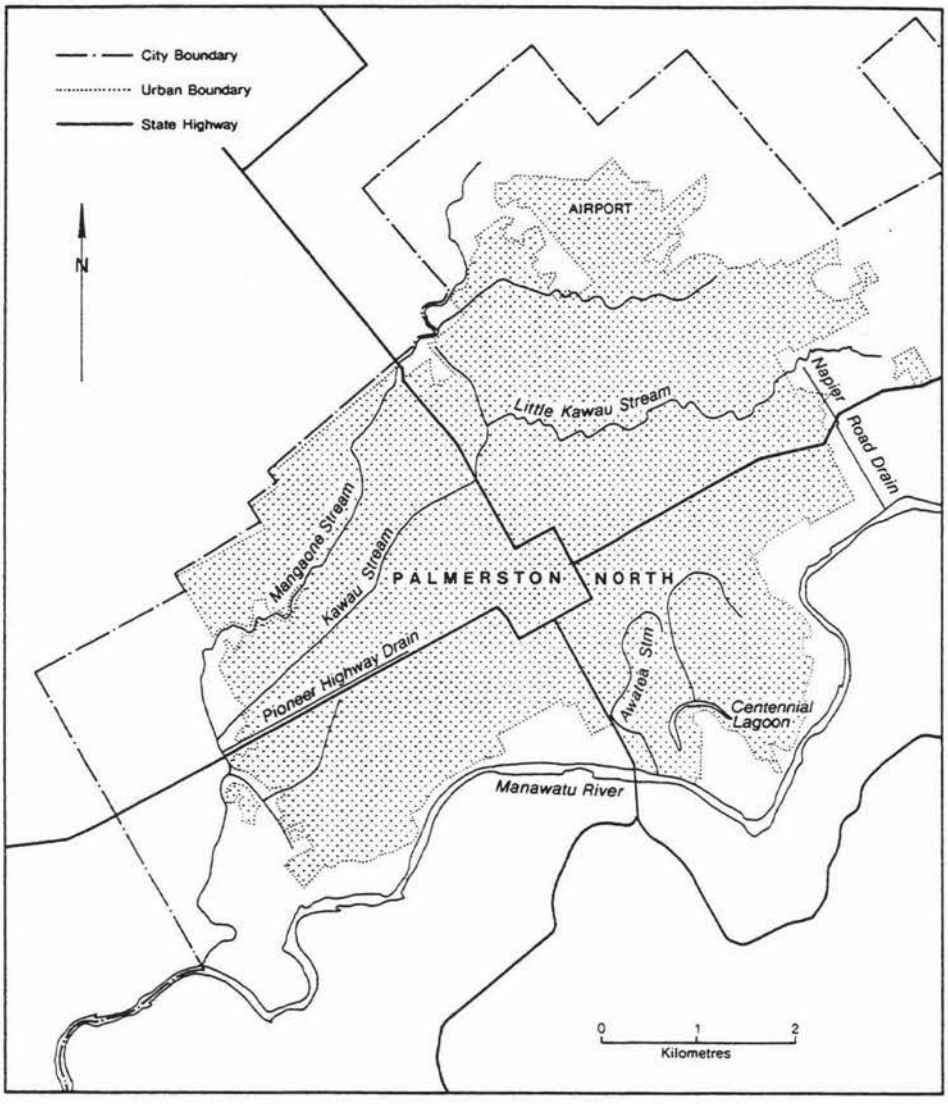
Palmerston North City was chosen as an example of a smaller New Zealand city which recognises stormwater as an important concern. Choosing Palmerston North gave a perspective on how councils with a smaller ratings base and district population size were managing urban runoff and waterways. Palmerston North has an average rainfall of 960mm per year (Statistics N.Z., 1996).

Flooding

The main concern with urban runoff and waterways in Palmerston North is flooding. The threat of significant inundation is greater by comparison to that of Auckland. The urban area of Palmerston North is shown in Map 4.3. As it is located on the river terraces of the Manawatu River and the low lying land adjacent to the Mangaone Stream it has suffered significant flooding in its history. Since the time of its founding in 1866 the natural drainage pattern, i.e., waterways, of the area have been extensively modified. Ericksen (1986) used the Mangaone Stream's history of progressive straightening, stopbanking and lining as a classic example to illustrate the traditional engineering approach to flood protection that often accompanied urbanisation in New Zealand.

The Palmerston North City Council recently produced a Comprehensive Stormwater Management Plan as a guideline to the council on how to go about mitigating the flood problems in the Palmerston North urban area. This revealed that the greatest threat to Palmerston North is from flood waters breaching the stopbanks along the Manawatu River. This is a Manawatu Wanganui Regional Council responsibility and not a concern of this thesis. Overflows from the urban Kawau and semi-urban Mangaone Streams are also considered a problem. Another threat was from the failure of the stormwater system to discharge out its natural outfall because of the relatively higher levels of receiving waters. This would subsequently lead to overflows from pipes and drains in the stormwater system that would result in large scale ponding and flooding especially in the naturally low areas around the city.

Map 4.3 Palmerston North City



Due to the limited capacity of the existing stormwater network the design philosophy is to keep water in the catchment until receiving waters have subsided sufficiently to allow it to escape. This results inevitably in local ponding. The situation is not helped by the fact that much of the soil especially in the low lying areas of the city is poorly drained. The possibilities for reducing stormwater runoff by infiltration is the worst of any of the three case study areas.

Receiving water quality

Urban runoff in Palmerston North is discharged into the Manawatu River and eventually ends up in the Manawatu estuary. The scale of the stormwater quality problem is much smaller relative to that of Auckland City. The Rangitikei/Hawkes Bay Conservation Board (1995) describe this as being due to both the relative differences in sizes between the cities and the Manawatu estuary experiencing stronger tidal flushing and a significant through-flow from the Manawatu River. The magnitude of the through-flow and tidal-flushing prevents an accumulation of contaminated sediments in the estuary substrate.

Stormwater is considered to be a minor contributor to pollution in the Manawatu River when compared with other sources. The main contributers are a number of point source discharges along the river and rural land-use activities producing non-point source pollution in the catchment. The Manawatu River has had a history of pollution problems including major fish kills in 1978 and 1984 although the situation has been significantly improved. The Manawatu River has in the MWRCs "Water Quality Plan" been designated as contact recreation (CR). Achieving this goal will require further improvements in the quality of the river including treating of the sewerage from Palmerston North city to a higher standard.

There are two scenarios where stormwater discharges into the Manawatu River could potentially pose a significant environmental threat. The first comes when the river is in low flow conditions during summer and heavy rainfall after a prolonged dry period results in a first flush of heavily contaminated material from the urban area entering the river system. The second is when hazardous substances or other material such as oils are accidentally spilled into the river.

Urban Waterways

Palmerston North's urban streams form tributaries of the Manawatu River. Information has been lacking until recently on the environmental quality of these streams which are characterised by being relatively small and highly modified.

The State of the Environment Report (SER) (1995) for the district of Palmerston North concludes that the urban waterways are characterised by a significant level of degradation and poor life supporting capabilities. The majority of pollution comes from the cumulative effects of numerous industrial and commercial sites in the city.

The degradation in the Kawau Stream is considered greater than that in the Mangaone. There are high levels of nutrient enrichment which result in periodic oxygen depletion, nuisance algal growths, odours and the production of potentially toxic ammonium concentrations. Heavy metal concentrations, particularly zinc, may be causing long-term chronic impacts. Monitoring in the upper third of the Kawau Stream in 1992-93 found that there were no fish, no aquatic insects and little plant life.

The Mangaone Stream, with the exception of a particular tributary is not subject to the same levels of heavy metal pollutants as the Kawau. It none-the-less does not contain any particular fish species. While the water quality is still enriched, the SER suggests that it is the flood protection measures and the absence of trees for shade that is having the greatest impact on the range of biodiversity in the river.

PLAN ANALYSIS

Plan analysis was applied as a technique for evaluating the quality of each council's policies and plans and their relationship to urban runoff and waterways. The analysis used a form of plan coding which involved the numerical scoring of council plans similar to that used by Berke (1994) to examine natural hazard policies within coercive and co-operative mandates. Plan coding was chosen for a number of reasons. It allowed for a systematic method of assessing the quality of the plans in relation to urban waterways and runoff. The range of measures being used to mitigate stormwater runoff were also identified. It also provided comparisons between plans in different areas to be made.

The coding scale was based on the degree to which urban runoff and waterways were referred to in the plans and policies in the case study areas as shown in Table 4.1.

Table 4.1: Coding Scale used for plans

0 = absent from plan or unlikely to relate to urban runoff or waterways 1 = vague - may apply to urban runoff and waterways 2 = specific reference to urban runoff and/or urban waterways

The plan coding examined several components of the plans and policy statements. The first, examined certain themes that are common to all plans and policy statements. Under the RMA, policy statements and plans must identify significant resource management issues, objectives sought to be achieved, policies and anticipated environmental results. The results of this are shown in the findings chapter in Figure 5.1. Ministry of the Environment (1994) guidelines on writing plan elements state that if a issue is identified, then objectives, policies and methods should follow logically out of each other to provide internal consistency.

Analysis of these themes was taken on a number of assumptions. First, "issues" (in Figure 5.1) should relate to environmental matters which need to be considered to achieve the purpose of the RMA. "Objectives" should state what the council wishes to see from the resolution from the issue (e.g., to ensure that urban development does not adversely affect water quality in the river). "Policies" should relate directly to the relevant objective and say how the adverse effect is going to be dealt with. "Environmental results" should articulate an understanding of the likely consequences of implementing a plan's objectives, policies and methods. They need to be useful and meaningful for the purposes of monitoring. Although not required under the RMA, "indicators", for the success of policies were also examined in this plan analysis (i.e., monitoring). The importance of specifying indicators lies in completing the feedback loop vital for adaptive management so that council policy can be evaluated for its effectiveness.

The plan and policy "themes" were examined according to how they related to urban runoff and waterways. Six criteria were selected to refer to different aspects of the environmental quality of urban runoff and waterways:

- **Water Quality** - refers to the water quality of both urban runoff and waterways.
- **Waterway flow** - any aspect relating to the quantity of water in waterways. This may refer for instance to the effects of urbanisation such as the increase in the peak runoff flow.
- **In/outstream ecology** - refers to both aquatic ecosystems in the urban streams and terrestrial vegetation adjacent to the waterways.
- **Waterway amenity** - this refers to aspects of public access, recreation and also aesthetics.
- **Flooding** - this refers to natural hazard mitigation by councils which has resulted specifically from urban runoff.
- **Hazardous substances** - this relates to the control of the use, storage and management of hazardous substances to prevent them entering either the stormwater system or urban waterways.

From the use of these criteria, all statements and references to the different themes (i.e., issues, objectives, policies, anticipated environmental results) were translated into numbers. As an example, for an issue relating to water quality to score a two from the coding scale it had to either relate directly to the aspects of urban runoff and waterways listed below, i.e., water quality etc., or as if it was the cause of a problem. An example of the latter would be that river water quality was being contaminated from urban runoff or stormwater.

The prominence to which references of urban runoff and waterways appear in the plans and policies is a measure of the degree to which they have been recognised as needing protection. A commitment to implementation, through appropriate methods, is a better indicator of how environmental considerations have been incorporated into urban runoff and waterways.

This was examined in the second part of the plan coding, shown in Figure 5.2, which identified the specific methods and techniques in the district plans used by territorial authorities. The criteria used in Figure 5.2 was developed from material used in the literature review. The definition of the techniques are either referred to in the literature review, glossary or are self-explanatory. Much use was made of the Auckland Regional Authority's (1983c) management guidelines. This appears to be the only New Zealand produced publication of its kind to advise general strategies for the control of urban stormwater and ensure improvements in urban stream quality. Although produced for the Upper Waitemata Harbour

Catchment (North Harbour, Auckland) the guidelines are general enough to be applicable to other areas. Not all the policies or methods in Figure 5.2 are equally applicable to each area. This was taken into account in the plan coding. If techniques were mentioned and rejected as being inappropriate they were still regarded as a reference. This is because alternatives are equally valid for discussion under s32 of the RMA.

As this was an independent piece of research, rather than engaging another coder for inter-coding reliability, I chose to code each plan twice to ensure consistency in coding. This was necessary as plans and policies could be subject to considerable interpretation in their application. When scores differed between the first and second coding the details were checked and reviewed.

INTERVIEWS

In-depth interviews were carried out with staff from the Auckland Regional Council, Auckland City Council, Christchurch Regional Council, Christchurch City Council, Manawatu-Wanganui Regional Council and Palmerston North Council. In total 17 people were interviewed from these agencies as shown in Appendix 4.1. Staff from regional and district councils were the most obvious people to interview as both regional and district tiers of government have specific functions to play in stormwater management. As they have different functions, the interview schedules were designed differently. Appendices 4.2, 4.3 and 4.4. provide an example of a tailored set of questions for each group of people interviewed. A lecturer from Lincoln University was also interviewed. The interviews aimed to clarify the full range of environmental considerations that had been incorporated into urban runoff and waterway management and the changes that local government reform and the RMA had brought. It provided the main source of information on the changes that had occurred since the RMA and local government reform.

SELECTION OF REGIONAL COUNCIL INTERVIEWEES

At a regional council level there was no one department that focused on stormwater management, except in the Auckland case study area. For the most part interviewees came from either the policy formulating section of the council or resource consents department. However, a number of interviewees who participated originated from other sections of the regional council. The approach taken to select interviewees were those who would be in the best position to speak on behalf of the council concerning the scheduled questions.

The process of arranging interviews first involved telephoning the council to ask for the most relevant person to interview. Often a conversation was undertaken with this person. An interview contact time was arranged. A confirmation letter was sent to each interviewee briefly stating my research aims, the purpose of my visit and time of the interview. Taping during the interview was requested and all respondents agreed to this. A copy of the interview schedule (example in Appendix 4.2) was also sent with the confirmation letter. The forwarding of the interview schedule allowed time for considered rather than spontaneous answers to the different questions. It also allowed interviewees to read through the questions and decide whether they or someone else was in a better position to answer the questions. In large councils, there was often no one person in a position to represent the views of the whole organisation. To compensate for this several people in each council were interviewed. However, in Palmerston North, and to some extent, Christchurch, there were certain key individuals who covered many of the key functions in relation to stormwater management. It was assumed that each interviewee would do their best to answer the questions as accurately as possible. In a case where there were significant differences of opinion this was revealed by other interviewees in the same case study area. Any view expressed by an individual could be compared to other interviewees' opinions and with the supplementary literature.

SELECTION OF DISTRICT COUNCIL INTERVIEWEES

There were two main groups in the district councils who needed to be interviewed separately. The first were the managers or engineers of the stormwater system. They had knowledge about the structural nature of the system especially what protective works were being carried out and what water quality treatment systems were being used. The second group were those staff involved in the preparation of council policy and regulation through the planning

process. This group could explain council objectives and policy as they related to urban runoff and waterways and the nature of source control regulations that the council implemented through the district plan. An interview schedule was prepared for each group (Appendices 4.3 and 4.4).

Deciding who should be intervieweed within the engineering and planning departments was determined in a similar process to that described for regional councils. Through the course of conducting the interviews I soon realised that, although I had correctly targeted the two most important groups in the district council related to my research, there were other relevant sections. For instance, those managing the subdivision and land consent process, trade wastes, parks and recreation, monitoring were all involved in aspects of urban runoff and waterway management. Given the constraints of this research, I was unable to interview representatives for staff in these areas. However, some staff in these other units were contacted either during the time I was conducting interviews or sometime after to provide clarification to certain questions. They were asked some of the same questions in the interview schedules but were not interviewed using the same format adopted for the other interviewees. Thus, their opinions supplemented those of the key participants.

One interview was conducted with a university lecturer with expertise in the field of stormwater management. The aim was partly to clarify the report written by him concerning the strategic options for urban stormwater quality controls in Christchurch. Also discussed was his thoughts concerning stormwater management in Christchurch and Auckland as those have been areas of familiarity to him.

INTERVIEW STRUCTURE

The interviews were of a semi-structured nature (Sarantakos, 1993). This was necessary to take into account the nature, role and responsibility of each of the main groups. This involved asking certain pre-determined questions. Where it was thought necessary, as shown below each question in the interview schedules in Appendices 4.2, 4.3 and 4.4, there was a certain degree of prompting given by way of a comment in italics. These comments were progressively refined as I learned how to clarify to the interviewee what was being asked of each question. I was particularly concerned that the terminology I had taken from the

literature might be misunderstood by those working in practice. This was generally not a significant problem as I pilot tested the interview schedule on a person whom I considered to be knowledgeable about the topic.

Many of the questions were what Gottlieb (1986) describes as being "open", allowing the possibility for digressions away from what the researcher was expecting. It was considered important that interviewees volunteered information as this sometimes proved to be as useful as the information gained through the question and answer process.

The number of questions that were asked in each interview was a function of what was needed to be asked, and the amount of interview time that I had available to use. The preliminary scan of the literature relating to stormwater management in each case study area was successful in setting the scene. This enabled me to draw up an interview schedule that focused not on verifying the information already known but where knowledge was still lacking. This approach of "gap filling" with the interview schedule was justified in practice because of time constraints in the interview process. The amount of time available to conduct the interviews was clarified when the interview was arranged. From this, I selected priority questions to ask the interviewee. The interview times ranged from about twenty minutes to two hours. Most interviews lasted on average one hour.

The interviews were all carried out face-to-face and conducted in the work place of the interviewee. Normally the interviews were carried out on an individual basis. On one occasion this was ignored, when requested, so that the opinion of several interviewees might be stated at the same time. As the interviewees were of the same group i.e., either stormwater managers or planners from the district council this did not compromise any of the opinions voiced.

At the beginning of each interview a number of points were clarified. It was explained that there were a number of key questions to be covered as outlined in the interview schedule. It was explained that once an interview was over I would summarise the interview information and send it back so that any deletions, additions, or other modifications could be made before I used that information in my thesis. When there were opposing views within a group this

feedback was not necessarily modified. While the interviews were tape recorded I took notes during the interview process as a backup in case the tapes did not record what was being said. There were relatively few problems associated with the taping process.

ANALYSIS OF THE INFORMATION

The analysis of the interview information was undertaken on completion of the interviews with the purpose of turning the accumulated information into meaning (Gottlieb, 1986). This involved three processes.

DATA REDUCTION AND DATA ORGANISATION

These two processes involve what Sarantakos (1993, 300-1) describes as the *"manipulating, integrating, transforming and highlighting the data"* (data reduction) and *"assembling information around certain themes and points, categorising information in more specific terms, and presenting the results in some form "* (data organisation).

The first step involved excluding any irrelevant information that was not directly related to my research. This occurred when interview participants, in the course of conversation, pro-offered information that had no relevance to my research questions. Such a process was carried out when I expanded upon my notes taken in the interviews by incorporating information from the tape recordings. A full transcription of the interviews was not carried out. While transcribing of the recorded interviews provides for the most accurate information it is noted by Sarantakos (1993) that listening to tapes after an interview can be very time consuming. I considered that the benefits of a full transcription of the recorded material were not justified. Rather, the process I used allowed important comments made by interviewees to be noted at length while irrelevant information could be ignored at the same time.

The second step was identification of the key questions that were asked during the interviews for each of the three groups; regional council staff, planning staff (district council) and stormwater engineers (district council). This was vital as not all agency participants were asked an identical set of questions.

As each interviewee was asked slightly different questions, the findings had to be reconciled and rearranged to provide a balanced view of the council perspective. This required considering what each interviewee said if there was more than one interviewee in each group. If significant differences existed, then this was incorporated in with the research findings. The information from all the interviewees for each key question was further summarised into a single paragraph and presented as part of the findings. This process was designed to reveal the most prevalent and important themes from the findings.

The key questions and summary answers were sent back out to the interviewees for feedback. A letter accompanied them explaining that they should review them, make any necessary modifications, and then send them back within a specified time frame of several weeks. The results of this process of data reduction and organisation are shown in Chapter Five.

INTERPRETATIONS

Sarantakos (1993, 301) identifies interpretation as the third main phase in the analysis of qualitative research, involving *"making decisions and drawing conclusions related to the research question"*. Interpreting the research findings and providing explanations for them was the aim of the sixth chapter.

This part of the research involved the identification of patterns, similarities and trends within the data obtained from both the interview findings and the plan analysis. This was then synthesised with what was discovered in chapters two and three. Such interpretations were arranged into the six different themes identified in the literature review, as shown in Table 2.3, so that the different managerial approaches taken in the case study areas could be compared and contrasted. Information that had been gathered during the literature review and which appeared insignificant at the time often took on a new meaning during this phase.

A number of factors can have an influence on the success or otherwise of the interview experience. One of the most basic principles is that an interview requires the active participation of all parties involved (Gottlieb, 1986). Burgess (1984) discusses age, gender, personal characteristics and the experiences of the researcher as important for gaining rapport with the people being interviewed. To prevent any potential problems I tried to make myself

aware, before I conducted the interview, of the likely characteristics of the organisation and people involved.

In general, I found the interviews to be very interesting. I met a range of people from different academic backgrounds. Many had an excellent knowledge of their operating environment. I also discovered that no interview is an entirely one way communication process (Gottlieb, 1986). Interviewees were interested not only in what others were doing around New Zealand but on my views on certain matters. All of those spoken to were very keen on participating in the research. Many positive comments were received, both at the time of the interviews, and once the modified interview summaries were returned to me.

CHAPTER FIVE

FINDINGS

This chapter presents the findings of the fieldwork interviews and plan coding. The interviews provide information on what councils are doing and explanations for the influences and motivations behind their actions. The plan coding supplements the results of the interviews. They identify how urban runoff and waterways have been considered in regional policy statements and district plans prepared under the RMA.

INTERVIEW RESULTS

The interview results are presented in Tables 5.1- 5.17. They include a range of the different aspects associated with urban runoff and waterway management based on the interview schedules in Appendices 4.2- 4.4. The response of each of the interviewees has been assessed against others and the results have been summarised under the agency that they work for. To further aid interpretation, a succinct analysis of the overall response of the interviewees has been provided under each heading.

Interviewees revealed that there are few resource management conflicts associated with urban waterways as users are relatively few. The main concern of councils is to avoid, remedy and mitigate the adverse effect that human activities are having on urban waterways. Issues in the case study areas vary considerably. In the past, the prime objective of management was flood mitigation. Despite the differences in the operating environments between case study areas, the issue of flooding remains the most universal concern. This is predominantly a reflection of the high potential for litigation if councils fail to protect private properties. Councils have also become more concerned with the control of diffuse runoff contaminants but the profile of this issue varies significantly between areas.

MAJOR URBAN RUNOFF AND WATERWAY ISSUES

Table 5.1 reveals that flooding is the only universal problem of significance for all three case study areas. Key concerns include developmental encroachment on floodplains and residential infilling. Stormwater quality is an issue in the case study areas although its relative importance varies widely depending on factors such as whether the council is a regional council or district council, the scale of the problem and the nature of the receiving environment. Recently publicised has been concern over the role of toxic substances in stormwater quality such as heavy metals and petroleum hydrocarbons.

Table 5.1 Major urban runoff and waterway issues

Auckland Auckland Regional Council Primary concern with respect to stormwater management in the ARC is the stormwater quality issue. The main cause for concern has not been with bio-degradable pollutants (nitrogen and phosphorous) but the persistent chemicals and substances such as PAHs, copper, lead, zinc and polyaromatic hydrocarbons that accumulate in the sediment of the harbours. The importance of flooding in the region has decreased in relative importance as the problem has been progressively brought under control and the issue of receiving water quality in the Auckland estuaries has become important.	Auckland City Council: Planning The most important issue is combined system overflows which has lead to flooding, public health and amenity issues. Urban intensification has stretched the drainage system capacity. The potential for groundwater pollution in the volcanic aquifers is also an issue. This comes from stormwater soakage and leaching from landfills and factories. Auckland City Council : City Design The biggest issue is flooding. This is followed by combined system overflows and associated threats to public health. Stormwater quality in the estuaries, i.e., from such sources as heavy metals, receives a relatively low priority at the present time. The RMA is making the council consider solutions to the quality of stormwater.
Christchurch Canterbury Regional Council Flooding is the greatest concern of the CRC particularly in the upper Heathcote River. The rural catchment is being subdivided and built upon resulting in increased stormwater runoff and sediment entering the riverine system, causing	Christchurch City Council The main issue is encroachment by development on river floodplains. Other issues include deciding upon the strategy for managing open drains into the future. Concern with this issue centers around deciding whether to replace timber linings or pipe

flooding downstream. Sediment, and in industrial areas heavy metals and organic solvents, are a water quality issue. The organic solvents present more of a problem to ground water than surface water. In the Avon River the quality of water from roads is of greatest concern. Industrial and trade premises are an important source of contamination. Also sewer overflows can occur in certain areas approximately twice a year.	with native vegetation. Another issue is determining the ultimate maintenance regime for the areas that have been through the waterway enhancement programme. With regards to water quality, litter and floating debris are the main pollutants of concern to the general public.
Palmerston North Manawatu-Wanganui Regional Council The issues vary depending on the time and place. For Jensen Street the issue is flooding, for the Kawau and Mangaone Streams during summer it is water quality. Overall, stormwater discharges are unlikely to pose a significant threat to the water quality in the Manawatu River except if hazardous substances enter the river.	Palmerston North City Council The first priority issue in Palmerston North is flooding. Flooding is being aggravated by the intensification of the city through infill housing. Water quality, particularly from spills and other sources of industrial contamination, is the next problem. Infrastructural planning and upgrading is another relevant issue. At the present time these issues are principally engineering concerns.

ENVIRONMENTAL GOALS FOR URBAN RUNOFF AND WATERWAYS

Environmental goals are taken from a range of council documents such as strategic plans, regional policy statements and district plans. Most councils have in place standards for receiving water quality. Table 5.2 reveals that urban waterways are, in general, treated differently in plans in relation to other rivers. In both Canterbury and the Manawatu-Wanganui regions, more "natural" rivers are going to be designated as Contact Recreation (CR). Urban waterways will be managed at the minimum water quality levels specified in the RMA.

Table 5.2: Environmental goals

Auckland Auckland Regional Council The Regional Policy Statement has set out the overarching goals for urban runoff and waterways. Basically these involve maintaining and enhancing the receiving water environment for a number of uses such as shell fish gathering and bathing. The Regional Policy Statement also contains policies for flood hazard avoidance and mitigation. The Regional Council has adopted a best management approach rather than specific water standards.	Auckland City Council: Planning The main goal concerning the stormwater system relates to the Strategic Plan's complete separation of sewers from the stormwater system. The District Plan's implicit goal is to maintain present water quality in the Waitemata and Manukau Harbours. Auckland City Council: City Design Overall, the goal for City Design is that of the Auckland City's strategic plan of being "clean and green". As catchment management plans are prepared, certain standards are aimed for. These are decided on a case by case basis. Goals relate back to the ARC's desire for a 75% removal rate of sediments. However, because the catchments have already been extensively developed it is unlikely that such a goal is achievable on a catchment basis.
Christchurch Canterbury Regional Council (CRC) The Regional Policy Statement outlines the broad goals of the CRC in relation to water. Standards for receiving waters are being prepared in a "Natural Resources Regional Plan" which will include a chapter on water quality and quantity.	Christchurch City Council Goals for stormwater have been set in the new City Plan. These include the maintenance and enhancement of the quality and availability of the water in waterways, aquatic and terrestrial vegetation and public access to these areas. There

The Avon and Heathcote Rivers are unlikely to be upgraded to the contact recreation standard as will other rivers. This is because even in the absence of stormwater discharges these rivers would not meet the standard because of the large faecal contribution from ducks on the rivers.	are also goals relating to the control and mitigation of flooding.
Palmerston North Manawatu-Wanganui Regional Council The MWRC is concerned only in maintaining the statutory minimum requirements contained in the RMA. As part of this it aims to make sure that industries provide cleaner production practices.	Palmerston North City Council The Council's Strategic Plan has several environmental goals. First, it seeks to provide a stated level of flood protection and secondly to maintain the quality of discharge to the receiving waters.

ENVIRONMENTAL PROJECTS AND OTHER NON-STATUTORY INITIATIVES

Table 5.3 reveals that the fish painting campaign and pollution hotline are common to all areas. Other than that, territorial authorities are predominantly concerned with their own projects such as Auckland City's separation of its combined sewer-stormwater system. With the exception of Auckland Regional Council, regional councils have in general been concerned only with ensuring their concerns are incorporated into resource consents and district plans.

Table 5.3: Environmental projects for urban runoff and waterway management

Auckland Auckland Regional Council The council has set up the Stormwater Liaison Group. This group will produce a regional stormwater strategy which sets up priorities on where to start addressing stormwater quality issues on a regional basis. The strategy seeks to give guidance to territorial authorities on where to focus resources. All the background investigations on why stormwater is a problem and the environmental impact it is having have already been undertaken by the ARC. The ARC also widely uses pollution patrols to spot water pollution problems. A pollution hotline has also been sent up.	Auckland City Council: Planning The Auckland City Council have been instrumental in forming the Regional Stormwater liaison group. The main programme is the sewer separation which will take up huge financial resources. Other than that, various ad-hoc programmes cover specific issues. For instance an action programme has been directed at managing contaminants that have been leaching from landfills. Auckland City Council: City Design City Design is heavily involved in the preparation of catchment management plans for specific catchments. These are used in support of the application to gain a comprehensive consent from the ARC.
Christchurch Canterbury Regional Council The Avon-Heathcote Flood management strategy is being prepared jointly with the Christchurch City Council. In addition a Water Pollution hotline has been set up.	Christchurch City Council Other than work on the Avon-Heathcote flood management strategy, council initiatives include; a Waterway Enhancement Programme to restore natural ecosystems in certain priority waterways, so that they can be incorporated into "green corridors" under a Natural Environmental Strategy. Environmental educational campaigns

	have bean encouraged through the council especially at school level. "Environmental Management Plans" and environmentally friendly practices are encouraged in trade services which consider the need to protect urban runoff and waterways.
Palmerston North Manawatu-Wanganui Regional Council No projects or programmes are being implemented other than a joint school based education programme with the Palmerston North City Council concerning the discharge of non-stormwater materials down the drains.	 Palmerston North City Council There has been an education programme in local schools that has been carried out jointly with the MWRC. An "Environmental Enhancement Programme" is scheduled in the near future to look at surveying existing business practices and identifying poor or inadequate management with the storage or use of hazardous substances. From these findings educational programmes will be developed.

USE OF SOURCE CONTROLS

Most effort has been directed at preventing chemicals, hazardous materials and sediments from entering the stormwater system. This is indicated by the responses in Table 5.4. The District Plan provides a range of rules many of which are common across districts such as preventing material from earthworks from entering the stormwater system and waterways. These are covered in the plan coding results. Other than the district plan regulations it has been education and BMPs (enforced through the resource consent process) that have been the main methods used. Various controls on industries and trade premises are also carried out in conjunction with the Building Code.

Table 5.4 Use of source controls

Auckland	
Auckland Regional Council First, the Council considers the control of pollution at source through education and site inspections to be the most effective way to protect urban waterways. Their methods include environmental audits and systematic inspections on all industries in particular catchment areas. They have an important advisory role on site design, drainage and chemical substances management practices for industry. A drain labeling program and proposed regional plan for the control of sediment is in place although the ARC is more involved with educational awareness programs than source control initiatives.	Auckland City Council: Planning At present the District Plan (Isthmus) contains many regulations concerning source controls. Other methods include by-laws against depositing litter and pollution in the stormwater and waterway system and for the storage, use or disposal of hazardous material. However bylaws are not widely used as the RMA contains harsher penalties. There are currently no education programs in place (the ACC rely on the ARC). The Council also undertakes street sweeping and is strengthening its controls on silt deposition in waterways. Auckland City Council: City Design Under the Regional Strategy stormwater issues will be considered in the next 10 years. By the year 2000 the ACC will be in a better position to know how to actively address stormwater quality. There is the intention that a range of new source controls will be implemented in the near future through the district plan and other means.

Christchurch Canterbury Regional Council A flood strategy for the city is currently being prepared. It will be implemented through rules in the CCC City Plan. Water quality will be considered as part of this strategy but only with regards to hazardous substances which are stored in flood prone areas and sewer overflows. It is probable that the removal of lead from petrol at the national level has reduced the level of contamination in stormwater and that replacing copper in brake linings would do the same for copper. This requires advocation from the CRC. Also the Council has encouraged such structural devices as oil interceptors on new car parks.	Christchurch City Council Various City Plan provisions are in place. The main focus to create a buffer around urban streams. In addition to setback rules there is a pro-active land purchase programme to provide a buffer around waterways. By-laws prohibit the discharge of pollutants, silts or other harmful material into stormwater drains. By-laws also prohibit the discharge of pollutants or any solid material to waterways and certain activities within or near them. On-site detention is being encouraged in new developments. Ground soakage is being promoted on developments. This is through the resource consents process. A street sweeping program has been initiated to collect rubbish on stormwater grates on the edge of the road.
Palmerston North Manawatu-Wanganui Regional Council None, as up until this stage the council has worked through the PNCC i.e., it has been involved in some consultation during the District Plan preparation and also in the preparation of the Regional Plan as it relates to stormwater. The council has suggested to the PNCC more frequent street cleaning, emptying of sumps, educating people about emptying pollutants down stormwater drains and educating people about removing dog faeces.	Palmerston North City Council The District Plan provides criteria for the type of stormwater system that needs to be installed in subdivisions. Other rules are aimed at preventing spills and releases of hazardous substances from entering waterways. Ponding areas have been provided in certain areas of the city. Minimum habitable floor levels have been established. Earthworks are controlled. Also there is a rule limiting the roof area in residential zones although this was originally aimed at protecting amenity values. In addition to the district plan, it has carried out the MWRC recommendations suggested during the preparation of the regional plan.

STRUCTURAL "BEST MANAGEMENT PRACTICES" AND RETROFITTING

Many councils are identified in Table 5.5 of being engaged in either trialing or encouraging the use of innovative BMPs such as artificial ponds. There has been no serious attempts at retrofitting to date. Attention has also been directed at the application of silt and oil traps. These are routinely required at new trade premises and car parks.

Table 5.5: Use of structural best management practices and retrofitting

Auckland	
Auckland Regional Council	Auckland City Council: City Design
The ARC have constructed a number of treatment devices in the ACC area for demonstration and research. They have been used as research tools to monitor their effectiveness as BMPs and also as educational tools. BMPs are subject to compliance with the Treatment Devices Design Guideline produced by the ARC which sets a 75% long-term sediment removal for BMPs. This figure has been based on laboratory and overseas studies and represents a cost-efficiency optimum.	City Design have considered a wide range of BMPs in the preparation of their Catchment Management Plans. In particular, wet ponds are used for the retention of water i.e., indicated in the Meola and Ellerslie-Waiatarua catchment management plans. In the future where the opportunity exists ponding will be used. In general, BMPs will be used whenever possible.
Christchurch	
Canterbury Regional Council	Christchurch City Council
Developers are being encouraged to use passive systems. Structural solutions e.g., oil separators are also encouraged. Sediment traps are specified for point source discharges of stormwater i.e., car parks. There has been no serious retro-fitting as there is not enough information to convince rate payers that it is necessary.	Two examples of stormwater retention ponds have been constructed in the Heathcote Catchment by the council. Some new developments have been required to construct dry detention ponds or other BMPs. Retrofitting has not been required in the urban catchments.
Palmerston North	
Manawatu-Wanganui Regional Council	Palmerston North City Council
There has been no requirement by the MWRC for stormwater treatment facilities or retrofitting in Palmerston North area to date.	At present there is only the use of naturally formed ponds like Centennial Lagoon, or street sumps as structural BMPs.

PUBLIC PARTICIPATION

All councils are involved in consultation with the public specifically with regards to the requirements of the RMA. The community have been involved in the preparation of catchment management plans which have in certain areas served as mechanisms to gain resource consents for discharges into rivers and the coastal environment. Table 5.6 reveals that several councils have gone further than others in providing the community with a much more "hands on" approach to urban runoff and waterway management.

Table 5.6: Public participation

Auckland Auckland Regional Council Public workshops have been undertaken as part of the stormwater liaison group. Other than that every comprehensive consent (s15) has to include public input. More public input will take place in the future.	Auckland City Council: Planning Other than the RMA's statutory requirements there has been relatively little community involvement except in a few instances. Auckland City Council: City Design The preparation of Catchment Management Plans has involved public consultation such as public meetings.
Christchurch Canterbury Regional Council There has been the odd conference but the consents process for stormwater hasn't included the public in the last few years. There is little need for greater consultation as compared with other areas the number of complaints from the public about stormwater/ waterways has been very small.	Christchurch City Council The CCC has the Carl Bertelsmann Prize (1993) for the way it operates with the general public. In particular the Water Services Unit has some of the highest levels of public participation within the council. The Waterway Enhancement Programme performs even better in this respect by involving the public in a partnership with the council.
Palmerston North Manawatu-Wanganui Regional Council Through submissions to the proposed Manawatu Catchment Water Quality Plan and the educational programs.	Palmerston North City Council The community participated in the District Plan and Comprehensive Stormwater Management Plan.

MAORI PARTICIPATION

Table 5.7 shows that Maori have participated through the resource consent and RMA plan preparation process. Other initiatives involving Maori are continuing to be developed.

Table 5.7: Maori participation

Auckland Auckland Regional Council Under the RMA iwi are automatically interested parties. Several iwis are very active in the Auckland area and a continual dialogue is maintained. Maori are actively involved in the resource consent process and this has resulted in a number of modifications to resource consent conditions. They are also involved with the Stormwater Liaison group in such matters as determining the priorities in the receiving environment.	Auckland City Council: Planning Iwi can have issues discussed through the Manawhenua Consultative Committee. Planning relies on the Iwi liaison officer to consult with the various iwi in the district. In particular Maori have desired that urban waterways should be retained in their natural form. Auckland City Council: City Design All resource consents are taken through iwi liaison as part of the RMA requirements. City Design has been greatly involved with Maori groups and is aware of certain Maori environmental principles in their operations.
Christchurch Canterbury Regional Council All resource consents for point source discharges to the Avon-Heathcote rivers go to local tangata whenua. Maori have been involved in identifying areas of cultural concern in the Upper Heathcote River Catchment.	Christchurch City Council There has been a genuine attempt by the council to develop their partnership with tangata whenua. For the Waterway Enhancement Programme this is at a very early stage but there are hopes for increased numbers of projects as the relationship develops. Council hope to offer Maori a more "hands on" approach than that which occurs at the present time.

Palmerston North Manawatu-Wanganui Regional Council There have been no known Maori concerns with specific regards to the management of urban stormwater and waterways.	Palmerston North City Council: Planning The Council are not aware of any concerns with urban runoff or waterways. Concern from local tangata whenua is with receiving waters such as the Manawatu River. Palmerston North City Council: Engineering Maori have been concerned about the protection of certain flax plants on waterways.

STORMWATER AND WATERWAY MONITORING REQUIREMENTS

No territorial authority in New Zealand has a stormwater quality monitoring programme in place. Monitoring requirements for urban runoff and waterways are still in their early days. Table 5.8 reveals that many councils have taken the initiative in monitoring their own area in recent years. From this periodic monitoring, information on the environmental quality of urban runoff/ waterways has been gained often for the first time. Particular concern has been recently directed towards the level of heavy metals and PAHs in aquatic ecosystems in New Zealand. While urban waterways in all areas have received only limited attention studies suggest that pollution levels can be high with these contaminants.

Table 5.8: Monitoring

Auckland	
Auckland Regional Council Monitoring to this stage has concentrated on identifying problem areas in the receiving environment i.e., estuary. No water quality monitoring is routinely required as a condition of stormwater discharge consents although all structural BMPs are monitored to ensure that their installation and operation has been correctly carried out. In addition the effectiveness of several demonstration treatment facilities are being monitored. Under previous legislation the "Baseline Water Quality Monitoring Programme" was set up and long term studies into shellfish, fresh water and sediment contamination levels have been undertaken. A new stage of monitoring will begin shortly to identify improvements and effectiveness of the councils actions.	Auckland City Council: Planning The ARC monitoring has been at too general a level to be particularly helpful for the ACC with regards to determining the quality of stormwater discharges etc. In particular the data did not have regard to the variability of levels of pollution after a rainfall event. The testing was taken far out in the estuary. Therefore the ACC have taken the initiative and additional sampling has been carried out. Auckland City Council: City Design The council are obliged to monitor rainfall and other items under the Local Government Act. They will be establishing contracts to meet this obligation. City Design has in the last year or so carried out water quality tests on their own initiative as part of the preparation of its catchment management plans.

Christchurch Canterbury Regional Council There has been no regular monitoring by the CRC. Monitoring of sediment has been carried out in the estuary. Certain site specific monitoring has been undertaken near industries on the Heathcote River.	Christchurch City Council There are four types of monitoring undertaken by the council: monitoring of the district plan, State of the Environment monitoring- (baseline water quality studies), project monitoring- (includes an ecological assessment of the Waterway Enhancement Programme and monitoring of the efficiency of council retention ponds), and finally compliance monitoring (i.e., discharge permits). At present the compliance monitoring cost is minimal.
Palmerston North Manawatu-Wanganui Regional Council The MWRC has taken the philosophy that it only monitors the effects of discharges on receiving waters such as the Manawatu River. For pollution complaints the MWRC and PNCC cooperate in necessary action relating to urban streams. It is assumed for the most part that stormwater is "clean". However the MWRC may require the PNCC to carry out monitoring on the receiving water quality when applying for stormwater discharge consents.	Palmerston North City Council The Palmerston North "State of the Environment Report" involved monitoring of the water quality in urban streams.

CHANGE IN PRACTICES IN STORMWATER MANAGEMENT SINCE THE INTRODUCTION OF THE RMA

There has been a very varied response to the introduction of the RMA as Table 5.9 reveals. This has ranged from a radical change in management philosophy to retaining the basic status quo. One council, in particular, has thought through the purpose and principles of the RMA and the consideration of urban waterways to a much greater extent than others. For many the RMA's main contribution has been ending the assumption that stormwater is always "clean". Water quality must now be considered in all discharge permits.

Table 5.9: Change in practices since the RMA

Auckland	
Auckland Regional Council	Auckland City Council: Planning
The RMA has provided improved mechanisms for dealing with the issues i.e., enabling water quality requirements to be put into consents. The RMA has spelled out priorities like enhancing the environment but overseas trends in stormwater pollution control has been more influential than the Act itself. The RMA has automatically made consultation an important part of the process.	Council has a much more rigorous process to go through to get resource consents. With regards to the District Plan the reasons behind policies and rules are more explicit. Auckland City Council: City Design The shift has been in the consideration of water quality rather than merely flooding. Also there is greater time taken for community consultation.
Christchurch	
Canterbury Regional Council	Christchurch City Council
The RMA has given the CRC the new responsibility of managing the urban waterways. The CRC has taken a "hands off" approach with this responsibility. Other things to emerge from the introduction of the RMA has been the need for developers to think through alternatives to a much greater extent. The RMA hasn't driven any significant changes in water quality standards or monitoring requirements.	The RMA has in conjunction with local government reform resulted in a dramatic shift in practices by council away from the Drainage Board's emphasis on drainage efficiency to taking on the concept of sustainable management. This has meant in particular the move away from piping to the restoration of open channels that support natural ecosystems.

Palmerston North	
Manawatu-Wanganui Regional Council Before the RMA the discharge of stormwater was seen as a necessary activity that should be allowed of as of right. The introduction of minimum water quality standards has meant that this can no longer be seen to be so. Effects on water quality must be considered in applications for discharge permits.	Palmerston North City Council: Planning A new consideration is the inclusion of hazardous substance control in the District Plan. Palmerston North: Engineering The RMA has shifted the role of council from finding solutions to identifying problems. This places greater responsibility on developers for mitigating effects.

THE LEVEL OF AGENCY CO-ORDINATION SINCE LOCAL GOVERNMENT REFORM AND THE RMA

Several councils found that local government reform was beneficial to the management of urban runoff and waterways. Interviewee responses, in Table 5.10, were indifferent to the effect of the RMA revealing that it has generally meant little change.

Table 5.10 Agency co-ordination since local government reform and the RMA

Auckland Auckland Regional Council Local government reform has reduced the number of territorial authorities and this has made co-ordination easier. The RMA allows input for councils into statutory documents like the Regional Policy Statement and the District Plan which again increases agency co-ordination.	Auckland City Council: Planning It is probably a case of local government reform having made things easier while the RMA has made a less significant difference. Auckland City Council: City Design The introduction of Assets Management planning is anticipated to improve the cost effective delivery of the service.
Christchurch Canterbury Regional Council There has been no significant change.	Christchurch City Council Local government reform has improved it. In the days of the Christchurch Drainage Board a lot of energy was taken up with "division of responsibility" arguments with the territorial authority. The RMA has also helped to clarify roles.
Palmerston North Manawatu-Wanganui Regional Council No change has been experienced except with regards to the ability of the RMA to allow the production of the Manawatu Catchment Water Quality Regional Plan to manage all discharges to water.	Palmerston North City Council Neither local government reform or the RMA have changed much. There has been a long association between the city council and the local Catchment Board or Regional Council.

THE RMA AND THE RESTORATION OF URBAN WATERWAYS

With one exception indicated in Table 5.11, most councils indicated that while the RMA made the restoration of ecosystems explicit, little of this work has been carried out .

Table 5.11: The RMA and the restoration of urban waterways

Auckland Auckland Regional Council Enhancement has been made explicit in the RMA as opposed to previous legislation and the goals of the regional policy statement have consequently taken this on board. As yet priorities have not been decided upon.	Auckland City Council: Planning The council is responding as resources become available to clean up streams. Public expectations rather than the RMA is the motivating force. Auckland City Council: City Design If possible streams are kept in a natural state. This is part of the Council's goal to be environmentally friendly. Restoration of streams is considered as a part of the preparation of catchment management plans.
Christchurch Canterbury Regional Council This work is part of the Christchurch City Council's responsibility.	Christchurch City Council The Waterway Enhancement Programme is a practical expression of the RMA's requirement to restore degraded ecosystems.
Palmerston North Manawatu-Wanganui Regional Council The RMA encourages the restoration of degraded ecosystems but there has been no examination of this with regards to urban streams.	Palmerston North City Council: Planning There is a need to look at water quality issues but rehabilitation is difficult due to jurisdictional control i.e, the regional council's ownership of Mangaone Stream and private ownership of the land by Awatea Stream. Palmerston North City Council: Engineering There is no going back to the pre-development waterways as the modifications that have carried out on them are needed for continued flood control.

STORMWATER RE-USE

Table 5.12 reveals that only in the Auckland area has the re-use of stormwater been systematically assessed. The use of it was rejected as being unfeasible. Other councils had either not seriously examined it or were dismissive of it. It is possible that some of the councils may encourage some limited form of stormwater re-use in the near future.

Table 5.12: Stormwater re-use

Auckland Auckland Regional Council Stormwater hasn't been seriously examined as a water supply alternative for Auckland city due to the perception that it would be of limited use. Watercare have assessed the option and considered it was a non-starter. However, the ARC are working to produce additional material to their TP10 Stormwater Treatment Devices Design Guidelines which will include methods for reusing water and they are most appropriate especially for irrigation.	Auckland City Council: Planning In general the ACC has taken a conservative line and have left it to other councils to pursue the policy of reusing water at the present time. Auckland City Council: City Design The council are preparing three schemes for potable water supply. Each of these schemes utilise groundwater from volcanic aquifers (which were previously urban runoff). These schemes are at various stages in the RMA process though all have been lodged with the ARC. The schemes are all projected to deliver a sustainable yield of 5000m cubed/ day totaling 15000m cubed/day.
Christchurch Canterbury Regional Council It has not been seriously considered. The only alternatives to the present supply arrangement has been an examination of extracting water from the Waimakariri River. For this option costs have been examined. The Christchurch City Council is the main agency involved in looking for alternative water supply.	Christchurch City Council Not as yet, but the coming publication of the Natural Environmental Strategy examine this concept. Too many people in Christchurch regard the existing groundwater supply as being unlimited i.e., its quantity is unknown and there is no sign of it becoming polluted. Therefore, if its not running out or becoming polluted then current consumption levels must be sustainable. The council is concerned about this situation changing in the future.

Palmerston North	
Manawatu-Wanganui Regional Council There has been no investigation by Council for re-using stormwater in Palmerston North.	Palmerston North City Council It was briefly considered as a means of limiting peak flows in the Stormwater management plan but rejected as being unfeasible.

THE ROLE OF URBAN RUNOFF AND WATERWAYS

There are a wide range of views shown in Table 5.13 on what the role of urban streams should be. Some see urban streams as having an important ecological role. Others view urban streams as being important from the viewpoint of amenity. Some still regard their role as being predominantly functional in the disposal of stormwater. All councils believe that natural streams should be protected from development if possible.

Table 5.13: Role of urban runoff and waterways

Auckland Auckland Regional Council There has been a shift away from the tendency to pipe rather than use natural waterways in undeveloped areas. The ARC is making use of resource consents, education and liaison with territorial authorities to make sure this occurs.	Auckland City Council: Planning Waterways should be places where people can go without any threat to public health. The ACC has a long term programme of setting up esplanade reserves along major streams for the purpose of public access and conservation i.e., for bank erosion. Enhancing human values has been the highest priority. Ecological values are being researched and monitored as resources permit. Auckland City Council: City Design Urban streams are part of the stormwater system. In the altered urban environment these streams should be life sustaining, a public amenity and not abused. City Design looks at retaining or restoring urban streams to their natural condition if possible.
Christchurch Canterbury Regional Council The CRC supports the CCC's Waterway Enhancement programme. They would go along with the importance of promoting aquatic life, biodiversity and amenity but not for a sink for greenhouse gases as they support a source based approach to this issue.	Christchurch City Council There is a strong commitment to provide opportunities along the waterways for the return of indigenous birds, plants and insects to enrich the Christchurch community. Many waterways will form part of "green corridors" in the future.

Palmerston North Manawatu-Wanganui Regional Council The restoration or enhancement of urban streams has not been investigated.	Palmerston North City Council Streams are of a functional nature and are likely to remain that way into the future. While the goal of restoring waterways to their original condition is unattainable, walkways along the streams such as the Mangaone Stream have been created to provide enhanced recreational value.

ENVIRONMENTAL TECHNIQUES

The larger councils in Table 5.14, are considering a much wider range of techniques to incorporate environmental considerations into the stormwater system than that which happened a number of years ago. Artificial ponding is considered an important option. There is a change in the management of these ponds away from that of a purely functional role. There is also a noticeable change to encourage more passive techniques in new developments although their use and application are still being developed.

Table 5.14: Environmental techniques

Auckland Auckland Regional Council Its a case-by-case basis with developers and territorial authorities. Originally, water quality has been the main consideration for detention ponds. Recently, amenity value has been incorporated into them as a useful selling point to convince developers of their worth.	Auckland City Council: City Design A range of techniques have been explored. Source controls, education, end of pipe solutions are all considered in the "tool box"! Retaining natural streams in favour to piping is encouraged. Porous pavements have been considered as an option in one catchment management plan but this has not been used. Swales aren't respected by the engineers and are therefore seldom employed.
Christchurch Canterbury Regional Council Minimising flooding and water pollution must come first. It is recognised that ponds can have additional benefits such as improving amenity value and biodiversity but these are "warm and fuzzy" extras. Passive systems are encouraged where possible in favour of pipes, curbs and channels.	Christchurch City Council Ponding should be at least dual purpose i.e., water quality/ quantity considerations. The first stormwater retention ponds e.g., Halswell Junction had a fence around them to keep people out. The council doesn't want this any more. Amenity values should be incorporated. The soakage basins that have been built are designed specifically to reduce surface runoff in areas which are difficult to drain.
Palmerston North Manawatu- Wanganui Regional Council There is unofficial concern expressed at the use of Centennial lagoon (a natural feature) as a stormwater treatment area as it has important community and recreational functions.	Palmerston North City Council Walkways have been created along waterways.

MITIGATION APPROACH TO FLOODING THROUGH THE STORMWATER SYSTEM

Table 5.15 shows the three territorial authorities no longer automatically increase the capacity of the stormwater system when considering options for reducing flooding. Some councils demonstrated that they were more innovative than others, with a greater willingness to explore the use of alternative techniques.

Table 5.15: Mitigation approach to reducing flooding

Auckland Auckland City Council: City Design All three options of increasing the stormwater system capacity, attenuating the flow and providing source controls are considered. Attenuating the flow by detention is carried out by detaining water on grassed fields or parks. Soakage pits, which discharge water into the volcanic aquifer system, have always been employed as a form of source control.
Christchurch Christchurch City Council For the Water Services Unit increasing the capacity of the system is discouraged. Attenuating by detention as an approach is encouraged and there is some preference for reducing the amount of water at the source through soakage mechanisms in certain areas.
Palmerston North Palmerston North City Council: Engineering Controlling flooding in Palmerston North is very dependent on retaining water in the catchment. Palmerston North's clay soils rule out reducing the amount of water at source by means such as infiltration. By necessity Palmerston North has always had a ponding philosophy in natural depressions and private property.

COUNCIL INTERACTION

Interviewee responses in Table 5.16 revealed no serious disputes between regional councils and territorial authorities. Division of responsibilities provided for in the RMA seem to be well established. Territorial authorities have, in general, taken responsibility for urban catchments and waterways. Communication outside of formal levels provided for by the RMA has been limited with the exception of Auckland.

Table 5.16 Council interaction

<table>
<tr><td colspan="2">Auckland</td></tr>
<tr><td><u>Auckland Regional Council</u>
Historically the ARC has had to resort more to threats etc to get things done. As awareness of water quality issues in the estuary have become clear the benefits of inter-council co-operation have become obvious. The ARC now has a close working relationship with the ACC and obviously things like the Stormwater Liaison Group is a formal component of this. The Stormwater Liaison group's strategy is to (1) identify existing environmental limitations (2) define the predicted effect of urban development and (3) establish the means to mitigate against these potentially adverse effects.</td><td><u>Auckland City Council: Planning</u>
The Stormwater Liaison Group's level of discussion is often too high to get things done. In particular there are too many issues to be discussed.

<u>Auckland City Council: City Design</u>
City Design is a business unit and separate from planning/policy development. There probably isn't enough interaction and input by City Design in the district plan is low. This is responsible for an example of misinterpretation in the district plan by planners regarding what City Design has specified. City Design also liaise with the Regional Council as part of the council's statutory functions.</td></tr>
<tr><td colspan="2">Christchurch
<u>Christchurch City Council and Canterbury Regional Council</u>
The CRC to some extent have a policing role over the City Council who represent a "resource user" (including the Waterway Enhancement Programme). There is no favouritism with territorial authorities. There is often a need to co-operate at joint hearings for consents and at other times for spillage's by 3rd parties into the waterways. At the policy level a liaison group has been set up to look at major issues in Canterbury and is attended by senior people. Issues such as minimum floor levels for dwellings and potential flood hazards have already been discussed.</td></tr>
</table>

Palmerston North	
Manawatu-Wanganui Regional Council	Palmerston North City Council
The interactions between the MWRC and PNCC in relationship to stormwater management have been quite formal. There has been no opposition from the PNCC to being required to apply for discharge permits although some concern was raised about what they could practically do and what treatment they would be required to do.	There has been a long association of the PNCC with the regional council and its predecessor. This stems from the historical problems of flooding on the Manawatu River.

THE FUTURE TO STORMWATER MANAGEMENT BY COUNCILS

Water quality is indicated in Table 5.17 as the most important issue for councils in the near future. The strategies for mitigating the effects of stormwater pollution are still being developed.

Table 5.17: The future approach to stormwater management by councils

Auckland Auckland Regional Council The regional strategy for mitigating the effects of stormwater is being developed. This will set out what the region will do over the next 20 years. There were mixed opinions from respondents about the production of a regional plan specifically for stormwater. Rules in a plan will be needed to make small activities i.e., discharges into streams a permitted activity when the WSCA (1967) "general authorisation" runs out. However given that co-operation already exists, the ARC will probably not need rules in a plan to make territorial authorities comply with the regional strategy for stormwater.	Auckland City Council: Planning The vision is simply to maintain or enhance water quality in the coastal environment, where practicable, and to limit siltation and hence sediment entering the waterways. For the most part the scale of urban development has made it difficult to restore the natural environment to any great degree. Auckland City Council: City Design In the future a variety of management tools will be employed to prevent as much pollution as possible from entering the stormwater system. Where opportunity exists storage basins will be built in the catchment. Where retrofitting can't be carried out for stormwater quality treatment, source control measures will be employed i.e., in the District Plan.
Christchurch Canterbury Regional Council In general it will be a case of maintaining the status quo. The CRC will continue to support the "Waterway Enhancement Programme". It will remain up to the CCC to ensure adequate disposal of stormwater. One difference in the future is the council's desire to achieve greater levels of flood protection i.e., 1/100 year. level. With regards to water quality the CRC have not developed a clear framework for mitigating the effects of stormwater pollution in the waterways.	Christchurch City Council In the future the council will continue to restore certain urban streams and encourage innovative solutions for stormwater disposal on new developments. They will proceed with the construction of ponds with caution. In general, there is a continuing desire to develop and implement a strategy for the sustainable management of Christchurch's stormwater and waterways.

Palmerston North Manawatu-Wanganui Regional Council The next step is the incorporation of the Regional Plan methods as they relate to stormwater into the District Plan. For example, appropriate performance standards will be required in district plans for Hazardous facilities and for earthworks associated with development. This is consistent with the overall philosophy of reducing contamination at source.	Palmerston North City Council: Planning By-laws will be produced to regulate what households can discharge to the stormwater system. Palmerston North City Council: Engineering Additional pre-treatment facilities such as retention ponds may be required to be built for some stormwater discharges due to the forthcoming water quality standards from the regional council.

PLAN CODING RESULTS

The plan analysis assesses how urban runoff and waterways have being planned for under the RMA framework. It is divided into two components. The first component, summarised in Figure 5.1, examines how specific resource management aspects of urban runoff and waterways have been dealt with in the issues, objectives, policies, and environmental results contained in the regional policy statements and district plans. The second section, summarised in Figure 5.2, identifies the specific policies and methods contained in the district plans that councils are using for urban runoff control.

ENVIRONMENTAL ELEMENTS REFERRED TO IN POLICIES AND PLANS

The results of the plan coding on a selection of various environmental elements is listed in Figure 5.1. A number of trends are identifiable. Of all the regional policy statements, the Auckland Regional Policy Statement contains the greatest number of references to urban runoff and waterways. The other regional policy statements contain only broad statements about the environment which did not necessarily refer specifically to urban runoff and waterways. The issue most often referred to is the quality of urban runoff.

Objectives are generally broad statements with little reference to the improvement of either urban runoff or waterways. Only the Christchurch City Plan refers specifically to such aspects through way of an explanatory statement. The Christchurch City Plan also scores highly with specific reference to expected environmental improvements for its waterways. All other plans are vague and unspecific. Most objectives relate to improvements in the surface water quality of the district in general and appear to be of little value for managers of urban runoff or waterways. Many plans and policy statements do not include environmental indicators or reference to general monitoring programmes. The Auckland Regional Policy Statement and the Christchurch City Plan provide the only two examples of documents that are specific about the use of monitoring or field surveys to determine the environmental quality of either urban runoff or waterways.

Figure 5.1: Environmental elements referred to in policies and plans

	Auckland		Palmerston North			Christchurch	
ISSUES	RPS	D. Plan	RPS	R. Plan	D. Plan	RPS	D. Plan
Water Quality	2	2	2	1	0	2	2
Waterway flow	2	0	1	0	0	2	2
In/outstream ecology	0	1	1	0	0	1	1
Waterway amenity	1	1	1	0	0	1	2
Flooding	2	2	1	0	2	1	2
Hazardous Sub.	2	2	1	0	1	1	0
OBJECTIVES							
Water Quality	1	2	1	1	0	1	2
Waterway flow	1	1	1	0	0	1	2
In/outstream ecology	1	1	1	0	0	1	2
Waterway amenity	1	0	1	0	0	1	2
Flooding	1	1	1	0	1	1	2
Hazardous Sub.	1	1	1	0	1	1	1
POLICIES							
Water quality	2	2	0	1	1	1	2
Waterway flow	2	2	0	0	0	1	2
In/outstream ecology	2	2	0	0	1	2	2
Waterway amenity	2	0	1	0	1	1	2
Flooding	2	2	2	0	1	1	2
Hazardous Sub.	1	1	1	1	1	1	1
ENV. RESULTS							
Water quality	1	1	0	1	1	1	2
Waterway flow	1	1	0	1	0	1	2
In/outstream ecology	1	1	0	1	1	1	2
Waterway amenity	1	0	0	1	1	1	2
Flooding	1	0	0	1	1	1	2
Hazardous Sub.	1	1	0	1	1	1	2
INDICATORS							
Water quality	2	1	0	1	0	1	2
Waterway flow	1	1	0	1	0	1	1
In/outstream ecology	1	1	0	1	0	1	2
Waterway amenity	1	0	0	0	0	1	2
Flooding	2	0	0	1	0	1	1
Hazardous Sub.	1	1	0	1	0	1	1

Key:

0 = absent from plan or unlikely to relate to urban runoff or waterways

1 = vague: may apply to urban runoff and/or urban waterways

2 = a specific reference to urban runoff and/or urban waterways

POLICIES AND METHODS IN REGIONAL AND DISTRICT PLANS

The second component of the plan coding contains policies and methods that territorial authorities are using to fulfill their environmental responsibilities in managing urban runoff and waterways. The results are presented in Figure 5.2. The emphasis has been placed on the district plans, rather than regional policy statements. The district plans are the most relevant documents for containing references to specific council policies and methods. The regional policy statements are overview documents and do not use regulations.

Figure 5.2 reveals that all plans contain rules controlling earthworks on urban subdivisions with the aim of reducing the sedimentation of waterways. Of all sections in the district plans that were examined, the "Roading or Transportation" sections display the least integration with urban runoff and waterway management. The only reference is in the Christchurch City Plan which seeks to restrict the construction of roads on waterway margins.

There are very few references to urban waterways in methods or policies in industrial or commercial areas (except through reference to hazardous materials). In residential areas setbacks are required in two district plans (the Palmerston North District Plan called these setbacks "ponding areas"). Some natural environment sections of district plans (or related sections) contain references to specific techniques such as lining channels in a natural manner.

The hazardous substances section in district plans gives the greatest reference to urban runoff and waterway management. All plans referred to the use of performance orientated standards which take into consideration the need to create a buffer of a certain distance between developments and the stormwater system or natural waterway.

All district councils are interested in promoting greater recreation options for their urban waterways, where possible, by such means as increasing public access to such areas. Two district plans have policies to protect the aquatic species in waterways. Only the Christchurch City Council was interested in the concept of "greenways" with reference to linking up remnants of existing open areas into plant and wildlife corridors through

waterways. The Christchurch City Plan also provides the clearest indication that when carrying out utility construction and maintenance works the environmental values of waterways need to taken into consideration.

Figure 5.2 Policies and methods in regional and district plans

	Auckland		Palmerston N.		Christchurch	
	D. Plan		D. Plan		D.Plan	
URBAN SUBDIVISION						
Control stormwater flows	1		0		2	
Reduce loss of sediments	2		2		2	
Conserve stream/ riparian zones	1		2		2	
Create esplanade reserves	1		2		2	
ROADING						
Street sweeping	0		0		0	
Street sump maintenance	0		0		0	
Restrict roads on waterway margins	0		0		2	
INDUSTRIAL/ BUSINESS						
Sealed area controls	2		0		0	
Retro-fitting	0		0		0	
RESIDENTIAL						
Coverage controls	2		0		0	
Setbacks	0		2*		2	
NATURAL ENVIRONMENT						
Protect or enhance aquatic life	2		0		2	
Artificial wetlands promotion	0		0		0	
Natural channel lining	1		0		2	
NATURAL HAZARDS						
Protect secondary channels	2		0		1	
Protect flood plains from development	2		2		2	
HAZARDOUS SUBSTANCES						
Performance orientated standards	2		2		2	
Discharge controls	2		2		2	
OPEN SPACE/ RECREATION						
Provide for green linkages	0		0		2	
Provide for recreational uses	1		2		2	
UTILITIES						
Conserve environ. values of waterways	1		1		2	

Key:

0 = absent from plan or unlikely to relate to urban runoff or waterways

1 = vague: may apply to urban runoff and/or urban waterways

2 = a specific reference to urban runoff and/or urban waterways

* = an option considered in the plan but rejected as being unfeasible

The findings from both the plan coding and interviews reveal, overall, that there are marked differences in how different councils are giving environmental consideration to the management of urban runoff and waterways. Generally though, the level of concern has increased in all areas since local government and resource management reform. The key issues associated with these findings and their implications for sustainable management are interpreted in the next chapter.

CHAPTER SIX

ANALYSIS AND DISCUSSION

The goal of this research is to examine how environmental considerations have been incorporated into urban runoff and waterways since local government reform and the RMA. This chapter synthesises the main research findings with the literature review and chapter on institutional arrangements. The discussion is based around the key themes identified in the literature review- management style, source control, storage, soft drainage, public participation and stormwater re-use and utilisation. Finally, the extent to which the case study councils manage urban runoff and waterways "sustainably" is discussed.

MANAGEMENT STYLE

The research findings showed that council management of urban runoff and waterways differed significantly between the case study areas. The approach of councils ranged from pragmatism to one of vision. Councils displayed a mixture of ideas from the traditional engineering-dominated thinking to new thinking that is based on a multi-disciplinary approach. Consequently, technical solutions that were applied in the case study areas included everything from the "end-of-pipe fix" to Niemcynowicz's (1993) "sustainable ecological solutions". In two of the case study areas the style of management exhibited was based most closely on the stormwater management model identified in Figure 2.1. This management style was characterised by a strong anthropocentric (or technocentric) view of nature. The overall strategy was to "minimise the environmental impacts of urbanisation while providing for safety and convenience in land development". The findings reveal one case study area where the management style went beyond the strategy of simply minimising adverse effects through the development of a programme to restore various urban waterways.

The variance in management approaches can be accounted by the co-operative mandate within which local government in New Zealand operates. In a co-operative mandate it is necessary to have a large degree of commitment and resources for it to be effectively

translated into practice (Dixon et al., 1995). This is in contrast to a coercive regime such as that which operates in the United States. For instance, the Environmental Protection Agency's National Pollutant Discharge Elimination System requires all cities with populations greater than 100, 000 people, industrial sites and construction sites of five acres or more to collect stormwater quality information and produce a control programme (Aitken, 1995). Nothing similar exists in New Zealand. The co-operative mandate and lack of guidance from any central authority means that it is up to the individual councils to motivate themselves and work with whatever resources they have available. Some councils have been taking the initiative in incorporating environmental considerations into urban runoff and waterways. This was shown by the amount of research and investigative work that has been carried out in the area of stormwater management in recent years. Others councils have adopted a more conservative role and have left the development and implementation of innovative programmes and techniques to others.

In theory, the potential for councils to apply an ecosystem approach to environmental management has been strengthened by the new institutional arrangement of local government reform and the RMA. Local government reform has transformed the complicated and ad-hoc structure of agencies in both Christchurch and the Auckland region to one which is much more simplified and integrated. This allows for improved comprehensive land and water planning to that possible under the previous institutional regime. The size of the operating boundaries for districts usually encompasses whole urban catchment areas. The Christchurch City Council boundary, for example, encompasses all of the Avon-Heathcote catchment area which prevents a situation of dysfunction where different agencies are seen to be handling upstream and downstream stormwater issues. When issues cross local authority boundaries, the co-operation of the main players in the catchment can be ensured through the regional councils. The hierarchical set of principles set up under the RMA framework has meant that conflicting environmental management goals are unlikely in the management of urban runoff and waterways.

Under the RMA, both regional and district councils are responsible for aspects of urban runoff and waterway management. An important finding is that regional councils have transferred their role, of managing the urban waterways (set out in s30 of the RMA), in a

practical sense to the territorial authorities. This in effect means that stormwater in the urban catchment, including quality and quantity considerations, is managed by a single authority and there is less need than might be expected for interaction to occur between the regional and territorial authorities. The "hands off" approach of the regional councils extends to the point at which the urban stream enters "receiving waters" whether it is the Manawatu River in Palmerston North or the Manukau and Waitemata Harbours in Auckland.

INTEGRATED MANAGEMENT

Issues associated with urban runoff touch on a wide variety of aspects that stretch across traditionally separate and isolated council departments. This necessitates a holistic approach to urban runoff and waterway management. Interviewees recognised that a "roof to river" or total water cycle planning and management approach as described by Lawrence and Reynolds (1995) has not been achieved in any of the case study areas. Catchment management planning, for instance, does not include water supply. Also the link between the disposal of stormwater and flooding remains weak in many areas. This was reflected in the policies and plans (i.e., control of stormwater on urban subdivisions as shown in Figure 5.2).

One of the main reasons for this is that many of the concepts associated with the integrated management of urban runoff are new and so there is still considerable resistance to changing management practices. Another hindrance is the separation that exists between council departments in terms of differences in mandates. For instance, roading departments have the narrow mandate to carry out construction at the least possible cost while stormwater managers have a mandate to protect the environment. There are also constraints associated with internal communication between departments. Some interviewees complained that not enough liaison was being done between planners and stormwater managers. In one example, this has led to data being misinterpreted in plan preparation. Again the differences varied between councils with some staff employing a more multi-disciplinary approach.

ENVIRONMENTAL STRATEGIES

Strategies for controlling the contamination of urban runoff are being prepared in the larger metropolitan areas. They are of a desirable, forward looking nature, although certainly not the 30- 150 year time frame urged by Rookwood (1993). The profile of toxins such as heavy

metals in urban runoff have, in the last 10 years or so, increased considerably in New Zealand. The situation can be described by Winsemius and Gunstram's (1992) "policy life cycle" with the four stages of policy recognition, formulation, implementation and control. Auckland can be seen to be coming out of the second stage (formulation) and into the third (implementation). For instance, the Auckland Regional Council has been active in dramatising the issue in the public arena, through such means as press releases, to create awareness of the problem. This is consistent with a tactic in Winsemius and Gunstram's (1992) second stage. The third stage of implementation will come about in earnest with the forthcoming publication of the draft strategy for stormwater management to formulate the region's response to the issue. However, it has not been developed in time for the first round of district plans to be prepared under the RMA framework.

URBAN RUNOFF AND WATERWAY PLANNING

The plan analysis reveals that the quality of formal goal setting for urban runoff and waterways varies significantly between councils. Some plans and policy statements referred specifically to urban runoff and waterways to a much greater degree than others. An absence of their mention in regional policy statements is understandable when the issues associated with urban runoff and waterways are of a local rather than a regional nature. However, the plan coding showed that the linkages between issues, objectives, policy and methods in a number of district plans varies greatly as well. This suggests that the integration of urban runoff and waterways into the resource management planning process has not been carried out in a comprehensive manner.

Interviewees revealed that the goals set out in strategic plans (often of an economic/ infrastructural nature) were more important than those referred to in district plans. This is perhaps a reflection that territorial authorities are service delivery orientated. Often sections in district plans relating to urban runoff and waterways revealed the carrying over of economic and financial goals reminiscent of the district schemes prepared under the old Town and Country Planning regime. This is not unduly surprising as some interviewees described their district plans as being dressed up "activities-based" plans.

Policies in some of the district plans have often been based on recommendations from catchment management plans (CMP). CMPs do not necessarily address environmental concerns, although in recent years some plans in certain areas have attempted to include water quality as an issue. They are produced with the intention of assisting councils in their drainage functions by proposing stormwater control policies and identifying upgrading and improvement works in areas where major flooding occurs. They often include land management practices, as part of the general package of recommendations, to address infrastructural needs such as reducing the potential for overloading in the existing system (Urbonas and Roesner, 1993). This explains why the impact of development on the efficiency of the stormwater system was an important consideration for permitting subdivision in some district plans. This is in contrast to the RMA's philosophy of allowing people to undertake their own activities provided that they address adverse environmental effects.

Some of the recommendations in CMPs may provide benefits for downstream ecosystems but this result is not intentional. The use of policies in district plans that are based on infrastructural considerations goes part of the way to explain the vagueness with which the anticipated environmental results in district plans are written, as shown in the plan coding. It indicates that planners are not sure what the effects of individual policies prepared in the district plan will be except in overly broad terms.

MONITORING

Another factor that has contributed to the poor quality of the sections relating to urban runoff in district plans is the level of data available to decision makers on the environmental quality of urban runoff and waterways. The literature stresses the importance of monitoring as an integral part of management activities. Monitoring provides one of the most important measures of an organisation's management strategy. In the case of stormwater contamination this relates to testing for improvements in receiving water pollution levels (Aitken, 1995). Reference to environmental indicators in plans was, on the whole, poor. None of the councils currently have data to indicate whether their performance in stormwater management was improving the environmental quality of their waterways. The gathering of such information is considered crucial in the literature for reducing uncertainties for decision makers.

Monitoring of urban runoff and streams has increased since the introduction of the RMA in all case study areas. There has been considerable interest in "state of the environment" monitoring spurred on by the requirements in s35 of the RMA (Stewart, 1995). No territorial authority currently has a stormwater quality monitoring programme in place in New Zealand. Instead periodic monitoring has been carried out to identify the extent of problems that were previously unknown. The nature of testing has been of a general nature and was criticised by some interviewees as being of limited use in decision making. Councils in different areas were found to be more advanced than others in terms of their monitoring activities. For instance, some councils were almost at the stage where the results of policies relating to stormwater would be evaluated.

SOURCE CONTROLS

Source controls to alleviate either flooding or downstream pollution are considered better to end-of-pipe solutions in the literature. Source controls to reduce the amount of stormwater generated on site are infrequently used at the present time in all areas. With respect to the importance of source controls in reducing stormwater contamination, the need for the "cleaner production philosophy" in industry and on trade premises has been recognised by councils.

SOURCE CONTROLS AND FLOODING

Flooding issues associated with urban runoff are still being treated as "downstream" structural concerns. At the same time the "concrete culture" thinking, which has led to the extensive use of impervious surfaces in cities, still dominates in the case study areas. The principles of minimising impervious surfaces or directly connected impervious areas have either been ignored or overlooked. This is partly a result of institutional arrangements. The Building Code (Building Industry Authority, 1992) deals with the required design of a individual household's guttering system but does not have considerations for retarding runoff flow for wider environmental benefit. There is therefore a need to rethink residential suburb design in connection with the wider environment. The mechanism for achieving this remains the district plan and although controlling roof area is common in district plans this relates to amenity concerns and not to urban runoff. There is only one example of a district plan specifying

coverage controls with the direct intention of minimising the extent of impervious surfaces. The performance of this regulation in fulfilling its intended function is unclear at this stage.

Soakage pits have been recognised as providing a cheap solution to reduce the quantity of flow entering the stormwater system. The use of soakage pits was in the past wide spread in Auckland. However, they are now relied upon less, and concerns have been raised about possible aquifer contamination. In Christchurch, the application of soakage pits is more recent. They are being employed in new development areas which are difficult to drain through more traditional methods. The use of soakage pits is promoted in several of the district plans and through the subdivision consents procedure although their appropriateness depends on catchment characteristics. The potential for their use in Palmerston North catchments, for instance, is limited.

Other innovative techniques to reduce stormwater flows at their source as discussed in the literature have not been seriously evaluated. Despite enthusiasm in the literature towards porous pavements, there has been little or no application in any of the case study areas. It has been considered as an option in a few situations but there was a reluctance to use it in favour of other solutions. The widespread introduction of porous pavements would likely be resisted by roading units, property owners and developers because of the increased expense that its use incurs.

Flood plain development

Controls to restrict urban development in flood prone areas have not been widely taken up by councils. Despite authors like Ericksen (1986) recommending that the flood loss potential along rivers be reduced, and many interviewees favouring the approach, councils face considerable political pressure to adopt infrastructural solutions to mitigate the effects of flooding. Interviewees indicated that restricting development in flood prone areas above the statutory minimum standards of the Building Act 1991 remains controversial. In one proposed district plan, development on private property was prohibited along an urban stream but was rejected during the hearings of the proposed plan in favour of the Building Act's (1991) statutory minimum standard. In another area, the setting of standards on the level of

flood protection remains a source of potential tension in the future where a regional council intends to set higher standards to that of the territorial authority.

SOURCE CONTROLS AND POLLUTION PREVENTION

Source controls will remain the dominant method of minimising pollution in all areas because of the expensive nature of treating stormwater. For instance, sediment controls for earthworks are common at both district and regional levels and have been in place for some time. To be effective, pollution prevention has to be carried out in a thorough and holistic manner encompassing households, businesses, industrial sites and the road network. Different councils are concerned with different types of pollutants. Territorial authorities are most concerned with litter and rubbish as it represents the pollutants most visible and obvious to the general public. Regional councils, who are more scientifically orientated (Buhrs and Bartlett, 1993) are more likely to be concerned with pollutants such as non-degradable toxins.

The main focus by councils with regard to urban runoff control since the RMA has been on industrial and trade premises. These sites have always been responsible for the worst instances of spillage and contamination of waterways. Control over industries has been strengthened under the RMA, particularly with regard to enforcement procedures. The RMA provides for the concept of strict liability. Penalties can be severe with fines, compensation for damage and imprisonment available to enforcers. Councils have, in general, made use of the tighter controls and have prosecuted businesses for failure to comply with standards. This has motivated industry to look deeper at their waste management programmes. Many of the problems have been isolated as being those of bad workplace practices. Councils have been involved in encouraging and assisting industry to develop their "cleaner production philosophy".

Hazardous substances control

Under the RMA, hazardous substances management has been brought into the district planning process for the first time. All district plans contained planning controls on site design with the aim of isolating areas of risk from the surrounding environment. Two territorial councils had opted for the incorporation of the Hazardous Facilities Screening Procedure (HFSP) into district plans. This system has been developed in New Zealand to be more in line

with an effects based approach to land uses. The HFSP provides a model for the assessment of the risk from the use or storage of hazardous substances. From this, the consent status of a proposed facility can be determined and the potential for adverse effects arising from contaminants getting into waterways or the stormwater system. This procedure takes into account such things as the proximity of a facility to waterways and the environmental sensitivity of the area.

Education and advocacy

Education was a major tool to encourage the community to become involved in pollution control especially with regard to the disposing of wastes to roadside drains. Educational methods range from newspaper articles to "pooper scooper" and fish painting campaigns. These campaigns, undertaken at both district and regional level, have provided a low cost/ no regrets method of modifying local community behaviour.

Education and advocacy programmes are commonly provided by local authorities to assist businesses in preventing hazardous substances from escaping into the wider environment. All case study areas are either examining or have in place special advisory programmes targeted at businesses. Two councils are currently involved in the use of environmental auditing of businesses to provide a thorough assessment of potential problems before they happen.

Street sweeping

Street sweeping was carried out to some extent in all case study areas. However, local government has been relatively slow to recognise the link between street sweeping and the pollutant load in urban runoff until recently. It will in the near future be made a condition for a stormwater discharge permit (s15) in one area.

Street sump maintenance regimes

The role of maintenance schedules for street sumps and cess pits has been reviewed since the introduction of the RMA. Street sumps are important as often they represent the only structural control preventing material going straight through the stormwater system and out into receiving waters. The State Pollution Control in New South Wales (NSW) has recommended emptying these quarterly and on the basis of rainfall event occurrence

(Rangitikei-Hawkes Bay Conservation Board, 1996). The maintenance regime for the sumps varies markedly between areas but none met the NSW standard.

The most common variety of sump employed on streets is the side-entry sump. There was a wide divergence of opinion among interviewees on the effectiveness of this unit in reducing pollution. Many considered its sediment removal efficiency to be very low. It does not stop much of the litter or rubbish from entering the stormwater system because, being designed to prevent local flooding, there is a need to allow for material to go through the system to prevent blockages. They are also most unsatisfactory in industrial areas for preventing spillages from running into waterways.

Oil interceptors

Another source of pollution that has come under greater scrutiny since the RMA has been runoff from car parks. Various structural controls are usually required by councils through the resource consent process to mitigate the effects of pollutant runoff. This was criticised by some interviewees as not being sufficiently justifiable since the cumulative effects of urban runoff from carparks is small relative to the overall road network. The structural controls are often expensive for the developer to install and maintain and the pollution removal efficiency was questioned by interviewees in a number of instances.

RIPARIAN MANAGEMENT

The most potentially effective source control outlined in the literature is riparian management. Those councils involved in such programmes as creating waterway buffers through esplanade reserves, setbacks rules and either protecting existing riparian buffers or re-vegetation should have the greatest potential for improving urban waterway quality. Overseas studies have shown that riparian strips have been able to provide environmental benefits (e.g., reduce heavy metal contamination, store nutrients, filter particulates and sediment, trap and kill off pathogens). However one interviewee indicated the need for more research into their effectiveness in the local context.

SOURCE CONTROL INADEQUACIES

Buhrs and Bartlett's (1993) concerns about the constraints on local authorities to apply certain categories of source controls were confirmed by a number of interviewees. The first related to construction materials used in buildings. Construction materials such as lead based paints and the use of iron roofs instead of tiles contribute to pollution in urban runoff but can not be adequately addressed under the resource management regime. They are more directly covered by the Building Act (1991). However, the Building Act does not make any direct links with water quality. The second constraint relates to the transportation sector. Controlling pollution emissions from cars directly requires central government involvement. Recently unleaded petrol was made mandatory at the national level. This was widely believed among interviewees to have significantly benefited urban runoff quality. Other national guidelines were suggested by interviewees such as reducing the copper component in the brake lining of cars. Overall, Elliot (1995) believes that given full comprehensive source controls, 80% of heavy metal pollution in urban runoff would be eliminated.

STORAGE

None of the case study areas rely on a stormwater system based entirely on conveyance although the use of urban storage ponds is not widespread. The use of storage in urban runoff control has increased in recent years in the bigger metropolitan centres. Territorial authorities are experiencing pressures to reduce peak discharge rates into receiving waters. The situation has been aggravated by such factors as residential infilling. There is a recognition amongst stormwater managers that infrastructural problems are becoming increasingly difficult to solve by the traditional approach of increasing the capacity of the stormwater system. District councils have been encouraging ground soakage if that is feasible in the catchment. If it is not possible to use ground soakage, or this technique is not by itself sufficient to alleviate problems, then ponding and detention are used. Urban storage has also provided important environmental benefits. It has been observed, for instance, that the construction of ponds in some areas has encouraged a noticeable increase in the native wetland bird population.

THE FUNCTION OF STORAGE FACILITIES

The type of storage facilities used differs between catchments. A major consideration is the catchment land-use which dictates the amount of space available to provide storage. Where space permits, permanent urban "lakes" have been built. In other places, where land is too expensive to be turned into a lake, various areas such as reserves have been set aside to be flooded in the event of a specific design storm.

While the principle identified in the literature (Table 2.3) was to detain and treat stormwater "as much as possible" there has been little emphasis, until recently, to treat stormwater in New Zealand to this extent. Up until now discharge permits for stormwater have been non notified and have imposed few conditions on the water quality of the discharge entering the receiving water. As such, treatment has not been necessary. This may change when the time frame for general authorisations under the old regime runs out and the councils need to apply for discharge permits under the RMA. Any increase in the standard for stormwater discharge quality in resource consents would be controversial because, given the volume of water in urban runoff, treating stormwater is very expensive. Even in large metropolitan areas there are only a few catchments that have had retention ponds constructed. Those storage ponds that have been constructed with the function of improving water quality are of an experimental nature and have been the subject of research to determine their effectiveness. In Auckland at present, there are only examples like the pond at Unitec that provide a water quality function. While more ponds are proposed in the catchment management plans they will only be implemented when funds become available. On account of a lack of priority for these ponds, they may not be constructed for some time into the future.

RETROFITTING

It is unlikely that a general programme of catchment retro-fitting will be carried out in any of the areas researched due to the cost involved in improving urban waterway and runoff quality. The conclusion of Elliot (1996) in a report on a possible strategy for retro-fitting existing catchments in Christchurch was that the extensive use of ponding was both expensive and unwise. The basic problem is that the sediment quality eventually leaving the ponds will be similar to that which enters. The only difference is that the quantity of pollution entering receiving waters is delayed. The benefits are therefore only short term. For instance, in

Auckland the ARC guideline is a 75% sediment removal for BMPs. This means in effect that 25% of the sediment passes through. Over time this amount of material getting through will still eventually end up having a detrimental effect on the receiving environment as it is not flushed out. Elliot's (1996) report states that in Christchurch even if retrofitting was carried out in a large scale manner to treat stormwater, the load of heavy metals such as zinc would be reduced by less than 20%. This represents a poor outcome for the potential money needed to be invested in such a project.

Before implementing policies and methods to improve environmental quality councils must be satisfied of the efficiency and effectiveness of the proposed methods under s32 of the RMA. Given the above analysis it is understandably hard to justify to ratepayers the need to construct numerous ponds to improve stormwater quality. It is likely that retrofitting will be considered in certain localised areas where there is a significant water pollution problem.

SOFT DRAINAGE

Since local government reform and the introduction of the RMA the use of soft drainage has been encouraged to a much greater extent than before. The legacy of previous approaches to the management of urban runoff and waterways has meant that "hard drainage" facilities still dominate stormwater systems. The existing infrastructure can not be replaced quickly. As such, hard drainage facilities will continue to remain prevalent in the near future.

The "ecological ethic" contained in Part II of the RMA has led to an increase in the recognition of environmental issues associated with urban runoff and waterways over recent years. This has been influential in promoting a shift in attitudes and practices concerning urban stream modification. It is now less acceptable than before the RMA for councils to modify rivers for the exclusive use of drainage efficiency although interviewees admitted that piping of streams is still continuing in certain areas. Stormwater managers have generally come to accept Simon's (1978) recommendation that streams are the best possible conductors of stormwater. An important motivation is that it was recognised that natural waterways are often a less expensive means of conveying urban runoff than that of piping. As such councils were at the very least promoting the maintenance of streams in their natural state.

There are no prescriptive regulations on imposing soft drainage features in new developments at present. The nearest many district plans come to supporting it is to require the protection of natural values associated with land that is to be subdivided. The most popular method for providing for natural waterways was through the taking of land for esplanade reserves along the banks of rivers during the subdivision consent's procedure. One district plan encouraged the use of soft drainage in preference to the traditional "curb and channel" by listing appropriate criteria to be taken into account in the granting of consents. Regional councils have also been supportive of the use of passive systems such as natural waterways. They have used a variety of techniques to promote soft drainage, such as conditions on resource consents, community education and liaison with district councils.

The main resistance to the use of passive systems has, understandably, come from developers who see them as not only being more awkward to apply but also taking up more land than comparative hard drainage facilities. It requires considerable initiative by councils to argue for habitat creation when granting resource consents despite the fact that these may be more effective in mitigating adverse effects than traditional solutions. When soft drainage and ponding solutions have been applied it has been found that the value of land has been increased through the enhanced amenity. This has encouraged developers in certain areas to become more accepting of passive systems.

WATERWAY RESTORATION

While the use of natural channels is encouraged in greenfield developments, the restoration of existing channels has only occurred in one case study area at the present time. Reasons against restoration include reducing the flood control potential of the waterway, a general lack of community interest and the expense and difficulty it entails. The Christchurch City Council has embarked on restoring sections of its waterways in a systematic manner. The strategy has seen waterways in Christchurch prioritised according to their suitability. The programme takes a whole waterway catchment and through a community process develops a plan to enhance and restore the stream which is then implemented. The end result is a waterway returned not to a pre-European appearance but rather to a stage where more natural processes are operating. This contrast in appearance is illustrated in Figure 6.1. and Figure 6.2. The benefits of such projects are wide ranging. They include enhanced

biodiversity through the planting of species native to Canterbury, stabilisation of stream banks, improved aesthetics and improvements in water quality.

ARTIFICIAL WETLANDS AND SWALES

All case study areas were supportive of the concept of artificial wetlands as a means of improving water quality. The concept of wetlands has been promoted in the literature by authors such as Smith et al. (1993) as representing a much more ecologically sound and sustainable method of stormwater treatment than traditional treatment plants. Natural wetlands have been used extensively to assimilate municipal and industrial wastes especially in the USA. They are a relatively new phenomena in New Zealand. The focus in New Zealand has been in investigating artificial wetlands to treat discharges from dairy shed effluent (Barnett, 1993). A number of experimental artificial wetlands are currently on trial in various parts of the country for this purpose. The ARC (1995) provide one example of an urban application of a combination pond and wetland to treat stormwater from an industrial site which is claimed to provide high efficiencies for the removal of heavy metals.

Christchurch has been the only area in which swales have been encouraged and widely applied . Swales are not respected elsewhere because of either the lack of free draining soil or problems that have been experienced in maintaining them.

PUBLIC PARTICIPATION

The level of public participation in urban runoff and waterway management varies significantly between case study areas although in general it has increased since the introduction of the RMA. In some areas it has been limited to involvement in the preparation of catchment management plans or the statutory provisions in the RMA such as notified resource consent applications and plan preparation. Some councils have gone much further than others in involving the community in the participation process.

Figure 6.1: Shirley Stream before enhancement (Sept. 1994)

(source: Christchurch City Council)

Figure 6.2: Shirley Stream after enhancement (May 1996)

(source: Christchurch City Council)

COUNCIL INITIATIVES

There has been an increasing number of initiatives by local government to involve the public and community groups in the setting of priorities and choices in respect to difficult trade-offs concerning urban runoff. One of the main examples has been in the setting of standards for receiving water quality. Another has been deciding which areas are to be concentrated on for enhancement. Various techniques have been used to provide for public participation including questionnaires and workshop forums. The Waterway Enhancement Programme in Christchurch represents the pinnacle of what has been done to integrate waterway management with community participation. Before a project to restore a section of a stream goes ahead the concerns of the community are addressed and local solutions are encouraged from the community. A "hands on" approach is taken in that groups such as school children and community organisations such as Zonta International (Heremaia, 1995) are involved in the planning and planting along specific waterways. The whole philosophy of the Waterway Enhancement Programme represents a move to give communities real power in the decision making process.

NON-NOTIFICATION OF RESOURCE CONSENTS

Despite the initiatives by some councils a large number of decisions concerning urban runoff and waterways continue to be taken without any involvement of the wider community. In particular, these relate to such things as consents to discharge stormwater from small outfalls. Interviewees justified non-notification in these circumstances on the basis that the large number of discharge points made the public participation process very expensive. Most of these discharge points were not individually (or collectively) considered of any great significance on the basis that, in areas where stormwater has been separated from sewage, there are generally few public complaints reported to the council concerning stormwater discharges.

PROBLEMS FOR PUBLIC PARTICIPATION

Often the community perception of urban runoff and waterways has not mirrored that of council concerns. The public traditionally has had a negative view of urban runoff and waterways. The piping of urban waterways has often been seen by developers and the public as being beneficial. This results in a definite bias by the community against "soft drainage"

options. Certain councils, particularly those involved in actively promoting open waterways, have been addressing the concerns of the community through a range of different educational forums. One example was a "Stream Care" project that was targeted at schools. Despite the efforts of councils, some interviewees thought that more public education was needed about stream restoration.

When issues were viewed differently between the public and councils, the community was often less willing to agree to council restrictions. The most notable example is the restriction of development in flood prone areas. It should have come as no surprise therefore that when people were asked about what options they prefer in one stormwater management plan they were highly supportive of engineering solutions that provide a high level of protection.

MAORI PARTICIPATION

While it can be unwise to generalise, Maori aspirations for waterways centre on restoring them to the point where traditional foods can be taken out and eaten. In the past Maori have been powerless to object to practices that resulted in the degradation of urban waterways and other issues that affected their lives. Since the introduction of the RMA, Maori form a special group who are automatically interested parties in the urban runoff and waterway management processes. The process of empowering Maori in resource management is still developing in the councils. Councils have established means to liaise with Maori and to have their concerns expressed. However, frustration was expressed by one Maori group that little progress was being achieved in real participation in stormwater management issues and that the process had turned into a "talkfest" (Nuttall, 1996).

Maori, in general, would like participation to include a redistribution of power. To protect such resources as waterways, the marae of Waikato, for instance, would like to see themselves empowered as environmental monitors (Nuttall, 1996). At the present time interviewees indicated that Maori are consulted on all resource consents that may affect them. However, their potential to make a real difference in the management of urban runoff and waterways is limited. It was mentioned by one interviewee that Maori suffer from the same problem as councils when given a resource consent to examine as they focus on the individual

effect of a proposal and not the cumulative effects by other developments in a catchment. This means they have little to object at concerning the individual proposal.

It is interesting to note that the more visionary and environmentally innovative council programmes have Maori concerns at the forefront. This occurs for instance in both the Christchurch Waterway Enhancement programme and the Auckland stormwater liaison group. The Christchurch City Council indicated that they would like to see Maori take on a partnership role in the management of waterways within the next few decades. In Auckland attempts have been made to reconcile Maori and European approaches to stormwater management. Maori have participated in the design of a filter to provide for the Maori environmental principle that when stormwater leaves a pipe it should cross land before entering water. The filter is basically a rock filled discharge platform.

RE-USE AND UTILISATION

Despite enthusiasm overseas for using rainwater or stormwater as a source of water supply, it has not been carried out in urban New Zealand. The reasons for this situation are straight forward. In general, New Zealand urban centres have had abundant water resources close to them. Only in rural areas has rooftop collection been used to any great degree in New Zealand. Given the lack of any driving force to encourage the use of innovative techniques, interdependencies between stormwater services and water supply have not been examined.

RE-USE OF URBAN RUNOFF AND RAINWATER COLLECTION

There were several comments from interviewees on the possibility for the reuse of water in New Zealand. There was concern expressed that such water would be too contaminated from urban activities to be safe for potable water supply in large urban centres. The possibility of reducing flood peaks by retaining the water at the source by the use of large scale rooftop collection in an urban area were generally discounted. Interviewees in both Palmerston North and Auckland were skeptical about the usefulness of collecting rainwater during a period of "wet" conditions. It was considered that too much rain fell during much of the year so that an "average" rain tank would be too near to capacity to be able to mitigate the effects of a significant storm event. Using larger tanks would be

either excessively expensive or take up too much space. The only environmental benefit would come from reducing the volume of water leaving the catchment via the stormwater system but peak flows will still be much the same.

These comments are supported by the few studies that have been carried out on the topic of reusing urban runoff in New Zealand. The Auckland Regional Authority (1978) provided the first known example of a systematic exploration of such possibilities. It considered a range of options for using both roof tank water and stormwater and concluded that none were feasible from a financial perspective. Almost 20 years later little has changed. Watercare in Auckland have reassessed the option and concluded that such possibilities remain non-starters. Given this finding it seems likely that neither roof tank water or stormwater will become an important source of water supply in the near future.

Such a situation may not remain forever. The Auckland City Council intends soon to extract a relatively small quantity of groundwater from urban catchments and Christchurch planners may consider the possibilities of rooftop storage for future water supply. As urban areas have expanded in population and spatial size, there has been a continual growth in the demand and exploitation of water resources at an increasing distance from the city (McConchie, 1992). Generally the focus has been to extract water from the closest most suitable river i.e., Waikato River near Auckland or the Waimakariri River in Christchurch. It is conceivable in the future that stormwater may prove a feasible water supply that has less environmental detriments over other sources of water. In the meantime the ARC intend to produce guidelines for the design of such systems for those users who are interested in voluntarily using urban runoff and rainwater.

UTILISATION OF URBAN WATERWAYS

The goal setting for the instream use of urban waterways in policy statements and plans was either vague or non-existent with the exception of a few specifics in one district plan. Resource management objectives were concerned with general improvements in the natural habitat of rivers, many of which would probably be located outside of the urban area. Only in one district plan was there a policy promoting the enhancement of waterway aquatic life.

There was no mention that Maori might in the future desire their traditional rights to utilise waterways as "mahika kai" (food and other resource producing places).

From this it can be concluded that urban waterways do not receive the same levels of environmental considerations as other rivers. Generally, councils see the uses of urban waterways as being predominantly for the disposal of urban runoff. At this time, the only plan concerning water quality standards has been the MWRC's regional plan for the Manawatu catchment. This specifies that all rivers shall be managed for the purpose of contact recreation but excludes urban streams such as the Mangaone and Kawau. A similar exception is likely when a regional plan is produced for Canterbury.

Given the public involvement in the RMA planning process, it is likely that the majority of the wider community either shares, or at least tolerates, the councils' views that significantly higher standards are not required for the water quality in urban streams. The only water quality standards for urban waterways will therefore remain the statutory minimum standards set in the RMA. It is likely for the most part that the management of urban waterways will not need to be greatly changed in the future to achieve this level of water quality. While this means that costly treatment or enhancement projects will not be required in the near future the use of urban waterways for instream recreation or as a food resource will remain limited.

Territorial authorities were interested in making greater use of waterway margins. All territorial authorities were involved in programmes to create reserves along parts of their urban waterways. These were generally regarded as providing for increased public access and conservation values, particularly erosion control. Only one council was preparing to make use of their waterways in so called "greenways" that encourage the flow of energy, plants and wildlife along corridors. This would involve the creation of a network to connect the city's outstanding natural features and landscapes. This difference in approach to waterway margins is partly a reflection of the difference in council priorities but also an acknowledgement that some districts may have limitations such as a relative lack of enough bush or tree cover with which to link into greenways (Stewart, 1995).

SUSTAINABLE URBAN RUNOFF/ WATERWAY MANAGEMENT

The RMA requires the protection of the life supporting capacity of water. Urban rivers, in general, pose a dilemma because they represent a resource that for the most part has been pushed well beyond its life supporting capacity. It was argued by some stormwater managers that urban streams are small and lack natural or social value and so consequently do not require further enhancement of their water quality. It does seem that given funding priorities it is more logical to protect other more "natural" water resources elsewhere. However, if urban runoff and waterways are to be managed sustainably, it is necessary to consider providing for the reasonably foreseeable needs of both present and future generations.

THE NEEDS OF PRESENT GENERATIONS

The main need at present is preventing the damage of property or lose of life from flooding and maintaining transportation accessibility so that urban areas can function with the minimum of disruption. This requirement will doubtless continue into the future. This means that none of the case study areas can be returned to their natural drainage patterns. Both Christchurch and Palmerston North have been built on areas that require substantial draining to remain operative. Palmerston North is an example of a city that was built on flood plain which depends on its flood protection works to prevent significant inundation. The site of Christchurch requires continued drainage into the future or else water table levels will rise to the point where the city once again reverts to a swamp. Thus both these cities will continue to require a high level of human domination over their respective drainage patterns.

THE NEEDS OF FUTURE GENERATIONS

Only in one of the case study areas has the needs of future generations been considered at the district level. Given that most councils operate in what Smith et al. (1993) describes as the philosophy of stormwater management this is not unsurprising. In the future there will be a continuing need to protect valuable natural resources that are being degraded by stormwater contaminants. To achieve this it is necessary to make sure that the levels of pollution entering do not exceed the assimilative capacity of receiving waters (IUCN et al., 1991, 142). For Auckland the situation is particularly acute because of the scale of urbanisation and the characteristics of the receiving environment. There is strong evidence that the build up is

degrading the life supporting capacity of the sediment and having an adverse effects on the animals that live there and form the basis of the estuarine ecosystem (ARC, 1995). Given present forecasts, the rate of sediment contamination will only increase in the future resulting in extensive long term chronic effects.

The current management approach to reduce the effects of pollution has been to use the Best Practical Option (BPO), rather than performance standards. The approach was taken on the basis that quality standards were unfeasible given the high variability of stormwater quality and the huge volumes of water that are prohibitally expensive to monitor. The BPO approach will not prevent the degradation of the waters receiving base in the long term. Even if they have a 75% removal efficiency they will still let contaminants through. In the long term there will still be an accumulation of contaminants. The removal of 75% of sediment can only delay this process. Eventually the upper estuary (or the "sink" as described by Lyle, 1994) will eventually become overloaded beyond its ability to function.

Other needs of future generations relate to integrating urban runoff with that of watersupply. The notion of turning urban runoff into a resource through re-use is consistent with the concept of urban sustainability because it improves the cities role as a producer of resources rather than a consumer. However, if a city's existing water supply is not under threat from over demand or is not having a detrimental impact on the local environment then re-use of stormwater can not been seen to be a necessary condition for sustainable management. In the future, if current supply is insufficient, then re-use of urban runoff either as potable water or greywater should be investigated before tapping into other water resources which may result in undesirable environmental effects.

The environmental quality of urban waterways

The role of urban waterways need to reconsidered in the era of sustainable management with respect to the reconciliation of economic, social and environmental objectives. Viewing waterways as merely being of functional value puts an over emphasis on economic objectives. In the future there is no reason why community expectations for the standard of environmental quality in urban waterways will not increase. While stormwater discharges, may at the present time only need to comply with the minimum water quality standards set in

the RMA, this may not always remain so. If there is a community aspiration to raise standards, then it will not be enough to simply continue trying to reduce non-stormwater discharges. These policies can only improve urban stream water quality to a certain extent. Action would be required towards restoring waterways to a more natural condition.

Even if water standards do not increase, stormwater infrastructure dominated by hard drainage can not in the long run be seen as being sustainable. If waterways continue to be managed as they have been traditionally then future generations will be left with a legacy of ongoing problems associated with "industrial" style infrastructure. For instance, the pipe systems will remain a burden in the sense that they require replacement over and over again.

The "ultimate goal" for urban waterways will be their application as a healthy food resource. This concept is already supported by some groups and individuals. It is also entirely consistent with the theme of turning the city around from being a consumer to being a producer of resources. The potential for achieving such a goal should not be considered beyond the ability of stormwater managers in certain areas. The Auckland Regional Authority (1983c, 7) stated that *"there is no reason why, in a residential suburb, the urban stream should not remain indefinitely as a valued enclave of nature in an urban context"*. It will not be possible to restore them to a pre-development condition but some facets of the habitat and aesthetic aspects of them can be enhanced (ARC, 1995).

Maximising natural assets in cities

Applying soft drainage is perhaps the most effective way to help aquatic habitats regenerate in urban waterways. Not only does it enhance water quality through filtration and assimilation but it also contributes to the "greening" of the city. The priority that some councils have at the present time towards the restoration of urban waterways is probably not high enough. Restoring urban streams was in some cases regarded as a low priority with the provision of a more natural appearance being considered a "warm and fuzzy" extra. This perception suggests that some councils are still technocentric in their outlook.

Various arguments have been put forward in Chapter Two concerning the need for increasing biodiversity in the urban environment. Perhaps the biggest benefit is that restoration is a

means to bridge the gap between people and their natural environment (Hough, 1989). Public participation in this process strengthens peoples' sense of identity with their local environment. This aspect has not been given the attention it deserves by many councils despite the fact that the implications may go deeper than many suspect, even affecting the form and location of the built environment of a city.

This notion is based on the premise that human beings are inherently drawn to natural areas as suggested by authors such as Bernatzky (1975) and Hough (1989). The process of suburbanisation, for instance, has been seen in the literature as a reaction against industrial slums and a means to return to an environment where nature is more apparent. However, ecological designers have criticised the existence of "nature" in our present day suburbs as being of an artificial nature, especially the nurtured "pedigree" landscape of lawns, fountains, flowerbeds and trees found on private sections and also in civic design (Hough, 1989). New Zealand's increasing shift to lifestyle blocks may be seen as a reaction against suburbanisation and this "lawn culture". Therefore restoring urban waterways can be viewed as a counter to this trend by encouraging people to stay in the city rather than setting up lifestyle blocks in the peri-urban fringe.

The sustainable management of urban runoff is inherently connected with other much wider issues. The largest is the nature of the transport system which remains a major source of pollution with the production of non-biodegradable toxins including heavy metals. The long term answers to the degradation of the environment from contaminated urban runoff are to change the nature of human activities such as industrialisation and wealth acquisition which result in wasteful production and consumption (IUCN et al., 1991). This may include, for example, reducing the use of the private motor car. Such an issue requires large and as yet politically unacceptable changes in community values (Rookwood, 1993) that are beyond the scope of this research. In the meantime, there are a range of options available for local government to improve the environmental quality of urban runoff and waterways. These are discussed in the next chapter.

CHAPTER SEVEN

CONCLUSIONS

This chapter brings the research to a conclusion by examining whether the aims and objectives set out in Chapter One have been achieved. A number of recommendations and aspects to consider are made concerning urban runoff control. Suggestions are made for ways in which the research design and methodology can be improved and finally, some reflective comments are made about this research topic.

OVERVIEW OF RESEARCH AIMS, OBJECTIVES AND FINDINGS

The aim of this research was to examine how environmental considerations have been incorporated into the management of urban runoff and waterways in the era of sustainable management. The impacts of urban development on the pre-existing drainage pattern have been as severe in New Zealand as they have been overseas and local authorities are still struggling with the consequences. The potential means through which urban runoff and waterways can be protected were examined at length in the literature review (Chapter Two). The opportunities and constraints for carrying out the different approaches to urban runoff and waterway management, provided by the institutional arrangements in New Zealand, were examined in Chapter Three. These chapters showed that there are potentially a range of structural and non-structural tools available to stormwater managers under New Zealand's institutional arrangements.

The initial difficulty in undertaking such a study was that the unique operating environments and different issues and priorities that the councils had to face made comparisons difficult. To enable comparisons to be made the theoretical approaches of how urban runoff and waterways could be managed were researched. The results of what were achieved have been outlined in Chapter Two and are summarised in Figure 2.1. Chapter three showed that because the RMA is conceptually a radical departure from previous environmental legislation, all facets of environmental management have needed

to be re-examined. The way councils have gone about adapting to these new institutional arrangements were addressed through interviews and a plan coding methodology.

It was found that some councils are still of the view that stormwater management is largely "business as usual" under the RMA. Consequently, environmental considerations for urban runoff and waterways are of low priority in these areas. Despite this, environmental practices have changed. It is increasingly unacceptable to ignore such aspects as the adverse effects caused by traditional engineering works (e.g., channel straightening) on rivers. Minimum water quality standards have meant that it is no longer possible to ignore the quality of stormwater discharges altogether. Community participation has also increased significantly as a result of the RMA and there is greater requirements for decision makers to address Maori concerns.

The most common management approach found in the case study areas was that of "stormwater management". The intention of such a approach was to minimise adverse effects while providing for the protection of property and roading from surface water. Attempts to incorporate environmental considerations into the management of urban runoff and waterways focused on reducing the non-stormwater discharges in them. Considerable investigative work has been carried out by one council on the effects that stormwater contamination is having on the environment. Particular concern was expressed about the role that heavy metals, petroleum hydrocarbons, solvents and other toxins are having on the environment.

An example of a "roof to river" management style for urban runoff was not found in any of the case study areas. This is partly the result of resistance from vested interests in the wider community and also a recognition that the issues are complex and cross a wide variety of traditionally separate council services. How individual councils have responded to issues associated with pollution have varied but all were concerned with promoting a "cleaner production philosophy". Non-structural source controls are recognised as the most important response although retrofitting in some catchments may take place in the future.

What became apparent was that local government reform and the RMA have not been the only motivation in the change of practices. Many independent factors have coincided with the legislative changes in 1989 and 1991. For instance, overseas trends in the management of stormwater have been influential. There is a growing recognition by stormwater managers that the traditional approach of increasing the capacity of the system is unfeasible and that they must either attenuate flows or reduce them at the source. Undoubtedly this will have some benefits for the wider environment.

When thought and effort have been applied to consider the implications of the RMA's "ecological ethos" the results have been impressive. It has been shown that it is possible to restore the urban drainage environment to a more natural state of processes, riparian cover and level of biodiversity. The Christchurch City Council have taken the lead with a programme of waterway restoration that is resulting in a radical change to the character and value of its urban waterways.

The differences in the approach that councils have adopted to urban runoff and waterway management reflect many factors. The shift to a more co-operative style of government mandate where local government is left with the task of setting policy objectives is a major influence. Achieving an approach to urban runoff and waterway management which is innovative and visionary depends upon a number of factors. The level of resources available to a council are important. A number of the councils investigated had significant financial resources which enabled them to carry out mammoth projects such as the separation of a combined sewer system. The main factor, however, was the vision of individuals both in the individual councils and the community and the commitment to change traditional practices. Conservative councils were less willing to investigate the full implications of how a "sustainable" approach to the management of stormwater and waterway management should be carried out.

RECOMMENDATIONS AND CONSIDERATIONS

There are no quick technical fixes to the adverse effects of urban runoff. The only long term solution to achieve an environmental quality equivalent to that which existed pre-

development is for a significant change in human activities and lifestyles. It would involve a re-evaluation of the whole concept of urbanisation. The environmental impacts of urban sprawl, the extensive use of impervious surfaces and that of the private motor vehicle which is a major contributor of pollution in the natural environment would need to be examined.

In the short and medium term there are a range of options that need to be considered. The most important parameter for local authorities in enhancing the quality of rivers and estuaries is cost to the ratepayers. The RMA requires that councils have to be satisfied that any strategy, policy or method they implement is necessary in achieving the goal of sustainable management and can demonstrate a positive cost/ benefit (s32 RMA). Therefore the benefits of increased environmental quality, for instance cleaner waterways, need to be assessed before policies are implemented.

PLANNING OF URBAN RUNOFF AND WATERWAYS

There is a need for more effective planning of urban runoff and waterways. This task should not be left to engineers. A multi-disciplinary approach is needed with the co-operation of an informed public. Imposing involuntary restrictions, however innovative, often backfire because of community resistance. District plans should provide a clear link between issues (e.g., water quality in waterways), objectives, policies, methods and environmental results in urban streams.

Policies and methods in plans must address the inputs required to achieve a desired environmental result. This acknowledges that the uniqueness of each council's operating environment has been taken into consideration. If councils are embarking on approaches to manage the problem, then they must be confident that what they intend to do will meet the desired goals. Too much of what is being done at present is based at a conceptual level where considerable uncertainty exists about the effectiveness of certain policies. It may, in many instances, be better to adopt a "do nothing approach". This poses a significant challenge for councils in the years after the district plan has been put into effect to assess the effectiveness of policies and where to prioritise expenditure in the future. Planning outside of the resource management regime also needs to examine how best to protect and enhance urban

waterways. This includes incorporating water quality and ecological concerns into catchment management plans.

FLOODING AND STORMWATER DISPOSAL

There is a need to strengthen the link between flooding and stormwater disposal. At the moment issues are principally engineering concerns and the impact of urban form and block and precinct design are ignored or face significant resistance from developers. There is a need for greater use to be made of source controls. Of particular concern are regulations on how stormwater is disposed of on private properties. This is an aspect that is dealt with in the Building Act. Both the Building Act and the RMA work in parallel to each other although not necessarily in harmony. In the Building Act there is no consideration of the wider environmental implications related to downstream water quantity or quality. It may be advantageous in certain circumstances to consider orientating rain gutters towards permeable surfaces. This allows the runoff a chance to infiltrate into the ground instead of flowing directly into the public stormwater system.

Councils need to consider how best to limit impervious surfaces and restore some of the lost infiltration capacity in urban areas, which is one of the principal causes for the existence of urban stormwater problems. This would include a re-examination of urban design. More research is needed on how pervious surfaces can be incorporated on both public and private property. One of the most important considerations is roading. The cost-benefit evaluation of options such as the design of roading should consider the environmental problems caused by the generation of surface runoff and associated pollutants. This may encourage the greater application of techniques such as permeable pavements. While permeable pavements are not always applicable in all circumstances their use by overseas organisations is becoming more widespread (Aitken, 1995). Other than pervious pavements, vegetation along roadsides and application of mulch are other useful options.

Residential infilling in cities is an important issue for the future of stormwater management in all areas. It results in the increasing of the catchment's impervious area and the placing of greater pressure on existing infrastructure to cope with increased

flows. Controlling the build up of "hard surfaces" on private property should include the use of coverage controls and the construction of driveways out of pervious materials.

POLLUTION CONTROL

Decision makers are faced with three categories of options for urban runoff control. These mitigation options include treating stormwater, source control and the restoration of riparian strips along urban streams. In order to keep stormwater from harming the natural system, before it reaches receiving water, it could be treated the same way as sanitary sewage. This approach is not favoured in New Zealand because of the capacity of the drainage system that would be needed to prevent overflows of raw sewage. However, where stormwater is treated in the same system as that of sewage there are positive environmental benefits. The impact of the "first flush", which contains the majority of toxins in urban runoff, is effectively mitigated.

In a fully separated stormwater system there are, none-the-less, possibilities for treatment. Few territorial authorities will be keen on extensive retrofitting as the treatment costs of doing so would be horrendous and unjustifiable to ratepayers. The decision to construct a treatment system of ponds or sediment traps to enhance stormwater quality should be only carried only after an appraisal of the long term benefits have been considered. When ponds are constructed they should be based on a multi-objective design. Ponds can provide significant benefit for wildlife and habitat creation. They can also bring financial benefits in the provision of stormwater infrastructure located downstream. Lastly, they can increase the surrounding areas amenity values which encourage land developers to accept the construction of them.

Many councils have realised that rather than treating stormwater, the first priority should be in controlling pollution at the source. The effectiveness of this approach depends on the extent to which comprehensive source controls can be implemented throughout New Zealand's environmental regime. This would mean examining all ways at which pollutants get into the receiving environment. Pollution prevention cannot be left solely to local authorities. There is a need to apply national regulations, for instance, to control the use of copper in car brake lining and certain building materials. Local authorities have only limited ability to encourage these forms of source controls.

In many circumstances, pollution control by itself, is not going to markedly improve the life supporting capacity of urban waterways. Natural habitats in waterways suffer from other factors such as a lack of shade and suitable flow regime. There is a need to consider hydraulic factors such as restoring waterways to a more natural state and constructing artificial wetlands to enhance water quality. The benefits of more natural waterways are that ecological processes are incorporated into cities. Urban waterways can form part of greenways providing the potential for greater diversity of both aquatic and terrestrial ecosystems. The aesthetic quality of streams is also enhanced.

IMPROVEMENTS FOR FUTURE RESEARCH

The research topic offers considerable scope for further work. In carrying out a similar investigation in the future it is important to incorporate the lessons learned from the design of the methodology.

There are definite constraints and difficulties in conducting a small scale investigation. It is recognised that because of the small sample size it would be unwise to generalise the research findings across the country. Further research could be undertaken to investigate whether the findings of this research are replicated elsewhere in New Zealand. It would be useful to ascertain what theoretical approach councils in other metropolitan centres have adopted to managing stormwater. From the information gathered during the course of this research it would appear that the work of the Auckland Regional Council and Christchurch City Council represent the most advanced that has taken place in New Zealand. From this basis it may be assumed that many other urban centres have adopted a more conservative approach.

This research set out to evaluate the complete urban runoff and waterway management situation in each of the urban case study areas. The methodological approach of focusing solely on regional council staff, district council planners and stormwater managers allowed for a manageable investigation. A more extensive research methodology would enhance this study. There are various other personnel in councils that are relevant to this topic including trade waste managers, roading managers, building and resource consent

personnel. It would also be useful to interview community groups that play an important role in urban runoff and waterway management. These groups could include Maori organisations and residential developers.

There are also means to go further in comparing and contrasting the differences in the management style of councils. It may be possible to take into account catchment management plans. A means of systematically analysing how environmental considerations have been incorporated into these plans could be developed. Another means for comparing areas in a quantitative manner was suggested by Aitken (1995) based on the expenditure on pollution control per head of population. Such a measurement contains its own inherent assumptions which would need to be taken into account.

REFLECTIONS ON THE RESEARCH

Researching how environmental considerations have been incorporated into urban runoff and waterways in New Zealand has proved to be a fascinating topic. It is at the interface between many disciplines such as planning, engineering, urban design, ecology and the environmental sciences.

Given that cities are criticised by some as the so called "consumers and polluters" of resources, urban streams represent a particularly good indicator of the overall commitment of councils to improving environmental quality. Of all natural resources they have the greatest potential for environmental degradation. The closer the water quality of urban streams is to natural levels, the greater the transformation of human activities and regard for the environment that community lifestyles are having. If water quality in streams is improving, then it is likely that the environmental management regime of the particular area will be succeeding elsewhere. This should be motivation enough for continued research in this field. The issues involved lie at the heart of the conflict between development and the environment. If a co-existence of nature and development can be obtained in cities, then major progress towards the goal of sustainable management will have been achieved.

APPENDIX 3.1

MINIMUM WATER STANDARDS

Section 70(1) and 107(1) provides that before a regional council:

(i) grants a permit to discharge directly or indirectly to water, or

(ii) includes in a regional plan a rule that allows discharges as a "permitted activity," either into water directly or via land, the regional council must be satisfied that:

"none of the following effects are likely to arise in the receiving water, after reasonable mixing, as a result of discharge of the contaminant (either by itself or in combination with the same, similar, or other contaminants):

- the production of any conspicuous oil or grease, scums or foams, or floatable or suspended materials,
- any conspicuous change in the colour or visual clarity,
- any emission of objectionable odour,
- the rendering of fresh water unsuitable for consumption by farm animals,
- any significant adverse effects on aquatic life."

APPENDIX 4.1

LIST OF INTERVIEWEES

Auckland Regional Council

Nigel Ironside	Team leader -Stormwater Management
Timothy Rix-Trott	Senior Water Resources Engineer

Auckland City Council: Planning

John Nash	Senior Planner
Terry Conner	Senior Planner

City Design

Boubaccar Coulibaly	Engineer
Greg Paterson	Stormwater Manager in Utilities Planning

Canterbury Regional Council

Leo Fietje	Investigations Manager
Malcolm Main	Surface Water Quality Scientist
Lynda Weastell	Resource Management Planner

Christchurch City Council

Rachael Barker Waterway	Enhancement Co-ordinator
Liz Briggs	Senior Planner Conservation
Ken Couling	Land Drainage Manager
Norm Fitt	Trade Wastes Manager

Manawatu-Wanganui Regional Council

Barry Gilliland	Manager of Resource Monitoring
Kirsten Forsyth	Senior Policy Analyst

Palmerston North City Council

Finlay Mason	Stormwater Engineer
Matthew Trlin	Resource Management Planning Officer

Others

A. H. Elliot	Lecturer in Environmental Engineering, Department of Natural Resources Engineering (Lincoln University).

APPENDIX 4.2

INTERVIEW SCHEDULE FOR REGIONAL COUNCILS

To the interviewee:
What is your job description and role within this organisation?

What is your educational background and professional affiliations?

(1) DEPARTMENTAL SECTION
- a question to evaluate where your department and organisation stands in relation to other agencies who are involved in stormwater management in your area

(a) How does your department interact with other council departments, territorial local authorities and the Ministry for the Environment?

(2) BACKGROUND
- questions to set up the background to stormwater management in the case study area so as to find out what the main issues are that the council is involved with

(a) What are the main stormwater management issues or problem(s) within your area?
- How would you rank the problems?
- Are they key priorities for council?
[this question is concerned with problems such as, flooding, erosion and water quality. What is the main source of water quality pollution and/or which is causing the most harm]

(3) ENVIRONMENTAL CONSIDERATIONS
- a set of questions to assess what the council is doing at the moment with respect to incorporating environmental aspects into the management of stormwater and waterways

(a) Have environmental goals been set for the region? What are they? Who has driven this response?
[the goals I am concerned with are, water quality, water quantity and "greening" of the waterways. This may include performance standards. I am interested in who has driven this response i.e., this council, community lobby groups, central government or the territorial local authorities]

(b) What source controls has the council considered or will consider in the near future?
Which areas are these source controls aimed at?
[examples are regulations in the regional/ district plan, economic incentives, vegetation programmes, site design controls, porous pavements etc. - the areas can be residential, commercial, industrial or public roading]

(c) What reactions has council experienced from the case study Territorial Authority (TA) in mitigating the effects of stormwater runoff?
[for example has there been any opposition to mitigating the effects of stormwater runoff in the case study city council area- if so then in what form has this opposition taken and what have been the main concerns of opponents]

(d) What is the nature of the council's attempts to retrofit existing areas with regard to treating the quality of the stormwater in the case study area?
[what is the council doing? Is it involved in the installation of treatment facilities? Who pays for retro-fitting in existing areas? Is the council satisfied with the progress from the TA with regards to retro-fitting?]

(e) What do you see as the nature of the "best practical option" with regard to mitigating the effects of stormwater runoff?
[there is a new power in the RMA to impose on those discharging into water, an obligation to adopt the best practical option for treatment and discharge]

(4) CHANGES IN PRACTICE SINCE RESOURCE MANAGEMENT LAW REFORM
- a set of questions to determine whether the approach by the council with regards to incorporating environmental considerations into the management of stormwater has changed since the introduction of local government reform and the Resource Management Act

(a) To what extent do your practices show a shift in thinking about stormwater management since the Resource Management Act 1991?

(b) For your council has the RMA signalled a shift towards anticipating pollution or flooding problems before it occurs- or does it react to damages? Explain.
[i.e., application of the "precautionary principle"]

(c) Has the RMA and/or local government reform improved agency co-ordination with regards to stormwater pollution control?

(d) Has the RMA signalled a need for the council to rehabilitate and restore degraded ecosystems in the urban environment such as urban streams?
[this question has regards to section 7 of the RMA]

(e) What are the information/ monitoring requirements in your council in relation to stormwater in the case study area? Have these been expanded upon since the introduction of the RMA?
[Section 35 puts a duty on councils to monitor their operations on the environment; how has the council responded to this challenge with respect to water quality, flooding and the protection of ecosystems in waterways and in receiving waters]

(5) LEVEL OF ENVIRONMENTAL CONSIDERATIONS
- this set of questions examines the level to which environmental considerations have been considered with respect to stormwater and waterways

(a) Has council considered the feasibility of utilising stormwater for an alternative source of water supply, greywater etc?
[this question is examining the RMA section 5(a) requirement that natural and physical resources may be needed to meet the reasonably foreseeable needs of future generations]

(b) What vision do you see for urban streams and/or runoff in the region particularly the case study area?
[This question is concerned with the role that the urban stream is supposed to have in the urban landscape of the region e.g., for aquatic life, biodiversity, aesthetics, sink for greenhouse gases, or part of a green corridor?]

(c) In general for what purpose are environmental considerations being incorporated into urban stormwater facilities such as detention ponds etc?
[i.e., amenity value, aesthetic considerations, recreation, acting as a greenhouse sink? Is enhancing biodiversity an important factor? if so what aspects? i.e., terrestrial, aquatic, a specific species]

(6) LEVEL OF PARTICIPATION
- a set of questions to evaluate the extent to which the public have been incorporated in managing stormwater with respect to environmental considerations

(a) What have been the concerns from the local tangata whenua as to how urban stormwater and waterways are managed in the case study TA's area?
[the RMA gives Maori certain rights in the decision making process especially the need for consultation- how has this occurred in relation to urban runoff and waterways?]

(b) In what ways have the public been encouraged to participate in decision making with respect to environmental issues with urban stormwater and waterways?
[literature on the implementation of projects that are geared to achieving "sustainability" emphasise the need for close participation of the local community to obtain a successful solution- is this what is occurring in the your area?]

(7) THE FUTURE
(a) What do you see as the ultimate response of the council in terms of stormwater management?
[i.e., is a regional plan to control stormwater likely in the future]

APPENDIX 4.3

INTERVIEW SCHEDULE FOR DISTRICT COUNCIL PLANNERS

To the interviewee:
What is your job description and role within this organisation?

What is your educational background/ professional affiliations?

(1) DEPARTMENTAL SECTION
- a set of questions to evaluate where the department/ organisation stands in relation to stormwater management in your area

(a) What is the role of your department in relation to stormwater?
[i.e., what projects and programmes is your department involved in]

(b) How does it interact with other council departments, the Regional Council and the Ministry for the Environment?

(2) BACKGROUND
- questions that set the scene to stormwater management in the district.

(a) What are the main stormwater management issues or problem(s) within your area?
How would you rank these problems?
[i.e., this question is concerned with any problems associated with the management of stormwater such as ageing infrastructure, lack of funding, flooding, erosion, water quality]

(3) ENVIRONMENTAL CONSIDERATIONS
- a set of questions to assess what the council is doing at the moment with respect to incorporating environmental aspects into the management of stormwater and waterways

(a) Have environmental goals been set for the district?
- What are they?
- Who has driven this response?
- Do you consider them appropriate?

[the goals I am concerned with are, water quality, water quantity and "greening" of the waterways. This may include performance standards. I am interested in who has driven this response i.e., this council, community lobby groups, central government or the territorial local authorities]

(b) What is the nature of any environmental projects/ programmes or other initiatives that the council has embarked on with regards to stormwater and urban waterways?

(c) How does the district plan propose to mitigate the effects of stormwater runoff?

(d) What alternatives, if any, to those proposed in the plan were considered?
[i.e., the no nothing option, education, regulation, incentives and disincentives]

(e) What opposition has there been to any attempts to mitigate the effects of stormwater runoff?
[by whom, in what form was this opposition, what were the main concerns of opponents?]

(f) Has the regional council been helpful in dealing with the problem of mitigating the effects of stormwater runoff?
[Has technical advice, financial resources or human resources been provided?]

(g) How do current councillors perceive the problem of stormwater pollution?
[Are they concerned about it or would they prefer not to know?]

(4) CHANGES IN PRACTICE SINCE RESOURCE MANAGEMENT LAW REFORM
- a set of questions to determine whether the approach by the council with regards to incorporating environmental considerations into the management of stormwater has changed since the introduction of local government reform and the Resource Management Act

(a) To what extent do your policy and practices show a shift in thinking about stormwater management since the introduction of the Resource Management Act 1991?

(b) For your council has the RMA signalled a shift towards anticipating pollution or flooding problems before it occurs- or does it react to damages? Explain.
[i.e., application of the "precautionary principle"]

(c) Has the RMA and/or local government reform improved agency co-ordination with respect to stormwater?

(d) Has the RMA signalled a need for the council to rehabilitate and restore degraded ecosystems in the urban environment such as urban streams?
[this question has regards to section 7 of the RMA]

(e) What are the information/ monitoring requirements in your council in relation to stormwater? Have these been expanded upon since the introduction of the RMA?
[Section 35 puts a duty on councils to monitor their operations on the environment; how has council responded to this challenge with respect to water quality, flooding and the protection of ecosystems in waterways and in receiving waters]

(5) LEVEL OF ENVIRONMENTAL CONCERN
- this set of questions examines the level to which environmental considerations have been considered with respect to stormwater and waterways

(a) Is it important for pipes to be replaced with waterways where technically possible?

(b) Has council considered the feasibility of utilising stormwater for an alternative source of water supply, greywater etc.?
[this question is examining the RMA section 5(a) requirement that natural and physical resources may be needed to meet the reasonably foreseeable needs of future generations]

(c) What vision do you see for urban streams and/or runoff in the region particularly the case study area?
[This question is concerned with the role that the urban stream is supposed to have in the urban landscape of the region e.g., for aquatic life, biodiversity, aesthetics, sink for greenhouse gases, or part of a green corridor?]

(6) LEVEL OF PUBLIC PARTICIPATION
- a set of questions to evaluate the extent to which the public has been incorporated in managing stormwater with respect to environmental considerations

(a) What have been the concerns from the local tangata whenua as to how urban stormwater and waterways are managed in the case study TA's area?
[the RMA gives Maori certain rights in the decision making process especially the need for consultation- how has this occurred in relation to urban runoff and waterways?]

(b) In what ways have the public been encouraged to participate in decision making with respect to environmental issues with urban stormwater and waterways?

(7) THE FUTURE
(a) What is the council considering as future options for controlling runoff and/ or rehabilitating urban waterways?
[examples are regulations in the district plan, economic incentives, vegetation programmes, porous pavements etc. - the areas could be residential, commercial, industrial or public roading]

APPENDIX 4.4

INTERVIEW SCHEDULE FOR STORMWATER MANAGERS

To the interviewee

What is your job description and role within this organisation?

What is your educational background/ professional affiliations?

(1) DEPARTMENTAL SECTION

- a set of questions to evaluate where the department/ organisation stands in relation to stormwater management in the case study area

(a) What is the role of your department/ organisation in relation to stormwater?
[i.e., the concern is with what projects and programmes the department/ organisation is involved in]

(b) How does it interact with other council departments, the Regional Council and the Ministry for the Environment?

(2) BACKGROUND

- questions to set up the background to stormwater management in your area and so as to find out what the main issues are that the council is involved with regardless of whether they are of an environmental nature or not

(a) What are the main stormwater management issues or problem(s) within your area?
How would you rank the problems?
[i.e., this question is concerned with problems such as ageing infrastructure, lack of funding, flooding, erosion, water quality]

(b) What has been the response of the council?
[is the council reacting or is it not? what programmes/ projects has the council put into place]

(c) How in general does it prioritise its expenditure?
[i.e., is it a case of "whoever shouts the loudest" receives priority]

(3) LEVEL OF ENVIRONMENTAL CONCERN

- a set of questions to assess what the council is doing at the moment with respect to incorporating environmental aspects into the management of stormwater and waterways

(a) Have environmental goals been set for the district? What are they? Who has driven this response?
[the goals concern water quality, water quantity and "greening" of the waterways- I am interested in who has driven this response i.e., the Regional Council, community lobby groups, central government or council initiative]

(b) What is the nature of any environmental projects/ programmes or other initiatives that the council has embarked on?

(c) What source controls has the council considered or will consider in the near future?
Which areas are these source controls aimed at?
[examples are regulations in the district plan, economic incentives, vegetation programmes, porous pavements etc. - the areas could be residential, commercial, industrial or public roading]

(d) Is the council concerned with:
(i) minimising impervious surfaces over the whole catchment?
(ii) minimising directly connected impervious areas over the whole catchment?

(e) What is the nature of the councils attempts to retrofit existing areas with regard to treating the quality of the stormwater?
[what techniques are being employed; would you say that the council is seeking to store and treat water as much as possible?]

(4) CHANGES IN PRACTICE SINCE RESOURCE MANAGEMENT LAW REFORM
- a set of questions to determine whether the approach by the council with regards to incorporating environmental considerations into the management of stormwater has changed since the introduction of local government reform and the Resource Management Act

(a) To what extent do your practices show a shift in thinking about stormwater management since the Resource Management Act 1991?

(b) For your council has the RMA signalled a shift towards anticipating pollution or flooding problems before it occurs- or does it react to damages? Explain.
[i.e., application of the "precautionary principle"]

(c) Has the RMA and/or local government reform improved agency co-ordination?

(d) Has the RMA signalled a need for the council to rehabilitate and restore degraded ecosystems in the urban environment such as urban streams?
[this question has regards to section 7 of the RMA]

(e) What are the information/ monitoring requirements in your council in relation to stormwater? Have these been expanded upon since the introduction of the RMA?
[Section 35 puts a duty on councils to monitor their operations on the environment; how has the council responded to this challenge with respect to water quality, flooding and the protection of ecosystems in waterways and in receiving waters]

(5) LEVEL OF ENVIRONMENTAL CONCERN

- this set of questions examines the level to which environmental considerations have been considered with respect to stormwater and waterways

(a) Has the council ever considered techniques such as:

(i) swales

(ii) restoration of the natural lining of urban waterways

(iii) artificial wetlands

What is your opinion of each of these in your area i.e., its technical and financial feasibility?

[From the literature these represent innovative techniques for urban runoff and waterway management and have been applied in various settings]

(b) Is stormwater considered a resource? Has council considered the feasibility of utilising stormwater for an alternative source of water supply, greywater etc.?

[this question is examining the RMA section 5(a) requirement that natural and physical resources may be needed to meet the reasonably foreseeable needs of future generations]

(c) In its catchment management plans what approach does this organisation prefer with respect to reduce flooding?

(i) increase capacity of the system?

(ii) attenuate by detention?

(iii) reduce the amount of water quantity at the source?

Why is this so? What about the alternatives?

[increasing the capacity of the system has historically been the favoured approach of managers; however current literature suggests that this approach is too expensive- is this true in your council's area?]

(d) What is the role of the urban stormwater system in the urban landscape of your district?

[i.e., is the council seeking to safeguard the life supporting capacity of air, water, soil and ecosystems?]

(e) What vision do you see for urban streams and/or runoff in the district?

[i.e., are they forming part of wider environmental considerations? i.e., green corridors]

(f) In general for what purpose are environmental considerations being incorporated into urban waterways and stormwater facilities?

[i.e., amenity value, aesthetic considerations, recreation, acting as a greenhouse sink? Is enhancing biodiversity an important factor? if so what aspects? i.e., terrestrial, aquatic, a specific species]

(6) LEVEL OF PUBLIC PARTICIPATION

- a set of questions to evaluate the extent to which the public has been incorporated in managing stormwater with respect to environmental considerations

(a) What have been the concerns from the local tangata whenua as to how urban stormwater and waterways are managed in the case study TA's area?

[the RMA gives Maori certain rights in the decision making process especially the need for consultation- how has this occurred in relation to urban runoff and waterways?]

(b) In what ways have the public been encouraged to participate in decision making with respect to environmental issues with urban stormwater and waterways?
[the literature on the implementation of projects that are geared to achieving "sustainability" emphasise the need for close participation of the local community to obtain a successful solution- is this what is occurring in your area?]

(7) THE FUTURE
(a) What is the council considering as future options for controlling runoff and/ or rehabilitating urban waterways?
[examples are regulations in the district plan, economic incentives, vegetation programmes, porous pavements etc. - the areas could be residential, commercial, industrial or public roading]

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