Dunedin 3 Waters Strategy

Ravensbourne Road Integrated Catchment Management Plan

OPUS

DUNEDIN CITY COUNCIL

URS

Ravensbourne Road Integrated Catchment Management Plan 2010-2060

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Dunedin 3 Waters Strategy

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Executive Summary

The Ravensbourne Road Integrated Catchment Management Plan 2010-2060 (ICMP) is one of ten long term ICMPs developed as part of the 3 Waters Strategy recently undertaken by Dunedin City Council (DCC).

In 2007, short term (5 year) stormwater discharge consents were granted by the Otago Regional Council (ORC) permitting stormwater discharges into the Otago Harbour pending the development of stormwater catchment management plans. The emphasis of such plans is on monitoring stormwater quality and mitigating adverse stormwater effects on the harbour receiving environment. These short term consents will be replaced with long term (35 year) consents following the completion of ICMPs.

Strategic objectives of stormwater management provide the overarching objectives that guide the development of this ICMP. These objectives are at the core of the relevant statutory and non-statutory documents addressing stormwater management, including the 3 Waters Strategic Direction Statement. These objectives have been developed with the aim of achieving benefits across the four 'wellbeings' (environmental, social, economic and cultural), within the context of a 50 year timeframe, and cover the following:

- Development;
- Levels of service;
- Environmental outcomes;
- Tangata whenua values;
- Natural hazards; and
- Affordability.

The Ravensbourne Road catchment is relatively small, covering an area of approximately 25 ha, located to the east of Dunedin CBD. Land use consists primarily of industrial lots on flat, harbourside reclaimed land below steep bush covered hillside adjacent to a quarry.

The natural stream network in this catchment is limited, comprising a single small gully draining the hillside to the north of the flat harbourside land. The natural flow is intercepted at Ravensbourne Road and diverted via pipework and an open channel to an outfall discharging to the Otago harbour. The flat industrial area and roads are drained via two stormwater pipe networks which discharge to the harbour via two further harbour outfalls.

The Otago Harbour is heavily modified by reclamation, road works and dredging. There are a number of stormwater discharge points into the upper harbour, and it is acknowledged that both historical and current stormwater management, as well as many other activities not related to stormwater management, have contributed to the state of this environment. The harbour is considered an important area for recreation; it is frequently used by wind surfers, kayakers, fishers and hobby sailors. A cultural impact assessment states that the increasing degradation of the harbour environment dramatically altered its place as mahika kai, as well as affecting Māori in many ways.

Monitoring of the stormwater discharge quality and the harbour environment is undertaken on an annual basis in accordance with the conditions of consent for DCC's stormwater discharges. To date, four rounds of monitoring have been undertaken (2007, 2008, 2009, and 2010). The annual monitoring involves biological, sediment and stormwater quality monitoring. The information gathered to date indicates that the stormwater quality discharged from this catchment is at the low end of the typical range of expected stormwater quality for the catchment's industrial land use. It is difficult at this stage to ascertain any trends in the harbour marine ecology or directly link the ecological health to stormwater or marine sediment contamination. Further rounds of ecological monitoring may provide a clearer understanding of the health of the marine ecology adjacent to this catchment.

A linked 1 and 2-dimensional hydrological and hydraulic model of the Ravensbourne Road catchment and stormwater network was developed to replicate the stormwater system performance, and to predict flood extents during a number of different land use, storm event and climate change scenarios. The model for this catchment was not calibrated and therefore confidence in the model is relatively low, however, it is still considered to be an adequate tool for the purpose of indicating areas of potential flooding and allowing the comparative effects of the different rainstorms and climate change scenarios to be assessed.

The model extent includes part of the stadium area, the stormwater from which is now managed on site and discharges into the Water of Leith. Stormwater from the new harbourside arterial extension is managed via a stormwater detention pond, which discharges into the western-most stormwater pipeline in the Ravensbourne catchment. It is not anticipated that these recent changes will significantly affect the discharges from the Ravensbourn outfalls, although future amendments to the model and ICMP should incorporate these changes.

An assessment of environmental effects, based on the interpretation of the outcomes of the stormwater network hydraulic modelling and the associated flood maps; the marine and stream assessments; information gathered during catchment walkovers; DCC flood complaints records; and information gathered during workshops with DCC Network Management staff, identified a number of stormwater related issues in the Ravensbourne Road catchment.

Stormwater issues were prioritised, and management targets and catchment specific approaches were developed for Ravensbourne Road based on each issue, and the strategic objectives for stormwater management. Table ES-1 below summarises the key issues, effects, targets and catchment specific approaches for Ravensbourne Road.

The prioritisation score assigned to each issue indicates whether active or passive management is required. Active management indicates that DCC will seek to implement changes to stormwater management in the catchment, whereas passive management would tend more towards monitoring and review of existing management practices to ensure that the targets set can be met. Only three issues were identified as requiring active management. The remaining issues were categorised as requiring passive management. This is predominantly due to the location, short duration, or shallow depth of predicted flooding in the catchment.

For the majority of issues explored in this ICMP, a limited number of options were available when considering the catchment specific approach and targets set, due mainly to the nature of each issue. This resulted in the recommendation of all options presented, with priority placed on the recommendations according to the prioritisation of each issue. Tables ES-2 to ES-4 below outline the recommendations, split into further studies, planning and education, and operation and maintenance. No capital works tasks are recommended for this catchment. The further studies recommended will assist in improving certainty around catchment management targets, or provide further information in order to develop options. Note that where a recommendation is to be resourced internally at DCC, a cost of $ 0 has been assigned.

The implementation of these recommendations will be determined by the 3 Waters Strategic Plan, which will assess all of the ICMPs developed by DCC, and develop a prioritised programme of works across the city.

Table ES 1: Ravensbourne Issues, Approach and Targets Summary

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Limited Confidence in the Knowledge of Effects on Harbour Environment and Variability of Stormwater Quality Results	High variability of stormwater quality results, any trends in stormwater contaminant levels remain unclear. Poor information on actual effects of stormwater on harbour environment. Lack of data to assess linkages between pipe discharge and harbour environment quality.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. No recorded breaches of the Resource Management Act. Ensure stormwater discharge quality does not deteriorate.	***Manage Actively*** Redesign DCC's monitoring programme to ensure stormwater quality and receiving environment data is collected within a robust framework. Develop method for determining linkages between stormwater management and harbour environment. Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high- contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality. Undertake monitoring to ensure stormwater quality does not deteriorate over time. Incorporate a feedback process to the ICMP if / when monitoring indicates potential adverse effects from stormwater discharges.	Robust monitoring framework developed and implemented by 2012. Improve confidence in data supporting analysis of stormwater discharge quality and effects on harbour environment, with improved confidence in data by 2013. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Flood Hazard – Future 1 in 100 yr ARI (Extreme Event)	Current: area of 'low' flood hazard in roads and some industrial locations. Future extreme events: areas of 'moderate' flood hazard in roads and some industrial locations resulting from stormwater. Areas of 'significant / extreme' flood hazard on harbour front predominantly due to tidal effects.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Actively*** Ensure new development does not increase the number of properties predicted to flood due to the stormwater system in a 1 in 100 yr Average Recurrence Interval (ARI) rainfall event. Work to avoid significant disruption to people and services during a large rainfall event. Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply etc) from flood hazard. Avoid development of vulnerable sites / critical infrastructure in flood prone areas. Ensure transport routes around flooding areas are available. Develop a better understanding of the likely effects and magnitude of climate change.	Develop a catchment specific emergency response plan by 2012. Provide modelled flood predictions to DCC Climate Change Adaptation Group to ensure information is taken into account during the development of a city-wide climate change adaptation plan.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Network Maintenance	Flooding extents and durations in Ravensbourne Road are potentially exacerbated by variations in the frequency and standards of catchpit cleaning and maintenance. City-wide inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures (inlets and catchpits) can lead to discrepancies in level of service.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Ensure consistency city-wide of stormwater structure cleaning and maintenance. Ensure cleaning and maintenance schedules and contracts are sufficiently robust. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets (city-wide) by 2012. Document cleaning and maintenance responsibilities for all stormwater inlet assets (city-wide) by 2013. Develop list of key stormwater assets in Ravensbourne Road catchment requiring additional cleaning and maintenance checks by 2013.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Blocking / Maintenance of Intake Structures	Accumulation of debris at the intake screen on Ravensbourne Road and blocking of catchpits on Parry Street is predicted to exacerbate nuisance flooding and overland flow.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Undertake an inspection of all open channel sections, to record status of intake structures. Ensure damaged screens are replaced / fixed. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk. Work with property owners to ensure intakes and screens are properly maintained.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets in the catchment (in conjunction with city-wide criteria) by 2012. Develop list of key stormwater intake structures in Ravensbourne Road catchment requiring additional cleaning and maintenance checks by 2013. Document cleaning and maintenance responsibilities for all stormwater inlet assets in the catchment by 2013. Ensure all damaged, poor performing, or missing screens are replaced (if appropriate) by 2013.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Low Level of Service	Most of the network has a low level of service between 1 in 2 yr ARI and 1 in 5 yr ARI rainfall event driven by network hydraulic capacity. Effect is nuisance flooding within the road. Currently occurring, no capacity for climate change effects.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. 95 % of customer emergency response times met. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Maintain or improve existing level of service in network – ensure no increase in the number of stormwater manholes predicted to overflow in a 1 in 10 yr ARI rainfall event. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Ensure new development does not increase potential habitable floor flooding due to the stormwater system in events up to a 1 in 50 yr ARI rainfall event. Use customer complaints and residents' opinion survey (ROS) to gauge satisfaction with the stormwater system performance.	< 25 % manholes overflowing during a 1 in 10 yr ARI rainfall event by 2060. < 0.2 % of catchment surface area predicted to flood during a1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (ongoing).
Nuisance Flooding	Currently occurring at locations within road during 1 in 5 yr ARI rainfall event. Extent is minor affecting < 0.1 % of the catchment. Effects rise to approximately 0.4 % of the catchment during a future 1 in 10 yr ARI rainfall event.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Passively*** Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances).	< 0.1 % of catchment surface area predicted to flood during a 1 in 5 yr ARI rainfall event by 2060.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Ongoing Stormwater Discharge	Could exacerbate existing / historical contaminant issues. Extent to which this is likely to occur is unconfirmed. Key stakeholder issue. Based on available data, consequence currently believed to be minor.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	***Manage Passively*** Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high- contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.	No deterioration of stormwater quality due to land use change or development in the catchment. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.

Table ES 2: Further Study Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Redesign the city-wide framework for stormwater quality and harbour environment monitoring.	$ 20 k	3 - 6 months
40	Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service.	$ 0	Ongoing

Table ES 3: Planning and Education Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
70	Develop a city-wide climate change adaptation plan, including ongoing monitoring of climate change predictions, incorporating damage assessment of the vulnerable infrastructure.	$ 0	6 - 12 months
40	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	$ 0	2 months
40	Work with ORC to develop a plan for education programmes in relation to best practice site management of industrial premises.	$ 20 k	6 months

Table ES 4: Operation and Maintenance Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Implement the revised city-wide monitoring framework.	$ 25 k	Annual
50	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance. Include Parry Street catchpits and the Ravensbourne Road stormwater intake structure.	$ 5 k	2 months
50	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	$ 20 k	2 months

Part 1
Introduction

1 Introduction

1.1 Background

Dunedin City Council (DCC) is currently in the process of implementing an integrated approach to asset management, and a business improvement project in order to meet capital and operational delivery targets. The process has two main components. The first; review of the existing business structure was completed in 2009. This established a better alignment between people, processes and outcomes. The second; to undertake a significant strategy development project incorporating the three water networks; water supply, wastewater and stormwater. The 3 Waters Strategy project Phases 1 and 2 were completed in 2011, and included the development of hydraulic models examining the entire water cycle within Dunedin's urban catchments, providing critical information on the performance of the networks. The 3 Waters Strategy outcomes are used to inform decisions on future capital expenditure programmes to address the following:

- Current known issues in the networks;
- Urban growth;
- Climate change; and
- Environmental sustainability (particularly in relation to new stormwater consents).

As part of this future strategy the 3 Waters Strategy project has been developed with the aim of providing an integrated decision making process for DCC.

The objectives of the 3 Waters Strategy are:

- Determine required levels of service for each of the three waters networks.
- Determine capital and operational costs associated with improvements to the three waters networks, including priorities and phasing for investment.
- Develop a greater understanding of the operations of the three waters networks through targeted asset and flow data collection.
- Develop decision support tools including network models.
- Develop Integrated Stormwater Catchment Management Plans.
- Provide sufficient data to support the development of council's Annual Plan and Long Term Plan (LTP).

To achieve the objectives of the Strategy the project comprises a three phase process:

Phase 1: Development of capital and operational investment needs at a macro level, determine the needs for more detailed investigations to be carried out in Phase 2, and determine high priority capital and operational works for major infrastructure items to be carried out in Phase 3.

Phase 2: Detailed investigations to determine capital and operational needs at a catchment or zonal level.

Phase 3: Implementation of capital and operational works to realise the required level of service improvements.

1.2 Context

The development of the Ravensbourne Road Integrated Catchment Management Plan 2010-2060 (ICMP) is part of the 3 Waters Strategy being undertaken by DCC, as described above. This ICMP is one of ten long term plans to be developed to fulfil consent requirements relating to the discharge of stormwater to the Otago Harbour, as well as to provide future direction for DCC's stormwater management at a catchment specific scale.

In 2007, short term (5 year) stormwater discharge consents were granted by the Otago Regional Council (ORC) permitting stormwater discharges into the Otago Harbour pending the development of stormwater catchment management plans. The emphasis of such plans is on monitoring stormwater quality and mitigating adverse stormwater effects on the harbour receiving environment. These short term consents will be replaced with long term (35 year) consents following the completion of ICMPs.

Appendix A contains the short term resource consents granted for stormwater discharges from the Ravensbourne Road catchment. Each consent (Consent Numbers: 2002.104, 2002.105, and 2002.106) has a condition which states the following:

> *"In consultation with the Consent Authority, the consent holder shall prepare and forward to the Consent Authority within four years of the commencement of this consent, a Long Term (35 year) Stormwater Catchment Management Plan for the Ravensbourne Road catchment that shall contribute to the effective and efficient management of stormwater in that catchment to minimise contamination of stormwater and mitigate any adverse effects caused by contaminant discharge and accumulation in the receiving environment."*

In 2008, a high level Quadruple Bottom Line (QBL) assessment of the nine largest stormwater catchments was undertaken, and identified South Dunedin as the highest priority catchment in terms of stormwater issues (refer *'Dunedin 3 Waters Strategy, Stormwater Catchment Prioritisation Framework'*; URS, 2008). Following the development of an ICMP for South Dunedin, the remaining stormwater catchments were re-prioritised, whereby the economic, social, cultural and environmental aspects of the catchments' assets were gauged based on 12 QBL indicators. The four QBL 'wellbeings' (categories) and 12 indicators were each defined and weighted in consultation with DCC Water and Waste Business Unit branch representatives to ensure that indicators which are considered most important have a greater impact on the final score than indicators which are considered less important at this stage. Each of the nine catchments were then scored against the indicators on a scale of zero to five (zero representing 'no issue' and five, a 'significant issue'), thus producing a final weighted score and ranking of the catchments. The results of this QBL prioritisation assessment are presented in Table 1-1: and further details can be found in the report: *'Phase 2 Stormwater Catchment Prioritisation Framework'* (URS, 2009).

The Ravensbourne Road stormwater catchment was ranked eighth out of the nine catchments prioritised, with only one indicator having a high score – potential point source pollution.

The scope of works for this ICMP was developed to collect sufficient information about current stormwater management in the catchment, as well as the effects of those practices. Objectives for stormwater management have been set by the 3 Waters Strategy Direction Statement in conjunction with objectives for water supply and wastewater management. Recommendations for future stormwater management are required to meet these objectives, based around avoiding, remedying or mitigating adverse effects of stormwater discharges on both the catchment itself and the receiving environment. Integration of stormwater, wastewater and water supply management is a key consideration throughout this ICMP, and further opportunities for integrated solutions in this catchment between the water supply, wastewater and stormwater networks, is likely to be in the co-ordination of the DCC capital works programme.

Table 1-1: Phase 2 Catchment Prioritisation

QBL Category	Label	Indicator	Main Weighting (%)	Sub Weighting (%)	Halsey Street	Orari Street	Mason Street	Kitchener Street	Shore Street	Port Chalmers	Portsmouth Drive	Ravensbourne Road	St Clair
Economic	1A	Annual OPEX	35	100	3	2	0	0	0	0	0	0	0
Social	2A	Community Pressures	-	-	-	-	-	-	-	-	-	-	-
Cultural	3A	Iwi (Käi Tahu) considerations	20	100	4	4	4	4	4	4	4	4	3
Environmental	4A	Sensitivity of Receiving Environment	45	10	3	3	3	3	4	3	3	3	1
	4B	Asset condition / age / capacity restraints		25	3	3	3	3	3	3	1	1	3
	4C	Reported Flooding incidents		10	4	2	3	1	2	1	1	3	2
	4D	Reported Water Quality incidents		10	4	2	4	3	1	3	1	0	2
	4E	Presence of point source pollution sources		20	3	2	3	3	1	2	4	4	1
	4F	Presence of diffuse pollution sources		10	3	2	3	3	2	0	5	3	1
	4G	Development proposed within catchment		-	-	-	-	-	-	-	-	-	-
	4H	Sediment generating / erosion areas		10	3	2	2	1	2	1	0	0	2
	4I	Potential for waste / stormwater system interaction		5	4	3	4	2	2	4	1	1	2
				Weighted Score:	**3.31**	**2.58**	**2.17**	**1.95**	**1.77**	**1.77**	**1.75**	**1.7**	**1.43**
				Rank:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

1.3 Overview

This ICMP comprises six parts:

Stage 1 – Introduction. This section provides the background to the study, and outlines the planning and statutory requirements of DCC with respect to stormwater discharge management.

Stage 2 – Baseline. This part of the report describes the stormwater catchment as it is now – topography, land use, receiving environments, stormwater discharge quantity and quality. The stormwater network is also described and current operational and capacity issues discussed.

Stage 3 – Analysis. Stormwater management problems and issues are identified in this section, by analysing the results of contaminant and network modelling, flood hazard mapping and other information collated in previous sections.

Stage 4 – Targets. Catchment stormwater management approaches and SMART targets are outlined in this section, as determined by the priority of each issue, and DCC's stormwater management objectives.

Stage 5 – Solutions. This section describes a number of potential solutions to the issues identified, for both stormwater quantity and quality).

Stage 6 – Way Forward. A prioritised programme of works is outlined, based on the Optimised Decision Making Framework developed for the DCC 3 Waters Strategy.

Figure 1-1 presents the scope of work for the stormwater component of the 3 Waters Strategy, including prioritisation of the catchments.

Figure 1-2 provides a process diagram of the ICMP process used for this project. The figure also indicates the position and influence of stakeholder consultation within this process. Ongoing consultation ensures that the project advances in a way that meets the needs and expectations of all parties involved. It can also significantly benefit the project by providing invaluable local knowledge and assist in identifying significant issues. Furthermore, successful consultation during development stages can often assist implementation of the ICMP.

An ICMP document is designed to accommodate a number of changes during its useful life, via monitoring and review processes (refer Section 17). Changes within the catchment, results of monitoring, or improved system knowledge are a number of things that may prompt a change in the ICMP.

The most significant changes in the Ravensbourne Road catchment, affecting the stormwater network, will be the completion of the Stadium development and the State Highway extension in the west of the catchment. These changes have not been incorporated into this version of the ICMP as at the time of model build and writing the ICMP these developments were still ongoing and design details and other information regarding the changes to the stormwater network was not available.

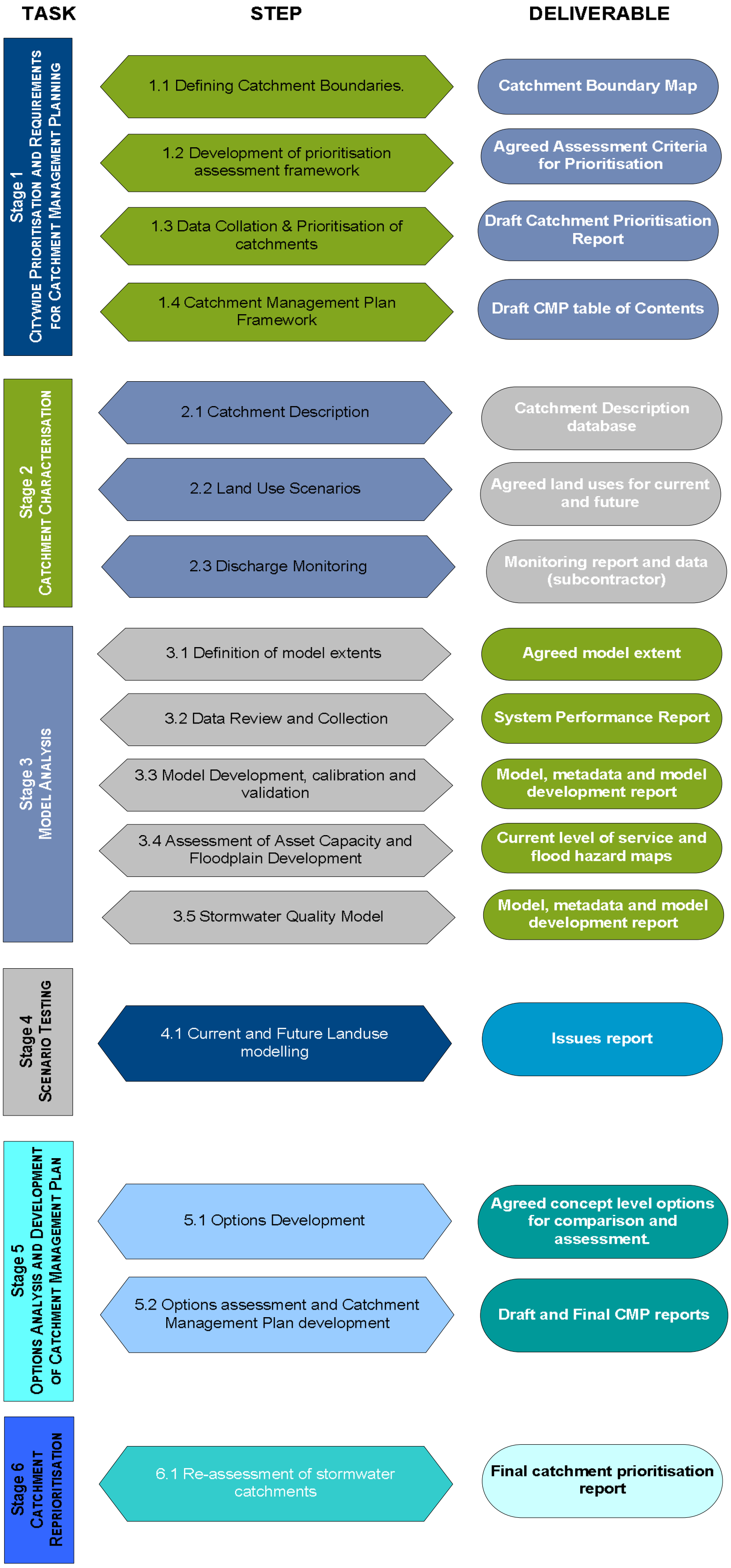


Figure 1-1: Scope of Work

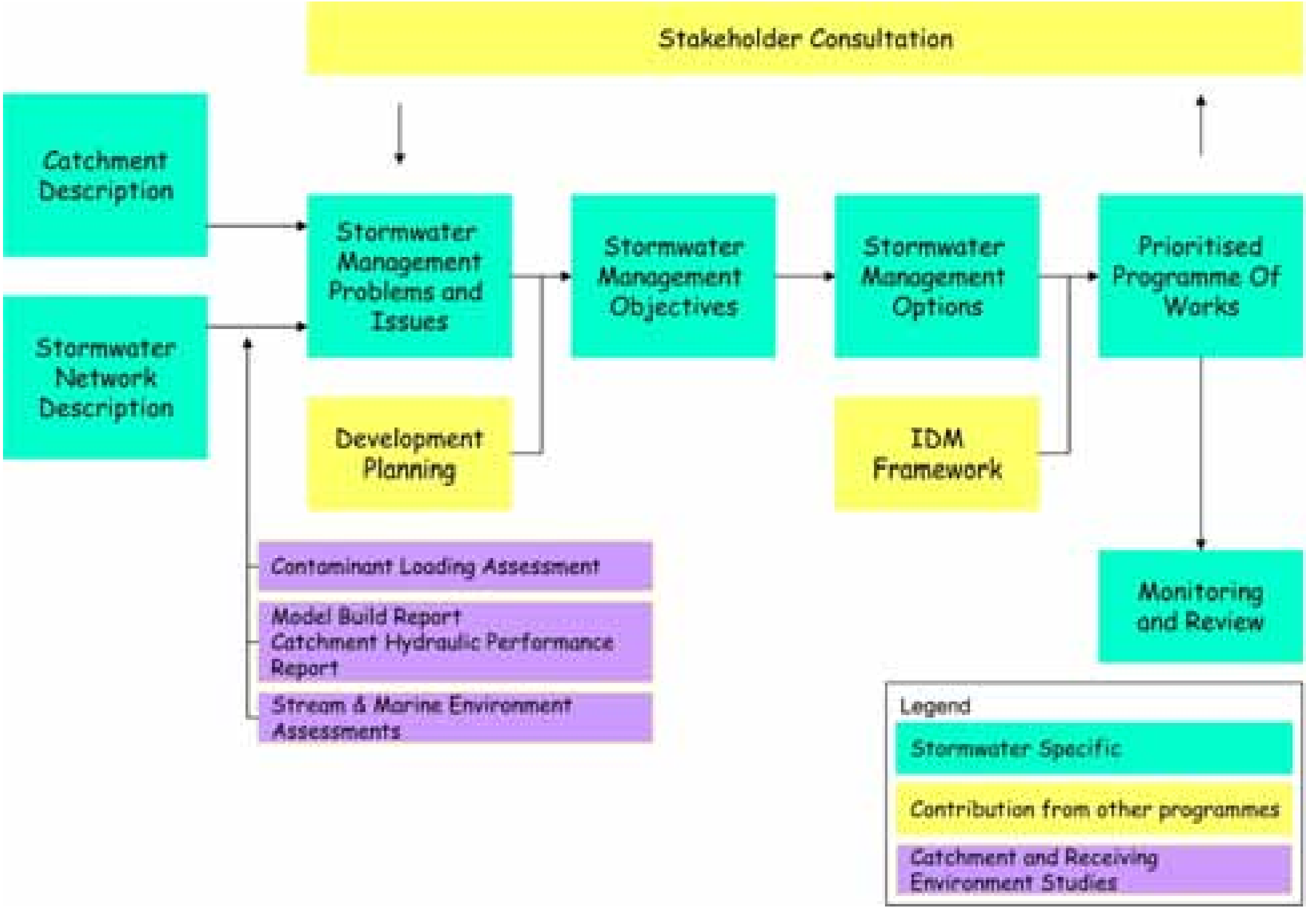


Figure 1-2: ICMP Development Process

2 Planning and Statutory Background

2.1 Planning Framework

An ICMP, and any stormwater development undertaken where the ICMP is applied, should be consistent with the objectives of national, regional and district planning documents and several key non-statutory documents. Figure 2-1 below provides the hierarchies of legislative and planning documents, both statutory and non-statutory which interact with this ICMP. As shown by the double ended arrows, there is often a two-way interaction between the ICMP and these documents.

The influence of each of the key current statutory and non-statutory documents relating to stormwater management and the development of an ICMP are discussed in Sections 2.2 to 2.6. It is important to note that these documents are subject to review and change. Therefore, the ICMP must be sufficiently flexible to endure variations to these documents while remaining relevant. In some cases the ICMP may provide direction to these variations.

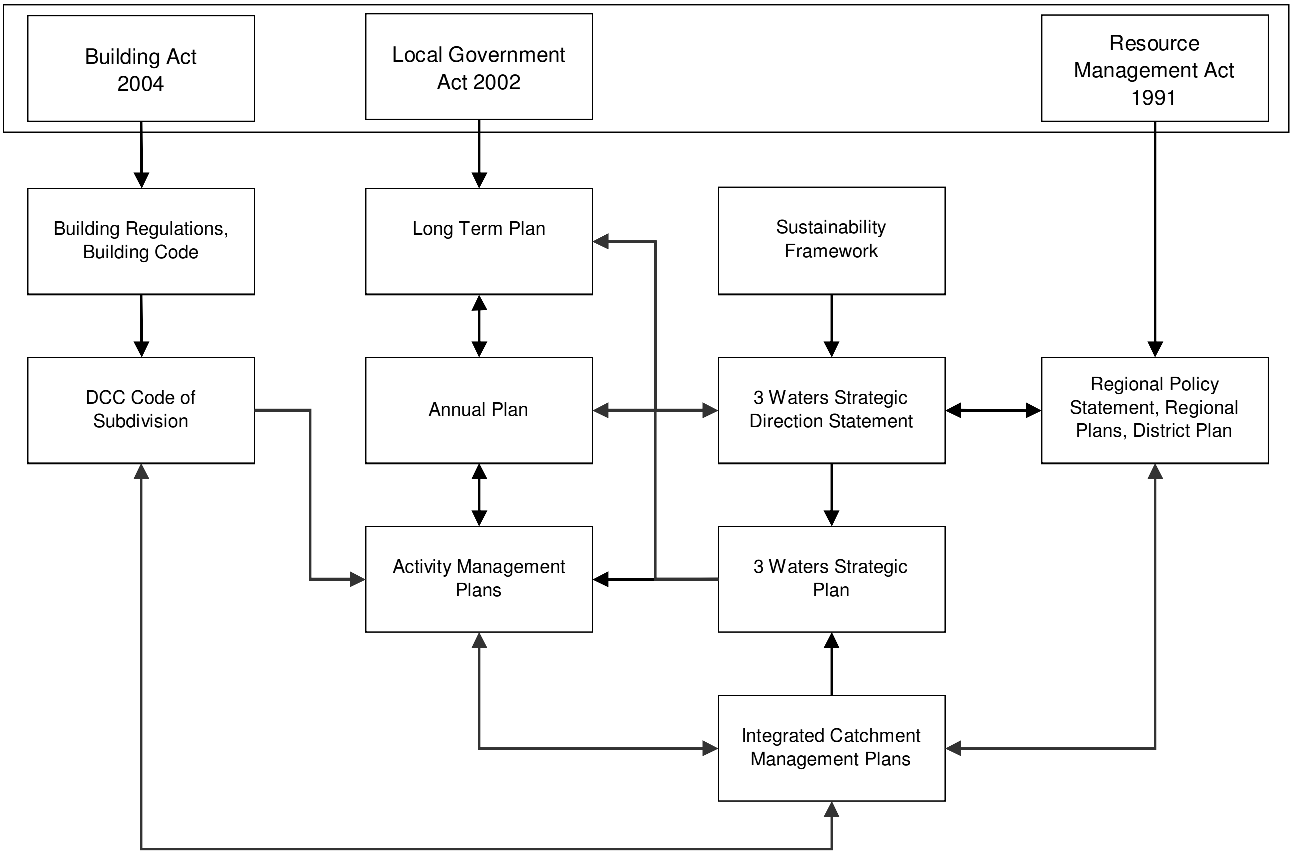


Figure 2-1: Legislative and Planning Document Hierarchies

2.2 The Local Government Act (2002)

The purpose of the Local Government Act 2002 (LGA) is to provide for democratic and effective local government that recognises the diversity of New Zealand communities and, to that end, this Act—

(a) *States the purpose of local government;*

(b) *Provides a framework and powers for local authorities to decide which activities they undertake and the manner in which they will undertake them;*

(c) *Promotes the accountability of local authorities to their communities; and*

(d) *Provides for local authorities to play a broad role in promoting the social, economic, environmental, and cultural wellbeing of their communities, taking a sustainable development approach.*

There are a number of responsibilities outlined within the LGA which are relevant to the ICMP. These include:

- Section 93, LTP;
- Section 95 Annual Plan; and
- Compliance with performance measures set by the Secretary of Local Government.

These are discussed below.

An ICMP needs to be consistent with the LGA. This can be achieved by promoting consultation with all parties affected by stormwater management decisions and accounting for and managing the stormwater infrastructure for Dunedin city in a manner that provides for the present and future needs of the public and the environment.

2.2.1 Long Term Plan (LTP)

Section 93 of the LGA requires a local authority to produce a LTP for the following purposes:

> *"to describe the activities of the local authority; to describe community outcomes; to provide integrated decision making and co-ordination of resources; to provide a long term focus for decisions and activities; and provide a basis for the accountability of the local authority to the community; and to provide an opportunity for participation by the public in decision making processes"*

2.2.2 Annual Plan

The Annual Plan required under Section 95 of the LGA supports the LTP by providing for the co-ordination of local authority resources, contributing to the accountability of the local authority to the community and extending the opportunities for participation by the public in decision making relating to costs and the funding of local authority activities.

2.2.3 Performance Measures

The Secretary of Local Government is required to provide regulations that establish rules specifying performance measures for water supply; sewerage treatment / disposal; stormwater; flood protection and the provision of roads and footpaths. The performance measures relating to stormwater, wastewater and flood protection will need to be taken into account when developing solutions under the ICMP.

2.2.4 Trade Waste Bylaw

The DCC Trade Waste Bylaw 2008 regulates the discharge of Trade Waste to a Sewerage System operated by DCC. The purpose of the Bylaw is

> *"to control and monitor trade waste discharges into public sewers in order to… (v) protect the stormwater system."*

Section 4A of the Bylaw states that it is an offence to discharge stormwater into the stormwater system that does not satisfy the discharge acceptance standards outlined in Schedule 1E of the Bylaw. Schedule 1E contains a number of acceptance standards, including limitations on the quality of the stormwater.

2.3 Resource Management Act (1991)

The purpose of the Resource Management Act (RMA), as defined in Section 5 of the Act, is to promote the sustainable management of New Zealand's natural and physical resources. This is to be achieved by managing the use of resources, in a manner that allows for people and communities to provide for their social, economic and cultural wellbeing, while sustaining the potential of natural and physical resource to meet the needs of future generations; safeguarding the life supporting capacity of air, water, soil and ecosystems; and avoiding, remedying or mitigating adverse effects of activities on the environment.

Section 6; Matters of National Importance, Section 7; Other Matters and Section 8; Treaty of Waitangi outline values which all persons exercising functions and powers under the RMA shall recognise and provide for, have particular regard to and take into account when achieving the purpose of the RMA.

Sections 14 and 15 of the RMA place restrictions on taking and using water, and on the discharge of contaminants into the environment.

In relation to stormwater management, the RMA therefore addresses the following:

- The need to sustainably manage our water resources to meet the needs of future generations;
- The need to preserve the natural character of our coastal environment, wetlands, lakes, rivers and their margins;
- Recognising and providing for the relationship of Māori with their ancestral lands and water;
- The control of the use of land for the purpose of the maintenance and enhancement of the quality of water in water bodies and coastal water;
- The control of discharges of contaminants and water into water;
- The control of the taking, use, damming and diversion of water, and the control of the quantity, level and flow of water in any water body, including:
    i) The setting of any maximum or minimum levels or flows of water;
    ii) The control of the range, or rate of change, of levels or flows of water.

It is considered that the development and implementation of an ICMP which is consistent with the purpose and principles of the RMA, will allow for the identification of in-catchment values, such as drainage patterns and sensitive receiving environments. Management recommendations are then made based on the best practicable option, to ensure that the natural and physical environment within a stormwater catchment and its receiving environment are managed sustainably. This approach helps to ensure that the natural and physical resources within Dunedin's stormwater catchments are used in a way that provides for the community's social, economic and cultural wellbeing.

2.3.1 The New Zealand Coastal Policy Statement (2010)

The purpose of the New Zealand Coastal Policy Statement 2010 (NZCPS) is to outline policies relevant to the coastal environment to achieve the purpose of the RMA. The term 'coastal environment' is broad, and although undefined in the RMA, it is generally considered an environment in which the coast is a significant element or part.

The NZCPS requires persons exercising functions and powers under the RMA to:

- Safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land;
- Preserve the natural character of the coastal environment and protect natural features and landscape values;
- Take account of the principles of the Treaty of Waitangi, recognise the role of tangata whenua as kaitiaki and provide for tangata whenua involvement in management of the coastal environment;
- Maintain and enhance the public open space qualities and recreation opportunities of the coastal environment, enable people and communities to provide for their social, economic, and cultural wellbeing and their health and safety, through subdivision, use, and development; and
- Ensure that management of the coastal environment recognises and provides for New Zealand's international obligations regarding the coastal environment, including the coastal marine area (CMA).

Policies within the NZCPS contain potential restrictions on the activities likely to be undertaken in relation to stormwater management and have been considered when making recommendations within this ICMP. Policy 23 (2) and (4), addressing the discharge of contaminants has particular relevance for Dunedin city.

Policy 23(2)(a) does not allow discharges of human sewage directly to water in the coastal environment without treatment unless there has been adequate consideration of alternative methods, sites and routes for undertaking the discharge that have been informed by an understanding of tangata whenua values and the effects on them. DCC does not currently have any planned direct sewage discharges. However, the wastewater infrastructure network does have emergency overflow facilities to the coastal environment. These facilities are to accommodate emergency overflow discharges only. All discharges during non-emergency events are provided for through the existing wastewater network. Adequate consideration has been given to alternatives to a coastal discharge by providing an alternative for any non emergency events therefore the current discharge scenario is consistent with this policy.

Policy 23(4) outlines steps to be taken to avoid the effects of a stormwater discharge on water in the coastal environment. These steps include:

- Avoiding where practicable and otherwise remedying cross contamination of sewage and stormwater systems;
- Reducing contaminant and sediment loadings in stormwater at source, through contaminant treatment and by controls on land use activities;
- Promoting integrated management of catchments and stormwater networks; and
- Promoting design options that reduce flows to stormwater reticulation systems at source.

The ICMP process by definition promotes the integrated management of catchments. Recommendations made within the ICMP will incorporate the other steps outlined where appropriate or required as determined by the results of stormwater quality and quantity monitoring.

The Ravensbourne Road catchment discharges into the Otago Harbour, which links with the Pacific Ocean, therefore the NZCPS must be considered when developing and implementing the ICMP. The ICMP provides a detailed assessment of the effects of current land use and development within the Ravensbourne Road catchment on the Otago Harbour. It is considered that the ICMP approach is consistent with the holistic nature of the NZCPS, in particular Policy 23(4)(c), and that the stormwater management options considered by the ICMP, such as source control, treatment devices, low impact design, and community education, will ensure that the adverse effects of stormwater runoff on the coastal environment will be avoided, remedied or mitigated.

2.3.2 Marine and Coastal Area Act (2011)

The Marine and Coastal Area Act repeals the Foreshore and Seabed Act 2004, and removes Crown ownership of the public foreshore and seabed.

The Act provides that any part of the common marine and coastal area owned by a local authority will form part of the common marine and coastal area, divesting local authorities of those areas. Current freehold title in existing reclamations would remain.

The Act states that resource consents in the common marine and coastal area that were in existence immediately before the commencement of the Act are not limited or affected by the Act. Existing leases, licences, and permits will run their course until expiry. Coastal permits will be available for the recognition of these interests after expiry.

The Act provides that, while there is no owner of the common marine and coastal area, existing ownership of structures and roads in the area will continue. New structures can be privately owned. Structures that have been abandoned will vest in the Crown so that it can ensure that health and safety laws are complied with.

The Marine and Coastal Area Bill was enacted on 24 March 2011. Stakeholder consultation will incorporate discussion on the Marine and Coastal Area Act.

2.3.3 National Environmental Standards

While there are currently no National Environmental Standards (NES) relevant to this ICMP. It is assumed that NES will be developed in time for the type of activities covered under this ICMP. As local or regional councils must enforce standards imposed by a NES, the ICMP must be flexible enough to incorporate these standards.

2.3.4 The Otago Regional Policy Statement (1998)

The Otago Regional Policy Statement (ORPS) is an operative document giving effect to the RMA. The ORPS discusses issues, objectives and policies relating to managing the use, development and protection of the natural and physical resources of the region. The ORPS identifies regional issues and provides a policy framework for managing environmental effects associated with urban and rural development.

The ICMP is influenced by the ORPS and the planning documents which sit below it (i.e. the Regional Plans). There are a number of policies contained within the ORPS which are relevant to the ICMP. Of particular relevance are Policies 6.5.5, 7.5.3, 8.5.6, 9.5.4 which seek to reduce the adverse effects on the environment of contaminant discharges, through the management of land use, air discharges, coastal discharges and the built environment. The management options discussed include adopting baseline water quality standards and where possible improving the quality of water to a level above these baselines. The policies mentioned give general guidance to any stormwater management initiatives within the Region by identifying anticipated environmental outcomes. This general guidance is the main starting point for determining the direction of the ICMP.

The ORPS also addresses natural hazards in Policies 11.5.2, 11.5.3 and 11.5.4. These policies give direction to hazard management through outlining steps that should be taken to avoid or mitigate the effects of natural hazards. These over arching policies may play a significant role in providing direction for the ICMP if natural hazards (such as flooding) are determined to be a priority.

The ORPS was due for full review in October 2008 however at the time this report was written the review process had not been initiated.

2.3.5 The Regional Plan: Coast for Otago

The purpose of the operative Regional Plan: Coast for Otago (Coastal Plan) is to provide a framework to promote the integrated and sustainable management of Otago's coastal environment. The Coastal Plan recognises that the coastal environment is one of the integral features of the Otago Region, and that it is dynamic, diverse and maintained by a complex web of physical and ecological processes. One of the principle considerations for this ICMP is the discharge of contaminants into the CMA.

Chapter 10 of the Coastal Plan addresses the discharge of contaminants to the CMA. This chapter contains a number of policies addressing issues such as: the effects of any discharge on Käi Tahu values; avoiding effects on coastal recreation areas; areas of significant landscape or wildlife habitat value; water quality; mixing zones; and discharge alternatives.

Policy 10.4.1 states that for any discharges to the CMA that are likely to have an adverse effect on cultural values Käi Tahu will be treated as an affected party. Details relating to issues of particular significance are contained within the Käi Tahu ki Otago Natural Resource Management Plan which is addressed below.

Objective 10.3.1 seeks *"to maintain existing water quality within Otago's coastal marine area and to seek to achieve water quality within the coastal marine area that is, at a minimum, suitable for contact recreation and the eating of shellfish within 10 years of the date of approval of this plan".* Further, Policy 10.4.3 states that where water quality already exceeds these standards, water quality should not be degraded beyond the limits of a mixing zone associated with each discharge

2.3.6 The Regional Plan: Water for Otago

The operative Regional Plan: Water for Otago (Water Plan) considers the use, development and protection of the fresh water resources of the Otago region, including the beds and margins of water bodies. Chapter 7 of the Water Plan outlines objectives and policies to address those issues relating to water quality and discharges.

Policies 7.7.3, 7.7.4, 7.7.5 and 7.7.7 outline matters which need to be considered when assessing resource consents for discharges including cumulative effects, the sensitivity of the receiving environment and any relevant standards. Policies 7.7.10 and 7.7.11 address stormwater systems directly, identifying required outcomes for new systems and requiring the progressive upgrade of older systems. These policies provide both general and specific guidance for any stormwater system or associated discharge within the Ravensbourne Road catchment and play a strong role in determining the suitability, consentability and priority of any management option chosen under the ICMP.

2.3.7 The Dunedin City District Plan

The operative Dunedin City District Plan contains objectives, policies and methods to manage the effects of land use activities on the environment.

The Dunedin City District Plan applies to all users of land and the surface of water bodies within the city; It is concerned with all areas above the line of mean high water spring (MHWS) tide. Issues pertaining to those areas below the line of MHWS, including coastal waters, are addressed in the Otago Regional Plan: Coast for Otago and the NZCPS.

Policy 21.3.1 seeks to protect the harvest potential and quality of water within catchments. Policy 21.3.8 seeks to avoid or otherwise remedy or mitigate the adverse effect of activities which discharge to water, land or air. While standards relating to water quality are the jurisdiction of ORC, the policies contained within the Dunedin City District Plan address the effects of land use on water quality, for example, through the consideration of matters such as stormwater runoff from subdivisions.

The Dunedin City District Plan also uses land use zoning as a method of regulating activities under DCC jurisdiction. The Ravensbourne Road catchment consists of Industrial 1, Stadium and Rural land uses. Activities which are permitted to occur within the Industrial 1 Zone include: industrial activity, service activity, retail activity specific to and complimentary to industrial or service activity, recreational

The Stadium Zone is divided into three distinct areas: the Stadium Building Area; Stadium Parking Area; and Leith Access Area. The Dunedin City District Plan rules permit activities within the Stadium Building Area relating to spectator events, conference and campus activities. Within the Stadium Parking Area, stand alone parking and parking for permitted activities occurring in the Stadium Building Area are permitted. Activities permitted within the Leith Access Area relate to pedestrian access and construction activities associated with authorised maintenance of the Water of Leith.

The Rural Zone rules permit activities such as farming, recreation, forestry and mineral prospecting and exploration. Limited residential activity is also permitted.

Careful consideration will need to be given to this land use zone and any potential changes to this zone when looking at management options under the ICMP, as different land uses produce different stormwater quantities and quality outputs. It may also be that data obtained during the development of the ICMP provides input into future land use zoning within the Dunedin City District Plan.

2.4 Building Act (2004)

The Building Act 2004 includes Sections 71 to 74 which relate to limitations and restrictions on building consents and the construction of buildings on land subject to natural hazards. Flooding is the primary natural hazard of concern within the Ravensbourne Road catchment therefore the ICMP must highlight areas where future development may exacerbate the risk of flooding.

The Building Regulations 1992 include the Building Code, which provides guidance as to the implementation of the Building Act. Section E of the Building Code includes various performance criteria relating to stormwater systems which are relevant to the ICMP. These criteria are specific to managing natural hazards and include drainage system design and inundation probability criteria. The ICMP will need to reference the performance criteria outlined within the code when identifying management options.

2.5 Civil Defence Emergency Management Act (2002)

The Civil Defence Emergency Management Act 2002 (CDEMA) addresses the management of emergencies including flooding. Section 64(1) of the CDEMA outlines the duties of local authorities and states:

> *"A local authority must plan and provide for civil defence emergency management within its district."*

Producing flood maps as part of the ICMP process may be one method of providing for civil defence emergency management however this method is not specifically prescribed by the CDEMA and therefore is at the discretion of the local authority concerned.

2.6 Non Statutory Documents

2.6.1 Käi Tahu ki Otago Natural Resource Management Plan

Käi Tahu ki Otago Natural Resource Management Plan (Käi Tahu Plan) provides a background to Käi Tahu's resource management issues in the Otago Region. The Käi Tahu Plan contains management guidelines and objectives relating to freshwater fisheries and coastal resources. Käi Tahu are particularly concerned with the destruction of the freshwater resource as a result of piping and channelisation, the mauri and life supporting capacity of water being compromised by structures and point source discharges, and the depletion of coastal fisheries due to discharges to the CMA.

The ICMP should consider the specific concerns of Käi Tahu where they are not addressed by the regional or district statutory planning documents, and should ensure that Käi Tahu are considered as a potentially affected party where appropriate.

2.6.2 Code of Subdivision and Development

Chapter 18 Subdivision, of the Dunedin City District Plan, contains Method 18.4.1 which makes reference to the Dunedin Code of Subdivision and Development. This code is not part of the District Plan but does contain guidelines, including levels of service, for any physical works (such as kerb and channel design), associated with subdivision activities and is considered by DCC when assessing consent applications. Stormwater targets and management options proposed by this ICMP should ensure that this code is complied with. It is likely that the content of the ICMP will also help shape the future direction of the Code.

2.6.3 The Dunedin City Council Sustainability Framework

This framework is a relatively new non-statutory document which has an overarching influence in all aspects of DCC's operations and decision making through the following sustainability principles:

- Affordable: reasonable cost, value for money, today / future costs.
- Environmental Care: clean energy, bio-diversity, safe.
- Enduring: forward looking, whole of life, long term, future generations.
- Supporting People: social connectivity, social equity, quality of life, safe.
- Efficient: using less, creating less waste, smarter use.

These sustainability principles will influence the content of this ICMP and any recommendations with regard to future capital works.

2.6.4 3 Waters Strategic Direction Statement and 3 Waters Strategic Plan

The purpose of the 3 Waters Strategic Direction Statement is to align the management of Dunedin's three waters activities with the city's sustainability principles. This document provides direction for the detailed 3 Waters Strategic Plan which will be largely influenced by the content of all the ICMPs. It is through the 3 Waters Strategic Plan that the ICMPs will provide input to long term community planning objectives and ultimately, Activity Management Plans (AMPs) and capital works programmes for stormwater.

2.6.5 Activity Management Plans

The DCC stormwater, wastewater and water supply AMPs contain objectives, levels of service, methods for delivering this service, asset management and levels of funding in relation to each activity. These plans are developed through the long term community planning process. The ICMP provides input to the content of the AMPs through its contribution to the 3 Waters Strategic Plan.

2.7 Resource Consents

This section outlines the classifying rules in the Dunedin City District Plan and the Water and Coastal Plans that are relevant to the activities likely to occur under the ICMP.

While there are no rules within the Dunedin City District Plan classifying the discharge of stormwater, the ICMP needs to be consistent with the policies and objectives of the Dunedin City District Plan as described in Section 2.3.7, by incorporating further investigations of the system and environment and monitoring any discharges that are occurring.

Most consent requirements will be addressed by The Regional Plan: Water for Otago and The Regional Plan: Coast for Otago. The Dunedin City District Plan however, contains methods for addressing water quality issues through investigations, monitoring, education, consultation and the creation of management plans such as this ICMP.

Rule 10.5.3 of the Regional Plan: Coast for Otago classifies the discharge of stormwater into the CMA as a permitted activity provided certain conditions are met. These conditions include restrictions on the type of discharge, the receiving environment and any effects of the discharge.

Stormwater discharge from the Ravensbourne Road Catchment is unlikely to comply with the conditions of the Rule 10.5.3 due to the catchment containing industrial or trade land uses. Any stormwater discharge would therefore be classified as a controlled activity under Rule 10.5.3.2 and would require resource consent with ORC exercising its control over matters such as: the location; volume; rate; and nature of the discharge.

It is recommended that the objectives of the ICMP should be aligned, as closely as possible, with the permitted activity rules to enable the objectives of the Coastal Plan to be met, where possible.

Rules 12.4 and 12.5 of the Regional Plan: Water for Otago classify the discharge of stormwater and the discharge of drainage water to water.

Rule 12.4.1 classifies the discharge of stormwater to water as a permitted activity provided that certain conditions are met. These conditions, among others include that; the discharge does not contain any human sewage, the discharge does not cause flooding of any other person's property, erosion, land instability, sedimentation or property damage and does not produce any conspicuous oil or grease films, scums or foams, or floatable or suspended materials or objectionable odours.

Should the conditions outlined in this rule not be met then the discharge of stormwater to water will be classified as a restricted discretionary activity requiring resource consent.

Rule 12.5.1 classifies the discharge of drainage water to water as a permitted activity provided the discharge does not cause flooding of any other person's property, erosion, land instability, sedimentation or property damage and does not produce any conspicuous oil or grease films, scums or foams, floatable or suspended materials or objectionable odours.

If the conditions outlined in Rule 12.5.1 cannot be satisfied, then the discharge of stormwater to water will be classified as a restricted discretionary activity requiring resource consent.

The objectives of the ICMP should be aligned as closely as possible to the permitted activity rules to enable the objectives of the Water Plan to be met where possible.

2.8 Objectives of Stormwater Management

2.8.1 Strategic Objectives

The strategic objectives of stormwater management are outlined in Table 2-1 below and provide the overarching objectives that guide the development of this ICMP. These objectives are at the core of the relevant statutory and non-statutory documents addressing stormwater management, including the 3 Waters Strategic Direction Statement. These objectives have been developed with the aim of achieving benefits across the four wellbeings (environmental, social, economic and cultural), and have been set within the context of a 50 year timeframe.

Table 2-1: Strategic Stormwater Management Objectives

Strategic Objectives
Development: Adapt to fluctuations in population while achieving key levels of service and improving the quality of stormwater discharges. Ensure new development provides a 1 in 10 year level of service, and avoids habitable floor flooding during a 1 in 50 year event.
Levels of service: Maintaining key levels of service of the stormwater network into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.
Environmental outcomes: Improve the quality of stormwater discharges to minimise the impact on the environment and reduce reliance on non-renewable energy sources and oil based products.
Tangata whenua values: Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges.
Natural hazards: Ensure there will be no increase in the numbers of properties at risk of flooding from the stormwater network.
Affordability: To meet strategic objectives while limiting cost increases to current affordability levels where practical.

2.8.2 Activity Management Plan / LTP Objectives and Targets

Table 2-2 outlines shorter term objectives, performance measures and targets derived from DCC's stormwater AMP and LTP. These objectives are to be reviewed annually but are set within the context of a 10 year timeframe. Therefore the measures and targets below may be subject to development or change based on findings from the ICMP development process. Influencing factors may include stormwater modelling results, or further research into costs surrounding changes to levels of service.

DCC also intend to begin reporting on a number of additional measures and targets relating to service provision. The ICMP development should inform this process, and help to identify the most appropriate measures and provide baseline information. It is intended that the following areas will be able to be reported on following the ICMP completion if appropriate and necessary:

- Number of written complaints;
- Number of properties with habitable floor stormwater flooding;
- Percentage of customers with stormwater provision that meets current design standards;
- Percentage of modelled network able to meet a 1 in 10 year storm event; and
- Number of properties at risk of stormwater flooding in a 1 in 10 year event.

Table 2-2 Activity Management Plan Measures and Targets

Objective	Performance Measure	2010 / 2011 Target	2021 Target
Stormwater Quality	Residents' satisfaction with the stormwater collection service	≥ 60 %	≥ 70 %
	Number of blockages in the stormwater network per 100 km of mains per annum	< 15	< 10
	Number of beach closures	0	0
Service Availability	Percentage of customer emergency response times met (stormwater)	≥ 95 %	≥ 95 %
Demand Management	Completion of stormwater catchment management plans	as plan	To be completed by 2013
Environmental Consent Compliance	Percentage compliance with stormwater discharge consents	≥ 75 %	tbc
	Number of prosecutions or infringement notices for non-compliance with resource consents	0	0
	Number of recorded breaches of RMA conditions	0	0
Asset Serviceability	Number of breaks per 100 km of stormwater sewer per annum	< 1	< 1
	< X % of critical network assets in condition grade 4 or 5	To increase % of known data	tbc
Supply Cost per m^3	Drainage uniform annual charge as a percentage of median income	≤ 1 %	≤ 1 %
	Total operational cost of stormwater service per rated household	$ 76.70	tbc

tbc: to be confirmed.

3 Consultation

During the application for coastal discharge consents in 2005, through Annual Plan consultation and through specific consultation in relation to the 3 Waters Strategy, a number of stakeholders have been identified as affected by, or interested in stormwater management in Dunedin. The following provides a summary of values identified through the consultative processes mentioned. These values have been considered when developing objectives and options for stormwater management of identified issues.

3.1 3 Waters Strategy Consultation- Stakeholder Workshops and Community Survey

For specific consultation relating to the 3 Waters Strategy, stakeholders were divided into three groups; environmental, economic / business and social / cultural. The outcomes of the specific consultation workshops were used to inform a community telephone survey to gauge the views of the wider community including catchment residents. Specific groups were also consulted directly, including: Käi Tahu ki Otago, ORC and East Otago Taiapure Management Committee From all consultation relating to the 3 Waters Strategy there was a general recognition that stormwater requirements and standards will need to increase, in terms of both quality and volume management.

A coordinated approach to stormwater management between ORC and DCC is desired; with the responsibilities for each organisation being clarified.

Overall, increasing the sustainability and efficiency of the network is also desired.

Views Relating to Quality

- A high awareness that stormwater contains many contaminants, and thus its management is not just a matter of transportation to the coast.
- That quality involves household drains and farm runoff as well as road runoff and sewage contamination.
- Recognise that the stormwater system does include recreational places, which underlines the need for better quality stormwater
- Improving quality of disposed stormwater is a key issue – the higher the quality, the better.

Views Relating to Volume

- Recognition that climate change may result in more frequent storm events, thus putting a greater episodic demand on the system; and thus likely to require increased capacity. This may be compounded by decreases in permeable land resulting from increased property development in certain areas.
- That managing volumes (which is partially related to quality) requires a more encompassing view of the system and its management.

In summary, the consultation identified that the key points in relation to stormwater management were:

- Legislative changes, e.g. changing planning or building consents standards to further reduce the impact of new developments on stormwater;

- Passive changes, e.g. increasing the use of swales and soakholes to better manage storm events, using landscaping to reduce the visual pollution of outfalls;

- Active changes, e.g. increasing outfall pipe numbers to reduce the impact in any given area; increasing treatment standards; installing low-flow regulators;

- Doing more than simply increasing pipe capacity – i.e. review requirements for new property developments, in order to reduce runoff volumes and minimise the loss of permeable land; and

- Consideration of sustainable options e.g. stormwater captured and used by households; implementing alternative energy sources for pump stations (such as wind turbines or micro hydro-electricity generators). In rural areas, also capture stormwater in detention ponds, both to slow flows and prevent flooding but also to balance with demand for other water-use activities e.g. irrigation.

During the development of the 3 Waters Strategic Direction Statement, objective setting took the results of the community consultation into account, for example by incorporating statements relating to the use of source control for stormwater management. The ICMP approach to stormwater management also considers a range of management options for stormwater, described as 'legislative, passive and active' changes above.

3.2 Resource Consent Submissions

The resource consent process for the coastal discharge permits identified the residents within the affected catchments as interested parties. Matters raised by submitters in relation to coastal stormwater discharge permit applications are also a valuable source of stakeholder opinion. A majority of the submissions echo the views outlined above however the Käi Tahu cultural impact assessment (CIA) outlined below goes into more detail. As part of the consent conditions for stormwater discharges, annual meetings are held with Save the Otago Peninsula Society Incorporated, and the Department of Conservation (DOC) Otago Conservancy.

3.2.1 Käi Tahu Cultural Impact Assessment

In October 2005, DCC commissioned Käi Tahu ki Otago Limited (KTKO Ltd.) to undertake a CIA (KTKO Ltd., 2005) on the discharge of stormwater into Otago Harbour and at Second Beach. This report was commissioned as part of the consent application process for the current discharge consent held for this catchment.

The report details historical use of the Otago Harbour by Käi Tahu and their descendents, particularly for transport and as a food resource (mahika kai).

The report studies the reported levels of contaminants in the stormwater discharged to the harbour, and also in sediments within the harbour, and states that runanga are concerned about the lack of information on biological impacts, on effects further afield than the immediate area of discharge, and that they are also concerned about the possibility of wastewater discharge into the harbour. Resource consent conditions for the current stormwater discharges include sampling and monitoring of sediments within the wider harbour, and biological monitoring. At present, given the size of the receiving environment, sampling and monitoring as part of the resource consent conditions is limited, and restricted to once per year and in a small number of locations. As sampling continues, understanding of the biological impacts of the stormwater discharges should increase.

Discharge of stormwater and associated contaminants has the potential to significantly impact Käi Tahu values and beliefs. These adverse impacts are associated with effects on the spiritual value of water, mahika kai, aquatic biota and water quality.

The traditional resource management methods of Käi Tahu require coordinated and holistic management of the interrelated elements of a catchment, from the air to the water, the land and the coast. The CIA notes that it is accepted by Käi Tahu that removal of all contaminants from stormwater is not possible. However, it is also considered that more could be done to reduce the level of contaminants discharged. Recommended management measures for consideration are as follows:

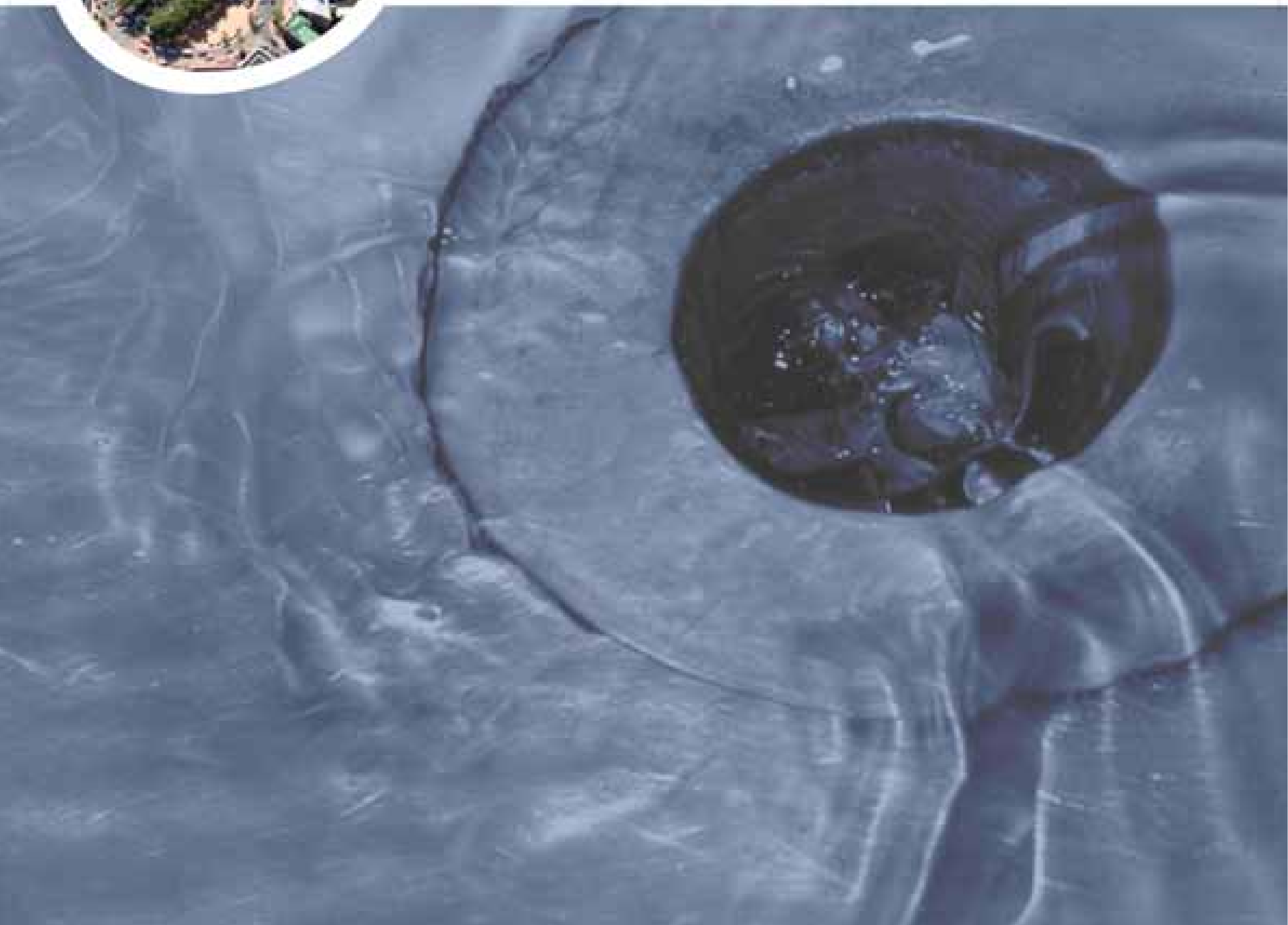
- Reducing the area of impervious land;
- Use of grass swales to filter stormwater;
- Covering car-parking areas and other areas where increased contaminants may be found;
- Sediment / grease traps to be installed at all industrial premises, petrol stations and car parks;
- Management plans for industrial and commercial facilities to minimise the contaminant loading into stormwater, including the management of spills;
- Ensuring industrial waste is not discharged to the stormwater system;
- Ensuring there is no discharge of human sewage to the stormwater system; and
- Ongoing awareness of best management practices and technological improvements that will reduce contaminant levels and a willingness to implement these as appropriate.

As with the wider community consultation results, it is considered that the ICMP approach to stormwater management encompasses much of what is desired by Käi Tahu, as described above. The 3 Waters Strategic Direction statement objectives used by this ICMP support the use of source control and low impact design options for stormwater management, as suggested above by Käi Tahu, as well as looking to reduce the incidence of wastewater discharge into the receiving environment.

3.3 Annual Plan Submissions

A number of submissions were made with respect to stormwater issues through the 2009 Annual Plan consultation process. These submissions mainly centred on the maintenance and upgrade of the existing system so to ensure adequate treatment and filtration of the stormwater prior to it being discharged. The issue of infrastructure capacity was also raised.

Part 2
Baseline



4 Catchment Description

4.1 Catchment Location

The Ravensbourne Road catchment is relatively small, covering an area of approximately 25 ha (refer Figure 4-1). Land use consists primarily of industrial lots on flat, harbourside land below steep bush covered hillside adjacent to a quarry. There are some small areas of road, including State Highway.

The flat industrial area and roads are drained via two stormwater pipe networks which discharge to the harbour. Runoff from the hillside is collected via a natural gulley which is intercepted at Ravensbourne Road and diverted via pipework and an open channel to the harbour.

Stormwater from the recently constructed Harbourside Arterial link (including a small part of the western end of the Ravensbourne Road catchment) is collected and stored in a stormwater detention pond, prior to discharging into the stormwater system at the western end of Magnet Street.

There are three outfalls discharging into the harbour within the tidal range. None have flap valves fitted The gully draining the catchment above Ravensbourne Road had a very small amount of flow when visited and is suspected to be ephemeral in nature, given the small catchment area.

The excavation of a quarry has reduced the area of steep hillside draining to Ravensbourne Road, thus significantly modifying the upper catchment drainage area and may have contributed to changes in the original flow regime. Some areas of the quarry are believed to contribute to the catchment at the high point based on LiDAR (light detecting and ranging) data, but the majority of the adjacent quarry drains elsewhere.

4.2 Topography and Geology

Figure 4-2 provides a contour map and Figure 4-3 a geological map of the catchment (Bishop & Turnbull, 1996). The catchment topography reflects the catchment geology. The coastal margins of the catchment, south of Ravensbourne Road, are low lying with a flat gradient and the geological material present in this low lying coastal area is of late Quaternary age (Q1an) and consists predominately of unconsolidated and unsorted material from a variety of sources that were deposited on the shoreline to reclaim seabed. The deposits include gravels, sands, marine silts and clays, most likely combined with anthropogenic materials from industrial and domestic waste, including mine tailings from the adjacent quarry operation. Drainage capabilities of this material will be variable, depending on the specific materials used in different areas of the reclamation.

The flat area of the catchment is contrasted by steep hills that rise sharply to the north of Ravensbourne Road, to a peak elevation of approximately 175 m above MSL over a horizontal distance of approximately 400 m. Ravensbourne Road has been cut into the base of the hills, which is evident through the near vertical rise in the land surface immediately adjacent to the road. A gully in the mid part of the catchment is likely to drain some overland runoff. The geology of the hills is characterised as volcanic deposits of basalt of the late to mid Miocene age (i.e. 11,000 to 15,000 years before present). The igneous rock is very resilient to erosion which is reflected in the topography by the lack of surface features that are generally formed by runoff erosion.

4.3 Surface Water

The catchment does not have an extensive natural stream network, one small gully exists through the hillside directly to the north of the culvert beneath Ravensbourne Road. This is likely to be ephemeral in nature. The stream flows down a waterfall, approximately 5 m high, before entering the stormwater network on Ravensbourne Road. The hills direct any runoff water down the steep slopes, to be captured at the base of the hills by the roadside drainage network. Flow is conveyed, via a culvert, under the road and into an open drain which discharges at the coast.

4.4 Groundwater

There is limited information relating to groundwater surface levels in the Ravensbourne Road catchment. However, based on limited information on the catchment geology, a conceptual understanding of the groundwater system has been developed.

Groundwater is likely to be limited to the coastal flats area and more likely to present in ‘natural’ water form (i.e. not saline) near the mouth of the Water of Leith. The tidal levels / range is likely to be representative of the groundwater elevation in the coastal area. However, the variability of the material associated with the reclaimed land suggests that groundwater may be perched in some areas where marine sediments have been deposited. Where gravels and sands are present in the lithology, the groundwater flow is expected to be towards the coast.

The basalt rocks in the north of the catchment may contain a fractured rock groundwater system. However, as there are no wells drilled in the catchment area, it is difficult to ascertain the extent of any fractured rock groundwater. Nevertheless, water that infiltrates the basalt is expected to move vertically down through fractures until it intercepts the quaternary groundwater system. Open pit quarries are located immediately to the north of the catchment boundary, within the same basalt material. Arial photographs of the quarries indicate the presence of surface water. It is unknown if this water is associated with surface runoff or groundwater seepage. However, it is likely to be the dominated more by the former.

There is no information currently available on the quality of the groundwater resource in this catchment. However, given the reclaimed nature of the coastal flats which have been used extensively for industrial purposes since the 1950’s (including extensive use of the land as a petroleum tank farm), it is possible that contamination of the groundwater system may have occurred. The extent of the potential contamination is not known.

DUNEDIN CITY COUNCIL / OPUS / URS	Dunedin 3 Waters Strategy	RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN **Figure 4-1** **Ravensbourne Road Catchment Location**	DISCIPLINE Stormwater	Drawn: MM; Checked: HES; Approved: SDH; Date: Sep 2011; Status: Final; Scale: 1:20,000; Plot Date: Sep 2011; Job. No: 42173227; Map No: Figure 4-1; Revision: -

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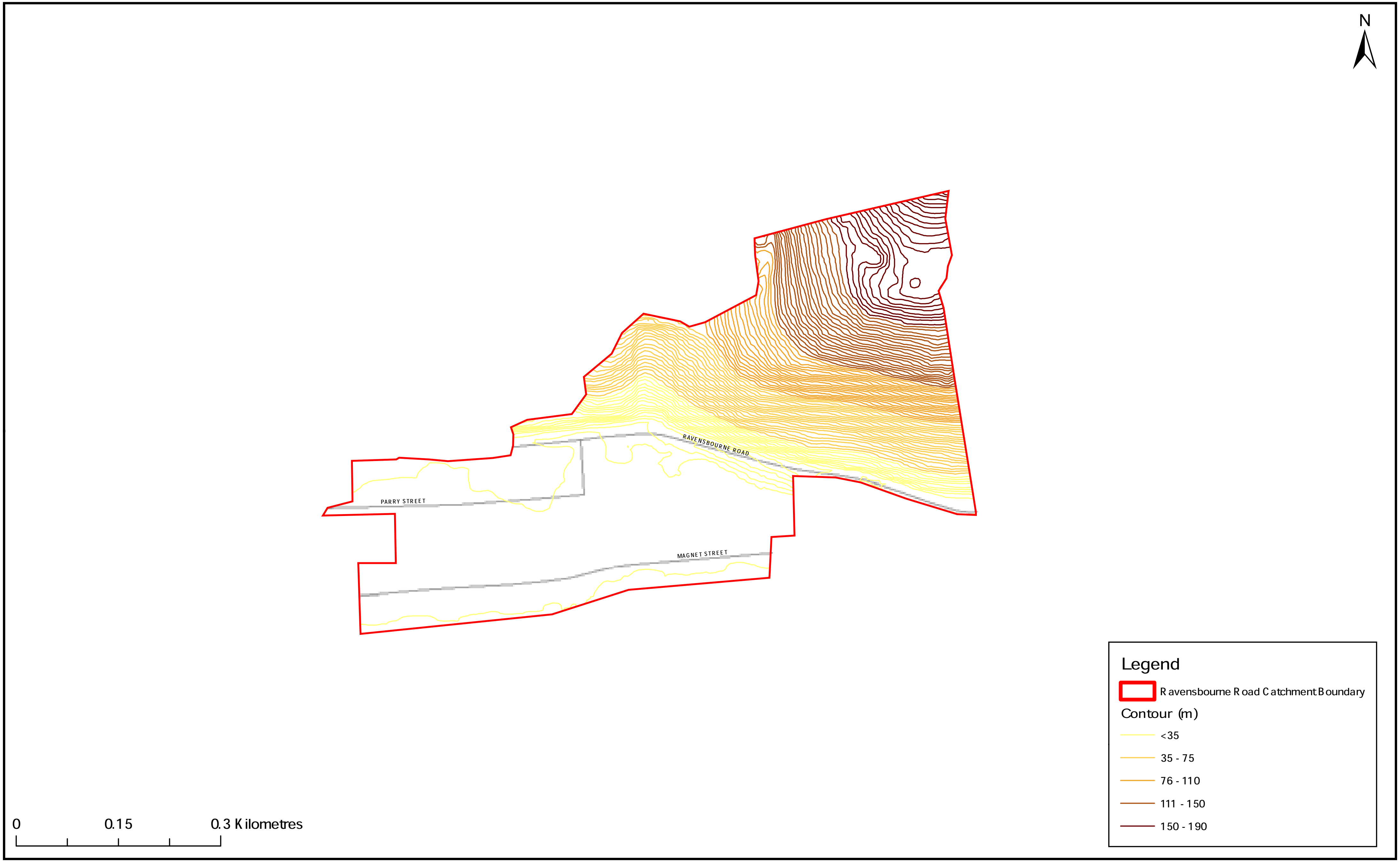

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Dunedin 3Waters Strategy

RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-2

Ravensbourne Road Catchment Contour Map

DISCIPLINE

Stormwater

Drawn: KC	Status: Final		
Checked: HES	Scale: 1:5000	Plot Date: July 2010	
Approved: SDH	Job No: 42173227	Map No: Figure 4-2	Revision: -
Date: July 2010			

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Dunedin 3 Waters Strategy	RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-3 Ravensboune Road Catchment Geology Map	DISCIPLINE Stormwater	Drawn: KC	Status: Final		
			Checked: HES	Scale: 1:5,000	Plot Date: Sep 2011	
			Approved: SDH	Job. No: 42173227	Map No: Figure 4-3	Revision: -
			Date: Sep 2011			

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4.5 Land Use

4.5.1 Historical and Current Land Use

The historical land use of the Ravensbourne Road catchment has changed little over time. The hill country within the catchment area is believed to have remained essentially unchanged, with the slopes covered in bush and scrub. It is not known to have been farmed; however, an area of plantation forest currently exists. The coastal flat area comprises reclaimed land, which was mainly formed between 1909 and 1921 to support a rail link between the industrial area on the reclaimed land and Port Chalmers.

Aerial photographs indicate that the reclaimed land was not extensively utilised until after the 1950's. Records indicate, however, that land use prior to the 1950's was industrial with activities such as wool storage and timber processing and storage occurring on Parry Street.

The petroleum tank farm on Ravensbourne Road is the first major industrial activity to occur in the catchment. Post 1950's. Other industrial activities shortly followed, with aerial photographs showing extensive areas of wood and wood products being stored in the open, records indicate wool scouring and tanning processes also occurred here in the 1980's. Between the 1970's and 1990's there has been an increase in covered buildings in the catchment and a reduction in the open storage of wood products.

There are has been no residential housing within the catchment in the past, with the land use on the reclaimed land essentially industrial in nature.

The current land use is not significantly different to the historical use (Figure 4-4). The coastal flat area which was reclaimed is still used for industrial purposes. The land use zoning for the majority of this area in the Dunedin City District Plan is Industrial 1, with a small area to the west of the coastal flat zoned for the new stadium. The two main land owners of the industrial land are DCC and BP New Zealand Limited. Seaward of the railway line the land is designated as a recreational reserve. The hills to the north of Ravensbourne Road are covered in bush and plantation forest and are classified in the DCC District Plan as a Rural.

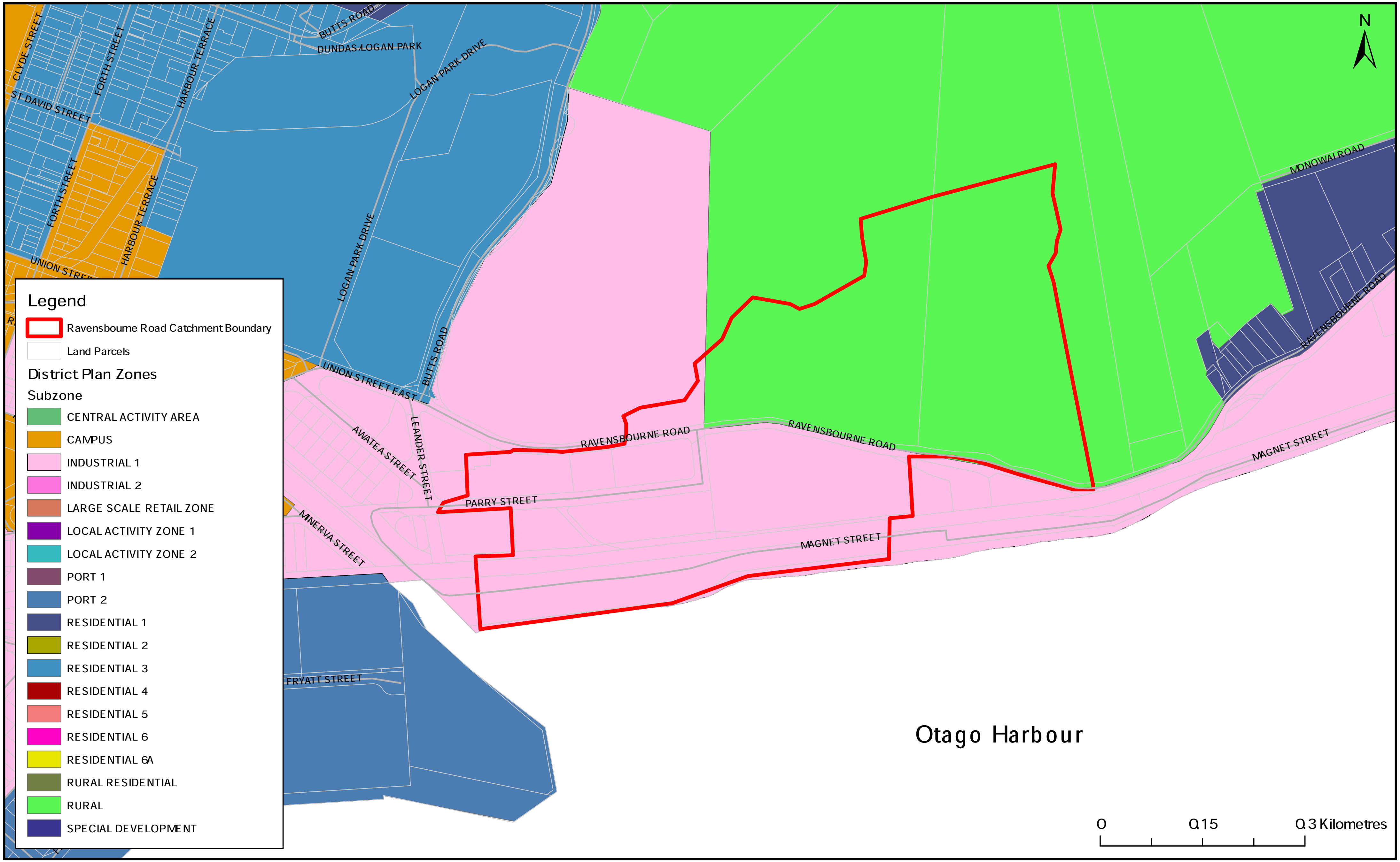
4.5.2 Cultural and Heritage Sites

According to DCC records of significant archaeological and heritage sites within Dunedin city, there are no significant archaeological or heritage sites within the Ravensbourne Road catchment and no specific sites that have been identified as culturally significant.

Māori cultural values are discussed further in Section 3.3, along with those of other stakeholders throughout Dunedin's community. Käi Tahu has been identified as a key stakeholder. It should be noted that coastal and freshwater environments hold particularly high values for Käi Tahu.

The Otago Boat Harbour Recreation Reserve occupies land, located on Magnet Street in the south of the catchment. The Reserve is a narrow strip of land, averaging about 30 metres wide and has a southerly aspect. It is about one kilometre in length, stretching from the mouth of the Water of Leith to Black Jacks Point. This area is highlighted in Figure 4-10, highlighted as a 'social minor' location.

The recreational value of the Reserve is based on its accessibility to the water's edge and also that several clubrooms for water related activities exist in the reserve. It is also used as a passive recreational area, for the Harbour views and for watching the activities on the water. DCC reports that this Reserve has high use.



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DUNEDIN CITY COUNCIL / OPUS / URS	Dunedin 3 Waters Strategy	RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-4 Ravensbourne Road Catchment Land Use Zones	DISCIPLINE Stormwater	Drawn: KC Checked: HES Approved: SDH Date: Sep 2011	Status: Final Scale: 1:5,000 / Plot Date: Sep 2011 Job. No: 42173227 / Map No: Figure 4-4 / Revision: -

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4.5.3 Resource Consents and Designations within the Catchment

Information has been provided by ORC and DCC with respect to resource consents granted in Dunedin city and city-wide District Plan Designations.

A number of consents have been granted, by ORC and DCC, within the Ravensbourne Road catchment. There are no other significant resource consents granted relating to stormwater management within the catchment. However, there are a number of consented discharges to the CMA from a series of outfalls from the Ravensdown Fertiliser Co-operative, which occupies a site adjacent to this catchment to the east. The consented discharges include: cooling water, process water, washdown water, stormwater and scrubber liquid from the fertiliser works.

DCC has granted a number of land use consents, the effects of which have been incorporated into the future catchment imperviousness calculations (Appendix B).

A number of District Plan Designations exist within this catchment, primarily for transport purposes. These include the existing Main South Railway in the south of the catchment and Ravensbourne Road (State Highway 88), which runs through the catchment.

An area of land in the west of the catchment is designated for the construction and operation of an arterial road corridor, known as the Harbourside Arterial Link. It is proposed to realign and extend the State Highway road corridor to connect to Ravensbourne Road. The physical works include the widening and realignment of the route north of Willis Street, construction of a new corridor, new road crossings of the railway corridor, a new bridge across the Water of Leith and a new entrance into the Boat Harbour. Work in this area has resulted in a change to the stormwater catchment boundary, however the effects on the discharge, and this ICMP are minimal. A stormwater detention pond has been constructed to manage flows and stormwater quality from the roading corridor, however this is under the control of the New Zealand Transport

Figure 4-5 provides the location of the resource consents granted by DCC and District Plan designations within the Ravensbourne Road catchment.

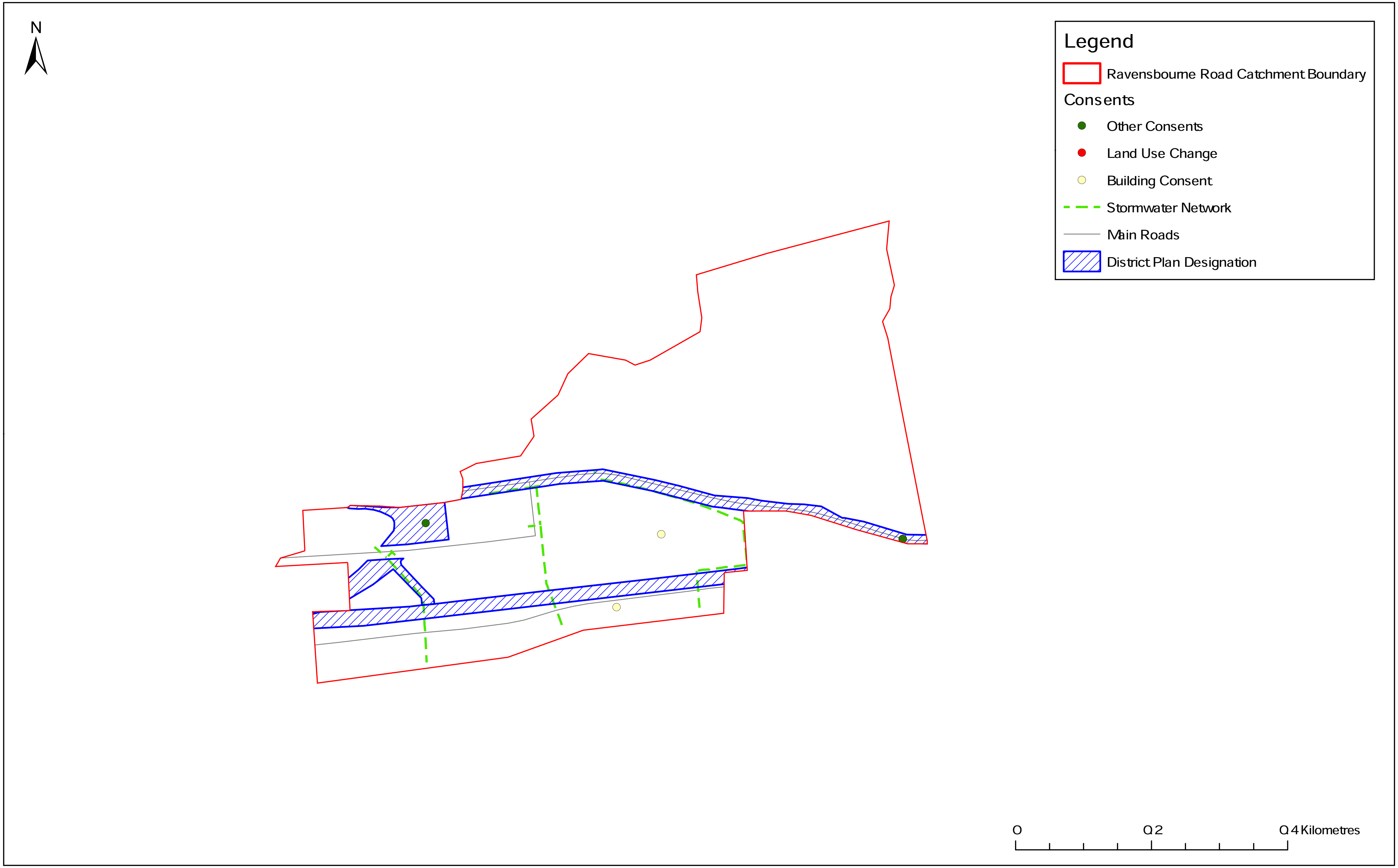
4.5.4 Contaminated Land

Data was collated from both ORC and DCC with respect to contaminated land around Dunedin city. It should be noted that the information available on contaminated land sites may be incomplete, and the extent of remediation is unknown in some instances.

Figure 4.6 provides the location of the known contaminated land sites within the Ravensbourne Road catchment. There may be further sites around the catchment, but any information relating to these sites is not available at this time.

To the west of the catchment within the site boundary for the new stadium, there is a contaminated site (77 Parry Street). This site was in use as a saw mill and timber storage area from approximately 1948 until 1980, where the site was issued with consents for tanning and woolscouring. Tanning and woolscouring activites continued until at least 1993, however prior to the stadium project the site was used for container unloading, storage and distribution of goods (SKM, 2006).

There is also a large area of reclaimed land adjacent to the harbour. Various and unknown types of fill may have been used during land reclamation, the fill material may contain contaminants, as discussed in Section 4.2.



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Dunedin 3 Waters Strategy

RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-5
Ravensbourne Road Catchment Recent Consents and Designations

DISCIPLINE
Stormwater

Drawn: KC	Status: Final		
Checked: HES	Scale: 1:5,000	Plot Date: Sep 2011	
Approved: SDH	Job. No: 42173227	Map No: Figure 4-5	Revision: -
Date: Sep 2011			

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Dunedin Three Waters Strategy

RAVENSBOURNE INTEGRATED CATCHMENT MANAGEMENT PLAN

FIGURE 4-6
CONTAMINATED LAND SITES WITHIN THE CATCHMENT

Discipline:

Stormwater

MG	Final		
LB	NTS	November 10	
HS	3-d1040.07		
November 10			

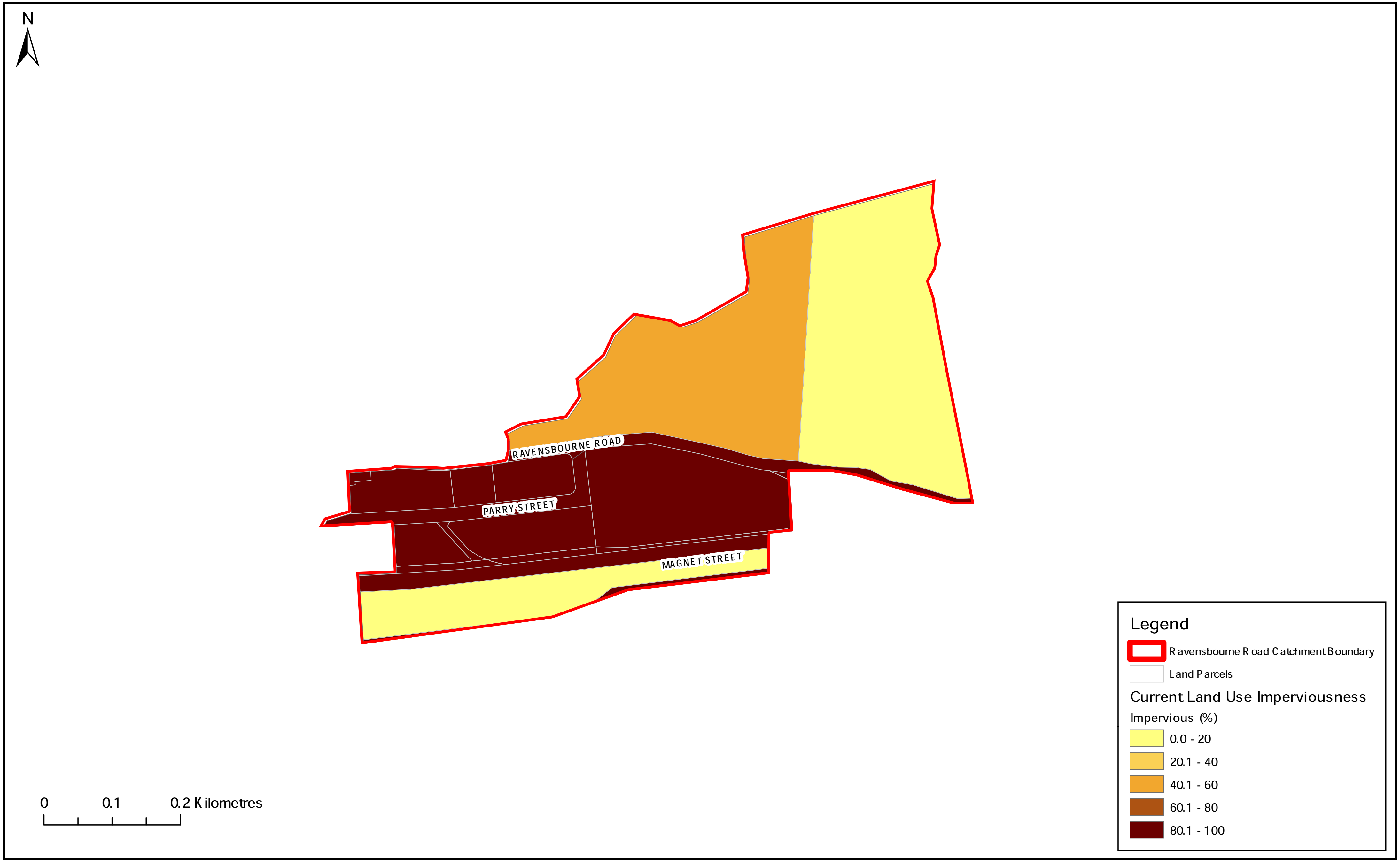
4.5.5 Future Land Use

Three future land use scenarios are being considered within the DCC 3 Waters Strategy along with the current situation. The scenarios are; 2008 (current), 2021, 2031 and 2060. For the purposes of stormwater modelling, the 2031 scenario contains the maximum allowable imperviousness for each zone, consistent with the planning horizon of the district plan (2036). The 2060 scenario also uses the maximum allowable imperviousness.

The Ravensbourne Road catchment is divided into three District Plan land use Zones, Industrial 1, Stadium and Rural. Approximately 40 % of the catchment is zoned Industrial and Stadium while the remainder is zoned Rural. The catchment land use is not expected to alter significantly over the next 50 years, with the current and future land use essentially the same.

4.6 Catchment Imperviousness

Figure 4-7 provides a map of the current impervious for the Ravensbourne Road catchment. The flat industrial area is mostly impervious with the exception of the reserve area adjacent to the shoreline, and the rural area, which are almost fully pervious. Overall, approximately 40 % of the current area is considered to be impervious, and it is not anticipated to change in the future as, apart from the Stadium and the Highway affecting a small part of the catchment, the land use is not expected to change within the planning horizons considered for this study.



Dunedin 3 Waters Strategy	RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-7 Ravensbourne Road Catchment Current Imperviousness	DISCIPLINE Stormwater	Drawn: KC	Status: Final		
			Checked: HES	Scale: 1:5,000	Plot Date: Sep 2011	
			Approved: SDH	Job. No: 42173227	Map No: Figure 4-7	Revision: -
			Date: Sep 2011			

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4.7 Stormwater Drainage Network

4.7.1 Network Description

Figure 4-8 below provides details of the stormwater network in the catchment. The Ravensbourne Road stormwater system comprises two short sub-networks, each with a consented outfall that discharges along Magnet Street. A third sub-network discharges the natural stream from a gully above Ravensbourne Road and road runoff via an open drain and piped network into the harbour.

The network in the Ravensbourne Road catchment comprises relatively small pipes laid at flat gradients. All of the pipes in the catchment have diameters of between 225 mm and 450 mm. The open channel through the industrial part of the catchment was estimated to be approximately 500 mm deep.

Key network features identified during the hydraulic model construction are as follows:

- Outfall 1: 25 Magnet Street. A 300 mm diameter concrete pipe discharges beneath a concrete block retaining wall and has a formed channel which allows the flow of water to enter the harbour within the tidal range.

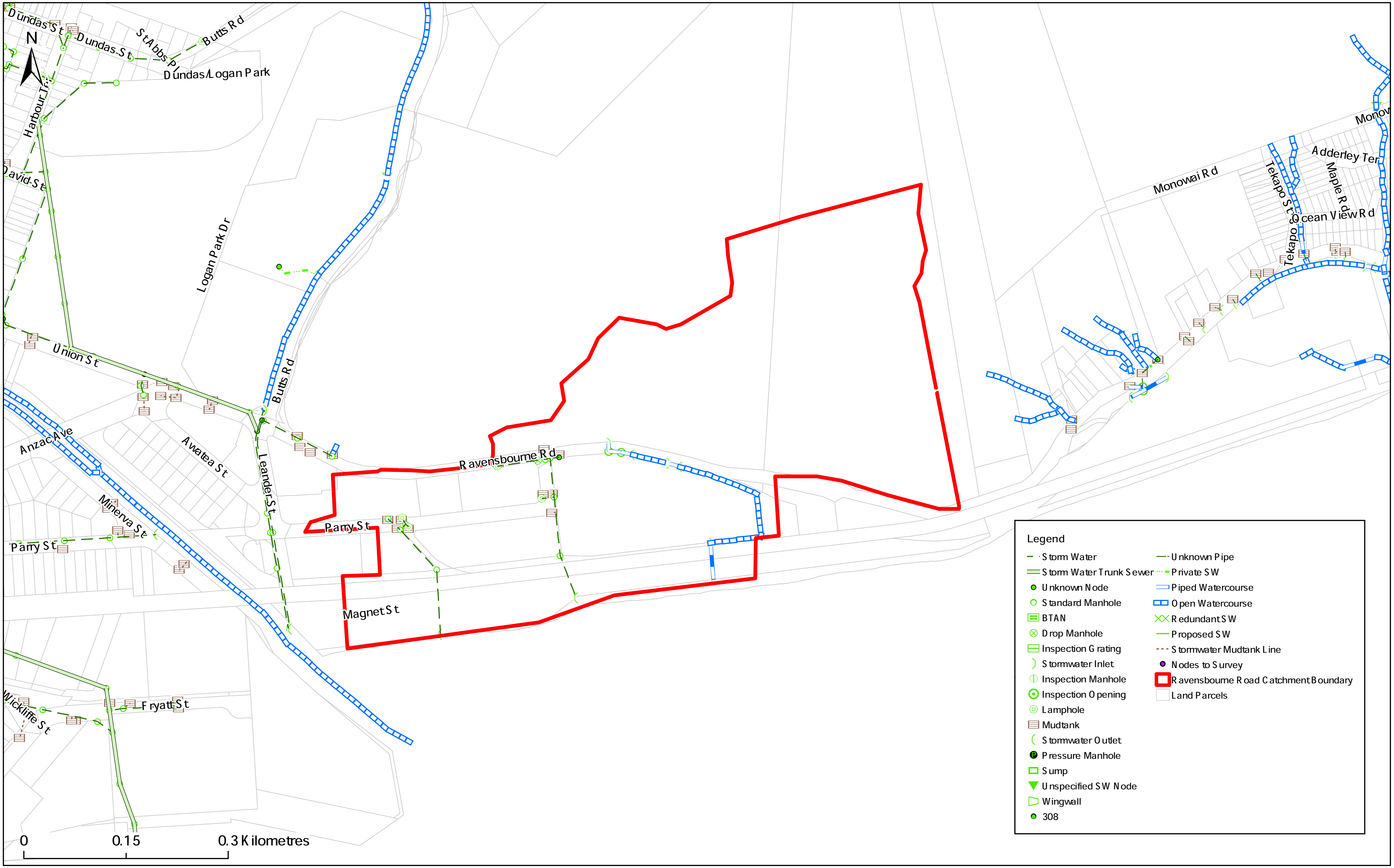
- Outfall 2: 55 Magnet Street. A 300 mm diameter concrete pipe which extends out from a stone rip-rap bank with flow falling onto the rip-rap stones and down into the harbour within the tidal range.

- Outfall 3: 65 Magnet Street. A 300 mm diameter concrete pipe discharges the water from the piped and open watercourse at the eastern end of the Ravensbourne Road catchment. It consists of a concrete headwall with angled wingwalls protecting the outfall from the stone rip-rap bank. The concrete structure is well within the tidal zone and as such tidal influences are likely to have a considerable effect on this outfall.

- Natural Stream: The small stream flows through a densely vegetated area. The channel of the stream conveys flow from the rural catchment above Ravensbourne Road, the flows are conveyed down a waterfall adjacent to Ravensbourne Road into an inlet structure.

- Gully Inlet and Culvert, Ravensbourne Road: The inlet is an open topped concrete chamber fitted with a bar screen, and is likely to be subject to blockage or partial blockage due to the accumulation of debris on the screen. The culvert beneath Ravensbourne Road has a diameter of 300 mm.

- Open Channel: This was not easily visible during catchment walkover due to dense vegetation. However, it was clear that the channel was likely to be larger in cross section area than the pipework upstream and downstream. It is estimated to be approximately 500 mm deep with a trapezoidal shaped cross-section following the LiDAR ground surface.



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Dunedin 3 Waters Strategy

RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-8

Ravensbourne Road Catchment Stormwater Drainage Network

DISCIPLINE	Drawn: SEW	Status: Final	
Stormwater	Checked: HES	Scale: 1:5,000	Plot Date: Sep 2011
	Approved: SDH	Job No: 42173227	Map No: Figure 4-8 / Revision: -
	Date: Sep 2011		

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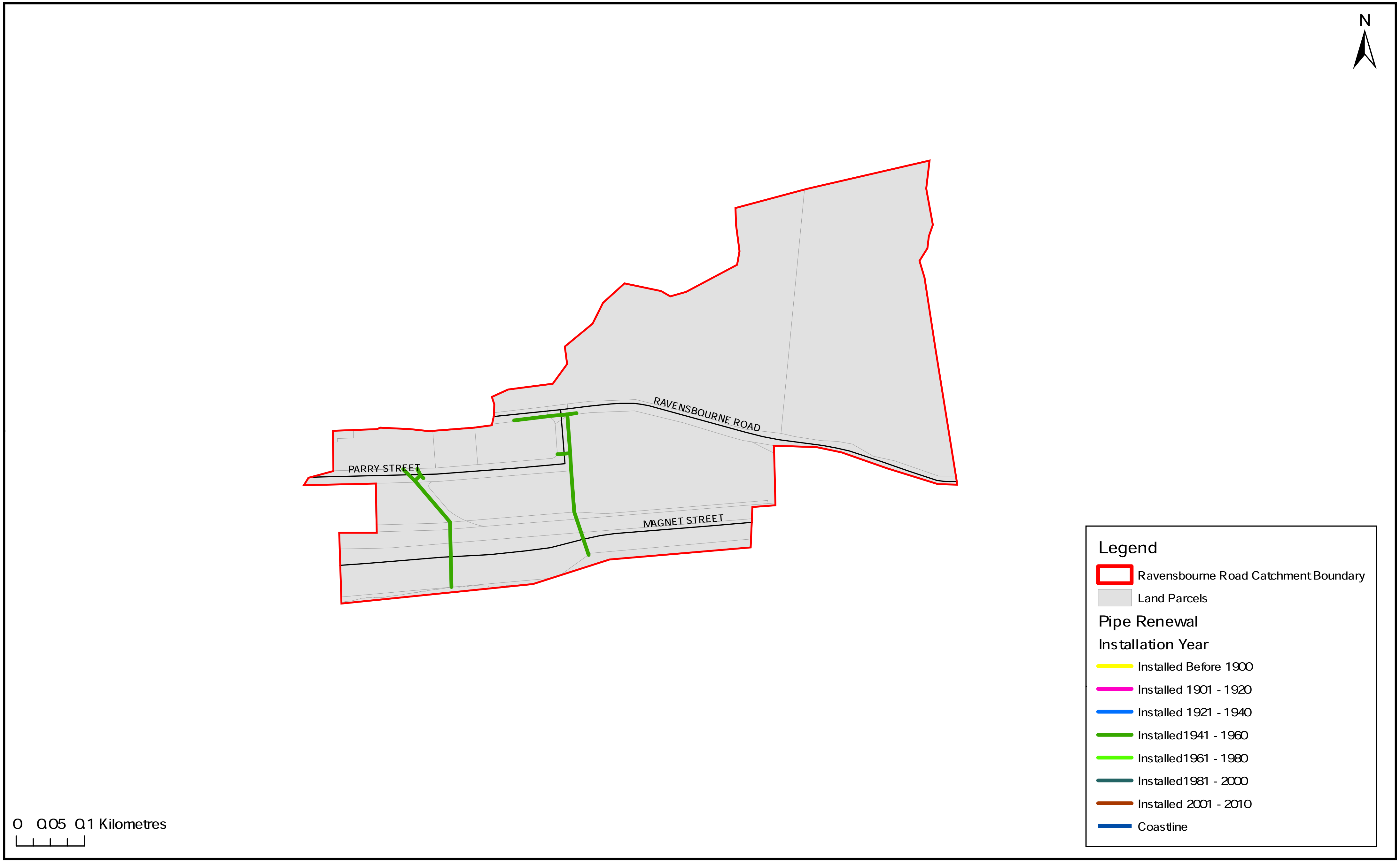
4.7.2 Network Age

DCC records show that the entire Ravensbourne Road pipe network was installed between 1941 and 1960. Figure 4-9 provides a map of pipe age based on location. The two outfalls that discharge piped stormwater into the harbour were also installed between 1941 and 1960. With the expected life of most stormwater infrastructure being approximately 100 years, the renewals programme for the network in Ravensbourne Road would begin in 2040. Via this programme, 100 % of the pipe network would be renewed by 2060 (ie within the planning horizon of this ICMP).



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Dunedin 3 Waters Strategy

RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-9

Ravensborne Road Catchment Pipe Network Ages

DISCIPLINE

Stormwater

Drawn: KC	Status: Final		
Checked: HES	Scale: 1:5,000	Plot Date: Sep 2011	
Approved: SDH	Job. No: 42173227	Map No: Figure 4-9	Revision: -
Date: Sep 2011			

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4.7.3 Asset Condition and Criticality

A condition assessment has not been undertaken of the Ravensbourne Road stormwater network.

DCC has developed and applied a first cut criticality assessment to all water, wastewater, and stormwater network assets across the city. The criticality score has been calculated based on three weighted criteria: extent, cost, and location. For the full version of the methodology used, the DCC methodology document (available on request) should be referred to. Table 4-1 summarises the first cut version used for stormwater assets as of November 2010. Note that stormwater intakes were rated slightly differently to remaining assets, with 20 % of the weighting assigned to cost and 20 % to each of the four wellbeings, given that the consequences of failure of an intake would be largely localised in nature due to area flooding.

Figure 4-10 shows a map of the Ravensbourne Road catchment, with criticality and the four wellbeing locations identified. This map shows pipe criticality only.

Table 4-1: Asset Criticality Score Criteria

Factor	Score	Rating Scale	Proxy Used - Pipes	Proxy Used - Manholes	Proxy Used - Outlets
Extent (20 %)	1	Insignificant function failure			Assigned same rating as upstream pipe
	2	Minor (delivery) failure – Small population	<= 600 mm diameter	Manholes on non-pressurised pipes	Assigned same rating as upstream pipe
	3	Major (delivery) failure – Large population	> 600 mm diameter	Manholes on pressurised pipes	Assigned same rating as upstream pipe
	4	Major (safety, supply, containment) failure – Small population			Assigned same rating as upstream pipe
	5	Major (safety, supply, containment) failure – Large population			Assigned same rating as upstream pipe
Cost (20 %)	1	Up to $ 20,000	All pipes	<3.5 m deep	<3.5 m deep
	2	$ 20,000 - $ 150,000		>3.5 m deep	>3.5 m deep
	3	$ 150,000 - $ 400,000			
	4	$ 400,000 - $ 1,000,000			
	5	Over $ 1 M			
Location (15 % to each of wellbeings)	1	Within 10 m of a 'minor' social, environmental, cultural, or economic wellbeing location			
	2	Within 5 m of a 'minor' social, environmental, cultural, or economic wellbeing location			
	3	Within 10 m of a 'major', or within 1 m of a 'minor' social, environmental, cultural, or economic wellbeing location			
	4	Within 5 m of a 'major' social, environmental, cultural, or economic wellbeing location			
	5	Within 1 m of a 'major' social, environmental, cultural, or economic wellbeing location			
Weighted Criticality Score	= (Extent Rating x 20 %) + (Cost Rating x 20 %) + (Social Rating x 15 %) + (Environmental Rating x 15 %) + (Cultural Rating x 15 %) + (Economic Rating x 15 %) = Criticality Rating				

Criticality 1 = Not Critical   *Criticality 5 = Very Critical*

Dunedin 3 Waters Strategy

RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-10

Ravensbourne Road Catchment Stormwater Network Criticality

DISCIPLINE Stormwater	Drawn: SEW	Status: Final	
	Checked: HS	Scale: 1:5,000	Plot Date: Sep 2011
	Approved: SDH	Job. No: 42173227	Map No: Figure 4-10 / Revision: -
	Date: Sep 2011		

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4.7.4 Salt Water / Saline Groundwater Intrusion

The intrusion of salt water into wastewater pipelines is a major concern for DCC, due to effects on pipe condition, and more particularly, wastewater treatment plant (WWTP) processes.

In terms of the stormwater system, salt water intrusion via the outfall pipes occurs regularly, however ingress of saline groundwater along the pipelines could further reduce the capacity of the network during high tides.

An investigation by Van Valkengoed & Wright (2009) examined the regions adjacent to the Otago Harbour and highlighted the key locations where salt water is entering the wastewater system. This investigation did not, however, examine the stormwater system, therefore the extent of saline groundwater intrusion into the stormwater network is unknown. Tidal influence on the system via the harbour outfalls is discussed further in Section 8.

4.7.5 Operational Issues

Discussions were held with DCC Water and Waste Business Unit personnel during catchment walkovers in November 2009, in order to identify known operational issues. Further discussions were held during a workshop with DCC Water and Waste Business Unit in September 2010. No serious issues were highlighted by DCC staff at these times.

Given the debris reservoir upstream, the Ravensbourne Road intake structure is considered to be at risk of at least partial blockage by debris if not periodically cleaned out. Blockage of this structure could result in stormwater flows running across Ravensbourne Road, however a sensitivity test of this during catchment modelling did not indicate that blockage of the screen resulted in serious flooding or would be likely to disrupt traffic significantly.

It was also noted during the workshop that current ongoing development in the catchment, for the new stadium and State Highway extension will result in changes to the stormwater network to the west of the catchment. It was noted that DCC must ensure adequate allowances are made in the final design for stormwater management from these new developments.

4.7.6 Maintenance and Cleaning

The maintenance of catchpits is perceived to be a general issue across Dunedin city according to the Water and Waste Business Unit. It was noted by the network maintenance team that during autumn months heavy rainfall can result in blocked catchpits or inlet screens regardless of how well maintained they are. Failure to remove silt and gravel from the catchpits can also lead to siltation and hence capacity reduction of the pipe network; siltation has been identified as an issue in some areas of Dunedin by the Network Management and Maintenance team, and this is currently being investigated as part of a city-wide CCTV (closed circuit television) programme.

The responsibility for the cleaning and maintenance of stormwater catchpits and other structures is divided between three DCC departments, Network Management (Water and Waste Business Unit), Transportation Operations and Community and Recreation Services (CARS).

Network Management

Stormwater structures under Network Management supervision are inspected on a weekly basis, after a rainfall event and before forecast bad weather. The specification for these inspections is as follows:

- Check access to the site in respect to Health and Safety requirements.
- Check the screen intake to ensure screen is 95 % or more clear.
- Check upstream channel is clear of debris (approximately first 5 metres).
- Check for any recent signs of overflow since last visit.
- If debris blocking intake screen, remove to achieve 95 % clearance. Type of material and approximate volume and weight to be recorded on the Screen / Intake Checklist.

In addition to the weekly inspections, condition assessments are completed every six months.

Transportation Operations

DCC Transportation Operations are responsible for stormwater structures within the road reserve (except State Highway, which are the responsibility of the New Zealand Transport Agency (NZTA)).

The cleaning and maintenance of these structures is contracted to a main contractor, managed by Transportation Operations. The main contractor then subcontracts the work to a third party.

Under the Transportation Operations cleaning and maintenance contract, with the main contractor, the asset cleaning and frequency levels of service are listed as follows:

- At any time at least 95 % of mud tanks shall have available 90 % of their grate waterway area clear of debris.
- At least 95 % of mud tanks, catchpits and sumps shall have at least 150 mm below the level of the outlet invert clear of debris.
- At least 95 % of culverts shall have at least 90 % of their waterway area clear of debris throughout the entire length of the structure including 5 m upstream and downstream.
- At least 90 % of all other stormwater structures shall have 90 % of the waterway area clear of debris.

Included in the contract is an initial six month cycle to bring all stormwater structures up to specification. Once up to specification, they must be maintained to the specified level of service. Information relating to the way that compliance with the required level of service is measured was unavailable.

The cleaning and maintenance of stormwater structures in the road is currently perceived by Water and Waste Business Unit maintenance team to be inadequate. DCC have concerns that the cleaning and maintenance contract is not specific enough and therefore the stormwater structures within the roads are not maintained to a satisfactory standard.

Community and Recreation Services

The maintenance and cleaning of stormwater structures located within parks and reserves, other than those listed under Network Management supervision, are the responsibility of CARS.

At the time of writing this plan, CARS did not have a maintenance schedule for stormwater structures within parks and reserves. They were unable to confirm the location of such stormwater structures or whether any existed within the parks and reserves.

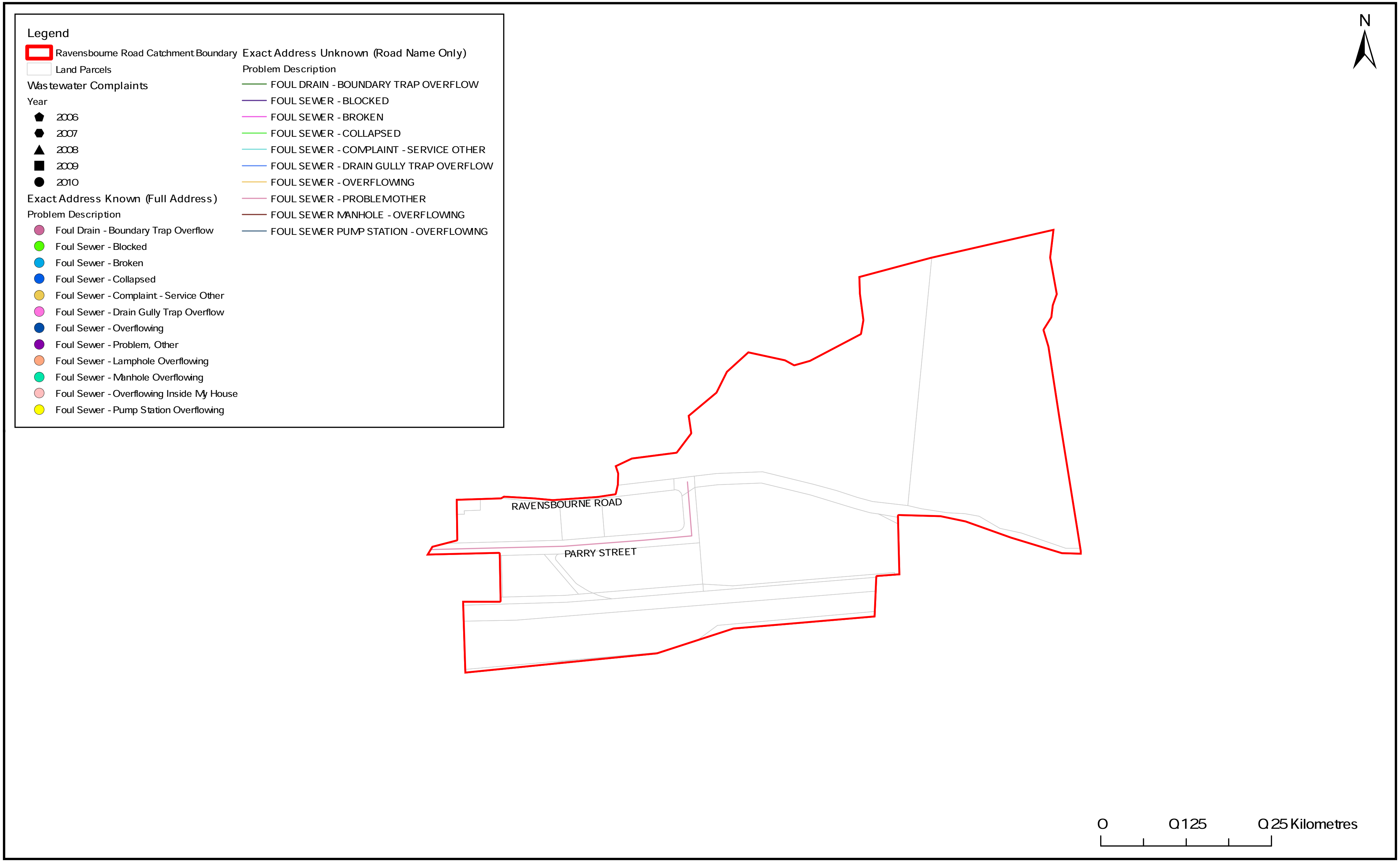
4.8 Customer Complaints

Discussions were held with DCC Water and Waste Business Unit personnel during catchment walkovers in November 2009, in order to identify known operational issues and locations of historical flooding. Further discussions were held during a workshop with DCC Water and Waste Business Unit in September 2010. No significant issues were raised during the catchment walkovers and it was noted at the workshop that this is a catchment that the Water and Waste Business Unit personnel are rarely called to in response to stormwater issues.

A review of customer complaints logged with DCC from 2005 to 2010 revealed no reported stormwater flooding issues in this catchment. There are anecdotal reports of flooding adjacent to the nearby quarry entrance, but this is outside the catchment boundary and unlikely to enter the catchment given the surface topography.

The review of customer complaints revealed a single reported wastewater flooding incident in this catchment in 2008. The information relating to the problem is sparse, and details only that there was a 'problem' with the wastewater pipe along Parry Street. This is shown in Figure 4-12.

Based on the information available, anecdotal and customer complaints information indicates that there are no significant issues with the service provided by the stormwater network in the Ravensbourne Road catchment.



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Dunedin Three Waters Strategy	RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-11 Ravensbourne Road Wastewater Flooding Complaints	DISCIPLINE Stormwater	Drawn: KC	Status: Final	
			Checked: HES	Scale: 1:5,000	Plot Date: Sep 2011
			Approved: SDH	Job. No: 42173227	Map No: Figure 4-11 / Revision: -
			Date: Sep 2011		

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4.9 Water and Wastewater Systems

Figure 4-12 provides a layout of the three waters networks in the Ravensbourne Road catchment.

Both the wastewater and water networks have been studied at a macro scale as part of the 3 Waters Strategy Phase 1, and in more detail during Phase 2. Section 12 further discusses modelling work undertaken on the water and wastewater systems throughout the city. Issues discovered in the Ravensbourne Road catchment during Phase 1 and 2 are highlighted below.

4.9.1 Water Supply System

The Dunedin water supply network was investigated for Phase 1 at a distribution mains level only, with further investigations focussing on key areas during Phase 2. A raw water study investigated the sources and reliability of water supply to the city.

The results indicated that the Dunedin water supply distribution (trunk mains) network provides sufficient treated water capacity and raw water storage, on a daily and weekly basis, to meet peak summer demands. It is recognised that there is a lack of strategic raw water storage during severe drought conditions.

The Dunedin water supply network receives treated water from the Mount Grand WTP to the north west of the city and the Southern WTP to the south west of the city. A number of sources supply raw water to the WTPs. Treated water from the WTPs is supplied to the city primarily by gravity, with the distribution mains, reservoirs and Pressure Reducing Valves (PRVs) controlling the pressure and flow to most of the water supply zones in the city. A number of pump stations are also required to boost water pressure to reservoirs at high points or at the extremities of the system.

The water for the Ravensbourne Road catchment is supplied from the North End reservoir located to the north east of the catchment, via a PRV in Hanover Street. There are approximately 1 km of water supply pipes within the catchment, ranging from 100 to 300 mm in diameter. The supply pipes in this catchment are a mixture of asbestos cement, cast iron, ductile iron and PVC-U.

The Ravensbourne Road catchment is within the CBD area of the treated water supply network. Leakage in the CBD has been identified as being higher than the average for Dunedin. Higher leakage in CBD areas is to be expected due to difficulties in locating and repairing leaks. No significant leakage issues have been identified in this area to date.

The DCC capital works programme (2010-2020) identifies the water main along Ravensbourne Road for renewal in 2010/11.

4.9.2 Wastewater System

The main areas of investigation into the Dunedin city wastewater system for Phase 1 were system capacity, hydraulic performance, wastewater overflows and pumping stations. Current and future anticipated issues within the system at a macro level were identified.

Flow survey and modelling from Phase 1 revealed a strong wet weather influence on the wastewater system city-wide, caused by both direct and indirect entry of stormwater via storm induced inflow and infiltration (I&I). This indicated that the Dunedin city wastewater system has a clear and significant response to rainfall. A number of manhole overflows were also predicted by the modelling whereby wastewater may then enter the stormwater system via curb and channel and stormwater sumps and contribute to stormwater flows. Investigations also revealed that a number of cross connections between the wastewater and stormwater and wastewater overflows directly to the receiving environment have been found to operate following rainfall events within Dunedin city.

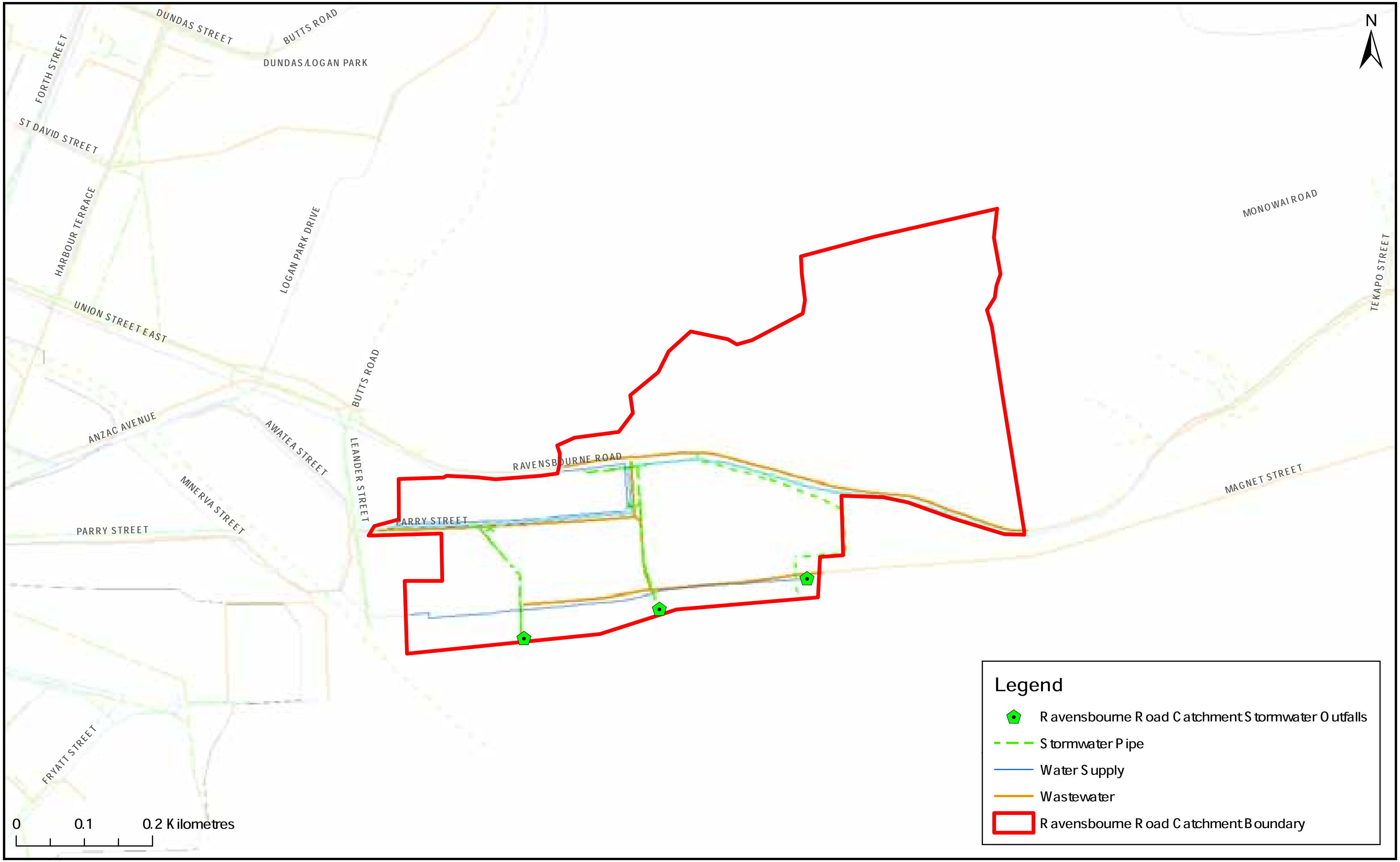
The Dunedin city wastewater system collects wastewater from commercial, industrial and residential customers in Dunedin city. It is split into three distinct schemes; the Dunedin Metropolitan Scheme, the Mosgiel Scheme and the Green Island Scheme.

The wastewater system within the Ravensbourne Road catchment is part of the Dunedin Metropolitan Scheme. The Metropolitan Scheme provides wastewater services to the urban area of Dunedin, West Harbour communities, Ocean Grove and the Peninsula down to Portobello. The main interceptor sewer (MIS) is the main sewer line that collects wastewater flows from the Metropolitan Scheme. It conveys flows to the pumping station at Musselburgh where they are then pumped to the Tahuna WWTP. The MIS extends from the Harrow Street / Frederick Street intersection in the city centre to the Musselburgh pumping station.

The wastewater system within the Ravensbourne Road catchment comprises approximately 2 km of wastewater pipeline, approximately 83 % of which are between 150 mm to 300 mm in diameter.

Wastewater flows pass through the Ravensbourne Road catchment via a combined pressure gravity main which services harbourside communities upstream of the catchment and ultimately conveys the flows to the MIS. Flows from within the catchment are conveyed, via gravity, to Parry Street pumping station which pumps the flows under the Water of Leith to the MIS.

The 3 Waters Strategy Project wastewater study did not identify any significant issues with the wastewater system within the Ravensbourne Road catchment.



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Dunedin 3 Waters Strategy	RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-12 Ravensbourne Road Catchment Three Waters Network	DISCIPLINE Stormwater	Drawn: KC	Status: Final		
			Checked: HES	Scale: 1:5,000	Plot Date: Sep 2011	
			Approved: SDH	Job. No: 42173227	Map No: Figure 4-12	Revision: -
			Date: Sep 2011			

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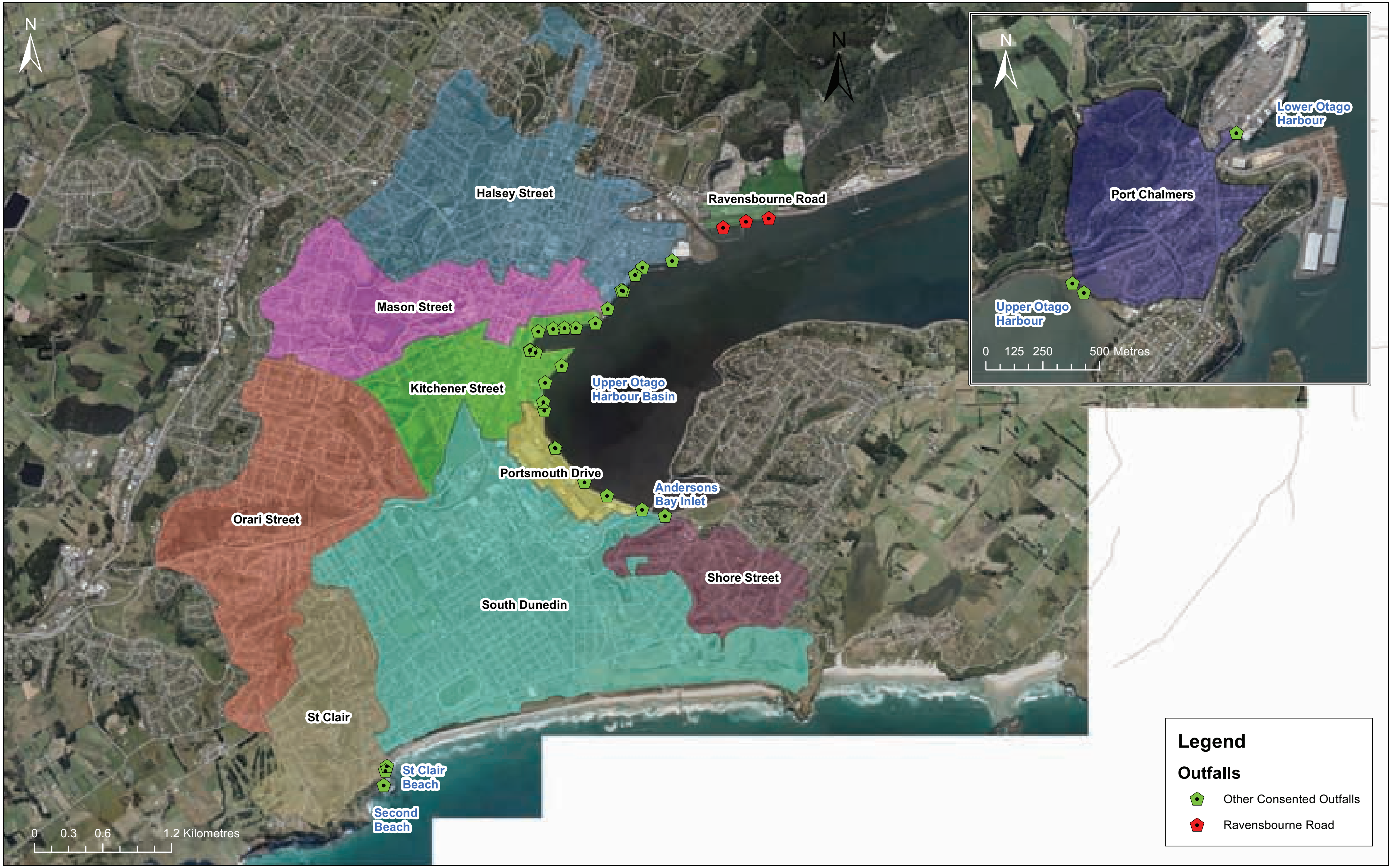
5 Receiving Environment

This section identifies and describes the stormwater receiving environment for the Ravensbourne Road catchment. An overview of the quality and value of the receiving environment is provided. It is acknowledged that both historical and current stormwater management, as well as many other activities not related to stormwater management within the catchment, have contributed to the state of this environment.

Part 3 of this report identifies and analyses the effects that specific stormwater management practices are considered to be having on the receiving environment of the catchment. Where the effects are considered to be unacceptable, options for avoiding, remedying or mitigating the effects are discussed in Part 5 of this report.

The stormwater network in the Ravensbourne Road catchment discharges directly to the marine environment via three small outfalls, at the northern shore of the Otago Harbour basin. All three outfalls are located along Magnet Street. The location of the outfalls, relative to the other DCC stormwater outfalls and the Otago Harbour receiving environment, are shown in Figure 5-1.

There is one natural stream in the Ravensbourne Road catchment. Whilst this does not receive discharges from the stormwater network, it will receive stormwater runoff from within the catchment. The location of the stream within this catchment is shown in Figure 5-3 below.



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Dunedin 3 Waters Strategy	RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 5-1 Ravensbourne Road Catchment Marine Receiving Environment	DISCIPLINE Stormwater	Drawn: MM	Status: Final	
			Checked: HES	Scale: 1:30,000	Plot Date: Sep 2011
			Approved: HES	Job. No: 42173227	Map No: Figure 5-1 / Revision: -
			Date: Sep 2011		

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5.1 Marine Receiving Environment

Monitoring of the harbour environment is undertaken on an annual basis in accordance with the conditions of consent for DCC's stormwater discharges. To date, four rounds of monitoring have been undertaken (2007, 2008, 2009, and 2010). The annual monitoring involves the following, and while intended to identify the effects of stormwater discharges, as noted above, may be measuring the effects of historical contamination (particularly in the case of sediment monitoring where annual deposition rates are thought to be low), as well as the effects of other contaminant sources other than stormwater:

- Biological monitoring: Macroalgae, epifauna and infauna are surveyed at low tide from four sites; two within 20 m and two a minimum of 50 m from each outfall monitored. shellfish and octopus are collected from within 20 m of the confluence of the stormwater outfall and water's edge at low tide; and fish (variable triplefins) are collected within 50 m of the stormwater outfalls. The flesh of the animals is then analysed for heavy metals and polycyclic aromatic hydrocarbons (PAHs).

- Sediment Monitoring: Replicate samples are collected from the top 200 mm of sediment within 20 m of each outfall monitored. The sediment is analysed for a suite of contaminants including heavy metals, bacteria and PAHs. In addition to the annual sampling, sediment is also analysed from four transects across the centre of the upper harbour, every 5 years.

- Stormwater Monitoring: Stormwater grab samples are taken from appropriate outfalls, within 1 hour of the commencement of a rain event greater than 0.5 mm, in an attempt to capture the first flush stormwater. The stormwater is then analysed for a suite of contaminants. Stormwater quality is discussed further in Section 6.

There have been a number of studies carried out to establish the condition of the Otago Harbour receiving environment. A study of Dunedin's marine stormwater outfalls was completed in 2010 by Ryder Consulting Ltd (Ryder, 2010a), for the purpose of assessing the current quality of the receiving environments and the potential effects of stormwater on the environments. This study comprises an assessment of the stormwater, sediments, and ecology in the vicinity of the major outfalls within the harbour using sites and methods generally in accordance with those carried out for the annual monitoring. The results of this study were compared with past surveys and historical data in order to determine the condition of the harbour receiving environment.

The following reports are provided for reference in Appendix C.

- Ryder (2010a) Ecological Assessment of Dunedin's Marine Stormwater Outfalls.

- Ryder (2010b). Compliance Monitoring 2010. Stormwater Discharges from Dunedin City.

- Ryder (2010c). Dunedin Three Waters Strategy Stream Assessments

- Ryder (2009). Compliance Monitoring 2009. Stormwater Discharges from Dunedin City.

- Ryder (2008). Compliance Monitoring 2008. Stormwater Discharges from Dunedin City.

- Ryder (2007). Compliance Monitoring 2007. Stormwater Discharges from Dunedin City.

- Ryder (2006). Remediation of Contaminated Sediments off the South Dunedin Stormwater Outfall: A proposed course of action.

- Ryder (2005a). Characterisation of Dunedin's Urban Stormwater Discharges & Their Effect on The Upper Harbour Basin Coastal Environment.

- Ryder (2005b). Spatial Distribution of Contaminants in Sediments off the South Dunedin Stormwater Outfall.

5.1.1 Upper Harbour Basin

The upper harbour basin is a highly modified environment as a result of reclamation, road works and dredging activities (Smith, 2007). Stormwater is received from the greater Dunedin urban area and surrounding rural catchments and discharged via outfalls into the Otago harbour at a number of locations (See Figure 5-1).

The tidal range in the Otago Harbour is approximately 2.2 m. Tidal current water velocities range from zero to 0.25 m/s (Ryder 2005), and estimates for harbour flushing times range from 4 to 15 days (Grove and Probert, 1999).

A study by Smith and Croot (1993), describes the circulation of water in the Otago Harbour as being dominated by the tide and inputs of heavy rainfall (See Figure 5-2). Smith and Croot (1993) report that flushing times in the harbour are hard to establish as heavy rainfall has a dramatic effect on dilution displacement of the water in the upper harbour. Harbour flushing times, therefore, may vary and be greatly reduced during rainfall events.

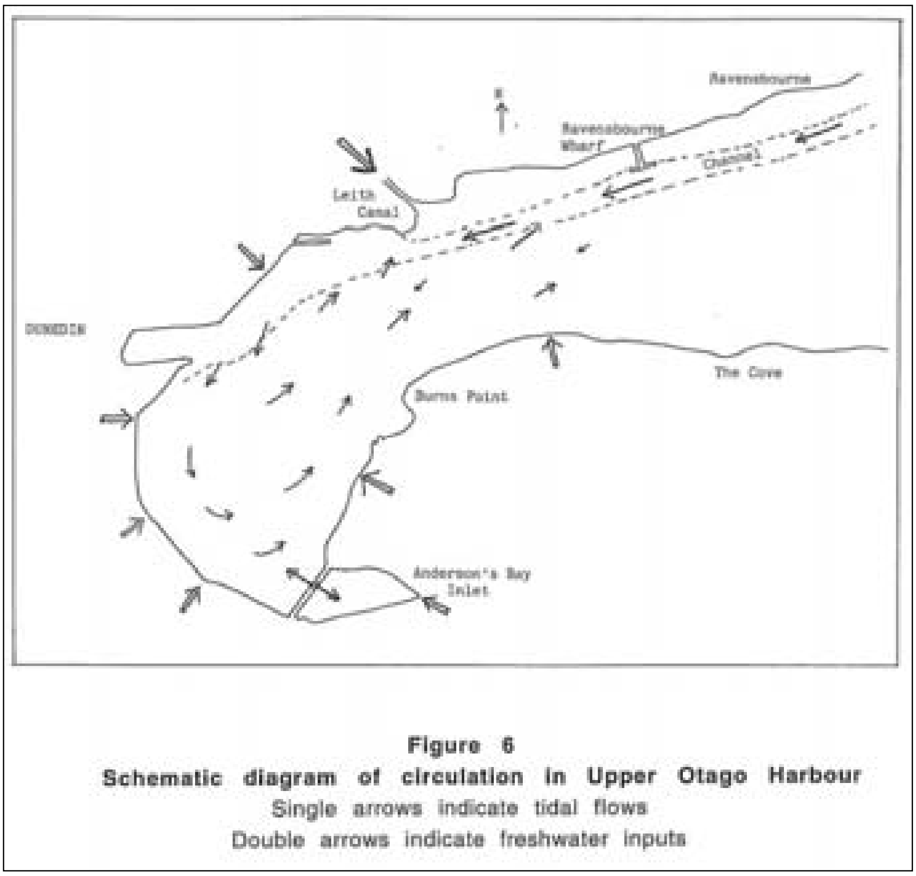


Figure 5-2: Circulation of Water in the Upper Otago Harbour (from Smith and Croot, 1993)

5.1.2 Recreational and Cultural Significance

The harbour is considered an important area for recreation. It is frequently used by wind surfers, fishers and hobby sailors. There are a number of boat clubs and tourism operators in the area that make use of the harbour.

The CIA undertaken by KTKO Ltd. (2005), relating to the initial applications for consent by DCC, to discharge stormwater into the marine environment, describes the strong relationship that Kai Tahu ki Otago have with the coastal environment. Evidence of Māori use of the harbour extends back to Māori earliest tribal history when the harbour was a valued food resource and used for transport. The report states that the increasing degradation of the harbour environment has affected Māori in many ways and its place as a mahika kai has been dramatically altered. Further consultation with Kai Tahu is discussed in Section 3 of this report.

5.1.3 Harbour Ecology

The discharge consents associated with the outfalls in the Ravensbourne Road catchment have no biological monitoring requirements so there is a lack of temporal biological data associated with this catchment. The 2010 study assessed the biology in the vicinity of outfall 3 at 65 Magnet Street. Macroflora, epifauna and infauna were investigated at sites at 5 m and greater than 20 m from the outfall. Within the report, the results of the study were discussed alongside the biological monitoring data relating to other stormwater outfalls and the wider upper harbour basin environment; the number of stormwater outfalls and other sources discharging into the harbour are numerous, and harbour ecology is affected by all inputs.

The biological investigations undertaken look at the effects of the presence (or otherwise) of stormwater associated contaminants on the ecological communities of the harbour. The diversity of benthic flora and fauna is generally accepted as a reasonable indicator of environmental health. The presence of pollution tolerant species, and an absence of pollution intolerant species, can be used to indicate contamination. However, significant amounts of data are required to link the presence or absence of indicator species with contamination.

The biological investigations undertaken to date look at the effects of the presence / absence of particular stormwater associated contaminants on the ecological communities of the harbour. The diversity of benthic flora and fauna is generally accepted as a reasonable indicator of environmental health. The presence of pollution tolerant species, and an absence of pollution intolerant species, can be used to indicate contamination. However, significant amounts of data are required to link the presence or absence of indicator species with contamination. Table 5-1 below provides typical sources of urban stormwater contaminants.

Table 5-1: Sources of Stormwater Contaminants

Contaminant	Potential Sources
Total Suspended Solids (TSS)	Erosion, including stream-bank erosion. Can be intensified by vegetation stripping and construction activities.
Arsenic (As)	Naturally occurring in soils / rocks of New Zealand; combustion of fossil fuels; industrial activities, including primary production of iron, steel, copper, nickel, and zinc.
Cadmium (Cd)	Zinc products (Cd occurs as a contaminant), soldering for aluminium, ink, batteries, paints, oils spills, industrial activities.
Chromium (Cr)	Pigments for paints & dyes; vehicle brake lining wear; corrosion of welded metal plating; wear of moving parts in engines; pesticides; fertilisers; industrial activities.
Copper (Cu)	Vehicle brake linings; plumbing (including gutters and downpipes); pesticides and fungicides; industrial activities.
Nickel (Ni)	Corrosion of welded metal plating; wear of moving parts in engines; electroplating and alloy manufacture
Lead (Pb)	Residues from historic paint and petrol (exhaust emissions), pipes, guttering & roof flashing; industrial activities.
Zinc (Zn)	Vehicle tyre wear and exhausts, galvanised building materials (e.g. roofs), paints, industrial activities
PAHs	Vehicle / engine oil; vehicle exhaust emissions; erosion of road surfaces; pesticides.
Faecal coliforms / E.coli	Animals (birds, rodents, domestic pets, livestock), sewage.
Fluorescent Whitening Agents (FWAs)	Constituent of domestic cleaning products, indicator of human sewage contamination.
References: ARC (2005); ROU (2002); Williamson (1993).	

The results of the biological assessment for the Ravensbourne Road catchment can be summarized as follows:

- Macroalgae: There was no algae evident in the intertidal zone.
- Epifauna: The results indicate that epifauna abundance was reasonably sparse at sites surveyed, at both 20 m and greater than 50 m from outfall, with the exception of the high number of barnacles observed. The diversity of epifauna overall was found to be very low with little change in diversity with distance from the outfall.
- Infauna: The substrate at the outfalls at this catchment was unsuitable for the assessment of infauna.

The single data set available (2010) for this catchment is not sufficient to clearly identify the state of the ecology in the receiving environment at this location.

The results of various historical studies and the biological monitoring carried out for consent compliance at other locations indicate that in general, a reasonably low diversity amongst the benthic and infaunal communities is likely to be symptomatic of much of the upper harbour basin.

The reports for the 2010 study and consent monitoring conclude that, whilst not pristine, the upper harbour and the communities associated with the intertidal areas adjacent to the major stormwater outfalls appear not to be undergoing any significant further degradation as a result of the stormwater inputs during the monitoring period (2007-2010).

5.1.4 Harbour Sediments

The upper harbour bed has been classified, in general, as muddy sands / sandy muds, with varying proportions of fine gravels (Ryder, 2005b). The harbour bed adjacent to the Ravensbourne Road catchment generally comprises coarse sand, clean gravel and small to medium cobbles.

The resource consents associated with the outfalls in the Ravensbourne Road catchment have no sediment monitoring requirements. However, samples were taken from within 20 m of outfall 3 at 65 Magnet Street as part of the ongoing monitoring surveys, to contribute to building an overall picture of the general harbour sediment quality. Sediment analysis was also carried out for the Ravensbourne Road catchment as part of the 2010 study.

The sediment analysis results for the Ravensbourne Road catchment are presented in Table 5-2 alongside Australian and New Zealand Environment and Conservation Council (ANZECC 2000) sediment quality guidelines and discussed below.

ANZECC (2000) sediment quality guidelines provide low and high trigger values. The low values are indicative of contaminant concentrations where the onset of adverse biological effects may occur, thus providing early warning and the potential for adverse environmental effects to be prevented or minimised. The high values are indicative of contaminant concentrations where significant adverse biological effects may be observed. Exceedence of these values could therefore indicate that adverse environmental effects may already be occurring. Contaminant concentrations below the ANZECC (2000) low trigger values therefore, are unlikely to result in the onset of adverse biological effects.

Within the 20 mm samples collected and analysed for monitoring purposes, there may a number of years' worth of sediment deposition and a chance that any contamination measured in the samples may be historic. Each sample should not therefore be considered as indicative of the contamination deposited in any given year.

Contaminant levels in much of the harbour have been found to be highly variable but are generally higher closer to the outfalls than further away. However, this is not true for all contaminants or for all outfalls in any given year.

The 2010 results for Ravensbourne Road indicate that the levels of contaminants within the sediments in the vicinity of the Magnet Street outfall were low with just arsenic exceeding the ANZECC (2000) interim sediment quality guideline trigger values at greater than 20 m from the outfall. However, elevated arsenic levels have not been observed at sample sites closer to the outfall (less than 20 m). It is therefore likely that the contamination at distances 20 m from the outfall is from sources other than the stormwater discharge from this catchment.

Previous investigations and monitoring have shown that, in general, the levels of PAHs in much of the upper harbour basin are moderate to high (Ryder 2010). The monitoring results from the

Ravensbourne Road catchment however, indicate that since 2009 the level of PAHs in the sediments at this location has been below ANZECC low trigger values.

All other contaminants measured for were at or below the ANZECC (2000) low trigger values for all years sampled for all sampling sites in this catchment.

For arsenic, chromium, copper, nickel and faecal coliforms, higher concentrations were observed at the more distant sampling site, suggesting that the Ravensbourne Road catchment is not discharging these contaminants. However, data is limited because samples from greater than 20 m from the outfall have only been taken once.

Cadmium, lead, zinc, PAH and Enterococci all had similar concentration levels at the near and more distant sampling sites in 2010.

The 2010 study concludes that to date contaminant levels in the sediments, from both the Ravensbourne Road catchment and the upper harbour generally, show high variability and that trends through time remain unclear. Trends may become clear with further data from future monitoring rounds, however the effects of other activities and other catchments discharging to the harbour on the sediment quality at this location is currently unknown.

Sections 6 and 8 of this report discuss stormwater quality and assess the effects on the environment in further detail.

Table 5-2: Marine Sediment Guideline Values and Measured Contaminant Levels

Contaminant	ANZECC Trigger Value[1]		65 Magnet Street (Outfall 3)					Comment
			< 20 m				> 20 m	
	Low	High	2007	2008	2009	2010	2010	
Arsenic (As)	20	70	10.6	9.8	7.3	13.0	20.0	All samples at or below ANZECC low trigger value.
Cadmium (Cd)	1.5	10	0.2	0.2	0.1	0.2	0.14	All samples below ANZECC low trigger value. Similar levels at near and distant sampling sites.
Chromium (Cr)	80	370	17.6	12.0	16.0	14.0	67.0	All samples below ANZECC low trigger value. Higher levels, nearing trigger value, away from outfall.
Copper (Cu)	65	270	14.0	13.0	14.0	9.0	18.3	All samples below ANZECC low trigger value. Slightly higher contamination levels away from outfall.
Nickel (Ni)	21	52	11.3	14.0	13.0	11.0	20.0	All samples below ANZECC low trigger value. Higher contamination levels away from outfall.
Lead (Pb)	50	220	18.9	27.0	27.0	28.0	28.0	All samples below ANZECC low trigger value. Similar levels at near and distant sampling sites.
Zinc (Zn)	200	410	101.0	130.0	160.0	149.0	127.0	All samples below ANZECC low trigger value. Similar contamination levels at near and distant sampling sites.
PAHs	4	45	7.0	5.8	0.5	3.7	2.4	Two past samples slightly exceed ANZECC low trigger value.
Enterococci*	-	-	2	11	< 2	< 3	24	Generally low numbers, within range of typical stormwater runoff.
Faecal coliforms*	-	-	< 2	17	5	2	170	Generally low numbers, within range of typical stormwater runoff.

1. All values in units of mg/kg dry weight, except those contaminants marked with an *, which are in MPN/g.
NB. Contaminant concentrations below low trigger values are unlikely to result in the onset of adverse biological effects and therefore are not considered significant.

KEY:

Exceeds Low ANZECC Trigger Value

Exceeds High ANZECC Trigger Value

5.2 Freshwater Receiving Environment Description

An assessment of the streams located within selected Dunedin stormwater catchments was completed in 2010 by Ryder Consulting Ltd (Ryder, 2010c) (refer Appendix C). This assessment was carried out for the purpose of identifying the current state of the streams within each catchment and identifying the potential effects of stormwater on stream health. This study comprised an assessment of the physical quality, water quality and ecology of the streams. The results of this study were also compared with past surveys and historical data, where available, in order to determine the condition of the freshwater receiving environment.

The effects of stormwater discharge on streams can take a number of forms; physical effects (e.g. erosion, substrate changes) are often the result of land use changes (increased imperviousness) changing the natural hydrological flow regime of the catchment; whereas chemical changes result from the quality of the stormwater being discharged. Each of these changes has an effect on the habitat, and hence the stream ecology. Modification of the stream environment through physical works also results in changes to the flow dynamics, and incorporation of fish barriers, in some instances.

DCC have published a watercourse information sheet (May 2010), for property owners with a watercourse. It includes the following information:

> *"'In Dunedin, a watercourse is defined as any natural, modified or artificial channel through which water flows or collects, either continually or intermittently, or has the potential to do so, and includes rivers, streams, gullies, natural depressions, ditches and drainage channels. This also includes any culvert or stormwater pipe that replaces a natural channel. A watercourse is owned by the property owner through which the watercourse passes through from the point of entry to the exit point of the property boundary."*
>
> *"Property owners are responsible for the following:*
>
> - *Ensuring that there are no obstructions or impediments in the watercourse which may inhibit the flow of water; and*
> - *Ensuring that any grates or outlets within your property are kept clear of debris at all times."*

In general, alterations to watercourses require consent from both DCC and ORC.

A single stream with a natural channel was identified as suitable for assessment in the Ravensbourne Road catchment. The stream had only one accessible section and therefore only one sampling site was selected. The location of the stream is shown in Figure 5-3.

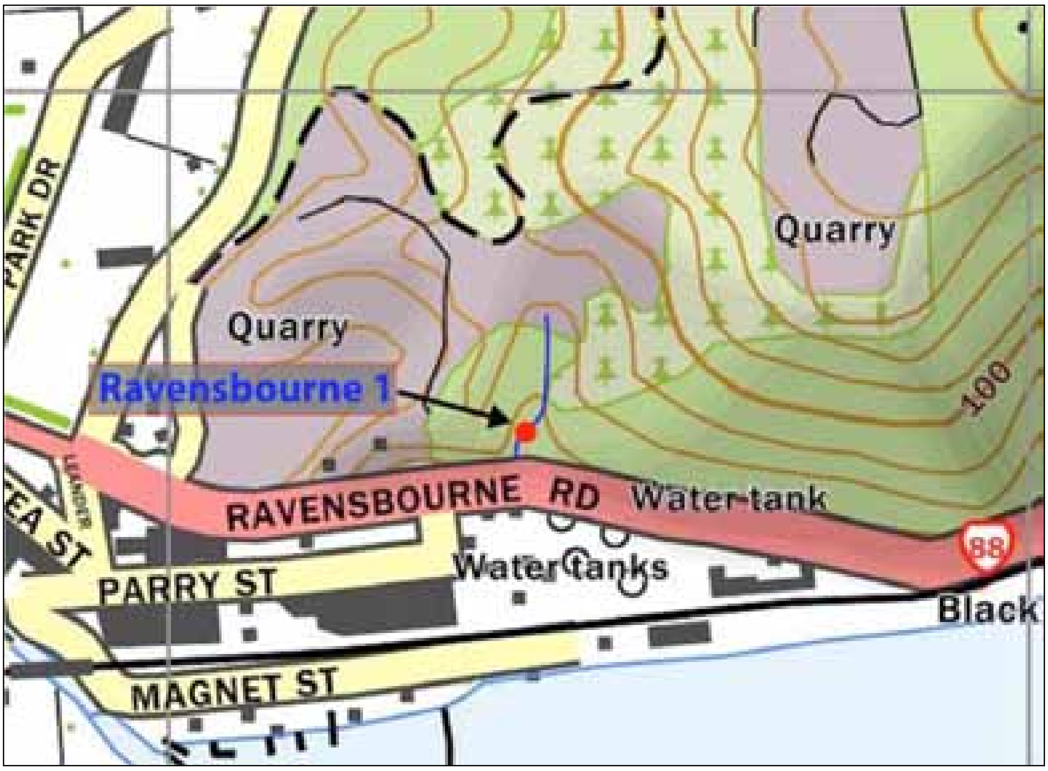


Figure 5-3: Freshwater Receiving Environment

5.2.1 Habitat Characteristics

The stream assessed is located on a terrace approximately 5 m above Ravensbourne Road. It drains, in a southerly direction, the slopes to the north and north east of Ravensbourne Road. At Ravensbourne Road the stream flows down a waterfall, approximately 5 m, before entering stormwater pipes (see Figure 5-4).

Land use surrounding the stream is dominated by forest and thick bush cover and a quarry to the north of the stream catchment head. Riparian cover comprises a canopy of sycamore, mahoe and tarata with a subcanopy of mapou. Ground cover is dominated by hounds tongue fern and supplejack. Buddleja, a common garden plant, is also present throughout the area.

At the assessment site the stream was contained within a narrow channel, 0.5 m to 1.0 m wide, with a wetted width of 0.2 m to 0.5 m and shallow water within the channel, between 1 and 10 cm deep at the time of the site visit (June, 2010). The stream banks were low, 0.2 m to 0.3 m high, and bank stability was moderately high with small sections of undercutting observed.

In-stream habitat was dominated by shallow riffles and drops, with small run and pool areas. Bed substrate was stable, comprising mainly gravels and cobbles with patches of fine sediments. Woody debris and leaves were common throughout.

No amenity values were identified.

Figure 5-4: Stream Assessment Site (left); Location of Stream Entry to Stormwater Pipes on Ravensbourne Road (right)

5.2.2 Water Quality

The pH level in the stream was within the range 6.5 to 9.0. This is typically cited as being the appropriate range for freshwater bodies in New Zealand (ANZECC, 1992). Water temperature was low reflecting the time of year of sampling.

Conductivity levels were high indicating nutrient enrichment.

The Third Schedule of the RMA (1991) states that a dissolved oxygen level of 80 % is an acceptable minimum standard for lowland river environments in New Zealand. The dissolved oxygen levels in the stream assessed in this catchment were relatively high, exceeding the minimum standard.

5.2.3 Stream Ecology

The ecological assessment of the streams involved the survey of aquatic plants, benthic macroinvertebrates and fish. A survey of the benthic algal cover and aquatic plants was undertaken and the relative abundance and diversity of species assessed.

Macroinvertebrates were sampled from a representative area of the stream bed substrate using a kicknet. The abundance and diversity of taxa was assessed and macroinvertebrate community health index score was calculated to give an indication of habitat quality. The health index score generally increases as water quality and habitat diversity increases. A semi-quantitative macroinvertebrate community Index (SQMCI) score was also calculated. This can be used to determine the level of organic enrichment in a stream.

In order to sample fish species and determine the fish community within the stream, electric fishing was carried out, at locations representative of the different habitats within the stream. Where electric fishing was not able to be carried out efficiently, spotlighting was carried out to visually identify the fish.

The results of the stream ecological assessment can be summarized as follows:

- Aquatic Plants: No aquatic plants or benthic algae were visible in the stream channel. The smaller bed substrate and high levels of shading by overhead vegetation do not provide suitable conditions for algal growth.

- Macroinvertebrates: The macroinvertebrate community was dominated by snails and chironomid (midge) larvae. A total of 12 taxa were observed which is below the national average (as determined in a nation-wide survey by Quinn and Hickey 1990). Health index scores were low and indicative of a 'fair' quality habitat (using narrative terminology of Stark and Maxted 2004). The SQMCI score was slightly lower than the health index score and was just below the threshold for 'fair' quality habitat.

- It was concluded that, based on the invertebrate community present, an overall site assessment of 'fair' was appropriate.

- Fish: No fish were caught or observed in the stream surveyed. The New Zealand Freshwater Fish Database did not contain any records of fish species in this catchment.

5.2.4 Summary

Whilst the water and habitat quality in the stream assessed were high, the macroinvertebrate community was of relatively poor quality, and no fish or benthic algae were observed.

The different habitat and ecosystem features have been interpreted relative to each other and the other streams in the Dunedin stormwater catchments assessed as part of this study. This is shown in Table 5-3.

Table 5-3: Summary of habitat and ecosystem quality in the Ravensbourne Road catchment
(Values are 'poor', 'good', and 'excellent')

Feature	Ravensbourne Road 1
Riparian vegetation	Good
In-stream cover	Excellent
Bank stability	Excellent
Bed substrate	Good
Flow variability	Good
Water quality	Excellent
Invertebrates	Poor
Fish	Poor

6 Stormwater Quality

This section of the report provides a description of stormwater quality monitoring undertaken to date in and around the catchment, and provides a characterisation of the stormwater quality being discharged from the Ravensbourne Road catchment Based on the information available.

6.1 Stormwater Quality Monitoring

Annual water quality sampling of the stormwater discharges in this catchment is required as a condition of the discharge consents. One outfall in the Ravensbourne Road catchment has been included in this sampling regime .

The resource consents for stormwater discharge in this catchment require that the water quality sampling shall be undertaken; following one storm event annually, during storms with an intensity of at least 2.5 mm of rainfall in a 24 hour period and the storms must be preceded by at least 72 hours of no measureable rainfall.

Monitoring of the stormwater quality at the outfall has been carried out by Ryder Consulting Ltd. Several rounds of monitoring have been completed to date; 2007, 2008, 2009 and 2010. A grab sample was taken from the stormwater outfall within 1 hour of the commencement of a rainfall event to attempt to ensure that the first flush, and therefore worst case scenario, is captured.

Three time-proportional stormwater quality samples have also been taken across Dunedin as part of the 3 Waters Strategy; one at South Dunedin (2009), one at Bauchop Street (2009), and one at Port Chalmers (2010). These three sites provide stormwater quality representing industrial / residential, commercial / residential, and residential land uses respectively.

6.2 Stormwater Quality Results

Urban stormwater can contain a wide range of contaminants, ranging from suspended sediments and micro-organisms to metals and petroleum compounds, amongst others. The sources of the contaminants are also wide ranging in urban environments with anthropogenic activities significantly contributing to runoff quality.

Table 6-1 presents the results of the annual monitoring at the Ravensbourne Road outfall, which is undertaken via a grab-sampling technique, providing a 'snapshot' of stormwater quality during a storm event.

Table 6-2 shows the results of the time proportional sampling in Dunedin. The results provide an indication of the variations in contaminant concentrations throughout the duration of a rainfall event for catchments with differing urban land uses.

There are no specific guidelines for stormwater discharge quality, either nationally or internationally, however Table 6-3 presents stormwater quality data from a variety of sources. This information provides an indication of 'typical' stormwater contaminant concentrations that might be expected from urban catchments.

The annual monitoring results indicate that the level of contaminants in the stormwater is variable between the years monitored, with many contaminants below detectable levels in certain years. Considerable variability can be expected in stormwater sampling due to antecedent conditions (the number of dry days prior to rainfall) and event characteristics (intensity and duration of rainfall) affecting the amount of sediment (and hence contaminants) present in the stormwater. Additionally, the grab-sampling technique employed may have taken a sample at any point during the event

The results of the 2010 monitoring indicate, in general, higher levels of contaminants than the previous year. Across the four sampling years however, the results do not clearly show any trends and therefore it is difficult to determine any deterioration or improvement in the quality of the stormwater being discharged from this catchment.

Despite fluctuations in the data, the range of heavy metal concentrations observed over the monitoring period to date, is at the lower end of typical concentrations in industrial stormwater when compared with stormwater data from the variety of sources presented in Table 6-3.

Suspended solid measurements have shown an increasing trend from 2008 to 2010, however they appear to be relatively low and typical of stormwater from an industrial catchment when compared both with the time proportional monitoring data collected in Dunedin and data from other similar catchment types elsewhere (see Tables 6-2 and 6-3).

Microbiological contamination of the stormwater is generally low, and results are within the typical range for urban stormwater for Faecal coliforms (1,000 – 21,000 MPN/100ml) (Metcalf and Eddy, 1991).

FWAs were present in the stormwater in 2009 and 2010 only, at very low levels. FWAs are present in cleaning products, and whilst usually present in wastewater, small concentrations in stormwater may originate from activities such as vehicle washing.

Table 6-1: Stormwater Quality Consent Monitoring Results – Ravensbourne Road Catchment Outfall

Year	Contaminant											
	pH	As	Cd	Cr	Cu	Ni	Pb	Zn	TSS	Oil and Grease	FWA	E.Coli	Faecal Coliforms
		g/m^3									µg/l	MPN/ 100ml	cfu/ 100ml
2007	-	-	-	-	-	-	-	-	-	-	-	-	-
2008	7.0	BDL	BDL	0.00061	0.0023	0.00066	0.0015	0.053	8.5	8.8	BDL	120	130
2009	8.1	BDL	BDL	BDL	BDL	BDL	0.0029	0.047	18	BDL	0.096	90	90
2010	7.3	BDL	BDL	BDL	0.0031	0.00148	0.00023	0.144	61	BDL	0.136	11,000	11,000

BDL = Below detection limits

Table 6-2: Dunedin Time Proportional Stormwater Monitoring Results, Contaminant Ranges

Location, Date (Land Use)	Contaminant											
	pH	As	Cd	Cr	Cu	Ni	Pb	Zn	TSS	Oil and Grease	E.Coli	Faecal Coliforms
		g/m^3									MPN/ 100ml	cfu/ 100ml
South Dunedin, 2009 (Industrial / Residential)	7.0 - 7.7	0.0012 - 0.0052	BDL - 0.00041	0.0011 - 0.0074	BDL - 0.064	0.0067 - 0.0730	0.0008 - 0.0044	0.230 - 0.840	17 - 160	26 - 42	3900 - 14000	5400 - 20000
Bauchop Street, 2009 (Commercial / Residential)	6.7 - 7.9	BDL - 0.0038	BDL - 0.00054	BDL - 0.0500	0.040 - 0.230	BDL - 0.0870	BDL - 0.0870	0.05 - 2.50	26 - 330	7 - 53	n / a	n / a
Port Chalmers, 2010 (Residential)	7.6 - 7.9	BDL	BDL	BDL	BDL	BDL - 0.1080	0.0024 - 0.0077	0.108 - 0.260	8 - 47	6 - 18	n / a	320 - 1000

BDL = below detection limit

Table 6-3: Comparison of Ravensbourne Road Catchment Stormwater Quality with Other Stormwater Quality Data

Contaminant (g/m^3)	Time Proportional Dunedin	Christchurch Recommended Provisional Mean Values[1]	Pacific Steel, Auckland[2]	Brookhaven Subdivision[3]	Australian Stormwater Mean [4]	Urban Highway, USA[5]	New Zealand Data Range[2]	Ravensbourne Road 2010
	Residential / Industrial	Christchurch	Industrial	Residential	Australian sites	Highway	Urban	Industrial
TSS	8 - 330	33 - 200	124	5 - 49	164	142	-	61
Zinc	0.05 - 2.50	0.40	2.80	0.003 - 0.260	0.910	0.329	0.09 - 0.80	0.144
Copper	BDL - 0.23	0.05	0.08	0.002 - 0.031	0.08	0.054	0.015 - 0.110	0.0031
Lead	BDL - 0.087	0.075	0.23	0.003 - 0.007	0.25	0.4	0.06 - 0.19	0.00023

BDL = below detection limit

[1] Christchurch City Council (2003). [2] Williamson (1993). [3] Zollhoefer (2008). [4] Wendelborn et al. (2005). [5] U.S. Department of Transportation Federal Highway Administration (1990).

7 Stormwater Quantity

7.1 Introduction

A linked 1 and 2-dimensional hydrological and hydraulic model of the Ravensbourne Road catchment and stormwater network was developed to replicate the stormwater system performance, and to predict flood extents during a number of different scenarios. Two modelling reports were produced for DCC; the '*Ravensbourne Road Model Build Report*' (Opus, 2010a), and the '*Ravensbourne Road Catchment Hydrualic Performance Report*' (Opus, 2010b), and the information presented in this Section is sourced from these reports. Figure 7-1 provides a diagram of the model extent.

The modelling analysed a number of influences on the system, as follows:

- Two alternative catchment imperviousness figures; one for the current land use, and one for the future, representing the likely maximum imperviousness.
- Seven different high tide situations; current mean high water springs (MHWS); MHWS with 2030 and 2060 medium and extreme climate change scenarios; and MHWS with two storm surges (1 in 2 yr Average Recurrence Interval (ARI) applied to current, and 1 in 20 year ARI applied to 2060 extreme climate change).
- Five design rainfall events; 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 50 year and 1 in 100 year ARI events (refer Rainfall Analysis, Appendix D).
- Three climate change scenarios; no climate change, mean climate change, and extreme climate change (for 2031 and 2060 design horizons).

No flow monitors were installed in the catchment due to its small size and multiple outfalls, and therefore the simplified model built of the Ravensbourne Road catchment and network was not calibrated. The model relied in the most part on DCC GIS (geographic information system) and Hansen (database) information regarding network configuration and detail. Site visit information, operational knowledge and LiDAR survey data were also incorporated into the model. Catchment hydrological (runoff) parameters were estimated based on the calibrated model built for the pilot catchment, South Dunedin. The model extent includes part of the stadium area, the stormwater from which is now managed on site and discharges into the Water of Leith. Stormwater from the harbourside arterial extension is managed via a stormwater detention pond, which discharges into the western-most stormwater pipeline in the Ravensbourne catchment. It is not anticipated that these recent changes will significantly affect the discharges from the Ravensbourn outfalls, although future amendments to the model and ICMP should incorporate these changes.

Confidence in the model output is considered to be low; however the model has been built using accepted sound methodology by experienced modellers and engineers. The model output is not absolute, however it is an adequate tool for the purposes of indicating areas with a potential to flood, and allowing the comparative effects of the different rainstorms and climate change to be assessed.

7.2 Model Results

Fourteen scenarios representing different land use, rainfall, climate change and tide combinations have been modelled. Tables 7-1 and 7-2 below provide the results of the modelling, in relation to information required to assess the performance of the system and enable the environmental effects to be determined.

In general, DCC are particularly concerned with the point at which a manhole is predicted to overflow and cause flooding (particularly to potential habitable floor level); however the pipe surcharge state, and manholes that are 'almost' overflowing are also of relevance when considering available capacity in the system. Section 8 analyses the modelling results in order to identify key issues relating to system capacity and flooding.

With respect to flooding of private property, model results are presented as a 'number of land parcels with flood depth potentially > = 300 mm', and are based on a GIS assessment of DCC cadastral maps, overlaid with modelled flood extents. When targets for protection of private property are set (Section 11) these are set to limit the flood risk to private property and habitable floors. As discussed further in Section 8, the modelled deep flooding of part of a parcel does not necessarily mean that the entire property is inundated; further detail (including survey) is generally required to confirm the risk to habitable floors.

Table 7-1: Ravensbourne Road Catchment Model Results – Current Land Use

Hydraulic Performance Measure	ARI	Current Land Use
Percentage of manholes predicted to overflow	1 in 2[1] yr	0
	1 in 5 yr	11
	1 in 10 yr	25
Number of land parcels with flood depth potentially > = 300 mm[2]	1 in 2 yr	0
	1 in 5 yr	0
	1 in 10 yr	0
	1 in 50 yr	0
	1 in 100 yr	0
Estimated flood extent (% of catchment area with flood depth > = 50 mm)	1 in 2 yr	0.00
	1 in 5 yr	0.03
	1 in 10 yr	0.20
	1 in 50 yr	0.59
	1 in 100 yr	0.86
Modelled percentage (by number) of pipes surcharging	1 in 2[1] yr	22
	1 in 5 yr	56
	1 in 10 yr	88
Percentage of manholes predicted to be close to overflowing (free water level within 300 mm of cover)	1 in 2[1] yr	8
	1 in 5 yr	33
	1 in 10 yr	44

[1] 1 in 2.33 year event (mean annual flood)

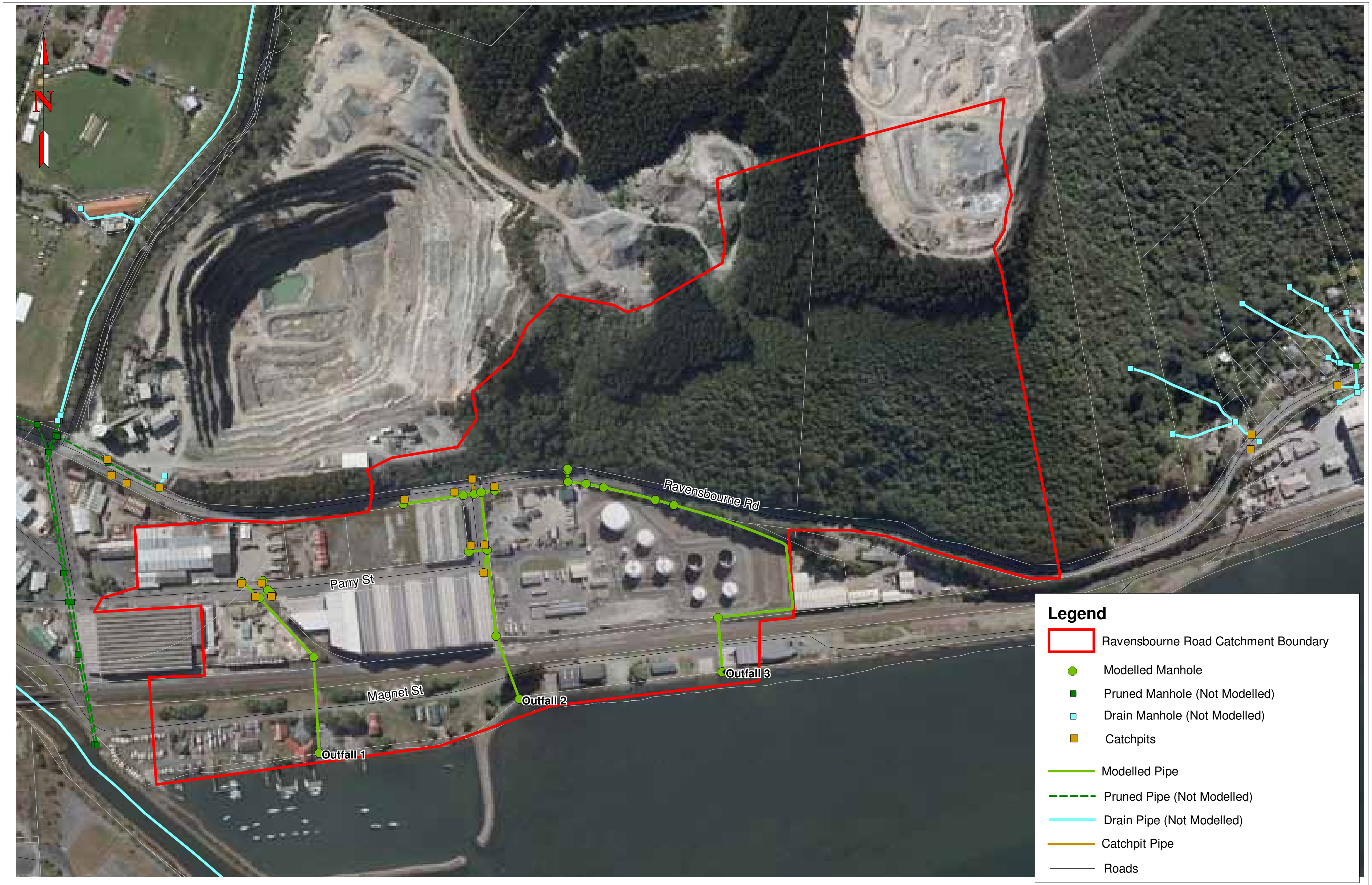
[2] On all or part of a land parcel, or against a building void in the 2-D surface.

Table 7-2: Ravensbourne Road Catchment Model Results – Future Land Use / Climate Change

Hydraulic Performance Measure	ARI	Planning Scenario				
		2031			2060	
		Growth Only	Mean Climate Change	Extreme Climate Change	Mean Climate Change	Extreme Climate Change
Percentage of manholes predicted to overflow	1 in 10 yr	25 %	28 %	28 %	28 %	42 %
Number of land parcels with flood depth potentially >= 300 mm[1]	1 in 10 yr	0	0	0	0	0
	1 in 50 yr		0		0	
	1 in 100 yr					8[2]
Estimated Flood Extent (% of catchment area with flood depth >= 50 mm)[2]	1 in 10 yr	0.20	0.24	0.26	0.28	0.43
	1 in 50 yr		0.75		0.92	
	1 in 100 yr					18.44[2]
Modelled percentage (by number) of pipes surcharging	1 in 10 yr	88 %	94 %	100 %	100 %	100 %
Percentage of manholes with free water level within 300 mm of cover	1 in 10 yr	44 %	44 %	47 %	47 %	61 %

[1] On all or part of a land parcel, or against a building void in the 2-D surface

[2] Includes areas flooded outside the catchment boundary



Dunedin Three Waters Strategy

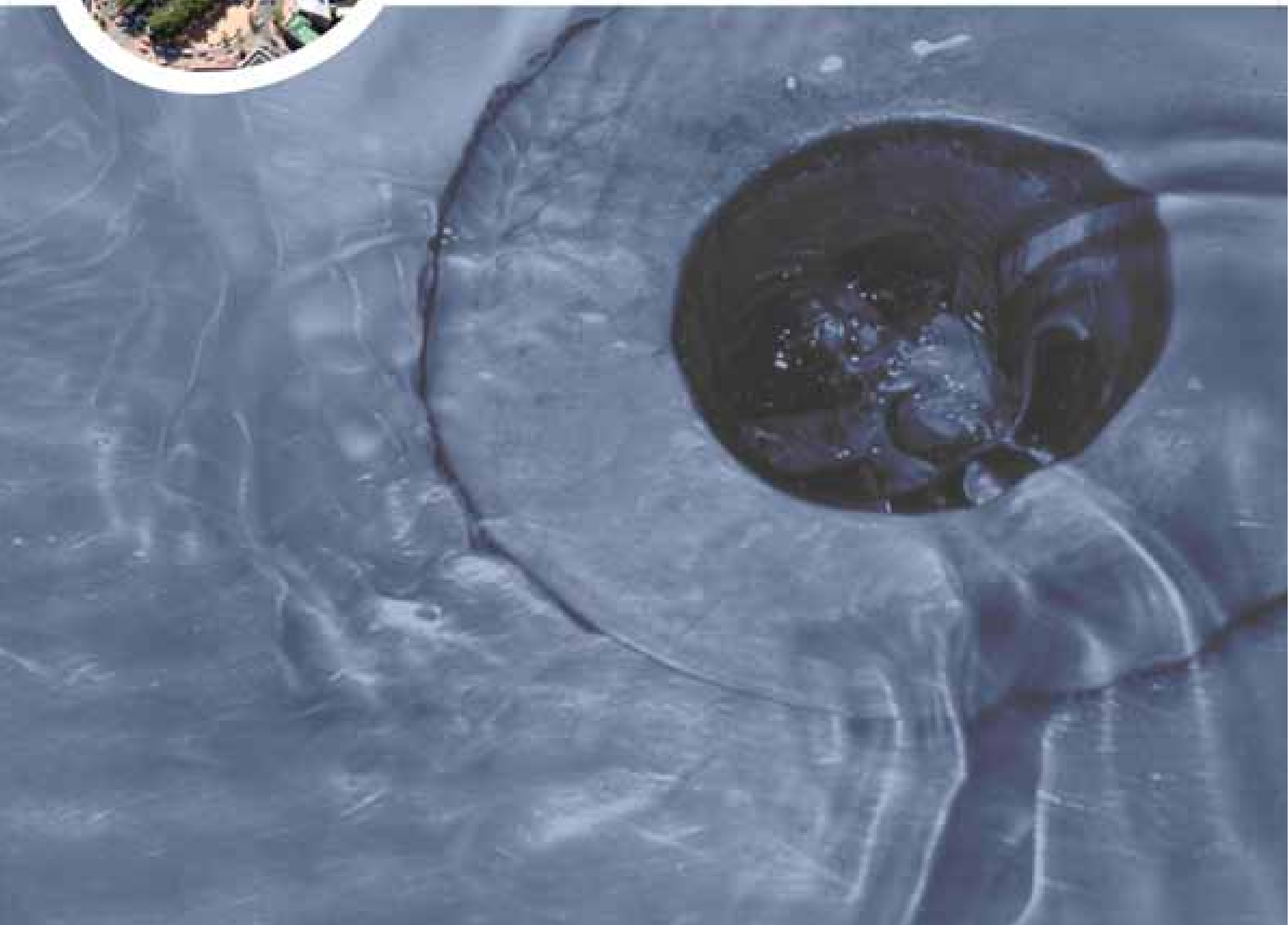
RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN
FIGURE 7-1
MODEL EXTENT

Discipline:

Stormwater

MH		Final	
MG	NTS	November 10	
WB	3-d1040.07		R0
November 10			

Part 3
Analysis



8 Assessment of Environmental Effects

This section identifies and summarises the actual and potential environmental effects on the stormwater network and natural environment relating to stormwater quantity and quality within the catchment.

The effects are summarised based on the interpretation of the outcomes of the stormwater network hydraulic modelling and the associated flood maps; the marine and stream assessments; information gathered during catchment walkovers; DCC flood complaints records; and information gathered during workshops with DCC Network Management staff.

8.1 Stormwater Quantity

8.1.1 Benefits of the Stormwater Network

Urban development significantly increases the area of impervious surfaces from which rainfall quickly runs off. These surfaces include building roofs, paved areas, roads and carparks, and they can also include, but to a lesser extent, grassed and garden areas. In Dunedin, the stormwater network controls the urban runoff, collecting the flows within the system and directing it to the receiving environment. The stormwater network therefore provides a number of benefits to the community.

DCC is responsible for managing the stormwater system in order to provide the best system possible at a reasonable cost to the ratepayer. The objectives set for stormwater management by DCC are outlined in the Stormwater AMP, as follows:

> *"The key objective of the Stormwater Activity is to protect public health and safety by providing clean, safe and reliable stormwater services to every customer connected to the network with minimal impact on the environment and at an acceptable financial cost. In addition to ensuring effective delivery of today's service, we also need to be planning to meet future service requirements and securing our ability to deliver appropriate services to future generations."*

The stormwater activity is particularly focused on providing protection from flooding and erosion, and controlling and reducing the levels of pollution and silt in stormwater discharge to waterways and the sea, and the overall objective is broken down into the individual activity objectives of:

- Ensuring stormwater discharges meet quality standards;
- Ensuring services are available;
- Managing demand;
- Complying with environmental consents;
- Strategic investment;
- Maintaining assets to ensure serviceability; and
- Managing costs.

8.1.2 Stormwater Quantity Effects

The hydraulic model results, summarised in Table 7-1 and 7-2, have been used to assess the hydraulic performance of the stormwater network with respect to the criteria shown in the table. This information has been analysed alongside flood maps, observed catchment issues, anecdotal evidence and operational information, to assess the effects of stormwater quantity within this catchment.

The hydraulic model is not calibrated as no flow monitoring was undertaken for this catchment due to its small size. This is considered acceptable, as long as assumptions are conservative. However, confidence in the model is low.

The effects of stormwater quantity on the network within the Ravensbourne Road catchment are discussed in the following section. The effects on the level of service, flooding and key system structures are identified in relation to current and future land use scenarios and projected climate change.

8.1.3 Infrastructure Capacity

The network analysis and flood mapping undertaken for the current land use shows that the predicted level of service provided by the stormwater network in the Ravensbourne Road catchment is between a 1 in 2 and a 1 in 5 yr ARI rainfall event.

No manholes are predicted to overflow during a 1 in 2 yr ARI event, however during a current 1 in 5 ARI rainfall event, 11 % of catchment manholes are predicted to overflow, with a further 33 % close to overflowing (water level within 300 mm of the surface). Surcharging across the network is predicted, however approximately 44 % of the network has some spare capacity, mainly in the east of the catchment. 25 % of manholes in the catchment are predicted to overflow in a current 1 in 10 yr ARI rainfall event (refer Figure 8-1).

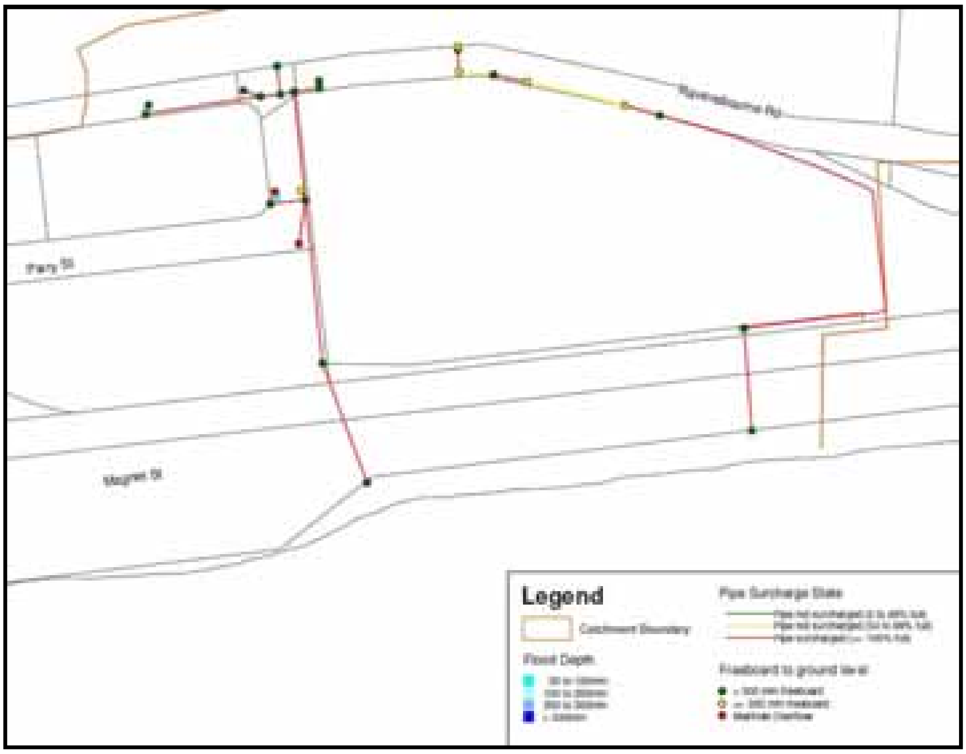


Figure 8-1: 2010 1 in 10 yr ARI Rainfall Event

Network surcharging and manhole overflows are predicted due to the hydraulic capacity of the system being insufficient to convey the predicted flows – the Ravensbourne Road catchment is very flat, and pipe sizes are relatively small. The network branches draining to outfalls 1 and 3 have been identified as being tidally influenced, however the effects of this in terms of flood extent and duration appear to be minor,

The area of the network providing the lowest level of service is at the western end of Parry Street. Manhole overflows are predicted to first occur during a 1 in 5 yr ARI rainfall event, ponding is predicted to occur in the road until the catchpits have the capacity to drain the water, following the peak of the rainfall event. Network surcharge increases during larger events. During a 1 in 10 yr ARI rainfall event, ponding within the road is predicted at both the eastern and western ends of Parry Street.

As this catchment is almost fully developed, future land use changes are unlikely to impact the catchment's hydrology. Climate change impacts are also predicted to be relatively minor for the moderate climate change scenarios, with 3 % more manholes predicted to overflow during a 2060 mean climate change scenario than in a current 1 in 10 yr ARI rainfall event. Effects of the extreme climate change scenario are discussed further below in section 8.1.4.

Discussions held with DCC Network Maintenance personnel during the catchment walkovers and workshops indicate that this is a catchment that the Water and Waste Business Unit personnel are rarely called to in response to stormwater issues. This, combined with a lack of stormwater flooding complaints, indicates that there are no significant issues with the service provided by the stormwater network in the Ravensbourne Road catchment.

8.1.4 Flooding

The hydraulic model has been used to indicate areas within the catchment potentially at risk of flooding during a variety of planning scenarios. This includes a range of storm events, current and future land use scenarios and climate change projections, generally modelled with a MHWS tide condition (adjusted for climate change where necessary). These predictions have been validated, where possible, with anecdotal evidence from DCC Network Management and Maintenance staff, and observations made on the catchment walkovers. As outlined in Section 4.8, no flood complaints have been made in the catchment in recent years, while not conclusive, this indicates that flooding in the catchment is not extensive or problematic.

Predicted nuisance flooding, habitable floor flooding and flood hazard ratings within the catchment have been assessed, and are discussed in the following sections.

8.1.4.1 Nuisance Flooding

Nuisance flooding constitutes predicted flood depths generally between 50 mm and 300 mm, or flooding in locations unlikely to cause habitable floor flooding or serious transport disruption. Flood depths greater than 300 mm deep pose a potential habitable floor flooding risk, and are discussed in the following section.

During a current 1 in 5 yr ARI rainfall event, ponding occurs at the location of the catchpits at the western end of Parry Street. During a 1 in 10 yr ARI rainfall event, the extent of ponding increases and the catchpits at the eastern end of Parry Street are also predicted to overflow causing localised flooding. This is, however, contained within the road and the flood depths are predicted to remain below 300 mm. Therefore, there is little risk of property interiors flooding. Furthermore, the predicted flooding is predominantly along the kerb and would not render this road impassable to traffic.

The nuisance flooding during a 1 in 10 yr ARI rainfall event is not predicted to deteriorate significantly when future planning scenarios are applied. Flood depths remain below 300 mm and concentrated along the kerbs of Parry Street.

Predicted flood depths remained shallow and confined to road corridors when larger events were modelled. For example, during a current 1 in 100 yr ARI event the total flood area is predicted to comprise approximately 0.86 % of the total catchment, the majority of which remains concentrated in the road around the catchpits at the eastern and western ends of Parry Street. Whilst the flooding at the western end of Parry Street extends the full width of the road, depths do not exceed 200 mm and therefore the road is unlikely to become completely impassable. Given that Parry Street is a minor road and not a strategic route, this flooding is unlikely to cause traffic disruptions..

The predicted flooding at the western end of Parry Street occurs at the boundary of the new stadium site which is a DCC wellbeing location (see Section 4.7.3). It is also within the designation for the State Highway arterial harbour link. The stormwater network (pipes and catchpits), at this location will be altered during the construction of the new stadium and State Highway extension. At the time of writing this plan construction was ongoing and design details, particularly for the State Highway extension, were not finalised. It is necessary to ensure that adequate allowances for stormwater are made during the design and development of these sites to prevent exacerbation of the nuisance flooding within the catchment.

8.1.4.2 Habitable Floor Flooding

Flood depths equal to or greater than 300 mm present a risk of habitable floor flooding. Habitable floor flooding is the flooding of 'useful floor space' for any zoning (including industrial). This is defined as the floor space of a dwelling or premises inside the outer wall, excluding cellars and non-habitable basements. Land parcels (properties) have been defined as 'at risk' of habitable floor flooding where the property boundary is intersected by a flood plain depth of equal to or greater than 300 mm. It should be noted however, that the exact location of buildings and corresponding floor levels are not documented so it is not usually known whether flooding may only occur within the property boundary or affect the building.

New stormwater systems are designed to avoid habitable floor flooding during a 1 in 50 yr ARI rainfall event. For existing systems, assessment of all rainfall events is undertaken in order to assess the risk of flooding.

There is little risk of habitable floor flooding within the Ravensbourne Road catchment for current and future scenarios during a 1 in 50 yr ARI rainfall event and during a current 1 in 100 yr ARI rainfall event, as flood depths are not predicted to be greater than 300 mm. There are no flood complaint records for this catchment to indicate that habitable floor flooding has been a problem in the past.

8.1.4.3 Flood Hazard

The hydraulic model has been used to predict flooding during two 'emergency planning' events: a 1 in 100 yr ARI rainfall event with current land use, and during a future worst case (extreme) climate change scenario. The results from the extreme planning scenario will allow DCC to put emergency planning measures in place to avoid future catastrophic effects within the catchment, and to identify where overland flow paths lie.

A predicted flood hazard rating has been calculated for the current and future (extreme) planning scenario during a 1 in 100 yr ARI event. A flood hazard rating is a factor of velocity and depth calculated from the hydraulic model results. It indicates the likely degree of flood hazard for a given area and the associated risk to the public. A definition of each Rating can be found in Table 8-1 below.

Table 8-1: Flood Hazard Rating

Flood Hazard Rating	Degree of Flood Hazard	Flood Hazard Description
< 0.75	Low	Caution – flood zone with shallow flowing water or deep standing water.
0.75 – 1.25	Moderate	Dangerous for some – (i.e. children). Flood zone with > 250 mm deep, or fast flowing water.
1.25 – 2.0	Significant	Dangerous for most – flood zone with 250 mm - 400 mm deep, fast flowing water.
> 2.0	Extreme	Dangerous for all – flood zone with 400+ mm deep, fast flowing water.

The maximum flood hazard rating for the Ravensbourne Road catchment during a current 1 in 100 yr ARI rainfall event is 'low'.

During a future 1 in 100 yr ARI rainfall event when the extreme planning scenario is applied, it is predicted that the total flood area will comprise approximately 18 % of the catchment (refer Figure 8-2). Much of this predicted flooding is associated with the extreme tide level and storm surge applied to the model. During this future event, a total of eight land parcels are predicted to experience flood depths of greater than 300 mm, six of which however, experience deep flooding directly due to the tidal inundation. Transport routes in the catchment would be significantly disrupted, resulting in certain locations being cut off. As mentioned above, it is beyond the scope of this management plan to detail or manage the effects of sea level change, however it is of importance that the stormwater network will not be functioning as designed at these extreme sea levels, and that a flood hazard risk may develop in the future should current climate change predictions remain valid.

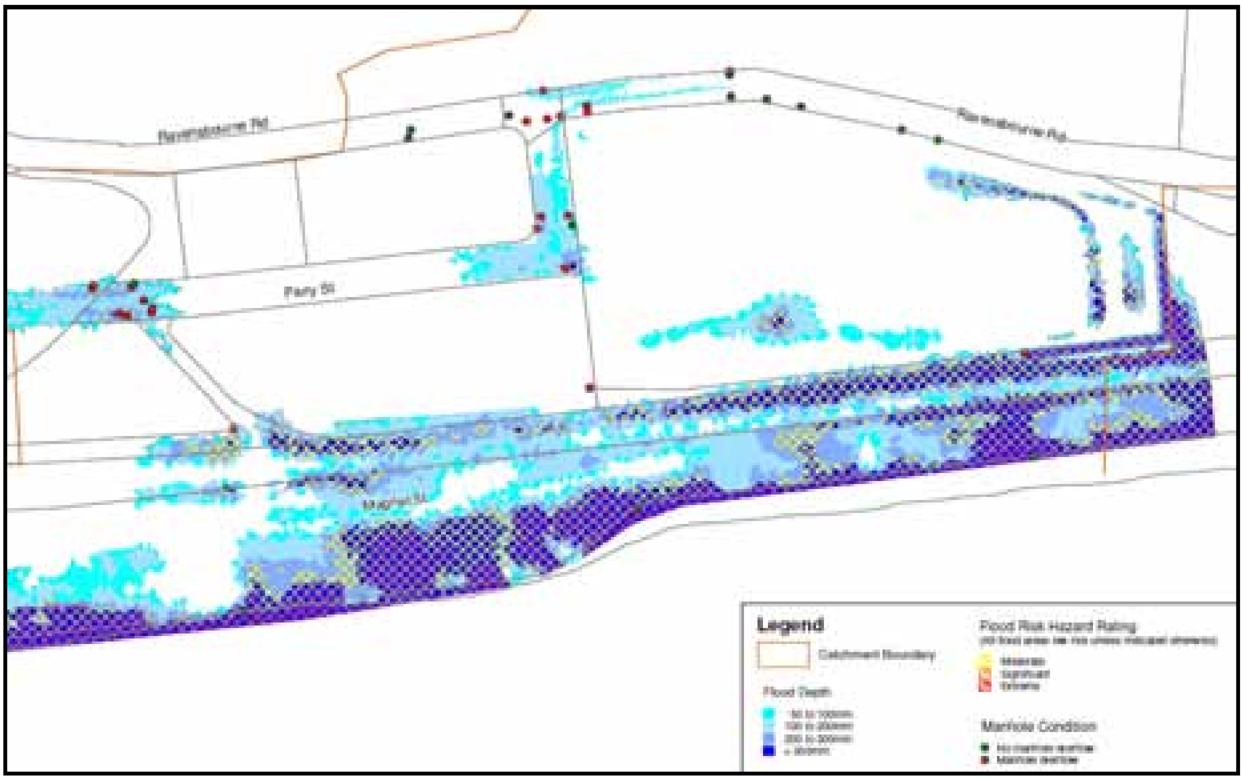


Figure 8-2: 2060 Predicted Flood Hazard, 1 in 100 yr ARI Rainfall Event

8.1.5 Network Age, Operation and Maintenance

As outlined in Section 4.7.6, depending on the location, catchpit and inlet maintenance is undertaken by a number of different teams with variations in inspection specification. This means that city-wide, there are variations in catchpit levels of service. During autumn months in particular, heavy rainfall can result in debris blocking the catchpits and inlet screens. A reduction in catchpit capacity due to silt build up can lead to extension of ponding durations and extents during a rainfall event. Similarly, blocking of inlet screens (of culverts or catchpits) prevents flow entering the network, also resulting in extended ponding, as well as increasing overland flow to other locations. This was verified by Network Maintenance and Management staff as a potential issue during walkovers and workshops.

To assess the impact of catchpit blockage within the Ravensbourne Road catchment, the hydraulic model was used to test the impact of catchpit blocking on flood predictions using a 1 in 10 yr ARI rainfall event. The model was run with half the catchpits set as blocked, and then with the capacity of all catchpits reduced by 50 %. The results were then compared with the original un-modified model for comparison.

The results showed that when half the modelled catchpits are set to blocked, the ponding water finds its way into the system via nearby adjacent catchpits resulting in little difference in peak flow or flood extent when compared with the original model. The lower Ravensbourne Road catchment is relatively flat and the catchpits in the road are grouped together thus providing alternative flow paths for surface flows.

When the entry of the catchpits is halved (all 50 % blocked), the results showed that ponding above the catchpits is slightly increased. This is not considered to be significant as there are no major differences in peak flow or flood extents or depths because only a small increase in head is required to drive additional flow through the catchpits, when compared to the original model.

To summarise, catchpit performance is predicted to cause only minor differences in the scale of flooding in this catchment.

It is known that the intake structure in Ravensbourne Road becomes partially blocked with debris at certain times of the year. This was observed during the catchment walkovers. During the current 1 in 10 yr ARI rainfall event the intake structure was not predicted to overtop, even with the level of blockage assumed being based on that observed at the time of the catchment walkover. It is however, predicted that a small increase in blockage would be sufficient for the structure to overtop, but this would only result in minor flooding at the side of the road, even when fully blocked.

8.1.6 Culture and Amenity

There are no significant cultural or recreation sites predicted to be adversely effected by stormwater quantity within the catchment with the exception of the future 'extreme' scenario, which will affect most of the recreation reserve along the harbour front on Magnet Street. It is likely that during the 'extreme' scenario, however, emergency planning responses and health and safety of the public will be the foremost concern rather than protection of recreational sites.

The predicted nuisance flooding at the western end of Parry Street is in the vicinity of a DCC wellbeing location, (the new stadium site) and the State Highway extension designation. Potential adverse effects on these sites arising from the predicted flooding in Parry Street can be mitigated by design of adequate stormwater provisions during the development of these sites. The effects, therefore, are likely to be less than minor.

8.1.7 Summary of Effects of Stormwater Quantity

A summary of the effects of stormwater quality is as follows:

- The current level of service for the network in this catchment is between a 1 in 2 yr and a 1 in 5 yr ARI rainfall event. However, only minor nuisance flooding is predicted to occur and the lack of flood complaints suggests that this is not an issue.

- The level of service of the stormwater network is slightly influenced by tide level, more significantly at outfall 1 and outfall 3.

- Flooding duration in the catchment is expected to be short, given the proximity of predicted flooding to catchpits, and the short distance to the outfalls.

- Potential blockage of catchpits within the catchment may contribute to flood duration and extent.

- Nuisance flooding is predicted in the catchment (predominantly on Parry Street), occurring during storms as small as a 1 in 5 yr ARI rainfall event. Flood depths are predicted to remain below 300 mm across the catchment in all but the extreme planning event. Parry Street is a minor road and not a strategic route, and this flooding therefore is unlikely to cause significant traffic disruptions.

- During a current 1 in 100 yr ARI rainfall event, predicted maximum flood hazard rating for the catchment is ‘low’.

- The application of an extreme climate change scenario with sea level rise and storm surge results in the model predicting that 18 % of the catchment may be flooded, presenting an extreme flood risk. The majority of this flooding is, however, the result of tidal inundation directly onto the low-lying catchment, and not the performance of the stormwater network.

8.2 Stormwater Quality

The north of the Ravensbourne Road catchment is undeveloped. There is a quarry at the head of the catchment and dense planted forest and bush cover to the north of Ravensbourne Road. Stormwater from this northern part of the catchment will comprise runoff from the planted forest and bush and as such is unlikely to contain significant anthropogenic contaminants. The southern portion of the catchment is almost fully developed. Stormwater runoff from this urban environment is likely to contribute to the majority of contaminants within the stormwater.

Stormwater quality is discussed in detail in Section 6. Annual monitoring of the quality of the stormwater discharged from the Ravensbourne Road catchment has been undertaken (2008 to 2010). The following observations must be viewed in the context of a very small dataset and the limitations of the sampling method (discussed below).

- The levels of all contaminants in the stormwater from the outfalls in this catchment are at the low end of the typical range of stormwater quality from an industrial catchment.
- The results show variability between years and to date, due to both the sampling method, and an insufficient number of samples to establish trends.
- Sampling data does not indicate presence of a wastewater overflow in the catchment.

The variability in the stormwater quality results is likely to be due not only to the relatively small data set, but also due to other factors, such as the time since the previous rainfall event within the catchment, and the intensity and distribution of rainfall. A long period between rainfall events allows contaminants to build up within the catchment and as such the contaminant concentrations in the stormwater following the first rainfall event for a significant period of time may be higher.

However, the key contributing factor to the data variability is likely to be the use of grab samples to monitor the stormwater. Grab sample results give a 'snapshot' of the stormwater quality at one point in time only. Throughout a storm event, the concentration of contaminants within the stormwater varies depending on the time since the start of the event. This is indicated in Figure 8-3 below.

The time, during the storm event, that grab samples are taken can significantly affect the results. While stormwater samples taken were targeted at sampling the 'first flush', and consent conditions detailed required storm size and antecedent conditions, it is not known when, during a rainfall event, the stormwater monitoring grab samples were taken for each monitoring year. It is possible that they were taken at differing times during rainfall events, hence the data variability and lack of clear trends. Time proportional monitoring of stormwater quality would yield results that provide a more accurate profile of contaminant concentrations within the stormwater from the catchment.

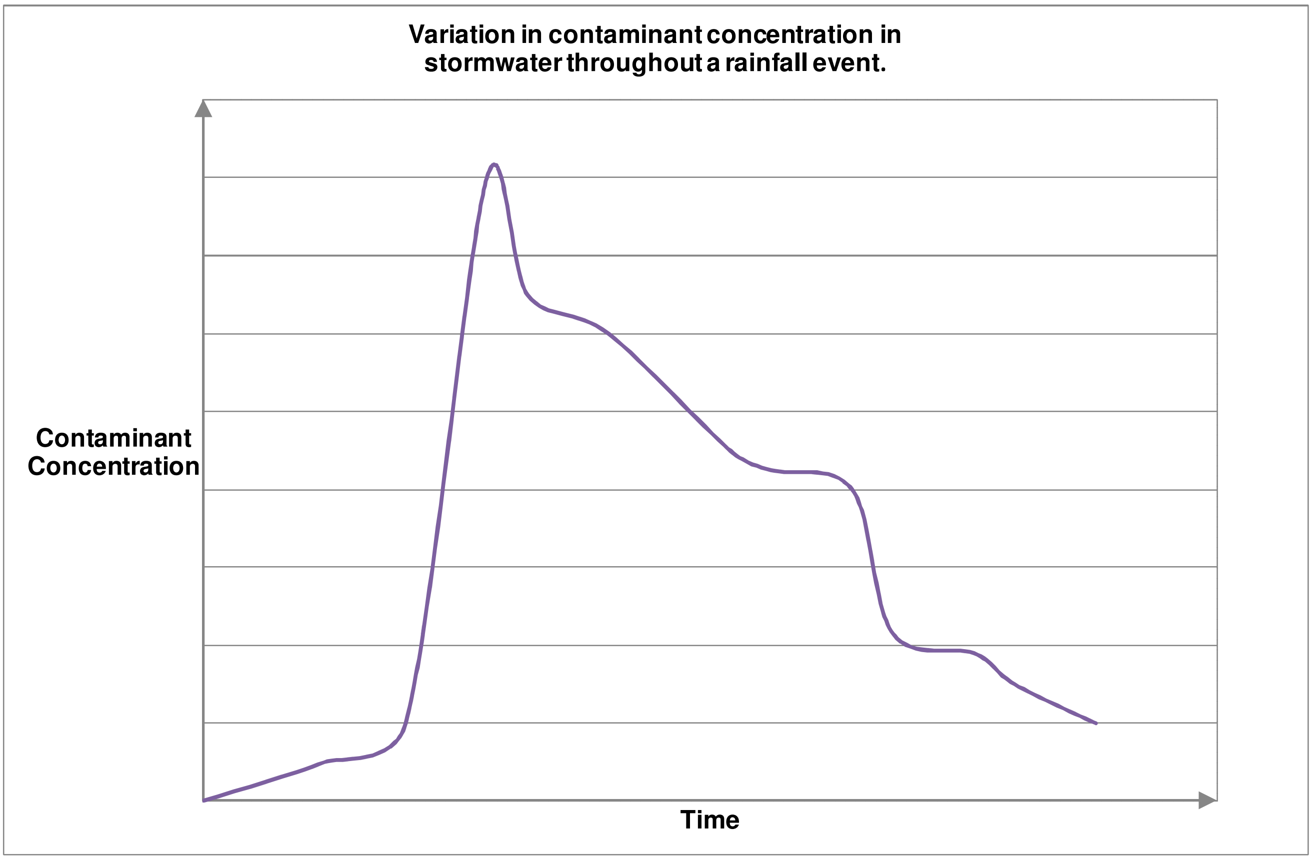


Figure 8-3: Concentration of Contaminants in Stormwater For Duration of a Rainfall Event
(Based on time-proportional sampling carried out in Dunedin)

8.2.1 Harbour Water Quality

The quality of the harbour water will be affected by numerous contaminant sources including, but not limited to: stormwater discharges from the entire harbour catchment; marine vessels; and other marine users. Currently, harbour water quality is not monitored by DCC and as such there is no clear link between the quality of stormwater leaving the outfall and the quality of the water in the harbour.

While no national or international guidelines are available for stormwater discharge quality, ANZECC guidelines are available for harbour water quality (as well as harbour sediment quality) which identify concentrations of contaminants within the marine environment under which 80 % or 99 % of species are protected.

Because of the different contaminant sources identified above, and the dilution that occurs when stormwater enters the marine environment, in order to fully utilise these guidelines, marine water quality monitoring would need to be undertaken alongside stormwater quality monitoring, and links established between stormwater discharge points and marine water quality within the harbour. Further clarity with respect to longer term environmental effects could then be established using sediment quality information.

Marine water quality is also highly variable both spatially and temporally, and sampling results would also only provide a ‘snapshot’ of water quality. Many factors influence the water quality, including dilution and dispersion; freshwater inputs; rainfall events; and tidal currents.

8.2.2 Harbour Sediment Quality

Contaminants in urban stormwater entering the marine environment potentially pose a risk to the health of marine organisms, primarily through the accumulation of the contaminants in marine sediments. Contaminants in the stormwater adhere to suspended particles and sediments in the marine environment and accumulate in the marine bed. High levels of contaminants within the sediments may result in adverse impact on marine flora and fauna which come into contact with those sediments.

To assess the potential effects of contaminated sediments on marine ecology, the contaminant concentrations within the sediments can be compared to sediment quality guidelines. It should be noted however, that guidelines provide indicative rather than conclusive evidence of adverse effects; any exceedence of the guidelines therefore indicates only a potential for adverse effects.

ANZECC (2000) sediment quality guidelines provide low and high trigger values. The low values are indicative of contaminant concentrations where the onset of adverse biological effects may occur, thus providing early warning and the potential for adverse environmental effects to be prevented or minimised. The high values are indicative of contaminant concentrations where significant adverse biological effects may be observed. Exceedence of these values could therefore indicate that adverse environmental effects may already be occurring.

8.2.2.1 Ravensbourne Road Catchment

The contaminant levels within the Ravensbourne Road catchment are discussed in detail in Section 5. To summarise, the levels of contaminants in the marine sediments sampled in 2010 were generally low, with just arsenic exceeding ANZECC (2000) low trigger values. In general, the levels of contaminants were similar to those observed in previous monitoring years.

The elevated level of arsenic within the sediments was observed in samples at a distance of greater than 20 m from the outfall only. Samples from this location have not been analysed in previous monitoring years. At a distance of less than 20 m from the outfall, arsenic levels were not elevated above guideline trigger levels during any monitoring year (2007 to 2010). Furthermore, arsenic was not elevated in the stormwater monitoring results for 2010.

Given the lack of arsenic contamination in sediment near the outfall and in the stormwater discharges, it is unlikely that the elevated arsenic levels in the samples from greater than 20 m from the outfall are associated with the quality of the stormwater discharges from this catchment, but could be as a result of historic contamination, ongoing contamination from sources outside the catchment or due to the high levels of arsenic that occur in naturally in the environment in New Zealand.

Previous land uses in the catchment, in particular on Parry Street, include tanning, wool scouring, timber storage and associated trades. All of which are industries which are potential sources of arsenic and may have resulted in historic contamination within the harbour sediments.

Current potential sources of arsenic contamination in the vicinity of the Ravensbourne Road catchment include a tannery on Awatea Street to the west of the catchment and a fertiliser supplier on Ravensbourne Road immediately to the east of the catchment. The impact of these industries, if any, on the quality of the harbour sediments is unknown.

It is difficult, with only one year’s sediment monitoring data for this catchment, to ascertain whether there is a problem with arsenic contamination in the marine sediments at a greater distance from the outfall, however, any elevated levels are unlikely to be a result of stormwater discharges from this catchment.

The data available to date does not indicate any significant contamination resulting from the current stormwater discharges from this catchment.

In summary, the sediment contaminant levels are below ANZECC (2000) trigger values which indicates that the stormwater discharged from the catchment is not causing significant adverse effects.

8.2.2.2 Harbour-Wide

Harbour-wide, trends in the levels of contaminants in the sediment remain unclear with just four years worth of monitoring data revealing high variability among contaminant levels and sites. Many contaminants are present in the sediments at various sites within the harbour at levels exceeding the ANZECC sediment guideline low trigger values.

However, levels of chromium, copper, nickel, lead, zinc and PAHs were generally found to be lower in 2010 than in previous years. It may be that contamination measured in the sediment is historic and sediment quality may be improving over time due to the deposition of ‘cleaner’ sediments. Deposition rates in the harbour are thought to be reasonably slow, however, and any trend may take some time to observe due to this slow deposition rate.

Further monitoring of the sediments harbour-wide is required to better understand the levels of contamination and establish whether any long term trends exist.

8.2.3 Marine Ecology

There is a lack of temporal biological data for this catchment with just 1 year of monitoring results. The 2010 investigations indicated that the marine benthic and infaunal communities in the vicinity of the outfalls in the catchment are of reasonably poor diversity with sparse abundance.

Historical data and the results of biological monitoring carried out for consent compliance indicate that, in general, a reasonably low diversity amongst the benthic and infaunal communities is likely to be symptomatic of a large proportion of the upper harbour basin. The lack of diversity may be attributable to anthropogenic influences, including stormwater quality, but other factors may also be contributing to the ecological health observed. It is not therefore possible to clearly link ecological health with stormwater quality.

Determining the ecological effects of contamination in the harbour environment is difficult. Unless contamination levels are very high within the sediments it is difficult to distinguish between the potential adverse effects of contamination from stormwater, contamination from other sources, and the effects of other environmental variables. However, as the quality of stormwater from the Ravensbourne catchment was found to be low for the land use, and level of contamination in the sediments in the vicinity of the outfalls was below recommended guidelines, it is likely that the poor ecology observed is as a result of other factors such as substrate composition or exposure at low tide.

8.2.4 Freshwater Habitat Quality

There is a single stream in the Ravensbourne Road catchment. The stream habitat, assessed in 2010, was found to be of good quality in relation to water quality, bed substrate and riparian and aquatic vegetation.

The stream is located within forest and thick bush cover and the majority of the stream catchment is rural, with a quarry at the head of the catchment. There is no development and so water entering the stream will consist of runoff from the surrounding forest and bush and direct rainfall. Runoff into the stream is likely to be gradual and the stormwater likely to be of reasonable quality. As such, the stream habitat quality remains good.

8.2.5 Freshwater Ecology

The aquatic ecology within the stream in this catchment was found to be poor. Given that habitat quality and water quality was found to be high, it is unlikely that the poor ecology can be attributed to these factors.

The stream and its ecology is likely to be limited by the small size of the stream catchment. The stream comprises only a short reach before it flows into a stormwater pipe on Ravensbourne Road. There is little scope for ecological migration up or downstream which would contribute to increased diversity.

No benthic algae was observed at this site, possibly due to the dense vegetation cover and associated reduced light levels within the stream. Benthic algae is a primary producer, a reduction in the primary producers within a stream can have a detrimental impact on the food chain and aquatic ecosystem as a whole. The location of this stream within the dense vegetation may also be a factor influencing the poor ecology in the stream.

To summarise, the poor ecology of the stream in Ravensbourne Road is likely to be as a result of the character of the environment and the stream catchment as opposed to detrimental effects caused by stormwater quality.

8.2.6 Culture and Amenity

The harbour is an important area for recreation with a number of boat clubs and tourism operators in the area. A decline in the quality of the harbour environment could adversely impact on recreational activities.

The harbour has been used historically by Käi Tahu and their descendents and the discharge of stormwater and associated contaminants has the potential to significantly impact Käi Tahu values and beliefs.

To date there is no evidence to suggest that the quality of the harbour continues to deteriorate significantly or that the quality of stormwater from the Ravensbourne Road catchment is significantly contributing to any deterioration of the harbour.

8.2.7 Summary of Effects of Stormwater Quality

A summary of the effects of stormwater quality is as follows:

- The levels of contaminants within the stormwater discharged from the Ravensbourne Road catchment varied throughout the monitoring years (2007-2010) with no clear trend emerging. The contaminant levels measured were not significantly different from levels considered to be typical from industrial and urban catchments.

- Harbour water quality is not currently monitored. Monitoring of harbour water quality would allow comparison with ANZECC (2000) marine water quality guidelines and may allow a link to be established between stormwater discharge quality and harbour water quality.

- In general, sediment contaminant levels from the Ravensbourne Road catchment are below ANZECC (2000) sediment guideline trigger values which suggests that the stormwater discharged from the catchment is not causing significant adverse effects on the marine sediments.

- Arsenic levels were found to be elevated in sediment samples in 2010, above ANZECC (2000) low trigger values, but only from sites greater than 20 m from the outfall. The source of the arsenic contamination is unclear but is unlikely to be as a result of DCC stormwater quality within this catchment.

- In general, harbour-wide, levels of key contaminants in the sediments were found to be slightly lower in 2010 than previous monitoring years. Further monitoring is required to better understand the contamination levels and establish any long term trends.

- The poor marine ecology in the vicinity of the Ravensbourne Road outfalls cannot be directly linked to stormwater or marine sediment contamination.

- Stormwater quality does not appear to be having an adverse effect on freshwater habitat quality.

- Freshwater ecology within the catchment was found to be poor. This is unlikely to be as a result of stormwater quality.

- The harbour has important cultural values and is an important area for recreation. The results of investigations do not indicate that harbour quality is continuing to deteriorate as a result of the quality of stormwater from this catchment.

9 Catchment Problems and Issues Summary

Following the Assessment of Environmental Effects (AEE), and identification of catchment specific targets for stormwater management, a number of key problems and issues can be identified in the Ravensbourne Road catchment, and prioritised for action. These are discussed below. Section 10 following prioritises these issues, and the remainder of this ICMP involves target setting and development of options to manage the stormwater from this catchment. Figure 9-1 presents the key issues for the Ravensbourne Road catchment.

9.1 Stormwater Quantity Issues

9.1.1 Low Level of Service

The modelling results indicate that the current level of service of the stormwater network in Ravensbourne Road catchment is low, estimated to be between a 1 in 2 yr ARI and a 1 in 5 yr ARI rainfall event, during mean high water spring (MHWS) tide conditions. Despite the lack of capacity to accommodate climate change, future scenarios result in only a small decrease in network performance.

The key factor in the low level of service is the insufficient hydraulic capacity of the network to convey the predicted flows. Tidal influence has a slight effect on hydraulic performance at Outfalls 1 and 3, however it is not considered to significantly alter predicted flooding in the catchment.

9.1.2 Nuisance Flooding

Small areas of nuisance flooding (between 50 mm and 300 mm deep) are predicted in the road at locations on Parry Street during high frequency events, the effects of which are exacerbated slightly with larger rain events and with the application of climate change projections. Nuisance flooding is also predicted on Ravensbourne Road during low frequency events and in the future when climate change projections are applied.

9.1.3 Flood Hazard – Future 1 in 100 yr ARI Extreme Event

A flood hazard rating of ‘moderate’ has been assigned to areas in the road and some industrial locations during the emergency planning scenario (1 in 100 yr ARI rainfall event with 2060 extreme climate change projections). An area of ‘significant / extreme’ flood hazard is predicted during this scenario along Magnet Street and the harbour front, predominantly due to direct tidal inundation.

9.1.4 Network Maintenance

Blockage of the intake structure on Ravensbourne Road is predicted to exacerbate nuisance flooding in the locality and cause overland flow to Parry Street. However, the effects of this are predicted to be minor.

Nuisance flooding extents and durations in Ravensbourne Road are potentially exacerbated by blocked catchpits, particularly on Parry Street

City-wide inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures (inlets and catchpits) can lead to discrepancies in level of service. This has the potential to exacerbate or transfer flooding.

9.2 Stormwater Quality Issues

It is clear that there is historical sediment contamination likely to be from a combination of the stormwater outfall and other sources. Although there is potential for ongoing contamination of the sediment from stormwater, current information indicates that this is unlikely, however monitoring results are ambiguous and it has not been possible to establish a causal link from available data.

9.2.1 High Variability of Stormwater Quality Results

Inconsistencies in stormwater quality results mean that we are unable to see clear trends in stormwater quality, or confidently identify key contaminants to aid stormwater management.

9.2.2 Limited Confidence in the Knowledge of Effects on the Otago Harbour Environment

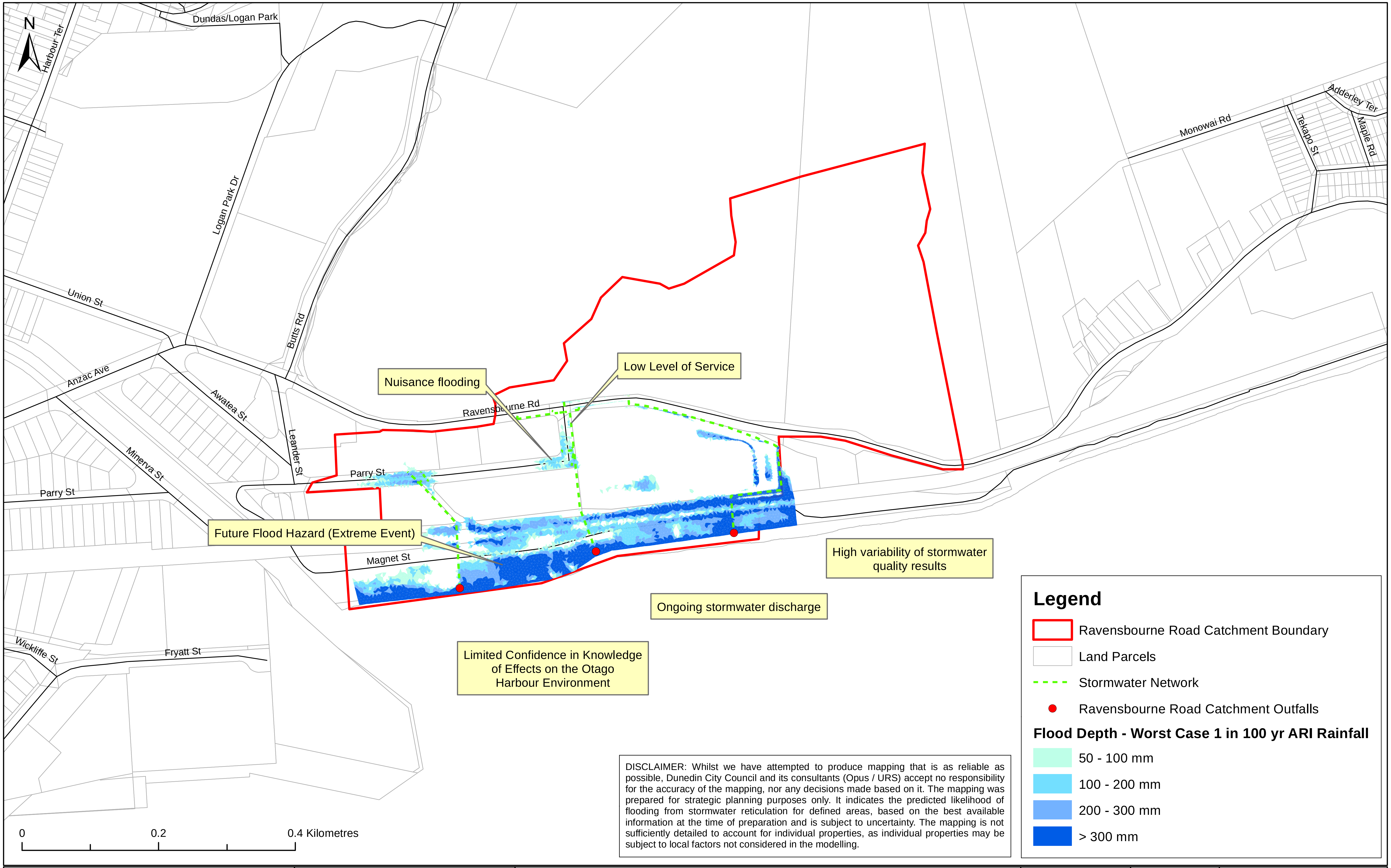
The current monitoring regime undertaken to meet consent conditions provides limited confidence in the following:

- The extent of historic versus current / ongoing harbour sediment contamination; and
- Links between stormwater quality, sediment quality, and the health of the harbour environment.

9.2.3 Ongoing Stormwater Discharge

Stormwater quality monitoring indicates that the stormwater quality discharged from Ravensbourne Road catchment appears to at the low end of typical levels for an industrial catchment, and contaminant sources are likely to be this land use. Indications from recent monitoring do not show that current stormwater discharges are having an obvious adverse effect on the receiving environment, however as discussed above, there is limited confidence in some of this information, and further data is required to validate this data.

Mechanisms already in place (e.g. the Dunedin Code of Subdivision and Development and the Trade Waste Bylaw) are designed to encourage source control in order to ensure that contaminant levels in the stormwater discharge do not increase, and that new development and existing land uses are managing stormwater quality in an appropriate manner into the future.



DISCLAIMER: Whilst we have attempted to produce mapping that is as reliable as possible, Dunedin City Council and its consultants (Opus / URS) accept no responsibility for the accuracy of the mapping, nor any decisions made based on it. The mapping was prepared for strategic planning purposes only. It indicates the predicted likelihood of flooding from stormwater reticulation for defined areas, based on the best available information at the time of preparation and is subject to uncertainty. The mapping is not sufficiently detailed to account for individual properties, as individual properties may be subject to local factors not considered in the modelling.

Created with ESRI ArcGIS

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Dunedin 3 Waters Strategy

RAVENSBOURNE ROAD INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 9-1

Ravensbourne Road Catchment Issues

DISCIPLINE

Stormwater

Drawn: JMH	Status: Final	
Checked: HES	Scale: 1:5,000	Plot Date: Sep 2011
Approved: HES	Job. No: 42173227	Map No: Figure 9-1 / Revision: -
Date: Sep 2011		

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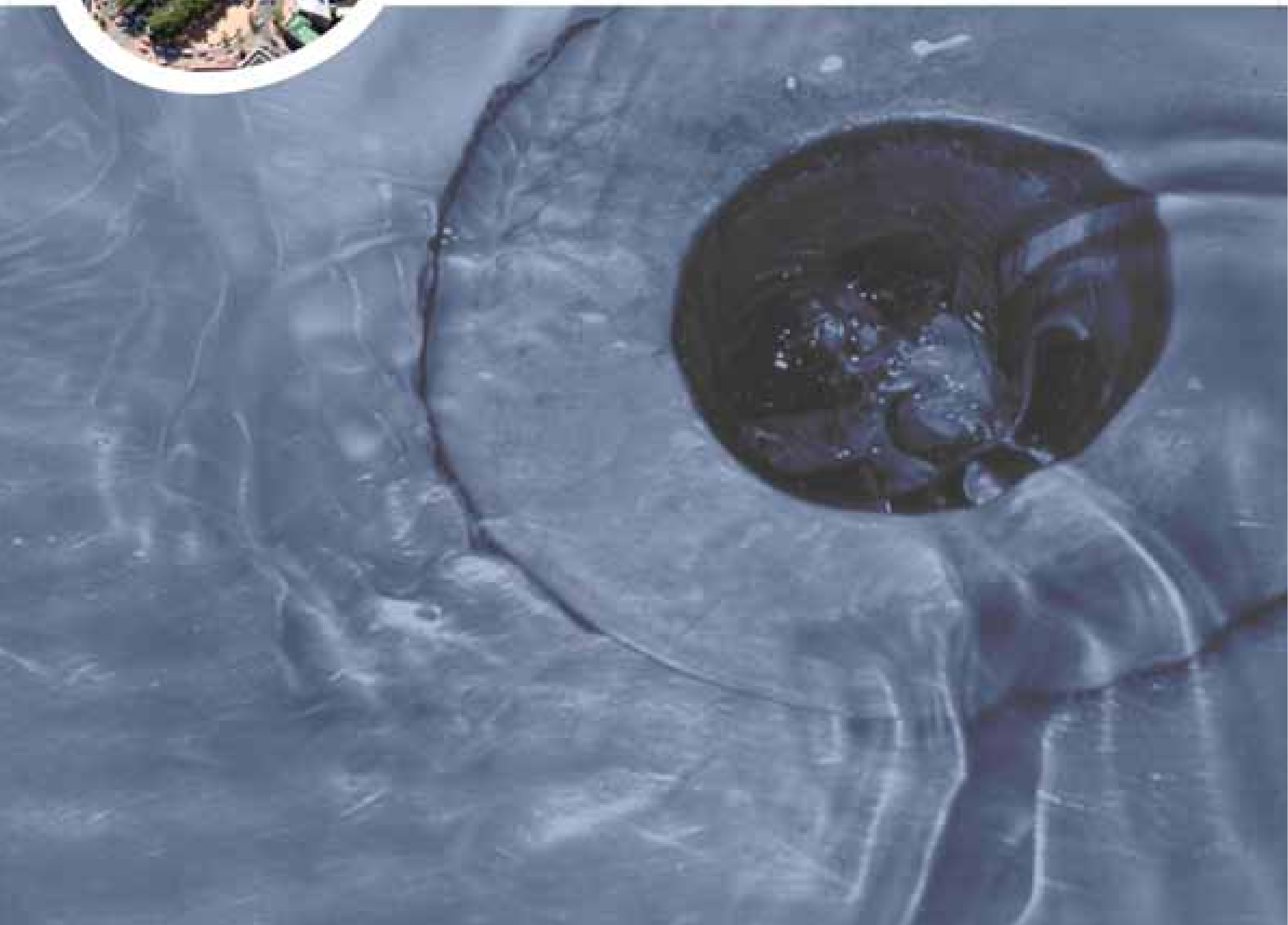
Part 4
Targets



10 Issues Prioritisation

DCC have developed a decision making framework (refer Appendix E) in line with the New Zealand and Australian risk management framework AS/NZS 4360 to enable the comparison of issues and options. A Consequence and Likelihood rating has been applied to each of the issues identified to provide a risk matrix score, leading to a definition of problem management. Figure 10-1 below shows the risk matrix used in this scoring. Other information relating to definitions for Consequence and Likelihood are provided in the analysis of each issue, and the guidelines on this are provided in Appendix E.

Table 10-1 below provides a list of the main issues identified for the Ravensbourne Road catchment, and a risk and consequence score for each, resulting in a 'manage passively' or 'manage actively' categorisation. The passive or active management categorisation then drives the catchment specific management approach for each issue, and later the options considered. Active management indicates that DCC will seek to implement changes to stormwater management in the catchment, whereas passive management would tend more towards monitoring and review of existing management practices to ensure that the targets set can be met.

RISK	CONSEQUENCE				
LIKELIHOOD	Negligible (1)	Minor (10)	Moderate (40)	Major (70)	Catastrophic (100)
Almost Certain (5)	**Low (5)** Manage Passively	**Moderate (50)** Manage Passively	**Very High (200)** Manage Actively	**Extreme (350)** Manage Actively	**Extreme (500)** Manage Actively
Likely (4)	**Low (4)** Manage Passively	**Moderate (40)** Manage Passively	**Very High (160)** Manage Actively	**Very High (280)** Manage Actively	**Extreme (400)** Manage Actively
Possible (3)	**Negligible (3)** Manage Passively	**Moderate (30)** Manage Passively	**High (120)** Manage Actively	**Very High (210)** Manage Actively	**Very High (300)** Manage Actively
Unlikely (2)	**Negligible (2)** Accept	**Low (20)** Manage Passively	**High (80)** Manage Actively	**High (140)** Manage Actively	**Very High (200)** Manage Actively
Rare (1)	**Negligible (1)** Accept	**Low (10)** Accept	**Moderate (40)** Manage Passively	**High (70)** Manage Actively	**High (100)** Manage Actively

Note
The Risk Matrix includes an indication of the minimum acceptable treatment strategy. In all cases the option of avoiding the risk should be considered first.

Figure 10-1: Risk / Consequence Matrix for Issues Prioritisation

Table 10-1: Issues Prioritisation

Issue	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Management Approach
Limited Confidence in Knowledge of Effects on the Otago Harbour Environment	40	4	Past sampling programmes provide inconclusive data which means that the ongoing effects of stormwater discharges are unclear. Without better knowledge, DCC will be unable to meet its strategic objectives and ensure ongoing sustainable stormwater management. Failure to establish clear links between stormwater quality and receiving environment quality may weaken DCC's position both legally and in terms of public perception	160	Manage Actively
High Variability of Stormwater Quality Results	40	3	Stormwater quality monitoring could be made more robust. Relatively low / moderate confidence in data. Without better knowledge, underpinned by good quality data, DCC cannot reliably meet its strategic objectives.	120	Manage Actively
Flood Hazard – Future 1 in 100 yr ARI (Extreme Event)	70	1	Areas of 'extreme' flood hazard are currently in roadways with alternative routes available. Deep flooding predicted in a small number of industrial locations under current conditions. Future extreme climate change effects pose significant potential threat. It is predicted that by 2060 during extreme weather and tide events there will be a 'significant' hazard across 18 % of the catchment. The extent of the threat is uncertain as it is predominantly driven by tidal influence, rather than being a stormwater issue. There is unknown certainty around climate change predictions.	70	Manage Actively
Network Maintenance	10	5	Inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures. Potential to exacerbate or transfer flooding effects.	50	Manage Passively
Blocking / Maintenance of Intake Structures	10	5	Accumulation of debris at the intake screen on Ravensbourne Road and blocking of catchpits on Parry Street is predicted to exacerbate nuisance flooding and overland flow.	50	Manage Passively

Issue	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Management Approach
Low Level of Service	10	4	The current level of service is below DCC's target for new infrastructure, as a result of both tidal influence and inadequate network capacity. Effects will be exacerbated by climate change therefore adaptation is required in order to meet future long term objectives of no increase in properties at risk of flooding due to climate change. However, consequence of this in terms of flood effects is minor.	40	Manage Passively
Nuisance Flooding	10	4	Flooding predicted in small number of locations, predominantly in road corridor. Likely to increase in future. Currently occurring during high frequency events but effects minor.	40	Manage Passively
Ongoing Stormwater Discharge	10	4	Ongoing discharge of stormwater (and associated contaminants) to the harbour. The extent of contamination is unconfirmed, but available data indicates that contaminants discharged are at the low end of the typical range for the land use, and the consequences are minor. Current discharges not believed to be as significant an issue as historical contaminant issues from a variety of sources.	40	Manage Passively

11 Catchment Specific Approaches and Targets for Stormwater Management

Figure 11-1 provides a breakdown of the link between stormwater management issues identification, objectives development and the setting of targets.

The information presented in the AEE section of this report has been used to identify the key stormwater management issues for the Ravensbourne Road catchment. These issues have been prioritised and ranked, according to DCC's risk matrix, which looks at the consequence and likelihood of each issue.

For each issue, DCC's commitment (in terms of strategic stormwater objectives) will be examined, and a catchment specific approach outlined depending on both the strategic objectives, and the issue's priority. SMART targets are then set to guide the design of options, and also to measure the success of the catchment management approach.

Following this section, stormwater management options are developed to ensure targets are met.

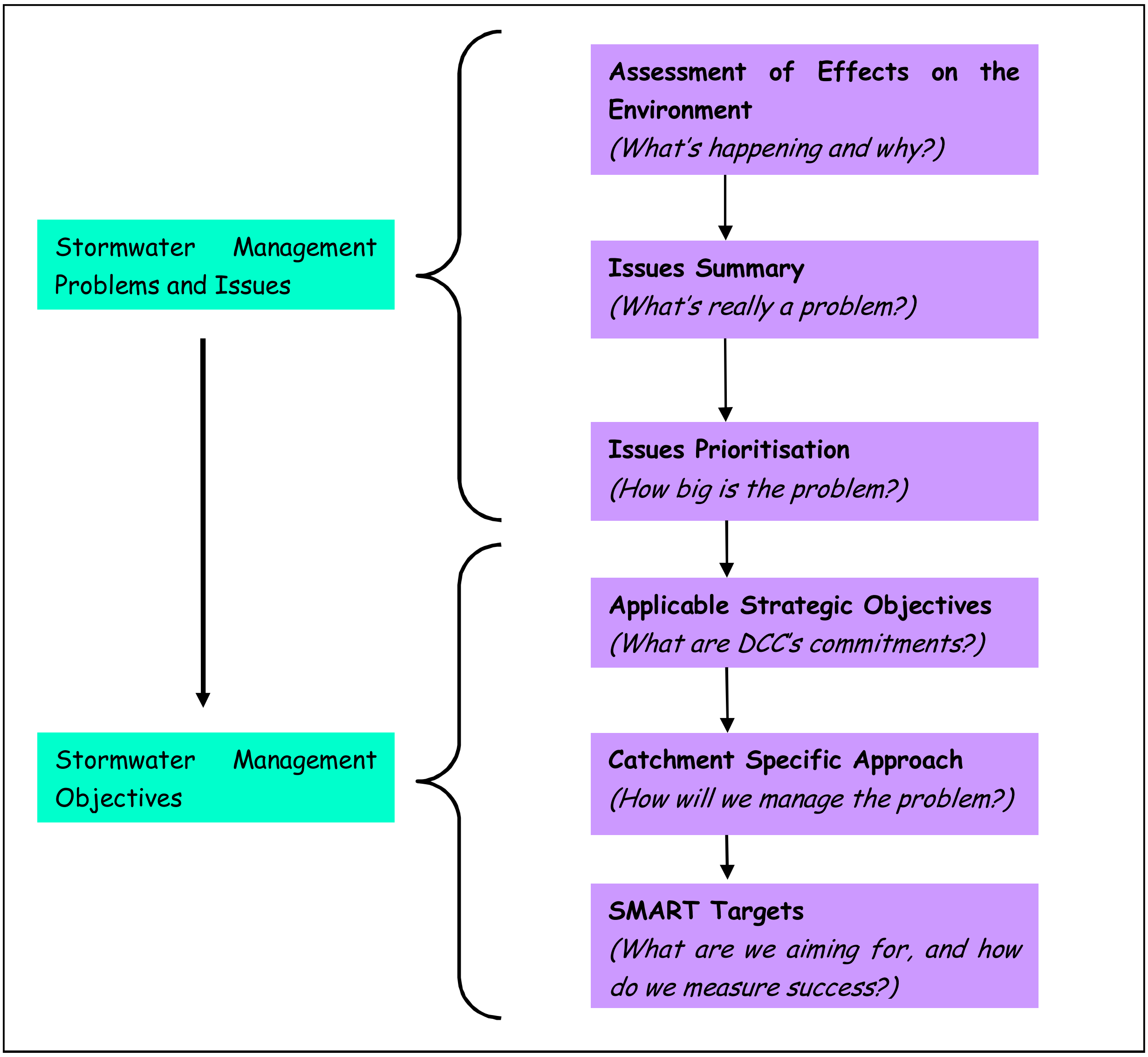


Figure 11-1: Target Development Process

Management approaches and targets are essential for providing information to ensure appropriate funding is made available for stormwater management, and that the management options implemented provide the best value for money to the community. A number of other ICMPs are being prepared by DCC for other outfalls discharging to the harbour. Similar targets will be developed for these ICMPs, and ultimately, issues prioritisation will be used to compare and prioritise recommendations across the catchments.

The catchment specific stormwater management approach is driven by the issues prioritisation, and provides guidance for options development in terms of a broad management approach for each issue, specific to each catchment. Management approaches are driven strongly by the applicable long term (50 year) strategic objectives, outlined in Section 2.

Stormwater management 'SMART' targets are an important tool for DCC; these follow a set of guidelines to ensure that they are well-defined and attainable, as outlined below:

- **S**pecific – well defined and clear targets, able to be understood;
- **M**easurable – to provide feedback to continually improve performance;
- **A**chievable – to ensure success;
- **R**ealistic – within available resources, knowledge and time; and
- **T**ime-Bound – to monitor progress on a number of timescales, and ensure time is available to achieve the goals.

Targets relate both to long and short term objectives outlined in Section 2, depending on the issue. For example, they may refer to maintenance of a certain level of service for the stormwater network, or commitments to minimise adverse effects on the receiving environment where appropriate. The AEE also guides the setting of targets. As some targets may be linked to monitoring information, it is essential that these targets are open to review and adjustment over time. Ongoing monitoring results may indicate a greater or lesser environmental impact than currently understood.

Tables 11-1 and 11-2 below outline catchment specific approaches and SMART targets for each of the key stormwater issues identified in the Ravensbourne Road catchment.

11.1 Stormwater Quantity Approaches and Targets

Table 11-1 presents a summary of stormwater management key effects relating to stormwater quantity, and catchment specific targets set for Ravensbourne Road. Approaches and targets developed for 'active' and 'passive' management of stormwater quantity issues in the Ravensbourne Road catchment are discussed in more detail below.

Despite the stormwater network in Ravensbourne Road having a low level of service (approximately 1 in 5 yr ARI), the high frequency flooding occurring in the catchment is predominantly nuisance flooding in the road, and no flood complaints have been lodged in the past five years.

The stormwater network in the catchment is undersized compared with current design criteria; as such the hydraulic capacity is insufficient to cope with increased flows during lower frequency events or future planning scenarios when climate change projections are applied. It is not predicted however, that deep flooding will result.

Deep flooding, with areas of 'significant' flood hazard, is predicted under the future extreme, emergency planning scenario.

11.1.1 Flood Hazard – Future 1 in 100 yr ARI (Extreme Event)

The significant flooding predicted during the future (extreme) climate change scenario modelled is predominantly due to direct tidal inundation (sea level rise plus storm surge), rather than the response of the stormwater system to the rainfall and tide boundaries.

If the flooding was predicted to be occurring currently, an emergency response plan would be required. However, due to the timeframe of this scenario (2060), it is more appropriate that the potential effects of climate change on this catchment be considered by DCC's Climate Change Adaptation Plan (currently being developed).

11.1.2 Network Maintenance and Blocking / Maintenance of Intake Structures

The maintenance and cleaning of catchpits and other stormwater structures is an essential part of maximising the efficiency and level of service of the stormwater network. As the owners of the network, DCC need to be certain that the asset is being maintained appropriately. Currently, the task of maintaining stormwater inlet assets is split between three DCC departments, and one national authority. Contracts for maintenance of catchpits and inlet structures have some differences in terms of performance criteria. Additionally, there would be benefit in identifying key assets as part of the catchment management process in order to focus maintenance and cleaning efforts further.

The target set for this issue is to first develop an understanding of the current level of maintenance and cleaning, and then, if required, recommend changes in order to focus efforts and optimise inlet efficiency of the stormwater network.

11.1.3 Low Level of Service and Nuisance Flooding

The recommended approaches and targets with respect to the stormwater network performance focus on maintaining or improving the existing level of service under reasonable future development and climate change scenarios. The strategic direction provided by the 3 Waters Strategic Direction Statement indicates that the main objective with respect to flooding is to ensure that the risk of flooding does not increase in the future as development occurs, or as climate change alters weather patterns and sea levels.

Additionally the lack of complaints in the area indicates that customers are satisfied, however the historical data collection methods used for customer complaints logging has resulted in variable information on complaints. Improvements in complaints recording will result in a clearer picture of customer satisfaction in the future.

However, the residents' opinion survey (ROS) has been running in its current format since 2003, and gauges Dunedin city residents' overall satisfaction with the stormwater collection service, amongst other council services.

In general, the council will adopt a long term approach to improving network performance and adapting to climate change by ensuring that all new network components (for example, planned pipe renewals, or upgrades in specific locations) are designed to a 1 in 10 yr ARI level of service, using conservative design storms that incorporate projected changes in rainfall intensity, coupled with conservative tidal boundary conditions. This is consistent with DCC's Code of Subdivision and Development, and also with the Building Act.

Based on the age of the network, a pipe renewals programme in the Ravensbourne Road catchment would commence in 2040. By 2060, 100 % of the pipes in the network (including those already at the desired level of service) will have been replaced (with new pipes designed to convey the 1 in 10 yr ARI rainfall event).

Table 11-1: Ravensbourne Road Catchment Management Targets: Stormwater Quantity

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Flood Hazard – Future 1 in 100 yr ARI (Extreme Event)	Current: area of 'low' flood hazard in roads and some industrial locations. Future extreme events: areas of 'moderate' flood hazard in roads and some industrial locations resulting from stormwater. Areas of 'significant / extreme' flood hazard on harbour front predominantly due to tidal effects.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Actively*** Ensure new development does not increase the number of properties predicted to flood due to the stormwater system in a 1 in 100 yr ARI rainfall event. Work to avoid significant disruption to people and services during a large rainfall event. Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply etc) from flood hazard. Avoid development of vulnerable sites / critical infrastructure in flood prone areas. Ensure transport routes around flooding areas are available. Develop a better understanding of the likely effects and magnitude of climate change.	Develop a catchment specific emergency response plan by 2012. Provide modelled flood predictions to DCC Climate Change Adaptation Group to ensure information is taken into account during the development of a city-wide climate change adaptation plan.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Network Maintenance	Flooding extents and durations in Ravensbourne Road are potentially exacerbated by variations in the frequency and standards of catchpit cleaning and maintenance. City-wide inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures (inlets and catchpits) can lead to discrepancies in level of service.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Ensure consistency city-wide of stormwater structure cleaning and maintenance. Ensure cleaning and maintenance schedules and contracts are sufficiently robust. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets (city-wide) by 2012. Document cleaning and maintenance responsibilities for all stormwater inlet assets (city-wide) by 2013. Develop list of key stormwater assets in Ravensbourne Road catchment requiring additional cleaning and maintenance checks by 2013.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Blocking / Maintenance of Intake Structures	Accumulation of debris at the intake screen on Ravensbourne Road and blocking of catchpits on Parry Street is predicted to exacerbate nuisance flooding and overland flow.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Undertake an inspection of all open channel sections, to record status of intake structures. Ensure damaged screens are replaced / fixed. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk. Work with property owners to ensure intakes and screens are properly maintained.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets in the catchment (in conjunction with city-wide criteria) by 2012. Develop list of key stormwater intake structures in Ravensbourne Road catchment requiring additional cleaning and maintenance checks by 2013. Document cleaning and maintenance responsibilities for all stormwater inlet assets in the catchment by 2013. Ensure all damaged, poor performing, or missing screens are replaced (if appropriate) by 2013.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Low Level of Service	Most of the network has a low level of service between 1 in 2 yr ARI and 1 in 5 yr ARI rainfall event driven by network hydraulic capacity. Effect is nuisance flooding within the road. Currently occurring, no capacity for climate change effects.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. 95 % of customer emergency response times met. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Maintain or improve existing level of service in network – ensure no increase in the number of stormwater manholes predicted to overflow in a 1 in 10 yr ARI rainfall event. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Ensure new development does not increase potential habitable floor flooding due to the stormwater system in events up to a 1 in 50 yr ARI rainfall event. Use customer complaints and ROS to gauge satisfaction with the stormwater system performance.	< 25 % manholes overflowing during a 1 in 10 yr ARI rainfall event by 2060. < 0.2 % of catchment surface area predicted to flood during a1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (ongoing).
Nuisance Flooding	Currently occurring at locations within road during 1 in 5 yr ARI rainfall event. Extent is minor affecting < 0.1 % of the catchment. Effects rise to approximately 0.4 % of the catchment during a future 1 in 10 yr ARI rainfall event.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Passively*** Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances).	< 0.1 % of catchment surface area predicted to flood during a 1 in 5 yr ARI rainfall event by 2060.

11.2 Stormwater Quality Approaches and Targets

A summary of key stormwater quality effects, and catchment specific approaches and targets set for Ravensbourne Road are presented in Table 11-2 below. The catchment specific approaches and targets are discussed in further detail below.

Whilst the monitoring information to date does not suggest that the stormwater quality from the Ravensbourne Road catchment is adversely affecting the marine environment, approaches and targets set out below describe a city-wide approach to stormwater quality as the Otago Harbour is a common receiving environment for all DCC coastal stormwater discharges.

It should be noted that the Regional Plan: Coast for Otago (ORC, 2009) sets out objectives and policies relating to discharges to the CMA. Objective 10.3.1 seeks *'to maintain existing water quality within Otago's coastal marine area and to seek to achieve water quality within the coastal marine area that is, at a minimum, suitable for contact recreation and the eating of shellfish within 10 years of the date of approval of this plan'* Further, Policy 10.4.3 states that where water quality already exceeds these standards, water quality should not be degraded beyond the limits of a mixing zone associated with each discharge.

11.2.1 Limited Confidence in the Knowledge of Effects on the Otago Harbour Environment and Variability of Stormwater Quality Results

There is high variability in stormwater quality monitoring results from each catchment. Whilst stormwater quality is influenced by many variables and it is not unusual to see a wide range of contaminant levels in monitoring results, it is considered that this issue is compounded by the current monitoring technique of obtaining single annual grab samples of stormwater for analysis.

Sediment monitoring has been carried out to date (2007 to 2010) to determine the quality of the marine sediments. Sampling across the catchments has indicated that there are some contaminants of concern within the harbour, measured at relatively high levels, (although no significant issues were observed in the Ravensbourne Road catchment). However, it remains unclear whether the contaminant levels observed are as a result of historic contamination or current discharges (from either stormwater or other sources). For this reason, the sources of contamination are difficult to identify, as are any links with the quality of DCC stormwater discharges.

The biological monitoring undertaken to date does not show any particular trends in diversity or abundance of fauna. The biological monitoring protocol is also highly variable between the catchments and not all catchments are monitored. With only 4 years of biological monitoring data that does not appear to be showing any trends, the variation in sampling protocols throughout the harbour and an absence of ecological baseline or control data for the harbour, it is difficult to draw conclusions from the biological monitoring results.

The monitoring regime to date has been insufficiently robust to enable the identification of any effects or otherwise, with any level of confidence, between stormwater quality and harbour environment health. In order to clearly identify discharges / catchments of concern and select appropriate stormwater management on a catchment by catchment basis to enable DCC to maintain or improve stormwater quality, a suitable monitoring framework, and improved confidence in monitoring data is required.

DCC have a commitment to improve the quality of stormwater discharges to the harbour and, in order to identify necessary and appropriate stormwater management actions within the catchment and city-wide, a sound understanding of the nature and effects of the stormwater discharge is required.

The approach and targets set for this issue include a staged approach that seeks to adjust the current monitoring programme in order to develop and implement an optimised monitoring framework that will provide more comprehensive and defendable information on current stormwater discharge quality and the effects thereof. Following this, it is expected that stormwater management approaches will be reviewed and adjusted to reflect DCC's strategic objectives. The recommended targets are as follows:

- Redesign the monitoring programme to develop a robust framework that will yield good quality, useful data at appropriate sites to enable a sound understanding of both catchment stormwater quality and health of the harbour environment and allow any linkages between the two to be identified.
- Using the monitoring results and other available information (such as land use), identify with confidence, discharges/catchments of concern and potential sources of unacceptable contaminant levels.
- Enable specific city-wide, targeted annual monitoring protocol to be established where necessary, including quality indicators, which can be used to provide feedback on stormwater management practices, and trigger further action as required.
- Use data to contribute to the stormwater management programme for Dunedin. This will include the identification of stormwater management actions to improve stormwater quality where required.

In the interim, while catchment specific stormwater actions and targets are still being established, DCC are committed to looking for quick-win opportunities where point source contamination has been identified, and at a minimum, to ensuring that stormwater quality does not deteriorate as a result of new development or changes in land use in the catchment. Examples of this include:

- Considering the cost and benefit of incorporating stormwater treatment into flood mitigation works where practicable.
- Requiring source control or management of stormwater contaminants in high contaminant generating land uses by enforcing the Trade Waste Bylaw, and working to educate occupiers of high-risk sites with respect to stormwater discharge quality.
- The Dunedin Code of Subdivision and Development indicates that at-source management of stormwater quantity is desirable and Low Impact Design methods are preferred.

11.2.2 Ongoing Stormwater Discharge

The monitoring data at present does not indicate that the levels of contaminants in stormwater from the Ravensbourne Road catchment stormwater are significantly high. Therefore based on the best available information at this time, the prioritisation of this issue has resulted in a 'passive management' approach.

However, it is acknowledged that there is low confidence in the current monitoring data; therefore, this issue is related to the above issue regarding limited confidence in the knowledge of effects on the harbour environment.

The approach and targets for this issue are related to the outcomes of the targets set for confidently identifying the levels of contaminants in the stormwater and any resulting effects on the harbour environment. Following the outcomes of the proposed monitoring and stormwater management prioritisation targets, the approach to stormwater management in this catchment will be revised and catchment specific targets, where appropriate will be applied.

In the mean time, DCC is committed to ensuring that there is no deterioration in current stormwater discharges and reducing the contaminant levels within stormwater discharges over time, as described above.

Table 11-2: Ravensbourne Road Catchment Management Targets: Stormwater Quality

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Limited Confidence in the Knowledge of Effects on Harbour Environment and Variability of Stormwater Quality Results	High variability of stormwater quality results, any trends in stormwater contaminant levels remain unclear. Poor information on actual effects of stormwater on harbour environment. Lack of data to assess linkages between pipe discharge and harbour environment quality.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. No recorded breaches of the RMA. Ensure stormwater discharge quality does not deteriorate.	***Manage Actively*** Redesign DCC's monitoring programme to ensure stormwater quality and receiving environment data is collected within a robust framework. Develop method for determining linkages between stormwater management and harbour environment. Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high- contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality. Undertake monitoring to ensure stormwater quality does not deteriorate over time. Incorporate a feedback process to the ICMP if / when monitoring indicates potential adverse effects from stormwater discharges.	Robust monitoring framework developed and implemented by 2012. Improve confidence in data supporting analysis of stormwater discharge quality and effects on harbour environment, with improved confidence in data by 2013. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Ongoing Stormwater Discharge	Could exacerbate existing / historical contaminant issues. Extent to which this is likely to occur is unconfirmed. Key stakeholder issue. Based on available data, consequence currently believed to be minor.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	***Manage Passively*** Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high- contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.	No deterioration of stormwater quality due to land use change or development in the catchment. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.

Part 5
Solutions

12 Stormwater Management Options

12.1 Introduction

Options are presented below to manage the stormwater issues identified in the Ravensbourne Road catchment. Options are generally capital work options, planning options, or operation and maintenance tasks. These have been developed in line with issues prioritisation and catchment specific targets and approaches set in Section 11.

When considering the options available for each issue, options considered to be 'deal breakers' are eliminated from the options to be evaluated. Example definitions of deal breakers are as follows:

- Option must be technically feasible
- Option must meet relevant legislative requirements
- Option must be consistent with the principles of the Treaty of Waitangi
- Option must be aligned with the catchment specific objectives developed in Section 9 of this document
- Option must not have greater negative environmental, social or cultural consequences than the 'do nothing' option
- Option should not contravene any explicitly stated political objective
- Option should not result in an increase in the risk category
- Option should not increase health and safety risks compared with the 'do nothing' option.

Active management indicates that DCC will seek to implement changes to stormwater management in the catchment, whereas 'passive management' would tend more towards monitoring and review of existing management practices to ensure that the targets set can be met. This section puts forward a number of options (where more than one exists) for each issue identified in the catchment.

Following the elimination of deal breakers, information on options for stormwater management is collated. The options identified for 'manage actively' issues are subsequently evaluated against the QBL evaluation criteria outlined in Section 14, with the most favourable stormwater management option selected.

Following the identification of options for each stormwater management issue, and options evaluation using QBL methodology, a prioritised programme of capital works and additional investigations recommended in the Ravensbourne Road catchment is then developed.

The implementation of the programme is expected to progressively improve stormwater management in the catchment as part of the wider 3 Waters Strategic Plan, which incorporates programming of the outcomes recommended in all ICMPs developed across the city.

12.2 Potential Options

Outlined below are preliminary options identified for the management of key stormwater issues present in the catchment. Option 'deal breakers' are eliminated and feasible options are described in further detail. Where an issue has been prioritised as 'manage passively', management options are discussed in more general terms, although planning based options may be presented where applicable. Where an issue is prioritised as 'manage actively', where available, a number of alternative options will be considered for further evaluation in Section 14.

12.2.1 Flood Hazard – Future (Extreme Event) – Manage Actively

During the extreme future scenario consisting of a 1 in 100 yr ARI rainfall event combined with a 2060 tide (including climate change impacts) and a 1 in 20 yr ARI storm surge, flooding is predicted to be widespread in the Ravensbourne Road catchment, and cover approximately 18 % of the catchment area, including the recreational reserve. Because of the low capacity of the network, and the effect of high tides and storm surge, flooding of properties and roads during an event this large is unavoidable, and much of the flooding is predicted to be due entirely to tide levels inundating the low lying catchment. Small benefits may be gained from other options seeking to alleviate more regular flooding, or improve network capacity. The catchment specific targets and approaches identified for this issue are as follows:

- Ensure new development does not increase the number of properties predicted to flood due to the stormwater system in a 1 in 100 yr ARI rainfall event.
- Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply etc) from flood hazard. Avoid development of vulnerable sites / critical infrastructure in flood prone areas.
- Ensure transport routes around flooding areas are available.
- Develop a better understanding of the likely effects and magnitude of climate change.

In terms of ensuring that development does not further exacerbate flooding, management of the effects of new development would be as per the requirements of DCC's Code of Subdivision and Development (refer below to a discussion on this regarding levels of service).

Because this issue is predicted to occur in the future, and is predominantly due to climate change impacts, only one option is presented, as follows:

Develop climate change adaptation plan

In order to develop a better understanding of the likely effects and magnitude of climate change, there needs to be an ongoing re-visitation of new information regarding climate change predictions, and the implications of these for the Ravensbourne Road catchment. The hydraulic model developed for this study would be a key tool in assessing the impacts of a range of further climate change scenarios. A climate change adaptation plan for the whole of Dunedin city would incorporate findings in terms of a plan for low-lying catchments such as Ravensbourne Road. This plan may affect the options chosen in terms of on-going provision of level of service of the network. Damage assessment of DCC owned critical and vulnerable sites would form part of this work, and information would be provided to other infrastructure owners to facilitate the development of site-specific plans.

12.2.2 Network Maintenance and Blocking / Maintenance of Intake Structures – Manage Passively

Flooding extents and durations in Ravensbourne Road could potentially be exacerbated should critical catchpits and inlet structures not be adequately cleaned.

Regular cleaning and maintenance of catchpits and stormwater structures is essential across the city, and city-wide inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures (inlets and catchpits) can lead to discrepancies in level of service. The following catchment approaches have been developed for these issues:

- Ensure consistency city-wide of stormwater structure cleaning and maintenance.
- Ensure cleaning and maintenance schedules and contracts are sufficiently robust.

A review of schedules and methods used across the city could be undertaken to ensure that all possible contaminant sources (e.g. catchpits) are cleaned regularly, and the flood risk is reduced as much as possible. Alignment of contracts for this maintenance (currently with a number of agencies) would provide confidence that catchpit and stormwater structures were operating optimally.

As part of the contracts, key structures identified in each catchment management plan could be incorporated as requiring additional or more frequent attention. In Ravensbourne Road, the following structures would be included:

- Parry Street - catchpits at the east of the street; and
- Ravensbourne Road - intake structure accepting flows from gully to the north.

12.2.3 Low Level of Service – Manage Passively

Hydraulic modelling results indicate that the network in this catchment has a relatively low level of service, and can only convey storm events of between 1 in 2 yr ARI and 1 in 5 yr ARI rainfall event, when modelled with a MHWS tide level. This is predominantly due to the hydraulic capacity of the network in this catchment, with tidal influences only having a small effect on flooding predictions during current scenarios.

A lack of complaints or DCC callouts in the catchment indicates that the actual level of service may be somewhat higher, or that residents / building owners are not dissatisfied with the current level of service provided. This, combined with the fact that the dominant result of the low level of service is nuisance flooding, sets the management of this issue as passive.

The catchment specific approach for this issue includes the following:

- Maintain or improve existing level of service in network – ensure no increase in the number of manholes predicted to overflow in a 1 in 10 yr ARI rainfall event.
- Design new pipes with capacity to convey a 1 in 10 year storm event.
- Undertake pipe renewals programme from 2040.
- Ensure new development does not increase potential habitable floor flooding in events up to a 1 in 50 yr ARI rainfall event.
- Use ROS to gauge satisfaction with the stormwater system performance.

The 'Dunedin Code of Subdivision and Development' is used by DCC to set requirements for land development and subdivision, but is also used by DCC to guide design of network upgrades undertaken by DCC. Table 12-1 below outlines the design criteria required by DCC for new stormwater work. Compliance with this document ensures that the approach to design new pipes to convey a 1 in 10 yr ARI rainfall event is met, and that secondary protection is provided up to a 1 in 100 yr ARI rainfall event.

As development occurs, or renewals are undertaken, the level of service of parts of the network gradually improves. Under DCC's pipe renewals programme, 100 % of the pipes in the catchment would be due for renewal between 2040 and 2060, based on the age of installation. This planned renewal work effectively re-designs the pipe network to meet current design criteria, and would include allowances for climate change predictions.

In the interim, the ROS can be used to gauge satisfaction with the stormwater system performance. As the Ravensbourne Road catchment is mainly industrial, the overall Dunedin residents' survey can provide some impression satisfaction with the stormwater system in general. Since the survey began in 2003, city-wide satisfaction with the stormwater collection service has been above 60 % in every year except 2004 / 2005 (Research First, 2010).

The details of a climate change adaptation plan for the city would be used to guide future works in the catchment.

Table 12-1: Stormwater Design Criteria

Function	Annual Exceedence Probability (AEP, %)	ARI (years)
Primary protection	10	10
Primary protection in areas where secondary flow paths are not available or are through private property	1	100
Secondary protection	1	100

12.2.4 Nuisance Flooding – Manage Passively

The strategic direction provided by the 3 Waters Strategic Direction Statement indicates that the main objective with respect to flooding is to ensure that the risk of flooding from the stormwater system does not increase in the future as development occurs, or climate change alters weather patterns and sea levels. Because the existing network has minimal capacity for increased flows, and the effects of future flooding are predominantly driven by climate change, the climate change adaptation plan will be needed to guide any flood mitigation options in this catchment.

Approximately 0.03 % of the catchment surface area in Ravensbourne Road floods during a 1 in 5 yr ARI rainfall event. This flooding is confined to road corridors, and is likely to dissipate in a short time.

Rules set for future development in DCC's Code of Subdivision and Development will ensure that into the future, new or re-development of sites will include the provision of stormwater detention or conveyance up to a 1 in 10 yr ARI rainfall event. It is likely that this, along with planned pipe renewals, will relieve nuisance flooding in the catchment over time.

12.2.5 Limited Confidence in the Knowledge of Effects on the Otago Harbour Environment and Variability of Stormwater Quality Results – Manage Actively

Although the stormwater and sediment quality results from the Ravensbourne Road catchment do not indicate than an adverse effect is occurring in the environment due to stormwater discharges currently, the stormwater and harbour environment monitoring regime to date has been insufficiently robust to enable the identification of any relationship between stormwater quality and harbour environment health.

In order to clearly identify discharges / catchments of concern and select appropriate stormwater management on a catchment by catchment basis to enable DCC to meet their objectives regarding stormwater quality, a suitable monitoring framework, and a high confidence in monitoring data is required. The catchment specific approaches recommended for this issue in the Ravensbourne Road catchment (and city-wide) are:

- Redesign the monitoring programme to develop a robust framework that will yield good quality, useful data at appropriate sites to enable a sound understanding of both catchment stormwater quality and health of the harbour environment and allow any linkages between the two to be identified.

- Using the monitoring results and other available information (such as land use), identify with confidence, discharges/catchments of concern and potential sources of unacceptable contaminant levels.

- Enable specific city-wide, targeted annual monitoring protocol to be established where necessary, including quality indicators, which can be used to provide feedback on stormwater management practices, and trigger further action as required.

- Use data to contribute to the stormwater management programme for Dunedin. This will include the identification of stormwater management actions to improve stormwater quality where required.

- Considering the cost and benefit of incorporating stormwater treatment into flood mitigation works where practicable.

- Requiring source control or management of stormwater contaminants in high contaminant generating land uses by enforcing the Trade Waste Bylaw, and working to educate occupiers of high-risk sites with respect to stormwater discharge quality.

Due to the importance of this information in developing stormwater management options for stormwater quality (where required), the SMART targets identified for this issue seek to obtain and analyse information as quickly as possible. The primary target is as follows:

- Develop and implement a robust monitoring framework by 2012.

The approach and targets recommended include a staged approach that seeks to redesign the current monitoring framework to ensure that it will provide more comprehensive and defendable information on current stormwater discharge quality and the effects thereof. Following this, stormwater management approaches will be reviewed and adjusted where necessary to reflect DCC's strategic objectives.

Despite a 'manage actively' classification, the issue of undefined effects of stormwater on the harbour environment has led to the approach of resolving the issue via the development of a suitable monitoring framework. Consequently, only one option alternative is presented:

Design a Framework for Stormwater Quality and Harbour Environment Monitoring

The augmentation of the current monitoring framework to result in the implementation of a more robust monitoring framework would allow the identification, with an improved level of confidence, any effects or otherwise of stormwater quality on the stormwater quality and harbour environment health.

The monitoring framework should be re-designed to focus on the following outcomes:

- Improved confidence in stormwater quality data;
- Sound understanding of marine sediment quality, including the extent of historic contamination and rate of any ongoing contamination and potential sources;
- Identification of harbour biological health, using suitable indicators to attempt to 'single out' effects of stormwater discharges on the harbour environment;
- Identification of any links between pipe discharge and sediment quality, marine water quality, marine biology; and
- Identification of catchments / discharges of concern and associated stormwater contaminants of concern.

The results of the monitoring undertaken according to the revised framework will allow the following targets to be met:

- Improve confidence in data supporting analysis of stormwater discharge quality and effects on harbour environment, with improved confidence in data by 2013.

Use of data following the outcomes of the monitoring framework will be via the monitoring and continuous improvement of the ICMPs, as described in Section 17. The improved data confidence will allow the prioritisation of stormwater management recommendations based on the significance of stormwater quality issues. This would occur city-wide and form part of the 3 Waters Strategic Plan.

12.2.6 Ongoing Stormwater Discharge – Manage Passively

The monitoring data at present indicates that the levels of contaminants in stormwater from the Ravensbourne Road stormwater are not high. Therefore based on the best available information at this time, the prioritisation of this issue has resulted in a 'passive management' approach. Options for management, detailed below, take into account the industrial nature of this catchment. It is recommended that all options are applied.

The approach to stormwater quality management in this catchment will be revised following the outcomes of the proposed new monitoring framework. This will be implemented by updating the ICMP and the continuous monitoring and improving of SMART targets.

The management of stormwater discharges as new development occurs could be undertaken using several mechanisms:

- Development Controls: DCC have a preference for at-source management and low impact stormwater design as outlined in the draft Code of Subdivision and Development. This document also requires a minimisation of damage to the environment from adverse effects of stormwater runoff; that habitat requirements are taken into account; that stormwater treatment is put into place where practical and that road drainage applies appropriate stormwater treatment.

- An amendment to the business processes used to manage subdivision and development. This would be aimed at ensuring that the developer / DCC representative review the appropriate ICMP for the area of development, in order to direct stormwater treatment based on catchment specific requirements.

- Trade Waste Bylaw: The Trade Waste Bylaw currently includes standards for stormwater discharge quality. Enforcement of this Bylaw would result in an improved quality of stormwater discharge leaving industrial or commercial sites. The Bylaw currently includes standards for stormwater discharge relating to the ANZECC (2000) guidelines for Fresh and Marine quality. Following improved understanding of stormwater discharge quality and its effects, this Bylaw may require review.

- Education and Assistance: Also under the Trade Waste Bylaw, inspections of industrial premises could be undertaken to ensure that adequate on site management practices are being applied. Assistance could be provided by DCC to help achieve higher stormwater quality. It is anticipated that ORC would be involved in this type of scheme for consented discharges, and potentially have resources available to assist in city-wide education.

13 Three Waters Integration

13.1 General

A key driver for the 3 Waters Strategy Project and indeed for the re-organisation of the DCC Water and Waste Business Unit, was to break down the “silo” based approach to the three waters and to encourage integration and efficiencies that can be gained by developing a holistic approach and understanding the inter-relationships and interactions between the three waters. Key advances in this respect relate to business systems integration; simultaneous and complementary modelling; use of identical growth and planning assumptions; and the consideration of integrated solutions.

Provided below is a summary of integration opportunities explored as part of this project, between stormwater and raw water / water supply and wastewater respectively. Reports relating to raw water, water supply, and wastewater studies undertaken as part of the 3 Waters Strategy Project are available from DCC upon request.

13.1.1 Raw Water and Water Supply

The key opportunity for integration between the water supply and stormwater systems is perhaps the need / potential for stormwater harvesting. Analysis of the water supply now and to the 2060 planning horizon indicates that generally the existing water sources will be adequate to meet future demand needs. The strategic water network and the reticulation is well placed to meet future demand and daily demand patterns. However, climate change predictions indicate that Dunedin will become drier for extended periods.

Population growth in Dunedin is relatively small and there is certainly potential to reduce leakage to counter the increased demand. Consequently, there is no need to encourage wide scale stormwater harvesting to meet system demand.

The suggested use of rain tanks is a frequent feature during public consultation. Whilst there are potential water quantity and quality benefits to the use of rain tanks, their widespread use has potential economic implications. Dunedin has adequate raw water sources to supply the city. Furthermore, the variable costs of treating water and wastewater are small when compared with fixed costs (including loans and depreciation). Consequently, any widespread initiatives to reduce water demand are likely to simply increase the unit cost for water and deliver little if any economic benefit to ratepayers. The environmental benefits of rain tanks, or any other demand management initiative need to be carefully balanced against the social and economic aspects of sustainability.

Leakage from the water supply can enter storm drains as infiltration. Whilst the amount of water entering the stormwater system is likely to be relatively small, any reduction in leakage will provide some limited benefit to the stormwater system through increasing the “headroom” by reducing the base flow in the pipes. This is a minor benefit however, and should not be considered as a main driver for leakage reduction or as a possible solution to stormwater system under-capacity.

13.1.2 Wastewater

There are many ways in which stormwater can enter into the wastewater system and vice versa. Upgrade / capital works of the wastewater systems can lead to changes in the quantity and quality of stormwater discharge.

In Dunedin, the following issues influencing both wastewater and stormwater have been identified:

- I&I has been identified as a problem in number of wastewater catchments city-wide. I&I may be occurring from any location in the network, for example, from mains right up to private laterals. Stormwater can enter through manhole joints and covers, broken pipes or dislodged joints. A portion of the I&I may be due to cross connections between the stormwater and wastewater, a result of illegal connections, or old combined connections which are a legacy of the once combined system.

- There are known constructed wastewater overflows which discharge wastewater to the stormwater system during wet weather. DCC state in the 3 Waters Strategic Direction Statement that they want to limit the use of these overflows in the short term with the long term target being total removal. As the overflows only occur in wet weather, if I&I can be limited in the first instance, the use of these overflows would reduce.

The success of any wastewater system rehabilitation and disconnection of cross connections will be dependent on the stormwater system having adequate capacity to take the additional flow.

A further opportunity for integrated solutions in this catchment between the wastewater and stormwater networks is likely to be in the co-ordination of the capital programme. This co-ordinated approach will be developed within the 3 Waters Strategic Plan.

14 Options Evaluation

14.1 Options Evaluation Criteria and Methodology

Options evaluation criteria have been developed based on objectives and decision making criteria set in the following:

- The 3 Waters Strategic Direction statement;
- DCC's Optimised Decision Making Matrix; and
- DCC's LTP

Stormwater specific criteria have been developed for the QBL (economic, social, cultural and environmental) analysis, with an additional two risk categories, Implementation Risk and Effectiveness (risk reduction) separated from the core QBL by DCC and given significant weighting; the first to ensure that operationally, capital works installed will work, and the second to highlight the benefits of each option in terms of reduction of current risk and levels of service. The scoring framework is presented in Table 14-1 below. Weighting for each of the criteria has been assigned by DCC.

14.2 Options Comparison

For the Ravensbourne Road catchment, the predominant 'passive management' of issues, and identification of single options for higher priority issues dictates that options comparison has not been necessary at the ICMP level. Comparison of recommendations for this catchment alongside other catchments will be undertaken as part of the 3 Waters Strategic Plan.

Table 14-1: Option Assessment Criteria and Scoring System

QBL	Option Assessment Criteria	-10	-5	0	5	10
Environmental (10)	Removal of known wastewater cross connections	Does not remove cross connection.	Reduces likelihood of cross connection occurring.	Assists in finding unknown cross connections.	Removes cross connection for design events (emergency overflow still exists).	Removes cross connection under all events.
	Contaminant Reduction	None	5 - 25 %	25 - 40 %	50 - 75 %	75 - 100 %
	Use of Source Control / LID	No treatment or control.	End of pipe treatment (catchment or sub-catchment based)	Site based in-line treatment / collection of contaminant.	LID with water reuse up to design event.	Source control - avoid generation of contaminant of concern.
	I&I reduction	No I&I reduction possible.	-	-	Minor I&I reduction possible without exacerbating stormwater flooding.	Major I&I reduction possible without exacerbating stormwater flooding.
	Construction effects	Major discharge of contaminants into environment during construction.	Minor discharge of contaminants into environment during construction.	-	All contaminants generated contained on site and disposed of appropriately.	No effects on environment - no contaminants generated during construction.
	Replication of current flow patterns	No volumetric control.	Minimal attenuation.	Replicates or reduces current flow patterns up to 1 in 2 year event.	Replicates or reduces current flow patterns up to 1 in 10 year event.	Replicates or reduces current flow patterns up to a 1 in 100 year event.
	Option flexibility	Constrained.	Flexible for short term scenarios but cannot be staged.	Will accommodate all scenarios but minimal staging.	Flexible for all but extreme scenarios and can be staged.	Flexible for all scenarios and can be staged.

QBL	Option Assessment Criteria	-10	-5	0	5	10
Social (10)	Interest / support of community / social interest groups	Major opposition from community / special interests groups.	Some opposition from community / special interests groups.	-	Some support from community / special interests groups.	Major support from community / special interests groups.
Cultural (10)	Fit with māori cultural values	Contradicts Key cultural values.	Unlikely to fit with values and preferred approaches.	Not specifically identified as preferred approach, but likely to fit.	Fits with preferred approach recommended by local iwi.	Involves iwi in development and design of option.
Implementation Risk (20)	Risk of operational failure	Likely operational failure. Unproven technology.	New technology. Extensive training required.	Moderately complicated new technology.	Minor modifications to technology already used. Simple new technology.	Proven technology, already utilised throughout city.
Economic (10)	Estimated Capital Cost - order of magnitude (note does not allow for internal costs)	$ 10m+	$ 1 - $ 10m	$ 500k - $ 1m	< $ 500k	Free
	Risk of cost escalation due to construction unknowns	High - escalation likely as no alternatives and insufficient information.	Moderate risk. Low number of alternatives available.	-	Can be managed via alternatives.	Low risk. Well known issue and design criteria.
	Risk of land availability	Unlikely to secure land.	Long process for negotiation, or high cost of land expected.	Moderate process / costs anticipated.	Unutilised land likely easy to secure.	Land already owned by DCC.
	Risk of protracted consent process with authorities	Consent unlikely.	High risk of long process.	Medium consent process anticipated.	Short consent process anticipated.	No consent necessary.

QBL	Option Assessment Criteria	-10	-5	0	5	10
Effectiveness (Risk Reduction) (30)	Risk Reduction	Extreme risk reduced to very high; Very High reduced to high.	Extreme risk reduced to High.	Extreme or Very High risk reduced to Moderate; High risk reduced to Moderate or low.	Extreme or Very High risk reduced to Moderate; High risk reduced to Low or negligible.	Extreme or Very High risk reduced to Low or negligible.
	Deep flooding 1 in 50 year future - current	Increase in number of properties flooding in current scenario.	No change in number of properties predicted to flood, current or future.	No change in properties flooding currently, reduction in future flooding.	Number of properties predicted to flood in future scenario same as predicted for current scenario.	Number of properties predicted to flood in future scenario less than predicted for current scenario.
	Manholes overflowing 1 in 10 yr ARI future-current	Increase in number of manholes overflowing in current scenario.	No change in number of manholes overflowing, current or future.	No change in number of manholes overflowing currently, reduction in future number of manholes overflowing.	Number of manholes overflowing in future scenario same as predicted for current scenario.	Number of manholes overflowing in future scenario less than predicted for current scenario.
	Improvement in level of service	Significant reduction in perceived level of service Increase in % customer complaints.	Perceived level of service likely to decrease, some increase in % customer complaints.	No change to perceived level of service or % customer complaints.	Minimal improvement to perceived level of service, some reduction in % customer complaints.	Significant improvement to perceived level of service, large reduction in % customer complaints.

15 Option Selection

As comparison of alternative options was not undertaken for the Ravensbourne Road catchment, all options presented in this ICMP have been recommended.

15.1 Approaches for Active Management

The issues that have been prioritised as requiring 'active management' are: *Flood Hazard – Future Extreme Event* and *Limited Confidence in Knowledge or Effects on the Otago Harbour Environment and Variability of Stormwater Quality Results*. The following options are recommended in order to manage those issues:

- Develop a city-wide climate change adaptation plan, including ongoing monitoring of climate change predictions, incorporating damage assessment of the vulnerable infrastructure.; and
- Redesign and implement the city-wide framework for stormwater quality and harbour environment monitoring.

Improved data confidence will allow the prioritisation of stormwater management recommendations based on the significance of stormwater quality issues. This would occur city-wide and form part of the 3 Waters Strategic Plan.

15.2 Approaches for Passive Management

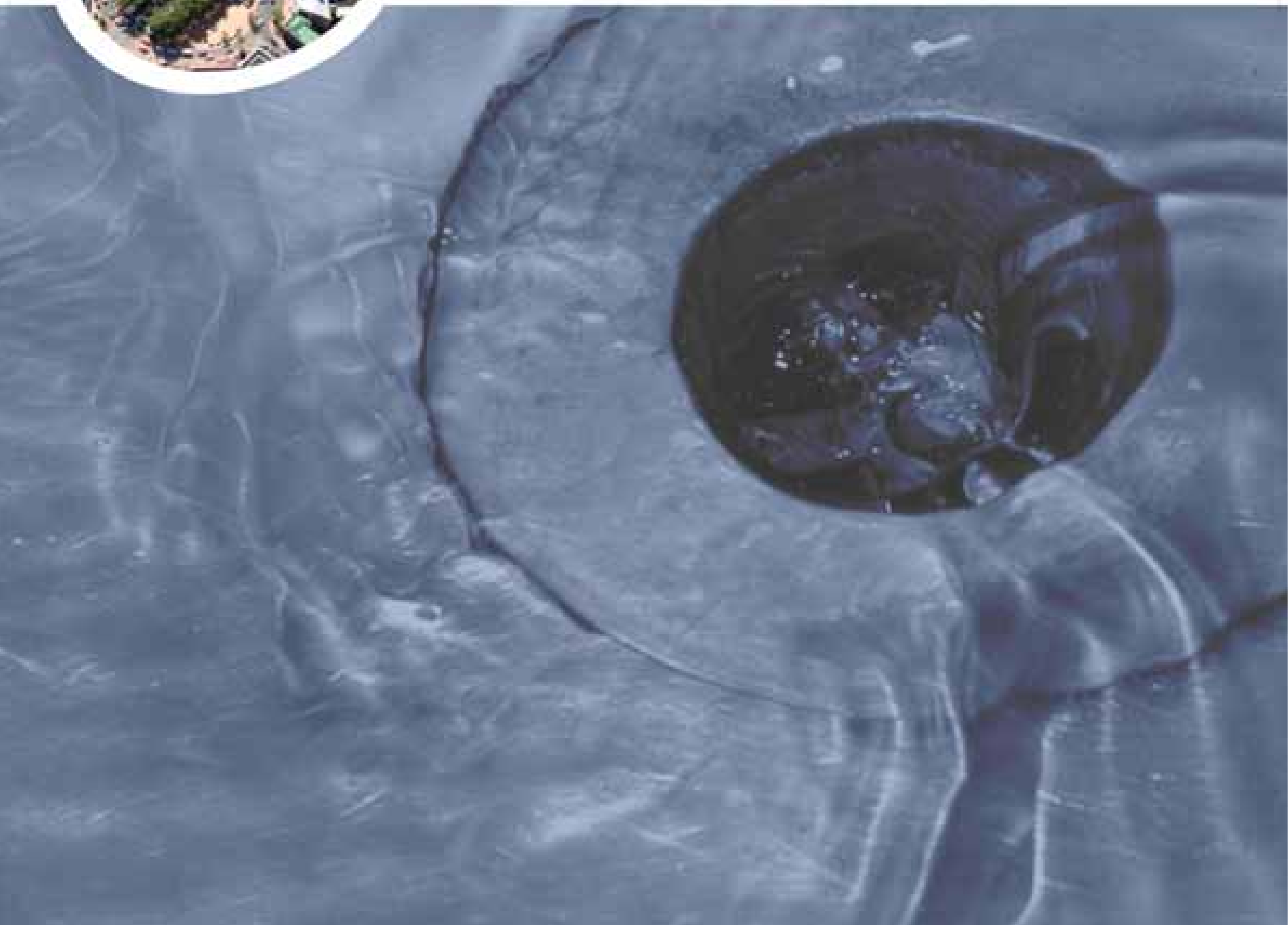
A number of other issues that have been prioritised as requiring 'passive' management will have targets achieved through measures already in place, or via the options identified for other issues in the catchment. The following options have also been identified to aid management of some of these issues:

- Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.
- Develop list of key stormwater structures for more regular cleaning as part of existing and / or future maintenance contracts, incorporating Parry Street catchpits and the Ravensbourne Road stormwater intake structure.
- Utilise ROS information to continuously gauge customer satisfaction with the stormwater service.
- Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.
- Work with ORC to develop a plan for education programmes in relation to best practice site management of industrial premises.



Part 6

Way Forward



16 Recommendations

The following table provides a list of recommendations relating to stormwater management in the Ravensbourne Road catchment, and provides an indicative cost, work period and delivery date for each recommendation. The recommendations are listed in order of priority, relating predominantly to issue prioritisation. The intention is that as each task is carried out, the influence on catchment management targets is assessed, and further tasks are undertaken as necessary to achieve targets. Where a cost of $ 0 has been applied, it is intended that DCC staff undertake the work. The recommendations will have their delivery dates set by the 3 Waters Strategic Plan, yet to be developed. Refer to the following Section regarding implementation of the Plan.

Recommendations are split into further studies, planning and education, operation and maintenance, and capital works tasks. Further studies recommended will assist in improving certainty around catchment management targets, or where further information is required in order to develop options.

Table 16-1: Further Study Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Redesign the city-wide framework for stormwater quality and harbour environment monitoring.	$ 20 k	3 - 6 months
40	Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service.	$ 0	Ongoing

Table 16-2: Planning and Education Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
70	Develop a city-wide climate change adaptation plan, including ongoing monitoring of climate change predictions, incorporating damage assessment of the vulnerable infrastructure.	$ 0	6 - 12 months
40	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	$ 0	2 months
40	Work with ORC to develop a plan for education programmes in relation to best practice site management of industrial premises.	$ 20 k	6 months

Table 16-3: Operation and Maintenance Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Implement the revised city-wide monitoring framework.	$ 25 k	Annual
50	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance. Include Parry Street catchpits and the Ravensbourne Road stormwater intake structure.	$ 5 k	2 months
50	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	$ 20 k	2 months

17 Implementation, Monitoring and Continuous Improvement of the ICMP

17.1 Implementation

As detailed in Section 1 of this report, there are a number of DCC documents are linked to the outcomes of this ICMP. These include the Code of Subdivision and Development, the District Plan, and the 3 Waters Strategic Plan. A number of other documents are subsequently also influenced by this document.

The DCC 3 Waters Strategic Plan pulls together the recommendations from all ICMPs, as well as other 3 Waters work prepared by DCC. Currently, 10 ICMPs are under development, and the recommended options presented by each ICMP will need to be managed in a coordinated manner. Targets set within each ICMP, and issue prioritisation will be used to determine the programme for commitment of staff resources, and both operational and capital funds for recommended works across the city over the coming years.

17.2 Monitoring and Continuous improvement

The continuous monitoring and reporting with respect to the SMART targets developed for each of the critical stormwater issues ensures that the success of this ICMP will be measurable.

Recommendations presented in Section 16 above have been prioritised, and provide the opportunity for DCC to progressively work towards these targets. It also ensures that when targets have been reached, DCC can re-evaluate capital works appropriately.

The revision of the ICMP will be required at a number of milestones, and may either be minor updates or major changes as follows:

1. When the revised stormwater and harbour environment monitoring programme has been implemented and information collated and assessed to identify any key stormwater quality issues requiring management;

2. Due to changes in climate change predictions; and

3. As monitoring data is collected and reviewed for trends. The monitoring framework developed for assessing the effects of stormwater discharges on the harbour environment will need to be refined as more information is learnt about the effects on the harbour, and key areas of concern.

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