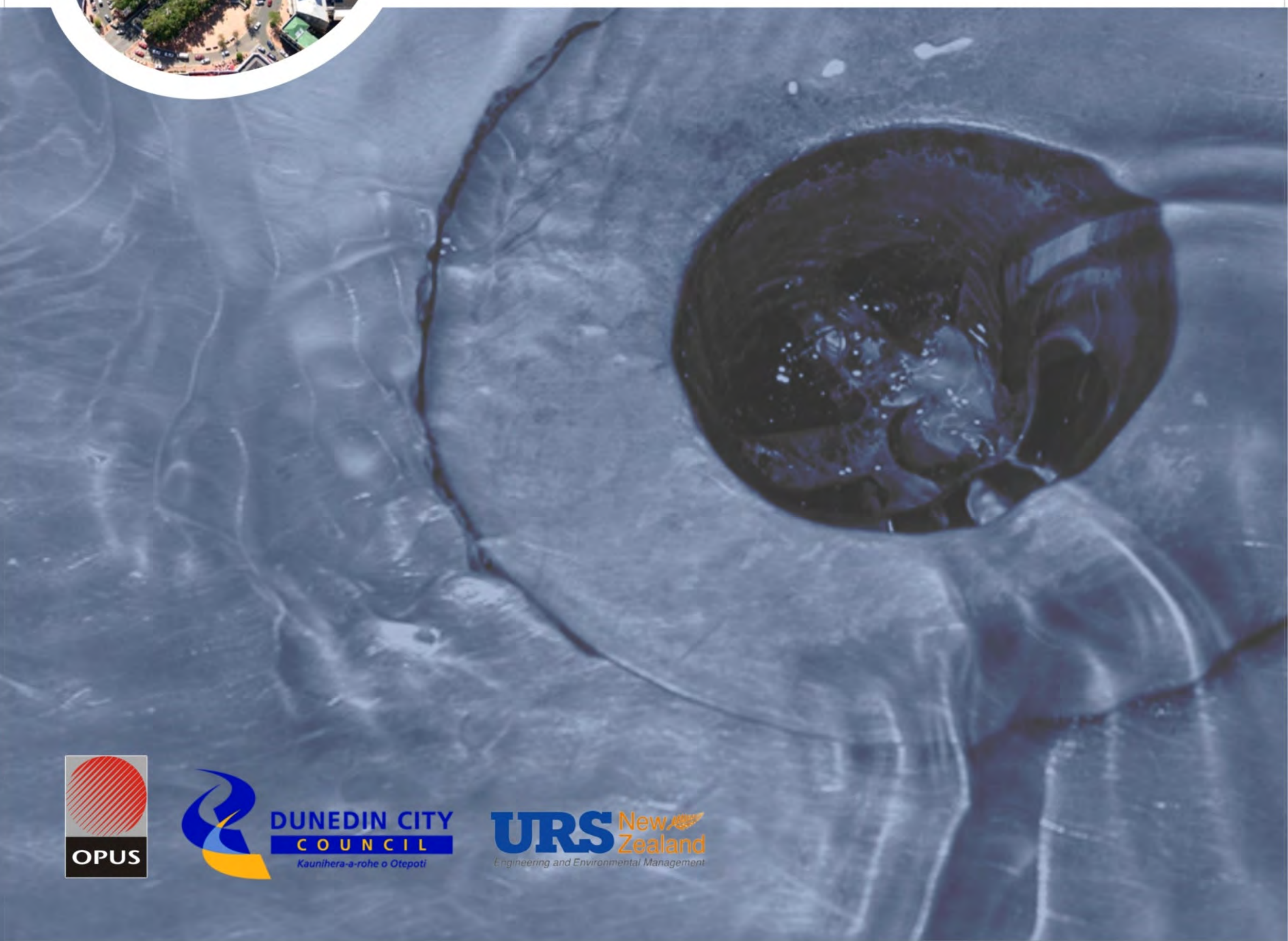
Dunedin 3 Waters Strategy

South Dunedin Integrated Catchment Management Plan



OPUS

DUNEDIN CITY COUNCIL
Kaunihera-a-rohe o Otepoti

URS New Zealand
Engineering and Environmental Management

South Dunedin Integrated Catchment Management Plan 2010-2060

Contract No. 2993
Dunedin 3 Waters Strategy

URS New Zealand
Level 5
URS House
287 Durham Street
Christchurch
New Zealand

Telephone: +64 3 374 8500
Facsimile: +64 3 377 0655
Date: 23 November 2011
URS Ref: 42166807
Status: Final, Version 2

Opus International Consultants Limited
Environmental
Opus House
20 Moorhouse Avenue
Christchurch
New Zealand

Telephone: +64 3 363 5400
Facsimile: +64 3 365 7858

Approved for Release:

Helen Shaw
Principal, URS New Zealand Ltd

Table of Contents

List of Appendices

List of Figures

List of Tables

Executive Summary

The South Dunedin 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 the 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 South Dunedin catchment has an area of approximately 570 ha, and covers approximately 10-15 % of the central urban area of Dunedin.

The catchment is generally flat, includes most of the South Dunedin suburb and is enclosed by the suburbs of St Clair, Caversham, Kensington and Andersons Bay. Soils in the area are generally well drained, however high groundwater (tidally affected) limits drainage opportunities.

Since its first period of intense development in the mid-1870s, South Dunedin's land use has primarily been a mixture of high / medium density residential land, combined with significant industry and commercial areas. In 1936 'the Flat' was the most densely populated urban area in New Zealand. Currently, land use in the catchment is predominantly residential, with some large scale commercial / retail zoning, and an area of industrial land use adjacent to the harbour. The South Dunedin catchment is currently considered by DCC planners to be almost fully developed; therefore future scenarios considered for planning purposes are not significantly different to the current situation. The average current imperviousness in the catchment is estimated to be 60 %.

No specific sites within the catchment have been identified as culturally significant; but the area is host to the only gas works museum in the southern hemisphere. Potentially contaminated sites include the disused gasworks site, and areas of reclaimed land adjacent to the harbour.

The stormwater drainage network in South Dunedin consists of 65 km of shallow pipes and box culverts with widths of up to 2400 mm, laid at flat gradients. All stormwater from the catchment discharges into the harbour via the Portobello Stormwater Pump Station. A second stormwater pump station, Tainui, pumps stormwater from a low-lying area in the south-east of the catchment to the Portobello Pump Station. Approximately 55 % of the pipes in the catchment are more than 50 years old.

The South Dunedin catchment has been the subject of a number of flooding incidents in recent years. Frequent flooding following intense rainfall events has been reported due to a number of reasons, including wastewater flooding, blocked catchpits, and street and surface flooding.

The water supply network in South Dunedin consists of approximately 125 km of pipes, and there are approximately 76 km of wastewater pipelines in place in the catchment, along with two pump stations (Musselburgh and Oval Pavilion). No specific water supply network issues are located within the South Dunedin stormwater catchment, and there are no identified wastewater overflows in the South Dunedin catchment. A foul / stormwater cross connection has been identified on the corner of Surrey Street and Hillside Road, however, and a study was undertaken in 2010 to identify ways of mitigating the reported and modelled flooding issues occurring due to this connection. An overflow monitor is now installed to record frequency and volume of overflows at this connection.

A linked 1 and 2-dimensional hydrological and hydraulic model of the South Dunedin catchment and stormwater network was developed to replicate the stormwater system performance, and to predict flood extents during a number of different land use, climate change and rainfall event scenarios. Confidence in the model output is considered to be moderate. 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.

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 assessments; information gathered during catchment walkovers; DCC flood complaints records; and information gathered during workshops with DCC Network Management and Maintenance staff, identified a number of stormwater related issues in the South Dunedin catchment.

The key area of issue in the catchment is the low level of service provided by the stormwater network, exacerbated by hydraulic bottlenecks in a number of locations. Extensive shallow flooding is predicted across the catchment, however areas affected by deep (hazardous) flooding are relatively few. Infrastructural options to relieve flooding in any of the locations are complicated, with many involving extensive upgrades from the point of issue to the pumping station. The pipe renewals programme may, however, provide the opportunity to progressively improve the level of service of the network over time.

The sediments in the harbour adjacent to the outfall from the South Dunedin catchment show signs of historical contamination, which is not unexpected given the historical land uses in the catchment. Recent stormwater monitoring indicates that there may still be sources of PAH and heavy metals in the catchment, however variability in monitoring results means that further work is needed to pinpoint the extent and source of this contamination, as there are a number of different potential sources.

Stormwater issues were prioritised, and management targets and catchment specific approaches were developed for the South Dunedin catchment 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 the South Dunedin catchment.

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.

Tables ES-2 to ES-4 below outline the recommendations, split into further studies, planning and education, and operation and maintenance tasks. 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: South Dunedin Issues, Approach and Targets Summary

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Hydraulic bottlenecks	A number of ‘bottlenecks’ in the system may be exacerbating flooding. These also result in a lower overall level of service in the network.	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. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Actively*** Maintain or improve existing level of service in network. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes and hydraulic bottlenecks prioritised). Monitor customer complaints and / or undertake site visits to confirm locations of flooding. Investigate local upgrade options.	Feasibility studies undertaken of upgrades to relieve hydraulic bottlenecks by 2014. > 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.
Blocking / Maintenance of Intake Structures	Blocking of intake screen leads to backwater effects throughout catchment.	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.	***Manage Actively*** Reducing the backwater effect caused by blocking Portobello Pump Station intake screens. Prioritise Portobello screens for early and regular attention during storms.	Document cleaning and maintenance responsibilities for all stormwater inlet assets in the catchment by 2013. Develop consistent cleaning and maintenance criteria for all stormwater inlet assets (city-wide) by 2012. Specifically include action plan for cleaning the Portobello screens. Measure frequency and effectiveness of manual cleaning of screens.

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Deep Flooding	Model results indicate 8 parcels affected by deep flooding during 1 in 10 yr ARI rainfall event; rises to 31 during 1 in 50 yr ARI rainfall event in current, and 40 land parcels in future planning scenarios.	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. 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 potential habitable floor flooding due to the stormwater system in events up to a 1 in 50 yr ARI rainfall event. Enhance understanding of effects of deep flooding, particularly on private property. Undertake pipe renewals programme as scheduled (with older pipes prioritised). Investigate options for reducing habitable floor flooding during frequent events.	< 31 properties at risk of deep flooding (> 300 mm) during a 1 in 50 yr ARI rainfall event by 2060. Undertake habitable floor survey and / or damage assessment of potentially flooded properties. > 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.
Pump Station Operation	Pump station operation is key to performance of infrastructure. There is an unknown level of optimisation. Future upgrades can only be made to network if pump station capacity and performance is optimised.	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. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Actively*** Ensure that the Portobello Road Pumping Station is running optimally, and has capacity to adjust for future flows, and potential upgrades to the overall South Dunedin network.	Ensure Portobello Road Pump Station is running optimally. Test Portobello Road Pump Station, and document capacity. Portobello Road Pump and Tainui pump stations to convey a 1 in 10 yr ARI rainfall event by 2060.

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Cross Connection with St Clair Network	Limited knowledge of the effects of the cross connection due to independent modelling of catchments. Stormwater exchange between the South Dunedin and St Clair networks may be reducing the available capacity of the receiving network during extreme events.	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.	***Manage Actively*** Quantify and investigate effects of overflows through the bypass structure between the two networks.	Quantify and assess the effects of overflows from St Clair on South Dunedin, and / or vice versa by 2013. > 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.
Overland Flow from other Catchments	Overland flow is predicted to move into the South Dunedin catchment area (‘the Flat’) from the Shore Street, St Clair and Kitchener Street catchments. The effects of the Shore Street catchment are particularly significant.	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.	***Manage Actively*** Quantify and investigate the effects of overland flow from other catchments. Prioritise study into the effects of the Shore Street / South Dunedin / St Clair catchment interaction.	Quantify and assess the effects of overland flow from other catchments on South Dunedin, prioritising Shore Street and St Clair interactions. Prioritise or develop options for mitigating flooding effects by 2015.

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Low Level of Service	44 % of the network cannot accept rainfall from a 1 in 10 yr ARI rainfall event, driving by network capacity. Manholes predicted to overflow throughout system. Network 99 % surcharged during a 1 in 2 yr ARI rainfall event.	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*** Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Use customer complaints and Resident's Opinion Survey to gauge satisfaction with the stormwater system performance.	> 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (on-going).

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Flood Hazard – Current and Future 1 in 100 yr ARI	'Moderate' to 'significant' flood hazard predicted in both current and future scenarios. Mainly affecting properties already at risk of deep flooding. Due to flatness of catchment, high velocity flows not predicted.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Passively*** 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. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances).	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. Provide modelled flood predictions to agencies responsible for transport routes.
Network Condition and Age	The age of the assets could be a concern for several reasons; impedance of flow (poor condition), leakage (in or out), and contaminant ingress (from pipes passing through contaminated sites).	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.	***Manage Passively*** Undertake pipe renewals programme as scheduled (with older pipes prioritised).	> 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Nuisance Flooding	Nuisance flooding is predicted on a regular basis throughout the catchment due to hydraulic restrictions throughout the network.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Use customer complaints and ROS to gauge satisfaction with the stormwater system performance.	> 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (on-going).
Network Maintenance	Flooding extents and durations in the South Dunedin catchment are potentially exacerbated by variations in the frequency and standards of catchpit and inlet screen 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. Use customer complaints and ROS to gauge satisfaction with the stormwater system performance.	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 the South Dunedin catchment requiring additional cleaning and maintenance checks by 2013.

Issue (Problem Description)	Effects Summary	Strategic Objectives	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, however results to date indicate moderately high contaminant concentrations in stormwater discharge. Poor information on actual effects of stormwater on harbour environment. Lack of data to assess linkages between pipe discharge and harbour environment quality.	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. Improve the quality of stormwater discharges to minimise the impact on the environment. 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 city-wide 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	Catchment Specific Approach	SMART Targets
Ongoing Stormwater Discharge	Could exacerbate historical contaminant issues in the harbour. Extent to which this is likely to occur is unconfirmed. Key stakeholder issue. Based on available data, there may be some ongoing contamination of stormwater.	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 Actively*** 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. Further characterise the stormwater quality from the catchment to confirm key contaminants. Undertake an investigation to identify the primary sources of key contaminants. Develop solutions to remove key contaminants at-source, or implement stormwater treatment.	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. Further characterisation of South Dunedin stormwater by 2012. Confirmation of key contaminants and primary sources by 2012. Implementation of measures to reduce contaminants in stormwater by 2013.

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Point Source Contamination	'Spikes' of high PAH in stormwater quality sampling, combined with historical (and potentially recent) PAH contamination of sediment indicates a point source may exist in the catchment. Old gasworks site in catchment. Additionally, ageing pipes may be allowing ingress of contaminated groundwater.	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 Actively*** Locate and remove point source Contamination of PAHs. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.	Lower the contaminant levels in sediment adjacent to the Portobello Road Outfall to below ANZECC 'high' trigger values within 20 years.

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
160	Undertake further stormwater monitoring to investigate the extent of potential PAH and heavy metal contamination and likely sources within the catchment.	$ 100 k	12 months
120	Combine the South Dunedin, Shore Street, Orari Street and St Clair 1-D and 2-D stormwater models.	$ 40 k	6 months
120	Identify and undertake floor level survey and damage assessment of properties potentially internally affected by deep flooding (up to a 1 in 50 yr ARI).	$ 20 k	3 - 6 months
50	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
160	Work with ORC to develop a plan for education programmes in relation to best practice site management of industrial premises.	$ 20 k	6 months
50	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	$ 0	2 months
40	Contribute information to a city-wide climate change adaptation plan.	$ 0	6 - 12 months

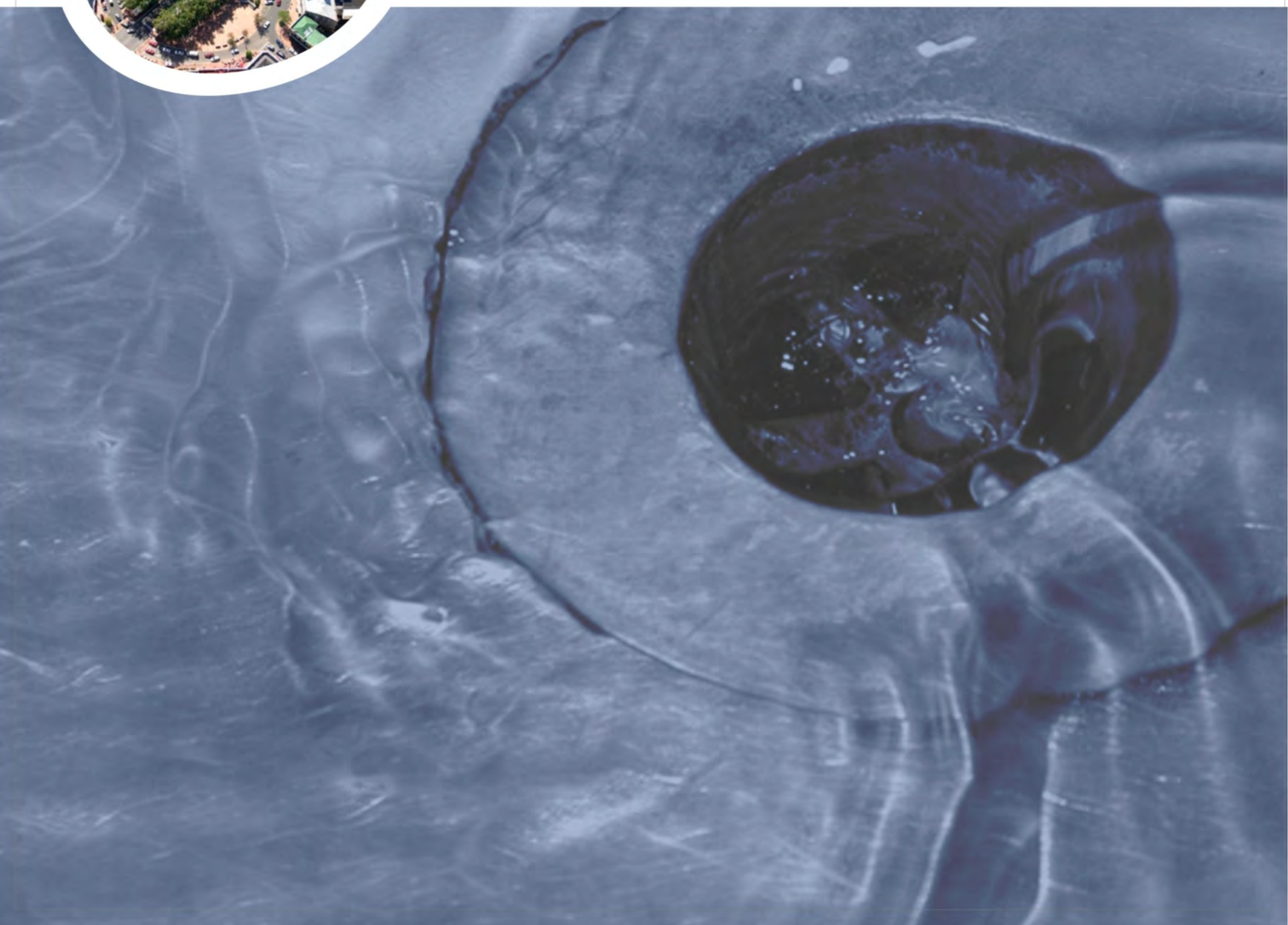
Table ES 4: Operation and Maintenance Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Implement the revised city-wide monitoring framework.	$ 25 k	Annual
160	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance.	$ 20 k	3 - 6 months
160	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	$ 20 k	2 months
50	Ensure planned renewals are designed to accommodate a 1 in 10 yr ARI rainfall event and incorporate allowances for climate change.	$ 0	Annual

Table ES 5: Capital Works Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
200	Progressively develop and implement infrastructural upgrades to reduce critical location flooding in 1 in 10 yr ARI through to 1 in 50 yr ARI events.	tba	tba

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 South Dunedin 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's 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 stormwater discharge consent granted for the South Dunedin catchment (via the South Dunedin outfall). This consent (Consent No. 2002.081), granted in November 2007, is for a period of five years. Condition 13 of the consent states:

> *"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 South Dunedin 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 catchments discharging to the harbour was made 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 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: Dunedin 3 Waters Strategy, Stormwater Catchment Prioritisation Framework (URS, 2008).

The outcome of the prioritisation analysis is that the South Dunedin catchment was found to have the most pressing stormwater issues. South Dunedin has the largest stormwater pipe network out of the catchments considered, and includes some of the oldest, biggest pipes. The catchment is subject to a number of pressures from pollution, pipe capacity and reported flooding. The sensitivity of the receiving environment was also considered to be greater at this outfall than at the adjacent discharge points. Therefore, the South Dunedin catchment was chosen as the pilot ICMP for 3 Waters Strategy.

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 current practices. Objectives for stormwater management have been set by the 3 Waters Strategic 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: Indicator List and Weighting Prioritisation

QBL Category	Label	Indicator	Main Weighting (%)	Sub Weighting (%)	South Dunedin	Halsey Street	Mason Street	Orari Street	Halsey Street	Shore Street	Wickliffe Street	Kitchener Street	St Clair
Economic	1A	Annual OPEX	35	100	4	0	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	3	4	3	3	1
	4B	Asset condition/age/capacity restraints		30	4	3	3	3	2	2	2	2	2
	4C	Reported Flooding incidents		10	4	3	2	1	2	2	3	0	1
	4D	Reported Water Quality incidents		10	3	2	3	3	3	1	1	2	2
	4E	Presence of point source pollution sources		20	4	3	4	2	2	0	3	4	0
	4F	Presence of diffuse pollution sources		10	4	2	0	3	0	3	0	2	0
	4G	Development proposed within catchment		-	-	-	-	-	-	-	-	-	-
	4H	Sediment generating / erosion areas		10	0	2	2	2	3	2	0	0	2
	4I	Extent of waste / stormwater system interaction		-	-	-	-	-	-	-	-	-	-
			Weighted Score:		**3.25**	**1.68**	**1.66**	**1.63**	**1.57**	**1.48**	**1.39**	**1.33**	**1.14**

1.3 Overview

This ICMP comprises six parts:

Part 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.

Part 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.

Part 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.

Part 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.

Part 5 – Solutions. This section describes a number of potential solutions to the issues identified (stormwater quantity and quality).

Part 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.

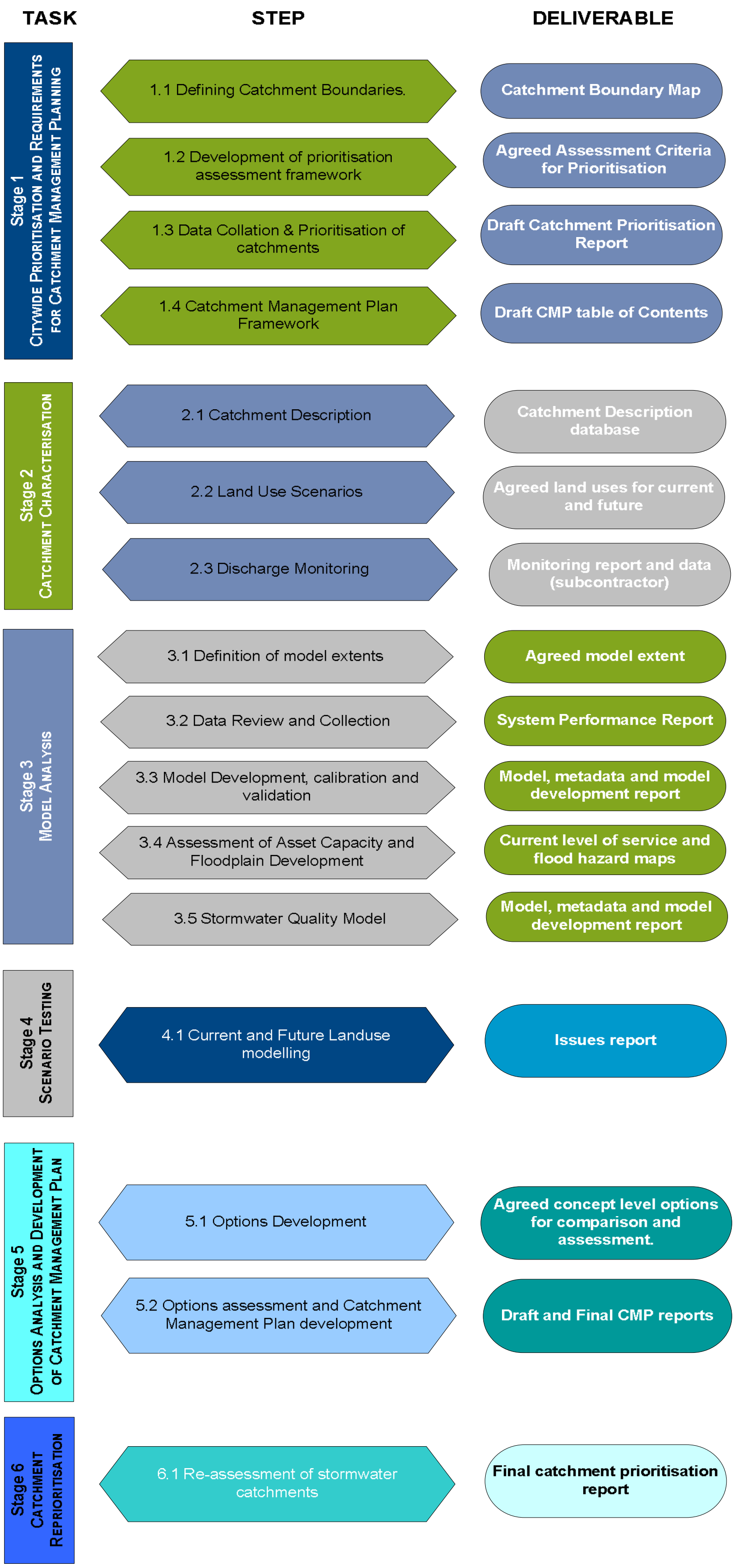


Figure 1-1: Scope of Work

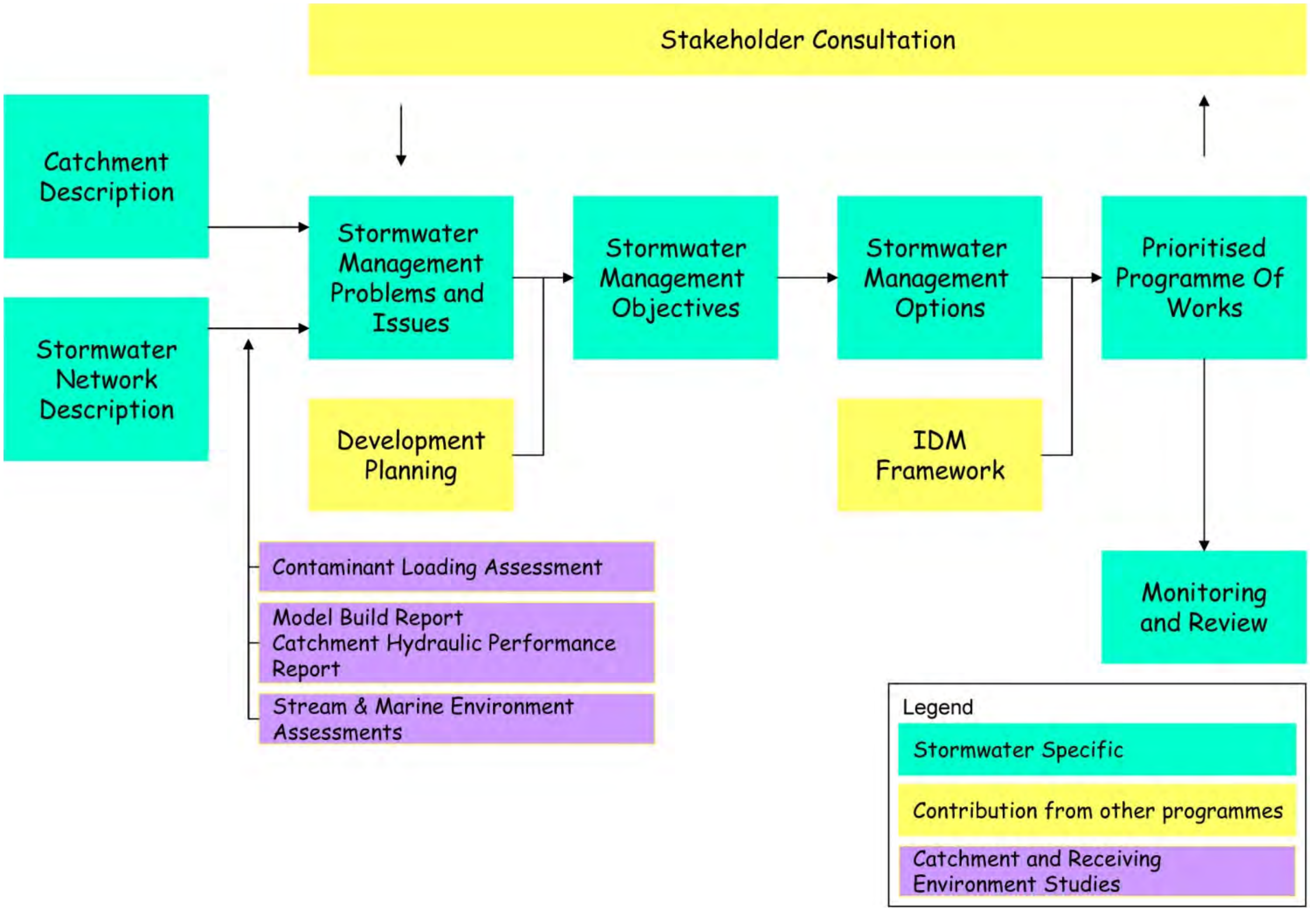


Figure 1-2: ICMP Development Process

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 central, regional and District Planning documents and key non-statutory strategic documents. Figure 2-1 below provides the hierarchies of legislative and planning documents, both statutory and non-statutory which interact with the 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 2.7. It is important to note that these documents are subject to review and change. Therefore, the ICMP needs to be sufficiently flexible to endure variations to these documents while remaining relevant. In some cases the ICMP may provide direction to these variations.

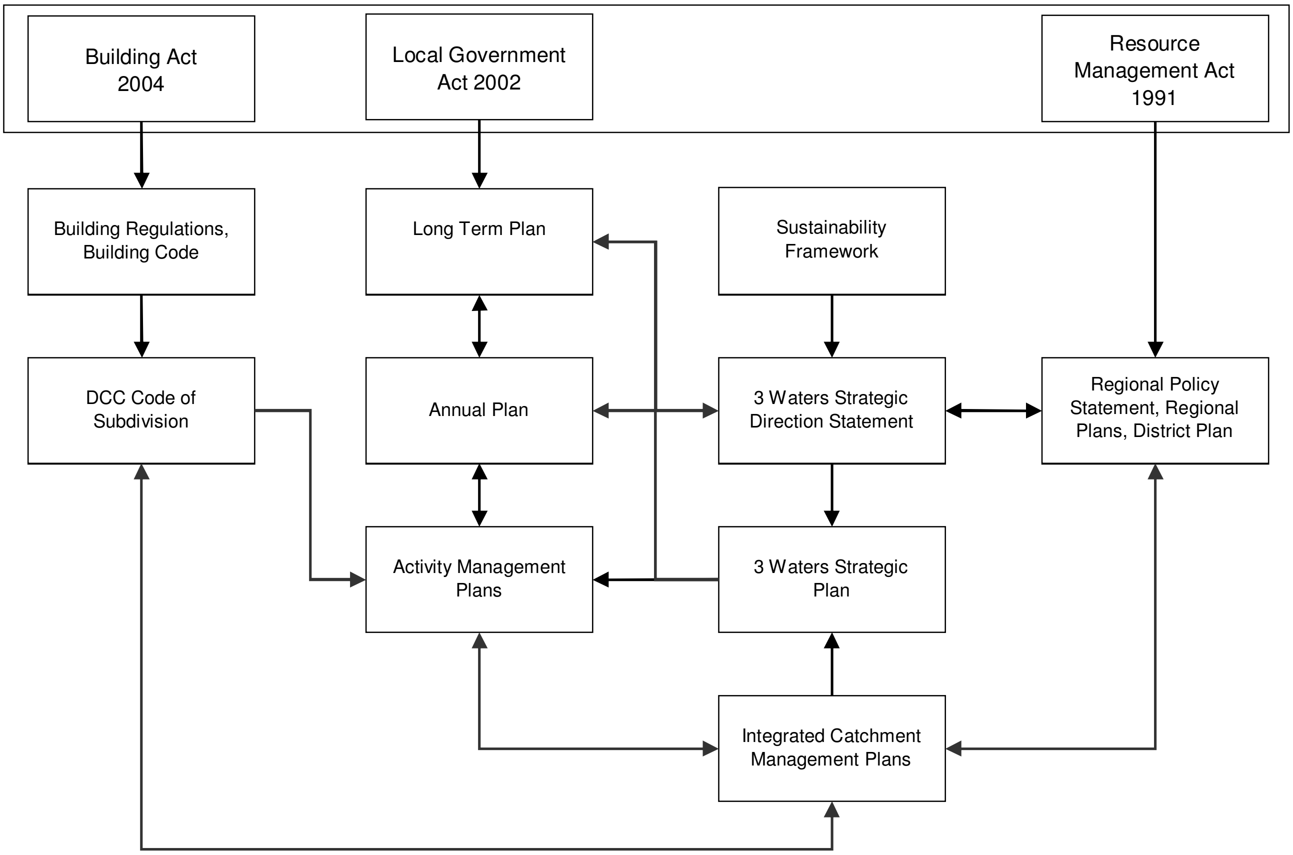


Figure 2-1: Legislative and Planning Document Hierarchies

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; and

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

(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; to 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 Maori 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; and
    - 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 that 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 South Dunedin catchment discharges into the Otago Harbour and 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 South Dunedin 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 the 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 give direction to hazard management through outlining steps that should be taken to avoid or mitigate the effects of natural hazards. With flooding being an issue within the South Dunedin catchment these overarching policies may play a significant role in providing direction for the ICMP if natural hazards 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 has 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 living in 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 the 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 South Dunedin 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 identifies issues and states 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 springs (MHWS). Issues pertaining to those areas below the line of MHWS, including coastal waters, are addressed in the Coastal Plan 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. These land uses will play an integral part in determining the quantity and quality of any stormwater runoff. The South Dunedin catchment is mainly characterised by Residential 2 land use. Residential 2 sites are characterised as having medium to high site coverage (40%) with little space between buildings. The South Dunedin catchment is also characterised by Residential 1 and Industrial 1 land use.

Careful consideration will need to be given to these land use zones and any potential changes to these zones 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 South Dunedin catchment therefore the ICMP needs to ensure that any development within the catchment will not 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 Dunedin City District Plan but does contain guidelines, including levels of service, for any physical works (such as kerb and channel design) associated with subdivision activity which is considered when assessing consent applications. Stormwater targets and management approaches proposed by the ICMP should ensure this code is complied with. It is also likely that the content of the ICMP may 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 on 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 the 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 of 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 Water Plan and the Coastal Plan. 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 Coastal Plan 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 South Dunedin catchment is unlikely to comply with the conditions of the rule due to the likelihood of contaminants having some effect on the receiving environment. Any stormwater discharge would therefore be classified as controlled under Rule 10.5.3.2 and would require a 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 align 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 Water Plan 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 drainage water 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.

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	X (should 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.

DCC also hope 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 hoped 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 rainfall event; and
- Number of properties at risk of stormwater flooding in a 1 in 10 year event.

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.

For specific consultation relating to the 3 Waters Strategy, stakeholders were divided into three groups; environmental, economic/business and social/cultural. The resource consent process for the coastal discharge permits identified the residents within the affected catchments as interested parties. 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, East Otago Taiapure Management Committee, and Fluoride Action Network.

3.1 Stakeholder Workshops and Community Survey

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 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 Strategy 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 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 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 descendants, 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 Kāi 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 Kāi Tahu require coordinated and holistic management of the interrelated elements of a catchment, from the air to the water, the land and the coast. It is accepted by Kāi 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:

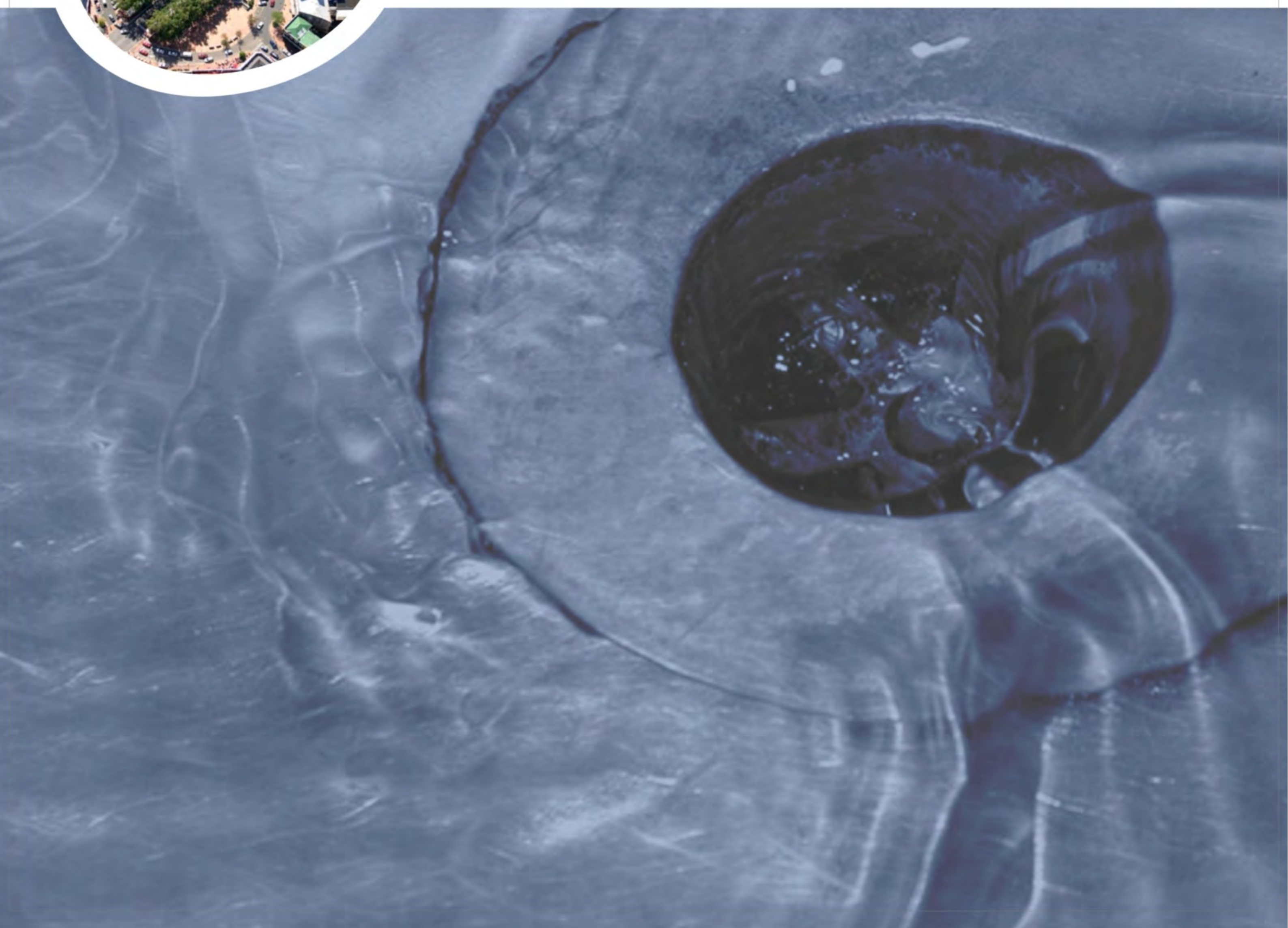
- Reducing the area of impervious land
- Use of grass swales to filter stormwater
- Covering car-parking areas and other areas where increased contaminants may be found
- Sediment/grease traps to be installed at all industrial premises, petrol stations and car parks
- Management plans for industrial 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
- 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 Kāi Tahu, as described above. The 3 Waters Strategy 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 Kāi 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

Figure 4-2 shows the location of the South Dunedin stormwater catchment. The catchment covers an area of approximately 570 ha, adjacent to the Otago Harbour, and covers approximately 10-15 % of the central urban area of Dunedin.

The catchment is generally flat, includes most of the South Dunedin suburb and is enclosed by the suburbs of St Clair, Caversham, Kensington and Andersons Bay. Land use in the catchment is predominantly residential, with a small amount of industrial and commercial around Hillside and King Edward Roads and adjacent to the harbour. Hillside Road, around Cargill's corner, is considered the city's second most important retail district and historically borders a significant industrial area.

Included in the catchment and located adjacent to Hillside Road is the Carisbrook Stadium. This stadium is earmarked for a land use zone change to 'Industrial 2', which would result in a change to the current runoff characteristics. The residential zones in the catchment are predominantly classified as 'Residential 2'; a reasonably high density residential zoning.

The catchment boundary has been determined for stormwater management purposes based on the area served by the pipe network and discharged to the Otago Harbour via the Portobello Road Stormwater Pump Station. There is a small area in the northeast of the catchment where overland flow travels into South Dunedin from the adjacent St Clair catchment during large storm events. A boundary re-adjustment was not required, as during small rain events the St Clair stormwater reticulation conveys this stormwater to the St Clair outfall.

4.2 Topography and Geology

Figure 4-3 is a contour map of the South Dunedin Catchment and surrounding area based on 10 m contours. The 570 ha catchment lies between 0 and 140 m above mean sea level, with approximately 72 % of the catchment no more than 20 m above sea level. This area has an average slope of only 0.008 %, providing the opportunity for flooding due to slow moving surface water. Shallow sand dunes lie between the catchment and the harbour in the south. There are hills to the west and east of the catchment. A digital terrain model has been generated as part of the model build process, and recent LiDAR (light detection and ranging) survey of the city provides much more definition of the catchment topography. Figure 4-1 shows a 3-D picture of the catchment.

Figure 4-4 provides a geological map of the catchment (Bishop & Turnbull, 1996). While it is clear from the map that the majority of the catchment consists of sediment type Q1al, a number of other types are also present. Descriptions of the geological features are as follows. Reclaimed land to the west of Portsmouth Drive was developed by the Otago Harbour Board, predominantly using dredge tailings. Reclamation commenced in the 1940s, but was not officially complete until 1978.

- Q1al; Behind the coastal dunes the catchment area primarily consists of flat land described as 'a well sorted gravel and sand, formed from sandstone, schist and volcanic rock'. This material is likely to be relatively well drained; however high groundwater (tidally influenced) in the area may limit drainage opportunities.

There are other rock and sediment types present in small quantities, described as follows (from Bishop & Turnbull, 1996):

- Q1b; A strip of land along the coastal side of the catchment boundary. Described as 'loose, well sorted sand, with minor gravels and silts'. Drainage along this area is likely to be good.
- Q5b; Loose, slightly weathered sand and gravel formed from beach and marine terrace deposits makes up small areas in the east and west of the catchment as illustrated.
- Q1an: Is a zone of reclaimed land near the harbour. Mainly gravel, a sub rock mixture of sand, mud, industrial and domestic waste could also be found here.
- Md1/Md2/Md3: Present in a number of areas on the outskirts of the catchment, there are pockets of basaltic rock arising from historic lava flows. Drainage in these locations can be unpredictable and would depend on the degree of rock fracture.
- Mo: A small pocket of marine sediments is also visible on the map. Consists of marine calcareous sandstone, phosphatic sandstone limestone, mudstone and minor tuff.

Figure 4-1: 3-D view of South Dunedin

4.3 Surface Water

The South Dunedin stormwater network is entirely piped, and no open drains or watercourses are present in the catchment.

4.4 Groundwater

ORC commenced a groundwater monitoring study in July 2009. Initial indications from this study are that groundwater levels in the catchment occur at shallow depths. Eight wells in the catchment monitor groundwater quality; one of which is located within the disused gasworks site.

Studies indicate that the groundwater is tidally influenced, and that there may be a drawdown effect, whereby the stormwater (and potentially wastewater) networks are conveying groundwater. This is discussed further in Section 4.7.4.

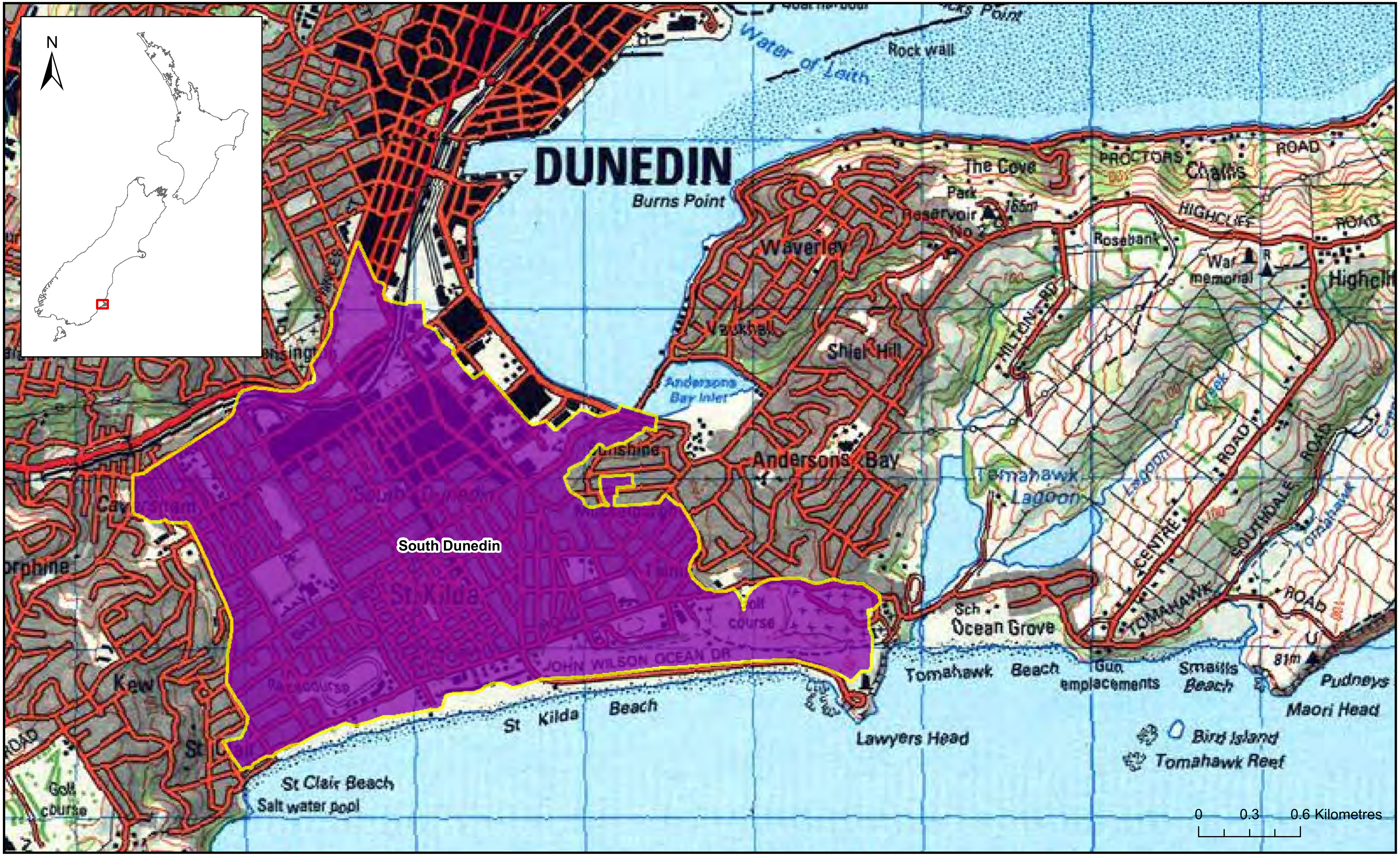
4.4.1 Groundwater Quality

Groundwater monitoring is undertaken at eight sites in South Dunedin (mainly for contaminated land monitoring purposes), in the vicinity of the disused gasworks. Table 4-1 provides mean values of contaminants sampled in groundwater between 2002 and 2009 at three locations; at the old gasworks site, to the west, and to the east (harbour-side) of the site. Water Quality Results obtained from monitoring wells that are located closer to the harbour than the gas-works monitoring wells exhibit significantly lower levels of contamination that the gas-works wells.

Table 4-1: Mean Contaminant Concentrations in Groundwater, 2002-2008

Contaminant (mg/kg)	Well 6 Braemar Street	Well 11 Gasworks site	Well 9 Andersons Bay Road
Arsenic (As)	0.004	0.003	0.010
Cadmium (Cd)	BDL	BDL	BDL
Chromium (Cr)	0.002	BDL	BDL
Copper (Cu)	0.0018	0.0027	0.0034
Nickel (Ni)	0.0015	0.0059	0.0010
Lead (Pb)	BDL	BDL	BDL
Zinc (Zn)	0.0057	0.0069	0.0040
Polycyclic Aromatic Hydrocarbons (PAHs)	0.001	0.021	0.0006

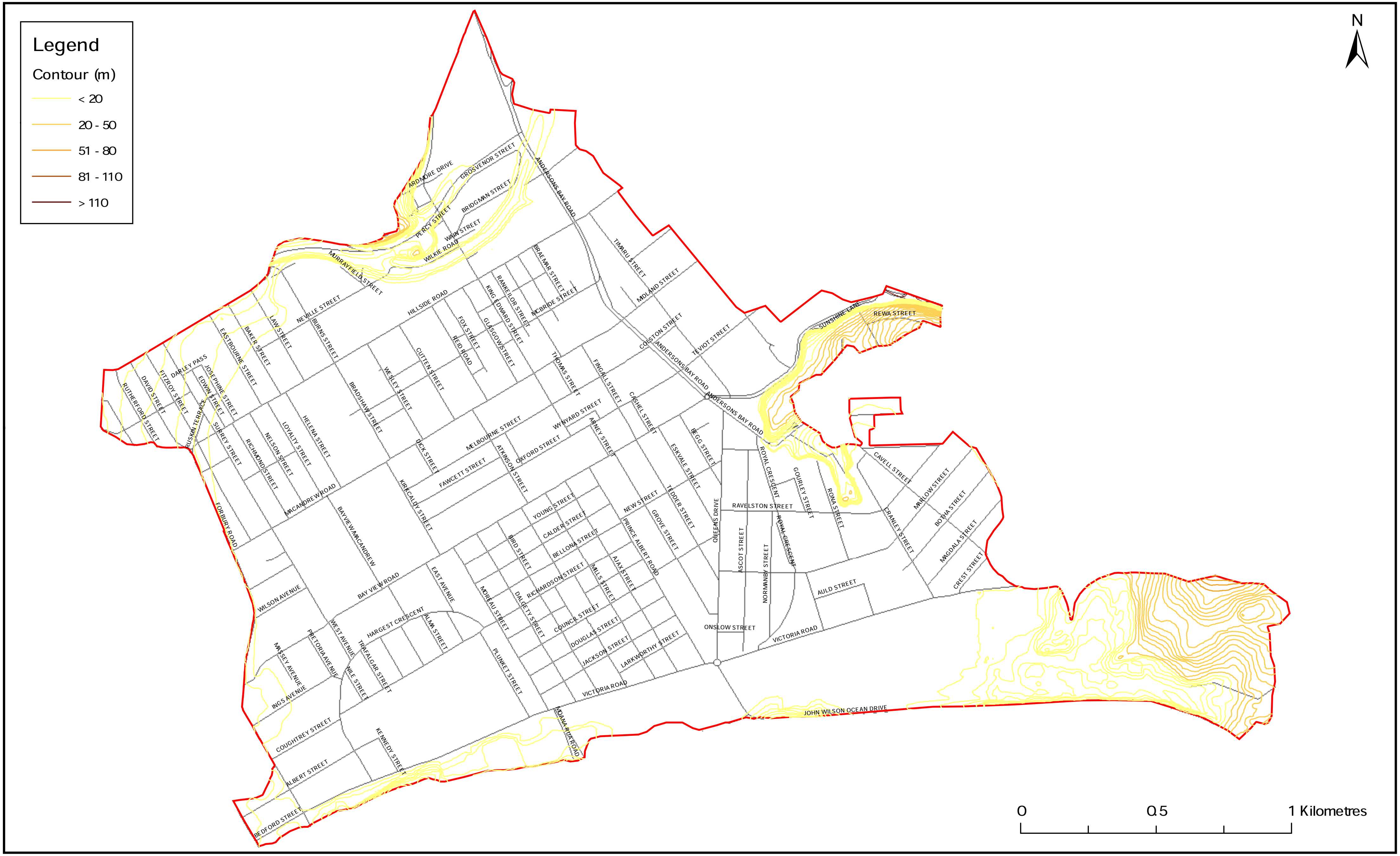
BDL: Below detection level



DUNEDIN CITY COUNCIL / OPUS / URS	Dunedin 3 Waters Strategy	SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-2 South Dunedin Catchment Location	DISCIPLINE Stormwater	Drawn: CJO	Status: Final		
				Checked: HES	Scale: 1:20,000	Plot Date: Sep 2011	
				Approved: HES	Job. No: 42173227	Map No: Figure 4-2	Revision: B
				Date: Sep 2011			

Created with ESRI ArcGIS

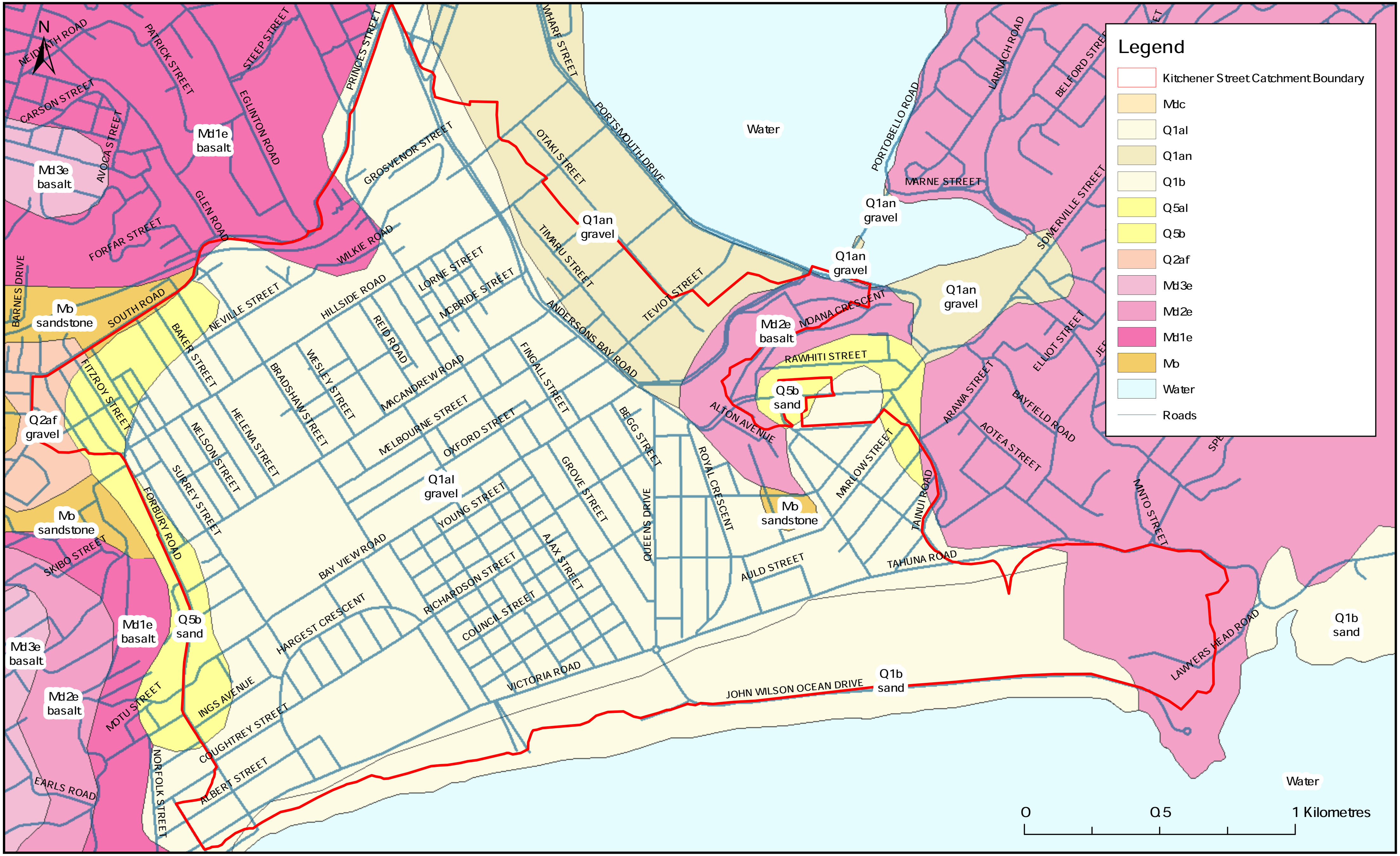
T:\Jobs\42173227\GIS\FIGURES\South Dunedin\SD_Catchment location.mxd Original Size A3



DUNEDIN CITY COUNCIL / OPUS / URS	Dunedin 3 Waters Strategy	KITCHENER STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-3 Kitchener Street Catchment Contour Map	DISCIPLINE Stormwater	Drawn: KC	Status: Final	
				Checked: HES	Scale: 1:12,500	Plot Date: Sep 2011
				Approved: SDH	Job. No: 42173227	Map No: Figure 4-3 / Revision: -
				Date: Sep 2011		

Created with ESRI ArcGIS

T:\Jobs\42173227\GIS\FIGURES\Kitchener St\K_Contour map.mxd Original Size A3



Created with ESRI ArcGIS

DUNEDIN CITY COUNCIL

OPUS

URS

Dunedin 3 Waters Strategy

SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-4

South Dunedin Catchment Geology Map

DISCIPLINE

Stormwater

Drawn: KC	Status: Draft	
Checked: HES	Scale: 1:12,500	Plot Date: Sep 2011
Approved: SDH	Job. No: 42173227	Map No: Figure 4-4 / Revision: -
Date: Sep 2011		

T:\Jobs\42173227\GIS\FIGURES\Kitchener St\K_Geological map.mxd Original Size A3

4.5 Land Use

4.5.1 Historical Land Use and Population Density

Since its first period of intense development in the mid-1870s, South Dunedin's land use has primarily been a mixture of high / medium density residential land, combined with significant industry and commercial areas.

During the gold boom, Dunedin's land was mainly used for manufacturing, and the capacity to produce the required machinery grew rapidly. From the 1870s cheap land on the flat attracted industry and people, and over the next 20 years a large number of industries were established in the Caversham borough and flat area, including a gasworks, brickworks, clay-pipe factory, and a tannery. The Hillside workshops, established near Cargill's corner in 1874, were Dunedin's biggest engineering factories. Figure 4-5 below provides a view of South Dunedin in 1878.

Figure 4-5: South Dunedin, 1878

In the early 1880s a new system of horse-drawn tramways opened up new areas of the flat and integrated the area into the city. Developments in the 1890s made it possible for large-scale mining to be carried out on the river-flats for the first time, resulting in the area's second gold boom.

When the 'golden' days eventually ended after more than three decades, Dunedin profited from maintaining relatively new businesses such as shipping, coal and refrigerated transport. Many Chinese gold prospectors took up market gardening, and some gardens were developed in South Dunedin between 1880 and 1913.

South Dunedin grew by almost 50 % between 1883 and 1900 and by 1900 it had a population density of 12.9 persons per square acre. This trend continued, and much of the current housing stock was built during the 1940s and 1960s. In 1936 'the Flat' was the most densely populated urban area in New Zealand.

4.5.2 Current Land Use

The South Dunedin Catchment is currently considered by DCC planners to be almost fully developed. Land use in the catchment is predominantly residential (zoned Residential 2), with some large scale commercial / retail zoning, and an area of industrial land use adjacent to the harbour. Table 4-2 summaries land use type proportions and Figure 4-7 provides a layout map of the various zones. As can be seen in the residential area, the variety in lot sizes provides a range of residential densities.

Table 4-2: Current Land Use in South Dunedin

DCC Zone	Proportion of Catchment
Residential 2	70 %
Residential 1	9 %
Industrial 1	19 %
Local Activity Zone 1 & 2 (commercial)	2 %

4.5.3 Cultural / Heritage Sites and Designations

According to DCC records of significant archaeological and heritage sites within Dunedin city, several clusters of heritage structures exist in the northern half of the South Dunedin catchment, as well as a townscape / heritage precinct along King Edward Street that encompasses a number of heritage facades. Figure 4-8 provides a map of these features. The location of these sites is relevant when planning stormwater management options, which may include devices requiring land acquisition, or capital works involving open trenching.

Māori cultural values are discussed further in Section 9. Käi Tahu have been identified as a key stakeholder. No specific sites within the catchment have been identified as culturally significant; but the area is host to the only gas works museum in the southern hemisphere, (Category 1 historic building, see Figure 4-6), as well as St Patrick's Basilica and the St Edward Picture Theatre (Category II historic buildings). Aside from this, it is also worth noting that coastal and freshwater environments hold particularly high values for Käi Tahu.

Figure 4-6: Historical Gas Works, South Dunedin

4.5.4 Resource Consents Recently Granted within the Catchment

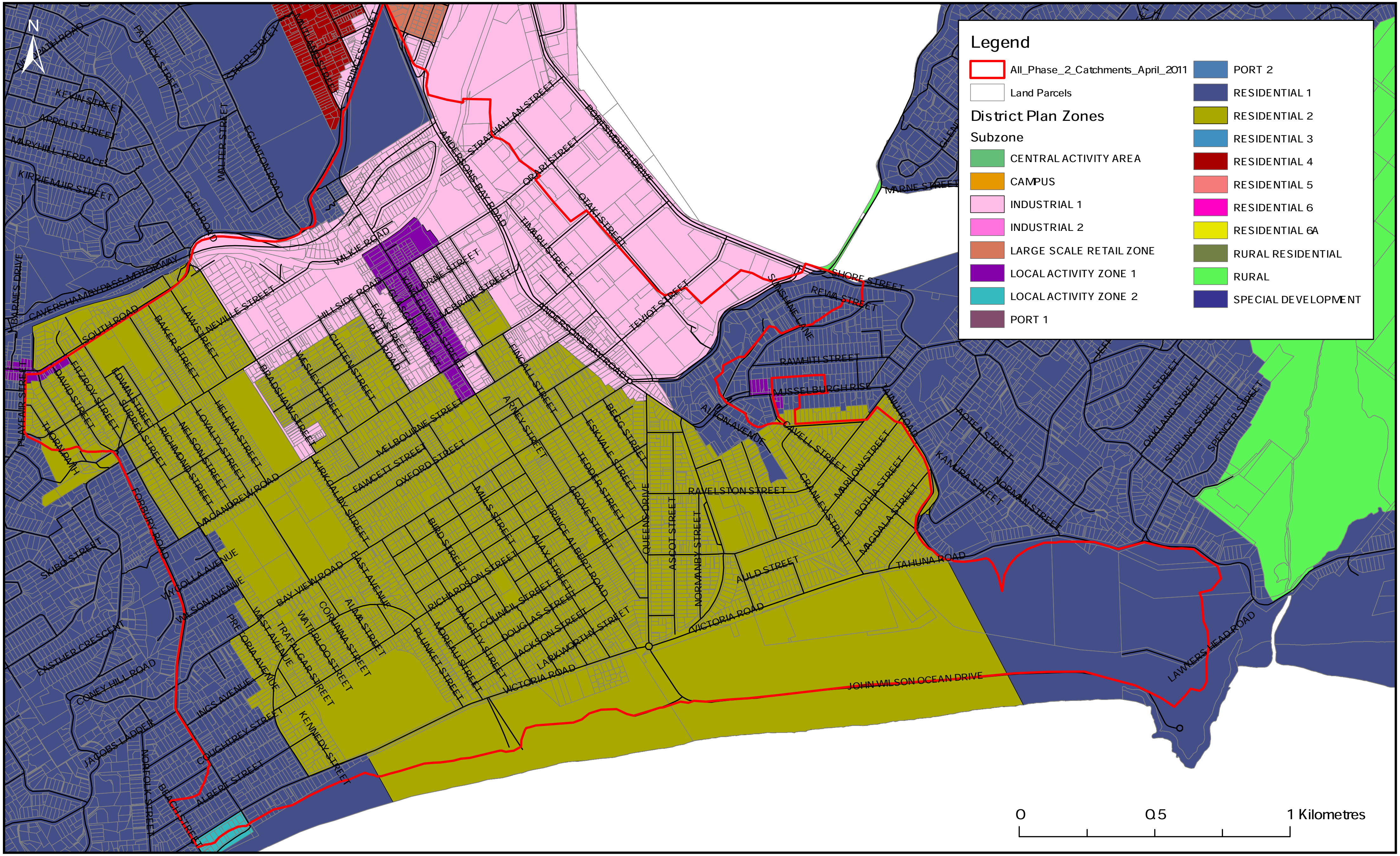
Both ORC and DCC were contacted with respect to recent resource consents granted in the catchment. ORC reported that there had been no resource consents recently granted relating to stormwater management in the catchment. However DCC have granted a number of consents (refer Figure 4-9). The majority of these consents are building consents - the effects of which have been incorporated into the future imperviousness calculations (Appendix B).

ORC consents previously granted (but now expired) include permission to disturb contaminated sites (e.g. the disused Gasworks site) for the purposes of building or excavation for site assessment. A number of consents exist for discharges to air by various industrial processes (e.g. diesel boilers, solvent and spray paint particles etc.). These have the potential to contaminate stormwater, should the discharged material settle on the ground.

4.5.5 Contaminated Land

Figure 4-10 provides the location of a number of known contaminated land sites. Data was collated from both ORC and DCC with respect to these sites. Information on contaminated sites around the city is incomplete, and the map provided below serves to provide information on the location of known contaminated sites. More sites around the catchment may exist, but information relating to these sites may not be available at this time.

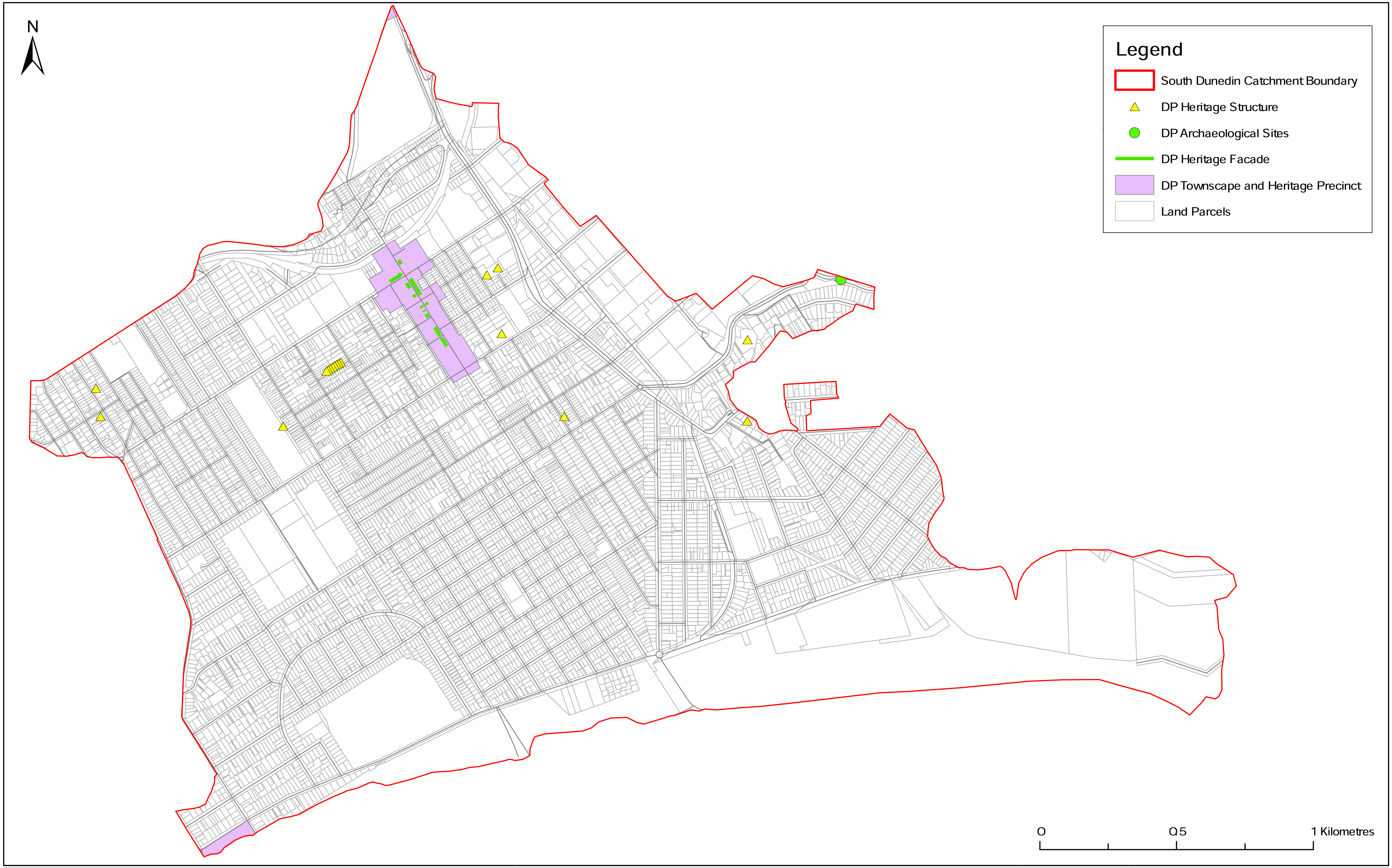
Contaminated sites of interest in Figure 4-10 include the disused gasworks site and areas of reclaimed land adjacent to the harbour. Various types of fill may have been used during land reclamation, so the material of the fill is likely to be varied and unknown, and may contain contaminants.



DUNEDIN CITY COUNCIL / OPUS / URS	Dunedin 3 Waters Strategy	3 WATERS INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-7 South Dunedin Catchment Current Land Use Zones	DISCIPLINE Stormwater	Drawn: CO; Status: Final; Checked: TE; Scale: 1:12,500; Plot Date: Sep 2011; Approved: HES; Job. No: 42173227; Map No: Figure 4-7; Revision: -; Date: Sep 2011

Created with ESRI ArcGIS

T:\Jobs\42173227\GIS\FIGURES\All Catchments\All_LanduseZones.mxd Original Size A3



Created with ESRI ArcGIS

DUNEDIN CITY COUNCIL

OPUS

URS

Dunedin 3 Waters Strategy

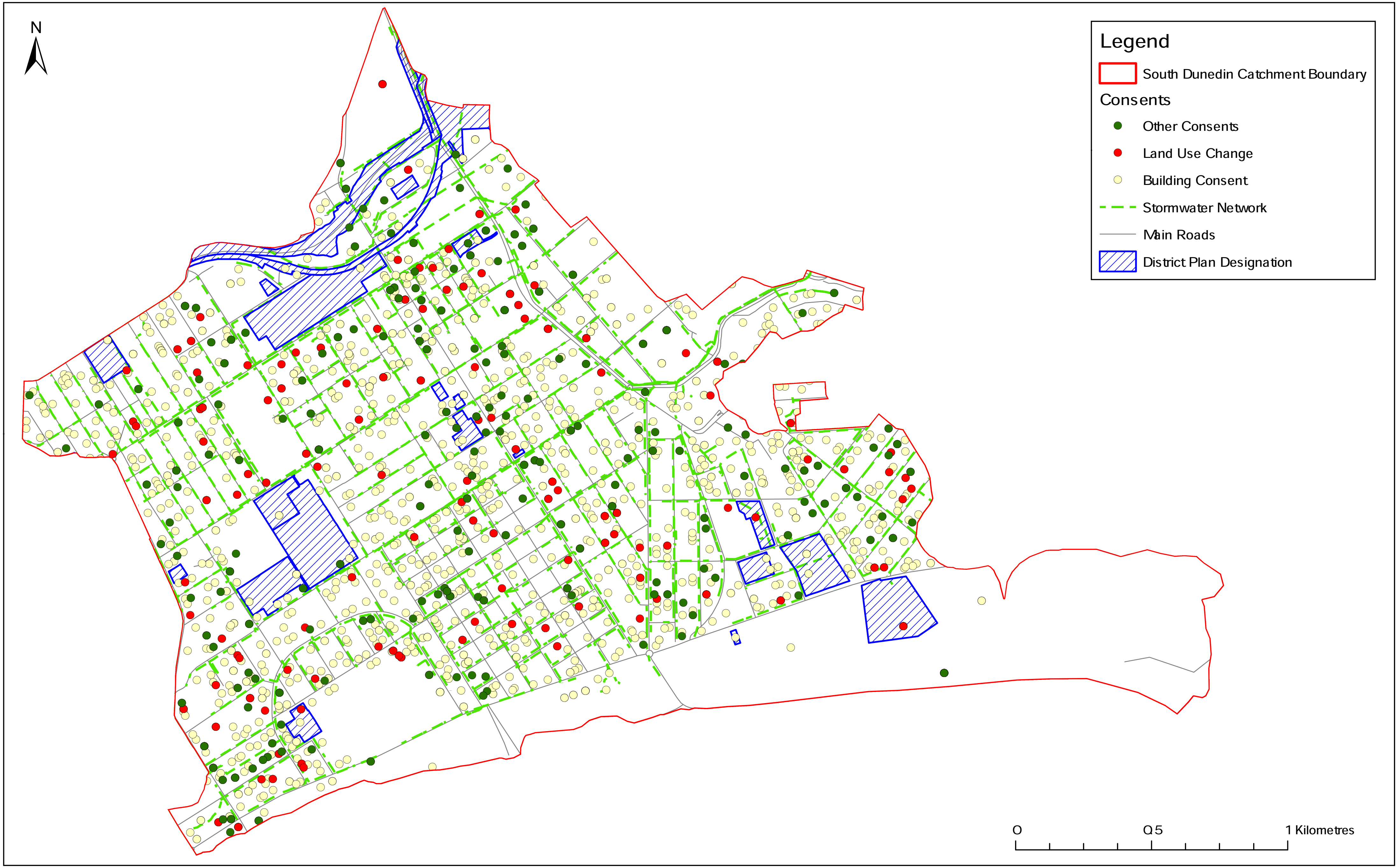
SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-8

South Dunedin Catchment Archaeological and Heritage Sites

DISCIPLINE				
Stormwater	Drawn: CO	Status: Final		
	Checked: TE	Scale: 1:12,500	Plot Date: Sep 2011	
	Approved: HES	Job. No: 42173227	Map No: Figure 4-8	Revision: -
	Date: Sep 2011			

T:\Jobs\42173227\GIS\FIGURES\All Catchments\All_Archaeological_Heritage.mxd Original Size: A3



Created with ESRI ArcGIS

DUNEDIN CITY COUNCIL

OPUS

URS

Dunedin 3 Waters Strategy

SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-9

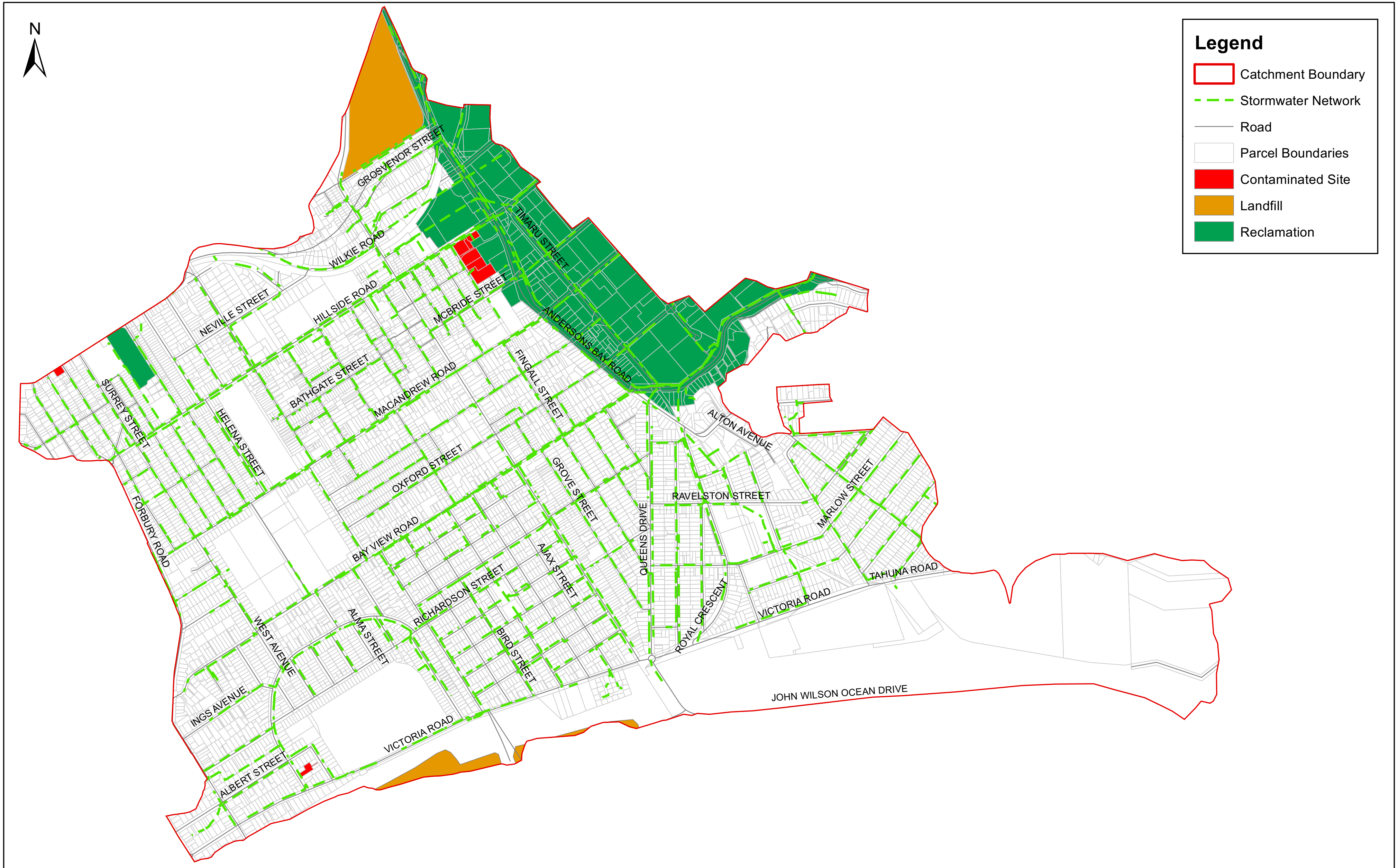
South Dunedin Catchment Recent Consents and Designations

DISCIPLINE

Stormwater

Drawn: KC	Status: Draft		
Checked: HES	Scale: 1:12,500	Plot Date: Sep 2011	
Approved: SDH	Job. No: 42173227	Map No: Figure 4-9	Revision: -
Date: Sep 2011			

T:\Jobs\42173227\GIS\FIGURES\Kitchener\K_LanduseZones.mxd Original Size A3



Created with ESRI ArcGIS

DUNEDIN CITY COUNCIL

OPUS

URS

Dunedin 3 Waters Strategy	SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-10 South Dunedin Catchment Contaminated Land Sites	DISCIPLINE Stormwater	Drawn: CO Checked: JH Approved: HES Date: Sep 2011	Status: Final Scale: 1:12,500 Job. No: 42173227	Plot Date: Sep 2011 Map No: Figure 4-10	Revision: -

T:\Jobs\42173227\GIS\FIGURES\Portsmouth Dr\P_Contaminated sites.mxd

Original Size: A3

4.5.6 Future Land Use

The land use in the catchment is not expected to change significantly in the future, with the exception of Carisbrook Stadium. Land use on the stadium site is likely to change to Industrial 2 (current zoning of the area) in the near future, due to the opening of the new Dunedin Stadium. The only possible mechanism for densification in the catchment, aside from a plan change, is through resource consent applications by private landowners.

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 South Dunedin catchment, it is anticipated that there will be little difference between the three future scenarios, and the 2060 scenario will be the most relevant for the purposes of stormwater management. Based on the Residential Capacity Study undertaken by DCC in 2005, which includes building consents recently granted in the catchment, the 2060 scenario has been developed based on potential opportunity for infill housing. As discussed above, there is not expected to be a dramatic change in land use zoning in the area. Additionally, maximum allowable imperviousness has been considered within each zone area. Current and future imperviousness changes are discussed in Section 4.6 below.

4.6 Catchment Imperviousness

Figure 4-11 provides a map of current imperviousness for the South Dunedin catchment (refer Appendix B for calculation methods). Land uses in the South Dunedin Catchment are predominantly Residential 2, and Industrial 1, with small pockets of Commercial and Residential 1 zoning. Overall, catchment imperviousness is calculated to be approximately 60 %.

As the majority of the catchment is zoned Residential 2, or Commercial/Industrial, imperviousness is already at or above the maximum allowable by the DCC district plan. Hence the catchment is considered to be fully developed.

The average size of Residential 2 sites is smaller than those in other residential zones, and has medium to high site coverage (with a limit in the Dunedin City District Plan of 50 % imperviousness). Side yards of 900 mm to 1 m are common; however the majority of the structures are single-storey. Currently, the Residential 2 areas in South Dunedin have a calculated imperviousness of approximately 54 %; this is anticipated to rise to approximately 56 % under the future scenario.

DUNEDIN CITY COUNCIL

OPUS

URS

Dunedin 3 Waters Strategy

SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-11

South Dunedin Catchment Current Imperviousness

DISCIPLINE

Stormwater

Drawn: CO	Status: Final	
Checked: TE	Scale: 1:12,500	Plot Date: Sep 2011
Approved: HES	Job. No: 42173227	Map No: Figure 4-11 / Revision: -
Date: Sep 2011		

Created with ESRI ArcGIS

T:\Jobs\42173227\GIS\FIGURES\All Catchments\All_current imperv.mxd Original Size A3

4.7 Stormwater Drainage Network

4.7.1 Network Description

Figure 4-13 shows the main components of the South Dunedin stormwater network. The stormwater drainage network consists of a network of shallow pipes (ranging between 100 and 1800 mm in diameter) and box culverts with widths up to 2400 mm. Figure 4-12 provides a frequency distribution of the pipe sizes in the catchment. Due to the catchment topography, the network generally consists of pipes / culverts laid at gentle gradients. The total network is approximately 65 km long. There are no streams or open channels, other than roadside kerbs, in the catchment.

All stormwater from the catchment discharges into the harbour via the Portobello Stormwater Pump Station. This pump station is equipped with seven pumps ranging in capacity from 0.2 m^3/s to 1.5 m^3/s. A second stormwater pump station, Tainui, is located at the Musselburgh wastewater Pump Station. This station pumps stormwater from a low-lying area in the south-east of the catchment to the Portobello Pump Station and has been operational for over 50 years.

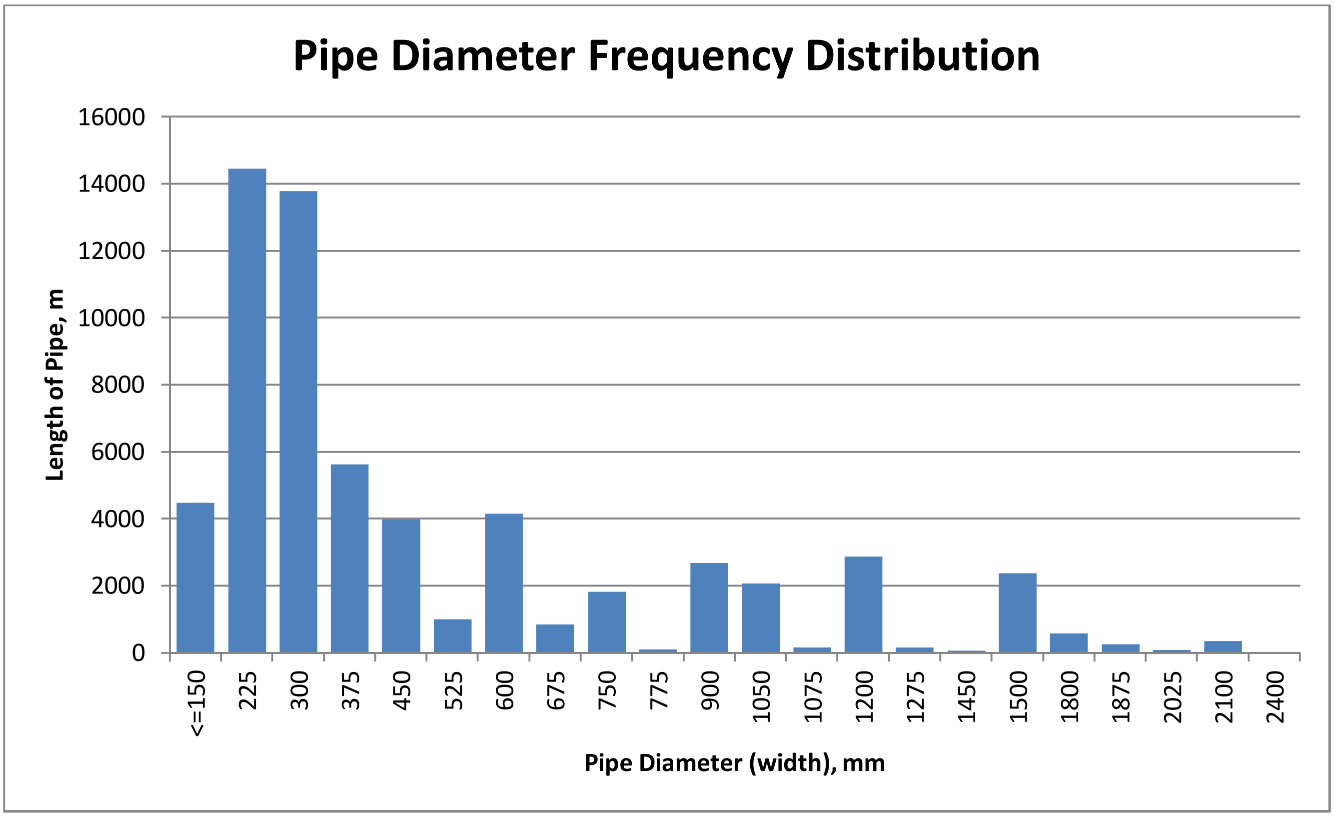
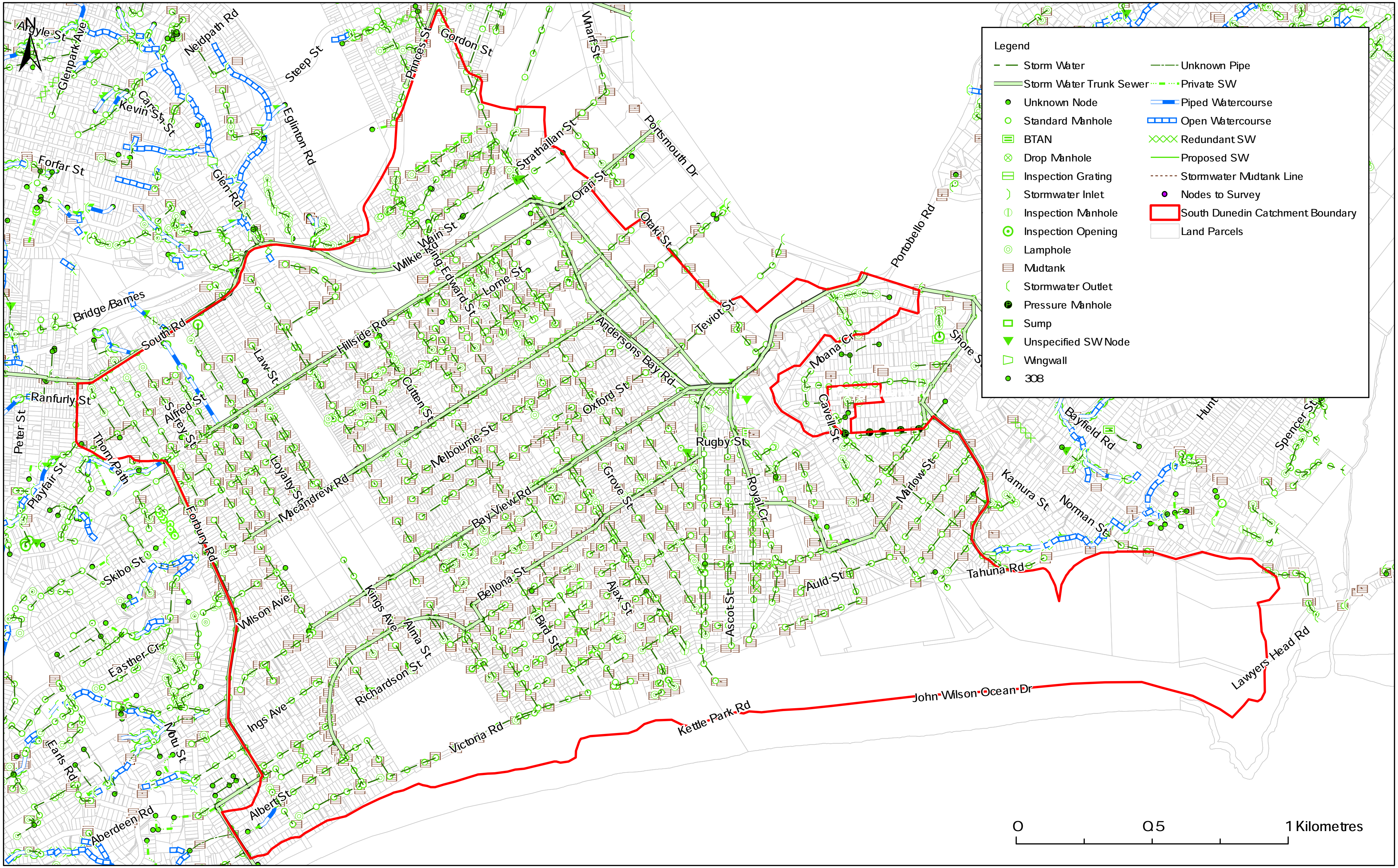


Figure 4-12: Pipe Diameter Frequency Distribution



DUNEDIN CITY COUNCIL / OPUS / URS	Dunedin 3 Waters Strategy	SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-13 South Dunedin Catchment Stormwater Drainage Network	DISCIPLINE Stormwater	Drawn: CO; Checked: HES; Approved: SDH; Date: Sep 2011; Status: Final; Scale: 1:12,500; Job. No: 42173227; Plot Date: Sep 2011; Map No: Figure 4-13; Revision: A

Created with ESRI ArcGIS

T:\Jobs\42173227\GIS\FIGURES\Kitchener\K_Drainage Network.mxd Original Size: A3

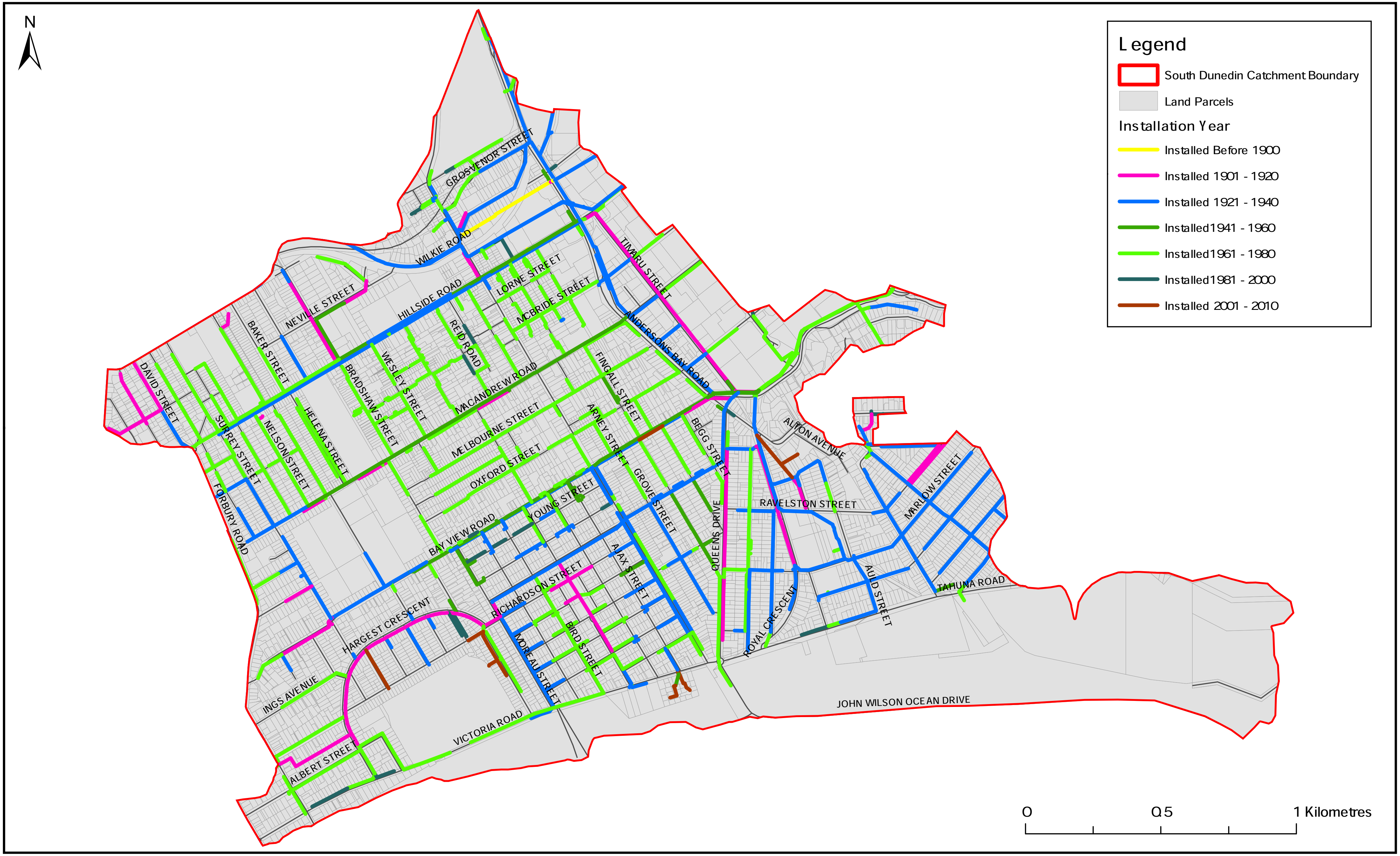
4.7.2 Network Age

Table 4-3 below provides a breakdown of pipe age in the South Dunedin catchment. Figure 4-14 provides a map of pipe age based on location.

Based on the current forecasts of theoretical asset life for stormwater mains, the majority of which have been assigned a theoretical life of 100 years, 55 % of the pipe network will be subject to inspection / condition assessment or be renewed by 2060. Remaining life forecasts will be improved based on condition assessment and related work on refining expected lives, and renewals planning adjusted accordingly.

Table 4-3: Pipe Network Age and Length Composition

Installation Date	Approximate Age	Number of Pipelines	Length of Pipe (m)	% of Pipe Length
Installed 1900 or before	> 110 years	0	0	0
Installed 1901 to 1920	90-110 years	163	7341	12
Installed 1921 to 1940	70-90 years	471	21683	34
Installed 1941 to 1960	50-70 years	139	5503	9
Installed 1961 to 1980	30-50 years	612	26149	41
Installed 1981 to 2000	10-30 years	32	1441	2
Installed 2001 to 2009	< 10 years	28	1014	2



Dunedin 3 Waters Strategy

SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-14

South Dunedin Catchment Pipe Network Ages

DISCIPLINE

Stormwater

Drawn: MM	Status: Final	
Checked: TE	Scale: 1:12,500	Plot Date: Sep 2011
Approved: HES	Job. No: 42173227	Map No: Figure 4-14 / Revision: -
Date: Sep 2011		

Created with ESRI ArcGIS

T:\Jobs\42173227\GIS\FIGURES\All Catchments\All_Pipe Network Ages.mxd Original Size A3

4.7.3 Asset Condition and Criticality

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 4-4 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.

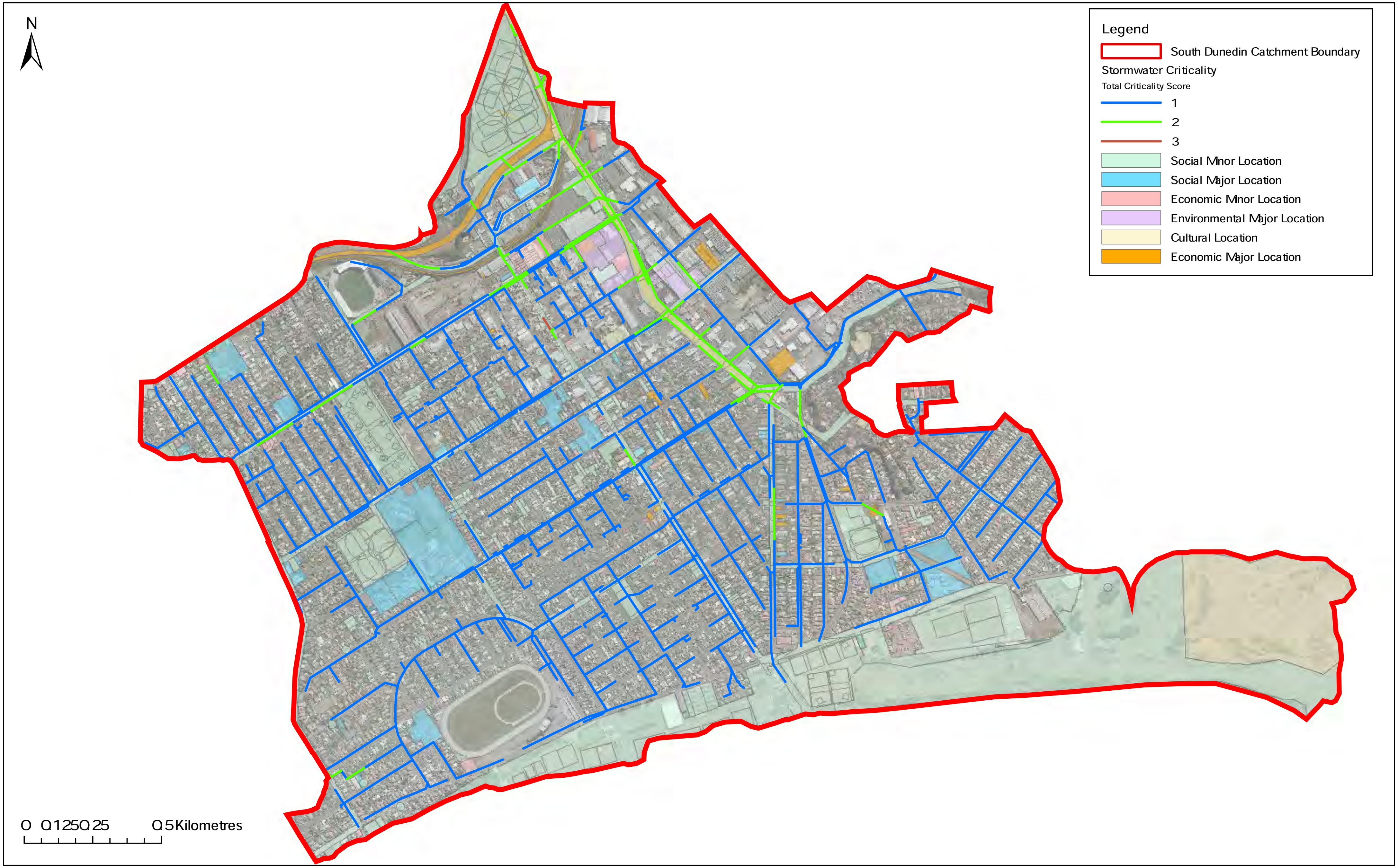
Figure 4-15 shows a map of the South Dunedin catchment, with criticality and the four wellbeing locations identified. This map shows pipe criticality only. Pipe condition assessment is currently being undertaken throughout the city on selected pipes, however to date little information is available on pipes in the South Dunedin Street catchment.

The majority of the pipes in the South Dunedin catchment have a criticality score of 1. Exceptions are pipes along the major transport routes (Andersons Bay Road, beneath the railway, and along bus routes). One pipe with a criticality score of 3 is on King Edward Street, where a pipe intersects cultural locations, social location (bus route), and a major economic location (shopping area).

Table 4-4: 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	SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-15 South Dunedin Catchment Stormwater Network Criticality	DISCIPLINE Stormwater	Drawn: CO	Status: Final		
			Checked: HS	Scale: 1:12,500	Plot Date: Sep 2011	
			Approved: HS	Job. No: 42173227	Map No: Figure 4-15	Revision: A
			Date: Sep 2011			

T:\Jobs\42173227\GIS\FIGURES\South Dunedin\SD_Criticality.mxd

Original Size: A3

4.7.4 Salt Water Intrusion

The intrusion of salt water into wastewater pipelines is a major concern for the 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. This is suspected to occur in South Dunedin, based on an assessment of modelled and measured flows.

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. Ongoing investigations are being undertaken by the Water and Waste Services Business Unit. Tidal influence on the system via the harbour outfalls is discussed further in Section 8.

4.7.5 Operational Issues

The South Dunedin catchment has been the subject of a number of flooding incidents in recent years. Flooding during intense rainfall events has been reported due to a number of reasons, including wastewater overflows, blocked catchpits, and street and surface flooding.

A site visit to the Midland Street Depot was carried out by URS in November 2008 to obtain an indication of observed stormwater problems in the area. In general, the DCC operations team did not consider South Dunedin to have many critical issues. Main issues of concern were identified as:

- Wet-weather flooding (wastewater) in Surrey Street. The interaction and configuration of the systems in this area may need to be addressed. A diversion to Green Island can reduce wastewater flows towards Surrey Street from the Kaikorai Valley, and provide additional capacity in the South Dunedin system. However, this diversion must also meet other objectives, namely flow-balancing for the WWTPs.

- Wet-weather flooding (stormwater) in Surrey Street. Residents have noted a high level of overland flow from Forbury to Fitzroy Road down to Sussex Street which ponds. Annual flooding has been recorded to occur at 93 Surrey Street due to runoff from Surrey Street and the adjacent Mobil station on Hillside Road. Further flooding occurs on Surrey Street as well as regular flooding outside 146 Hillside Road.

- Direct connections from the stormwater systems into the wastewater system are also suspected to contribute to network problems. In the past many of the houses were serviced by a single waste / stormwater system, however it is now a requirement that a separate storm and wastewater connection is installed. DCC have undertaken a stormwater separation programme and inspected the system for cross connections but it is plausible that this has not occurred at all private connection points, or that some assets remain mis-connected.

- The major wastewater problems stem from large events. Issues in this area are currently subject to ad hoc operational measures that attempt to mitigate these problems. There are more regular storm events that result in surface flooding.

The following known operational issues have been identified within the catchment that could directly or indirectly relate to the reported flooding incidents.

High Level Stormwater Overflows

There is a 'high level overflow', which operates to transfer flows between South Dunedin and the adjacent St Clair catchment (from the Forbury Road stormwater interceptor) during heavy flows. At this stage it is unknown how often this operates. To reflect this interconnection, parts of the St Clair catchment have been included in the hydrological model of South Dunedin during large events.

Portobello Pump Station

The catchment relies on a large pump station for discharge of the stormwater to the harbour. From the modelling results and discussions with pump station operation staff, it appears that the pump station pumping rate is determined by the measured flow entering the pump station; i.e. the pump rate which matches the incoming flow the closest is automatically selected to discharge flow from the pump station.

There is the possibility that operating the pump station in this manner creates backflow and uses the storage within the pipe network system of the South Dunedin catchment, potentially exacerbating flooding during large rainfall events. Matching flows at the downstream end of the network would not allow for compensation or fluctuations in rainfall intensity and rate of stormwater entering the system at the catchpits.

Wastewater Overflows

A wastewater overflow to a stormwater pipe with a broken valve flap at Hillside and Surrey Street was reported and has been subsequently fixed. A monitor has been installed at this location to measure volume and frequency of overflows.

Blocked Screens

Operationally, blocking of intake screens can impede stormwater flow, causing stormwater systems to back up. This is identified as a risk in several catchments, as well as at the Portobello Pump Station intake points. It is understood that visits to this location by DCC staff to clear the screens are undertaken in or prior to forecast wet weather events to prevent flooding.

Blocked Catchpits

Catchpit blocking is another operational issue that can contribute to surface flooding; DCC have a regular catchpit cleaning programme, however depending on season and intensity of rainfall, blocked catchpits can still occur.

4.7.6 Network Maintenance and Cleaning

The maintenance of catchpits is perceived to be a general issue across Dunedin city according to the Water and Waste Services Business Unit team. It was noted by the Network Management and 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 and Maintenance (Water and Waste

Services 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 five 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 Highways, which are the responsibility of the New Zealand Transport Agency).

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 catchpits 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 Services Business Unit Network Management and 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

A number of recent floods have prompted registering of a large number of flooding issues with DCC. The resultant database of flooding complaints (primarily comprising of complaints during the 2005 and 2006 flood events, and updated to include complaints up until 2010) has been used to develop a map of stormwater flood complaints for the South Dunedin catchment (Figure 4-17), although it should be noted that the most severe flooding in Dunedin during the 2005, 2006 and 2007 events did not occur in the South Dunedin catchment. Reports (anecdotal and council-generated) on a number of historical events also provide an indication of key flooding concerns for the catchment, as described below.

1923 and 1929 Storm Events

During the storm of April 1923, (Figure 4-16) flood waters from the Kaikorai Stream washed through the old Caversham railway tunnel and spread out across ‘the Flat’. Hundreds of people had to evacuate their homes. (University of Otago: the Caversham Project). A similar flood occurred in 1929.

Figure 4-16: Flooding, April 1923

2005 Storm Event

A high intensity short duration storm in February 2005 saw 35 mm of rain fall in only 20 minutes over the central business district of Dunedin. A sudden flash flood overwhelmed stormwater drainage systems and added to the localised flooding of the area.

Several pump station operations were affected, including Hazlet Road, Carlyle Road / Tyne Street and Cliffs Road. A number of intakes were also damaged. The flood report (MWH, 2005) concludes that:

"Given the magnitude and the widespread extent of the rainfall, the city's stormwater system could never have coped."

This flood event did not cause major flooding in the South Dunedin catchment, due to the highly localised nature of this rainfall event.

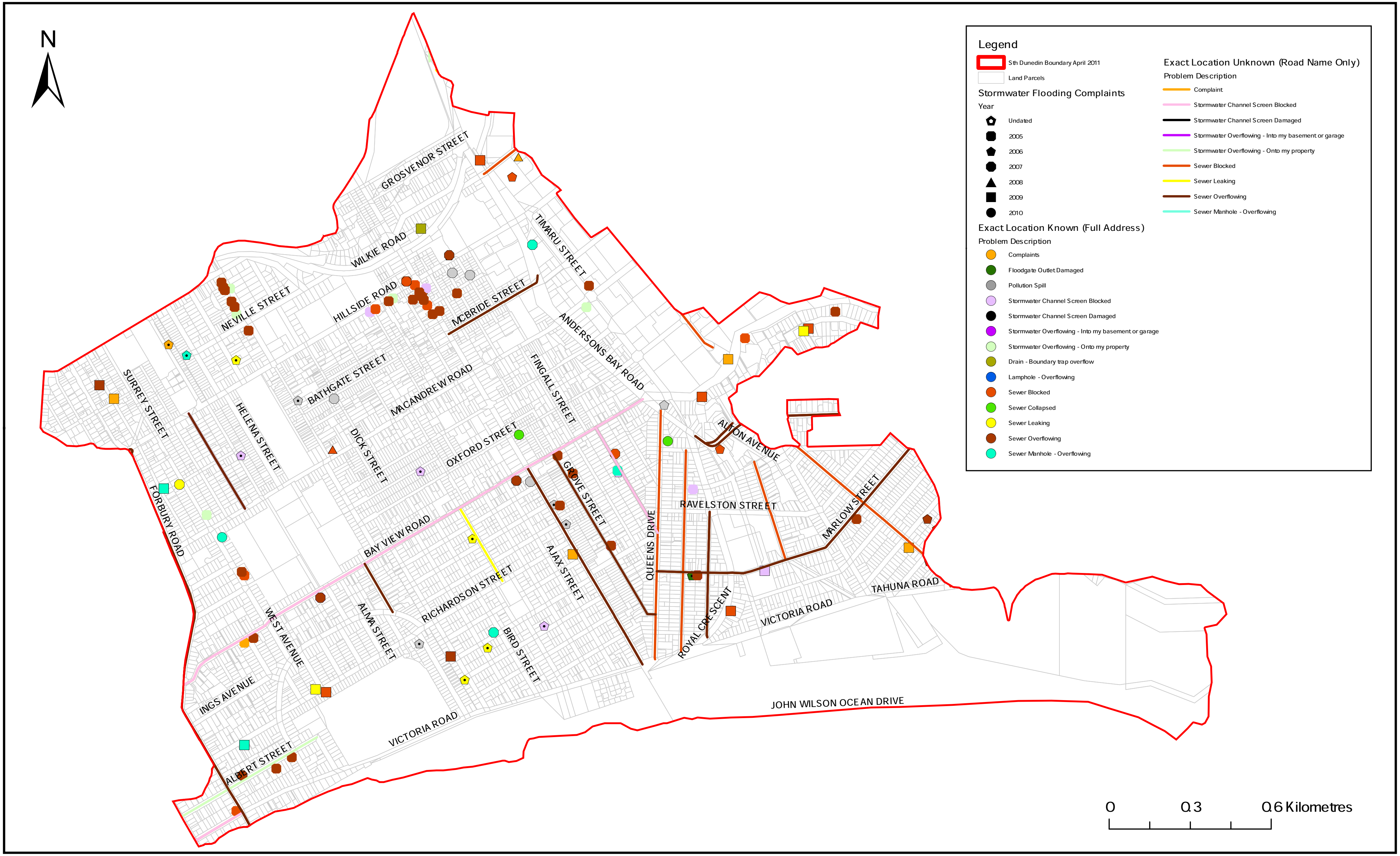
2006 Storm Event

Prolonged heavy rainfall on 25 and 26 April 2006 caused localised flooding affecting storm drains and pump stations. This time the Dunedin urban area was fortunate, although levels of the Waitati and Silver stream were dangerously high more serious flooding was narrowly avoided. The highest intensity focus of the storm was recorded as being over the Mount Cargill area. The combination of peak rainfall over Mount Cargill and increased flow levels in the Mosgiel area, Silver Stream, Waitati and the Water of Leith, coincides with the worst affected areas (MWH, 2006).

2007 Rainfall and Flooding Event

Over a two day period on 29 and 30 July 2007 Dunedin was subject to 92 mm of rain which caused substantial flooding in many parts of the city. Although not as severe as the 2005 and 2006 events, considerable disruption to stormwater services occurred. As previously noted problems were primarily caused by stormwater facilities backing up. Musselburgh reportedly received 70 mm over a 12 hour period which eventually resulted in the wastewater pump station over-flowing (DCC, 2007).

Wastewater customer complaints compiled between 2005 and 2010 (Figure 4-18) are also numerous, but appear to be spread across the catchment reasonably consistently.



Created with ESRI ArcGIS

DUNEDIN CITY COUNCIL

OPUS

URS

Dunedin 3 Waters Strategy

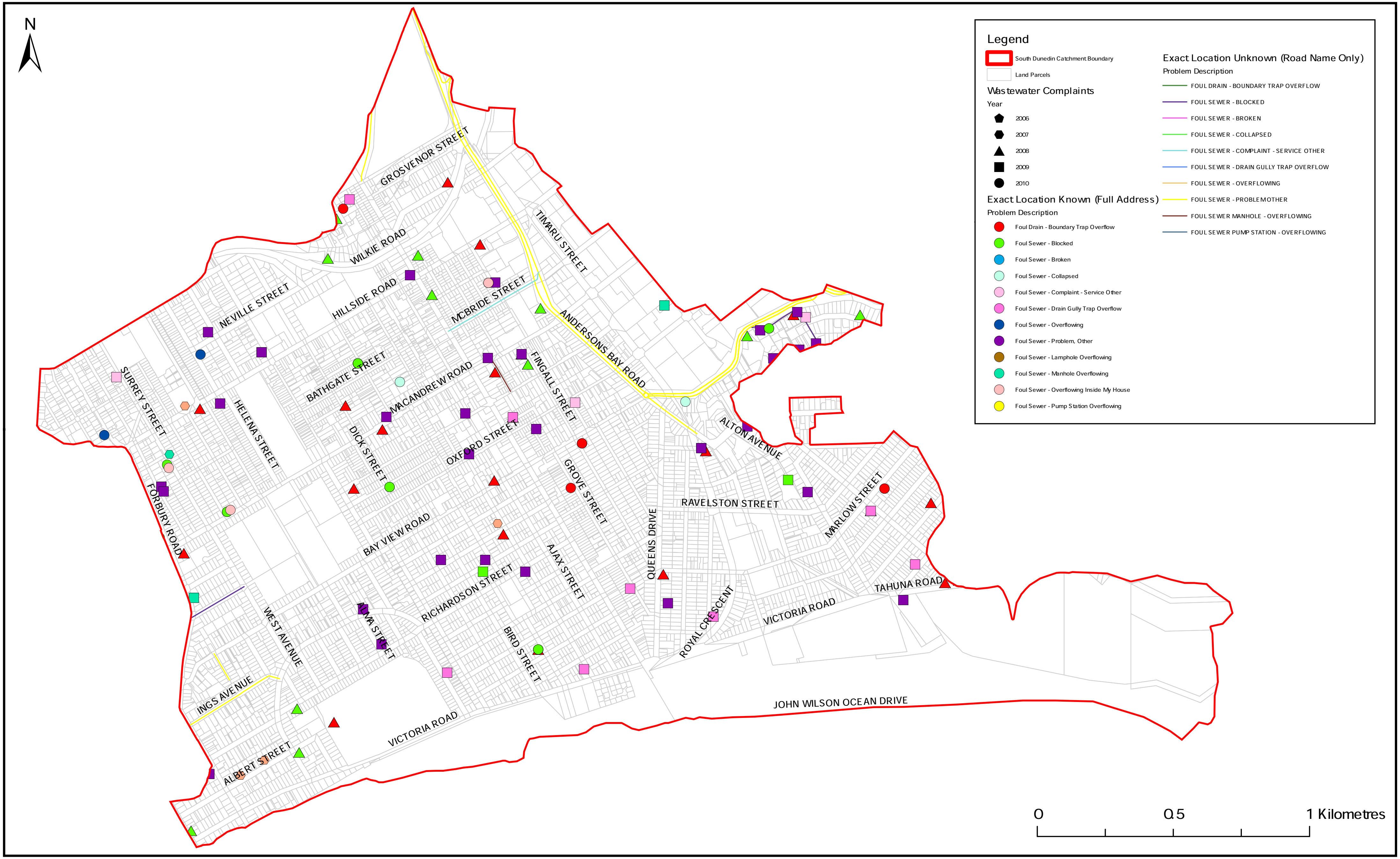
SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-17

South Dunedin Catchment Reported Stormwater Flooding

DISCIPLINE	Drawn: CO	Status: Final	
Stormwater	Checked: HS	Scale: 1:12,500	Plot Date: Sep 2011
	Approved: HS	Job. No: 42173227	Map No: Figure 4-17	Revision: -
	Date: Sep 2011		

T:\Jobs\42173227\GIS\FIGURES\StClair\SC_Stormwater_Flood_Complaints.mxd Original Size A3



DUNEDIN CITY COUNCIL
OPUS
URS

Dunedin 3 Waters Strategy

SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-18

South Dunedin Catchment Reported Wastewater Flooding

DISCIPLINE

Stormwater

Drawn: CO	Status: Final		
Checked: HES	Scale: 1:12,500	Plot Date: Sep 2011	
Approved: SDH	Job. No: 42173227	Map No: Figure 4-18	Revision: -
Date: Sep 2011			

T:\Jobs\42173227\GIS\FIGURES\Kitchener St\K_Wastewater_Flood_Complaints.mxd Original Size A3

4.9 Water and Wastewater Systems

Figure 4-19 provides a layout of the 3 waters networks in South Dunedin.

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 South Dunedin 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 water supply network in South Dunedin consists of approximately 125 km of pipes, with the majority of these around 100 mm in diameter. The water mains supplying the South Dunedin catchment area are largely constructed from cast iron. At present the extent of leakage in the catchment is unknown, but it is likely that all mains will need replacing over the next 20 years.

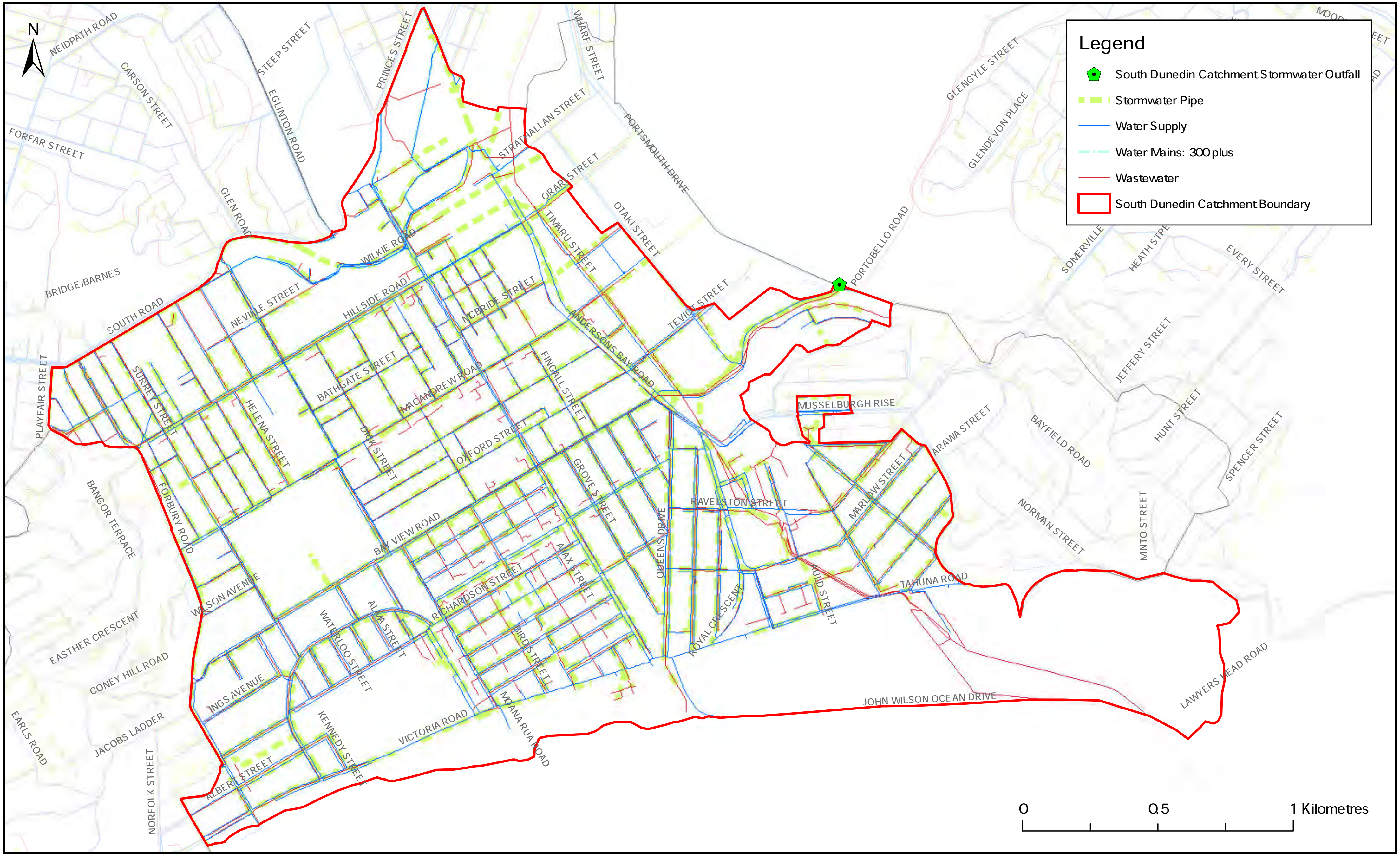
The capital works master plan identifies a number of specific water supply network issues across the city, which have been explored in detail during Phase 2 of the project, however none are located within the South Dunedin stormwater catchment.

4.9.2 Wastewater System

There are approximately 76 km of wastewater pipeline in place in South Dunedin, along with two pump stations (Musselburgh and Oval Pavilion). The majority of pipes are between 150 mm to 300 mm in diameter (80 %) and drain the catchment wastewater via gravity. The wastewater system in South Dunedin conveys wastewater from as far as Halfway Bush and Wakari to the north-west. Flows are collected from the Kaikorai Valley before entering the old Caversham rail tunnel and flow down to South Road where flows from the Caversham and Mornington areas are also collected. A trunk main then runs along Surrey Street collecting further flows from Corstorphine West and St Clair catchments before following Macandrew Road downstream to a confluence with the main interceptor sewer (MIS). The MIS conveys flows from North and Central Dunedin and the built up urban area of Dunedin West Harbour communities (Saint Leonards, Burkes, Port Chalmers), to Musselburgh Pump Station. Musselburgh Pump Station is a combined screening and pump station. Wastewater from this pump station is pumped to the Tahuna WWTP for treatment and discharged to the ocean.

There are no identified wastewater overflows in the South Dunedin catchment, however there is a foul / stormwater cross connection on the corner of Surrey Street and Hillside Road. A number of historical complaints from residents, together with operational team comments confirm that this area of the South Dunedin catchment is of concern. Complaints and observations relate to a combination of wastewater and stormwater flooding. However, they are not always specific on the location or cause of flooding.

A study has been undertaken to address the Surrey Street wastewater / stormwater flooding issue. Investigations to date have located the wastewater / stormwater cross connection, and calculated the hydraulic capacity of the wastewater trunk main running along Surrey Street. The primary cause of flooding from the wastewater network is thought to be excessive inflow and infiltration (I&I) occurring outside of the South Dunedin catchment, with high volumes flowing through the MIS during wet weather. In the short term, this issue has been alleviated through the use of a diversion to the Green Island WWTP upstream of Surrey Street. Long term permanent solutions need to be assessed, and DCC requires further investigation into this issue before investing in a major capital works programme.



DUNEDIN CITY COUNCIL / OPUS / URS	Dunedin 3 Waters Strategy	SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-19 South Dunedin Catchment Three Waters Networks	DISCIPLINE Stormwater	Drawn: CO	Status: Draft	
				Checked: HES	Scale: 1:12,500	Plot Date: Sep 2011
				Approved: SDH	Job. No: 42173227	Map No: Figure 4-19 / Revision: -
				Date: Sep 2011		

Created with ESRI ArcGIS

T:\Jobs\42173227\GIS\FIGURES\Kitchener\K_Three waters networks.mxd Original Size A3

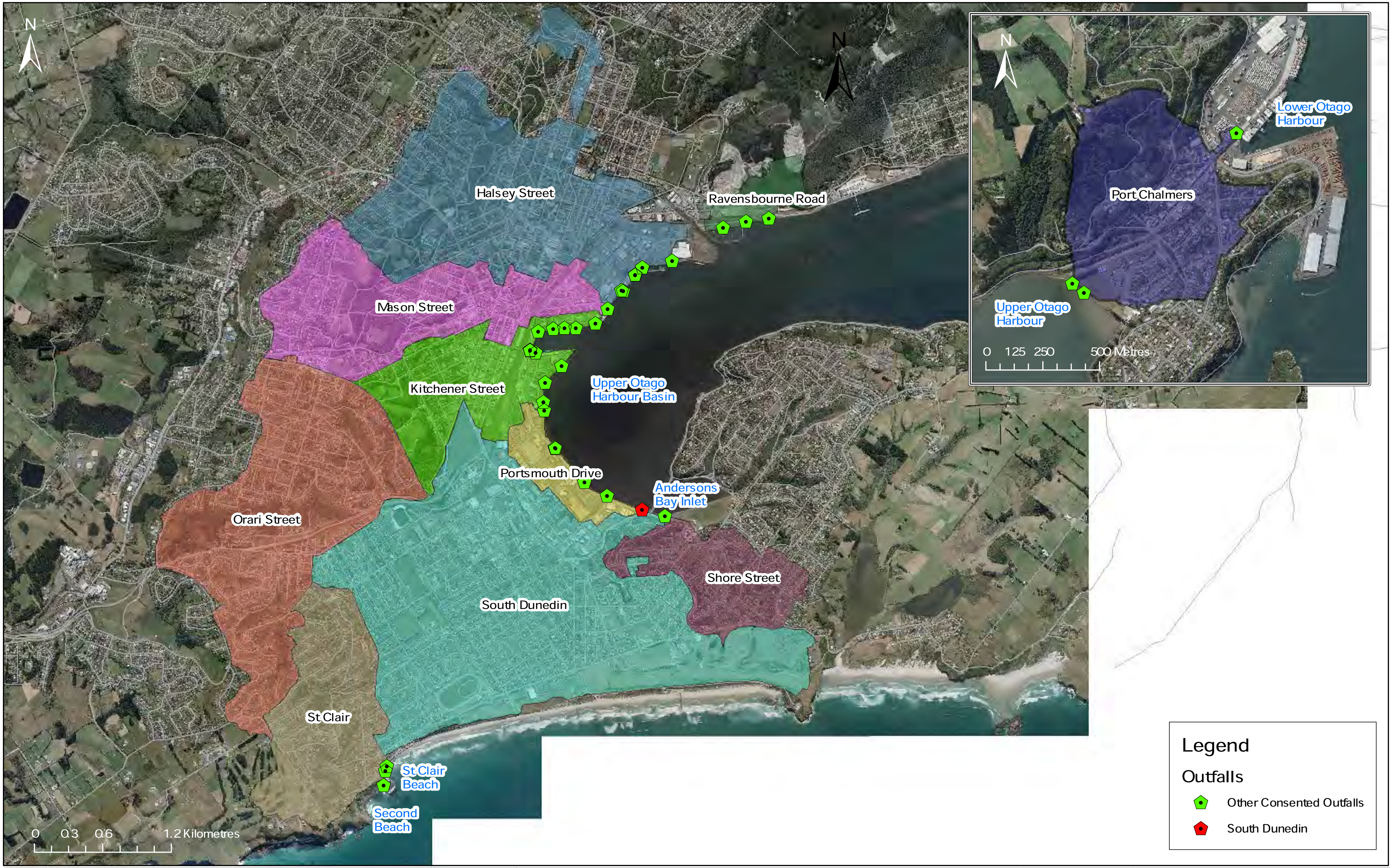
5 Receiving Environment

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

Part 3 of this report identifies and analyses the effects that specific current 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.

There are no natural streams or wetlands present in the South Dunedin catchment. The catchment (via the Portobello Pump Station) discharges stormwater into the south-east corner of the Otago Harbour Basin via the twin outfalls shown in Figure 5-1. The location of the South Dunedin Stormwater Outfall is shown in Figure 5-2 below, relative to other DCC Stormwater Outfalls, and the receiving environment of the Otago Harbour.

Figure 5-1: Portobello Pump Station Outfall



Created with ESRI ArcGIS

Dunedin 3 Waters Strategy	SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 5-2 South Dunedin 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 5-2	Revision: -
Date: Sep 2011			

T:\Jobs\42173227\GIS\FIGURES\South Dunedin\SD_Marine Receiving Environment.mxd Original Size: A3

5.1 Marine Receiving Environment

Monitoring of the harbour environment is undertaken on an annual basis in accordance with the conditions of resource consent for DCC's stormwater discharges. To date, four rounds of monitoring have been undertaken (2007, 2008, 2009, and 2010). The annual monitoring in the Otago Harbour 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 20 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 a number of 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. There have also been a number of studies undertaken specifically to assess the environment around the South Dunedin outfall.

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, shown in Figure 5-2.

The tidal range of the Otago Harbour is approximately 2.2 m, and the Portobello Road Pump Station outfall pipes are submerged during high tide. No gates are installed on the outfalls and no measurement of the extent of inundation is available.

Tidal current water velocities in the inner harbour range from 0.25 m/s to almost zero around the outfall (Ryder, 2005b), 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 (Figure 5-3). Smith and Croot (1993) report that flushing times in the harbour are hard to establish, due to inputs of heavy rainfall having a dramatic effect on dilution displacement of water in the upper harbour. Hence, harbour flushing times may vary and be greatly reduced during rainfall events.

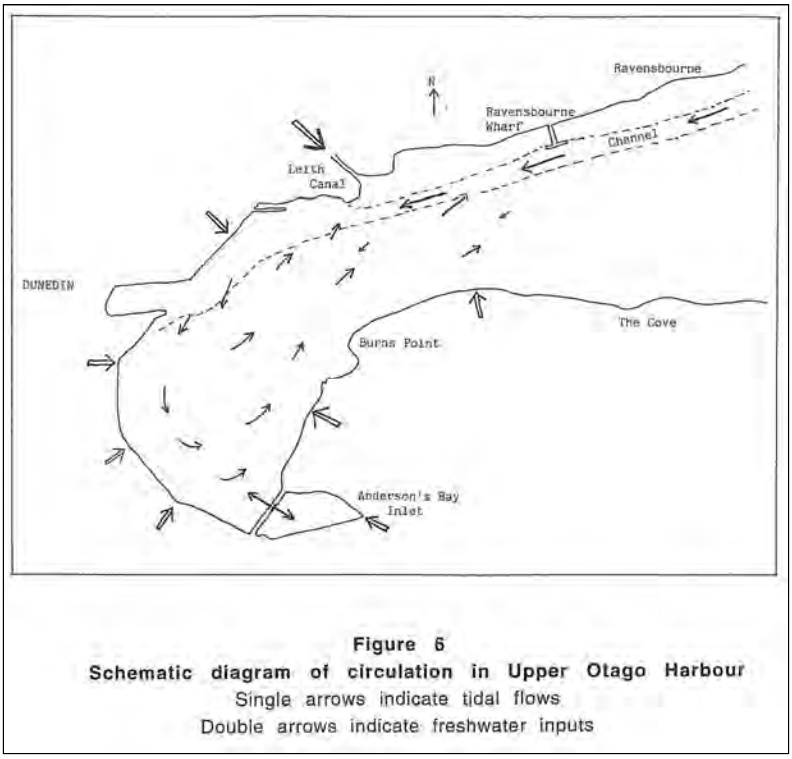


Figure 5-3: Circulation of Water in Upper Otago Harbour

5.1.2 Recreation and cultural significance

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

The CIA undertaken by KTKO (2005), relating to the initial applications for consent by DCC, to discharge stormwater into the marine environment, describes the strong relationship that KTKO Ltd. have with the coastal environment. Evidence of Māori use of the harbour extends back to earliest Māori 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 käi had been dramatically altered. Further consultation with Käi Tahu is discussed in Section 3 of this report.

5.1.3 Harbour Ecology

Biological monitoring of three significant organism groups is undertaken on an annual basis in accordance with the stormwater discharge consent conditions for the Portobello Road Outfall. To date, four rounds of monitoring have been undertaken (2007, 2008, 2009 and 2010). The purpose of collecting biological samples is to look at the effects of presence / accumulation (or otherwise) of particular stormwater-associated contaminants. The diversity of benthic flora and fauna is generally accepted as a reasonable indicator of environmental health. Presence of pollution tolerant species can be used to indicate contamination; however significant amounts of data are required to link the presence or absence of these types of 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).	
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, and 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, and industrial activities.
Contaminant	Potential Sources
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).	

Biological monitoring of epifauna and infauna involves the collection of flora and fauna samples from the sediments at four sites; two within 20 m of the outfall, and two not less than 50 m from the outfall. Monitoring of cockles, mussels, fish and octopus requires shoreline beach patrols adjacent to the outfalls to seek dead octopus, collection of shellfish within 20 m of the outfall, and fish-traps set within 50 m of the outfall. Monitoring at a number of stormwater outfalls is undertaken simultaneously.

Results from the 2007, 2008, 2009 and 2010 biological monitoring at the Portobello Road outfall can be summarised as follows:

- Macroalgae: There was low diversity of macro algae (only one species) present in the proximity of the Portobello Road outfall during 2007 and 2008. However, the diversity had increased in 2009 and 2010, although cover was generally low.

- Epifauna: There has been lower diversity and lower number of snails and bivalves at the discharge point from the Portobello Road outfall than there is at the adjacent Kitchener Street and Orari Street outfalls, but the conclusion in 2009 and 2010 was that epifauna was moderately abundant. The population increases with distance from the outfall. There was little change between 2007 and 2008, however the diversity of epifauna in 2009 was greater than in the previous two years, and compared more favourably with the adjacent outfalls.

- Cockles, Mussels, Fish and Octopus: All metals (except nickel) were present in higher concentrations at the Portobello Road site than at the Kitchener Street outfall in 2009, however no clear distinction could be made in 2010 when comparing the sites. However, the concentrations of all heavy metals have been within acceptable food standards despite fluctuations in concentrations (values in cockles doubled from 2007 to 2008, but reduced again in 2009). PAH levels in cockles have decreased annually over the monitoring period but the concentrations are still high compared with British Colombia guidelines for B(a)P concentrations for human consumption. High faecal coliforms were present in 2008 (low values were evident in 2007 and 2009). In all years, the survey has shown that cockles become noticeably smaller closer to the Portobello Road outfall.

- Contaminant concentrations in octopus collected in 2009 were well below British Colombia food guidelines.

The fluctuations in the concentrations of contaminants over time and area which have been discussed above indicate that the monitoring period has not yet been sufficient to determine any clear trends in the state of the ecology in the receiving environment.

A further comment from the monitoring reports is that the low diversity of benthic and infaunal communities is not necessarily associated with one individual outfall. It is more likely the result of combined discharges to the harbour and exposure to freshwater inputs, coupled with exposure to the atmosphere at low tide (the Portobello Road outfall discharges into a shallow part of the upper harbour).

5.1.4 Harbour Sediments

The resource consent associated with the outfall from the South Dunedin catchment has a sediment monitoring requirement. Sediments have been collected from sample sites less than 20 m and greater than 20 m from the outfall. As noted above, the influence of other urban stormwater discharges, and discharges from a variety of other activities, both current and historical, are also expected to be evident in harbour sediments at this location, and throughout the upper harbour.

The upper harbour bed has been classified as muddy sands/sandy muds, with varying proportions of fine gravels (Ryder, 2005b). During modelling work undertaken by Smith (2007), the harbour has been treated as a storage area with respect to sediments, with sediment removal from the harbour dominated by dredging from the shipping channels. This indicates that the removal of sediment from the harbour by natural processes may be minimal. However, Smith (2007) has limited information on stormwater associated sediment, and does not examine the transport of this sediment throughout the harbour.

A review of studies on sediments and contaminants in the upper Otago Harbour Basin referenced in Ryder (2006) suggests that levels of contaminants in the south-eastern corner of the harbour basin are of concern.

A range of historic data is available regarding contamination levels within harbour sediments, including sediments near the Orari Street catchment outfall. However, historic values should be viewed with caution as sampling in previous years may have used different protocols and sediments may have been collected from different substrate depths and by different methods

Ryder (2009) provides sediment contaminant concentration data from historical monitoring, as well as the ongoing monitoring being undertaken for consent compliance. Sediments are sampled annually around the edges of the upper harbour, as well as in a transect through the centre of the upper harbour (i.e. five samples annually).

The sediment analysis results for consent monitoring 2007-2010, and the 2010 study, are presented in Table 5-2 alongside Australian and New Zealand Environment and Conservation Council (ANZECC 2000) sediment quality guidelines and are 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 (Ryder, 2010b). For example, in 2010 copper and zinc levels were found to increase with distance from the Kitchener Street outfall.

The monitoring results presented in Table 5-2 show that heavy metal and PAH contamination of the sediments has occurred; many of the samples have contaminant concentrations exceeding the ANZECC high trigger values, at both of the monitoring sites, near to and far from the outfall. The heavy metals and PAHs identified in significant concentrations are generally associated with roofing materials, industrial activities, and heavy traffic. Sections 6 and 8 of this report discuss stormwater quality and assess the effects on the environment in further detail.

Ryder (2005b) provides the results of sediment sampling from transects radiating out from the Portobello Road outfall. Sediments were sampled from the top 10 – 20 mm of sediment in the harbour, in an attempt to show 'current status' rather than historical contamination.

The results of this sampling show that contamination is generally confined to the area within 50 m of the outfall, and along the roads adjacent to the harbour. Figure 5-4 below provides some of the heavy metal and PAH results from the sediment monitoring. Each graph shows concentrations of contaminants in sediments at various distances from the Portobello outfall. There is evidence of high heavy metals adjacent to the Portobello Road causeway (at least 50 m from the outfall), and Portsmouth Drive. PAHs are high immediately around the outfall location, and also along Portsmouth Drive. Most of the heavy metals exceeded the ANZECC (2000) interim sediment quality guideline trigger values, with the exception of chromium.

Ryder (2006) identifies an increase in PAH concentrations in sediments over time (i.e. increased contaminant concentrations closer to the surface) using analysis of a deep sediment core. However, for a number of samples, PAHs show a high concentration 'spike' at approximately 50 mm depth. This spike could potentially date back 20 years or so (B Stewart, pers comm.).

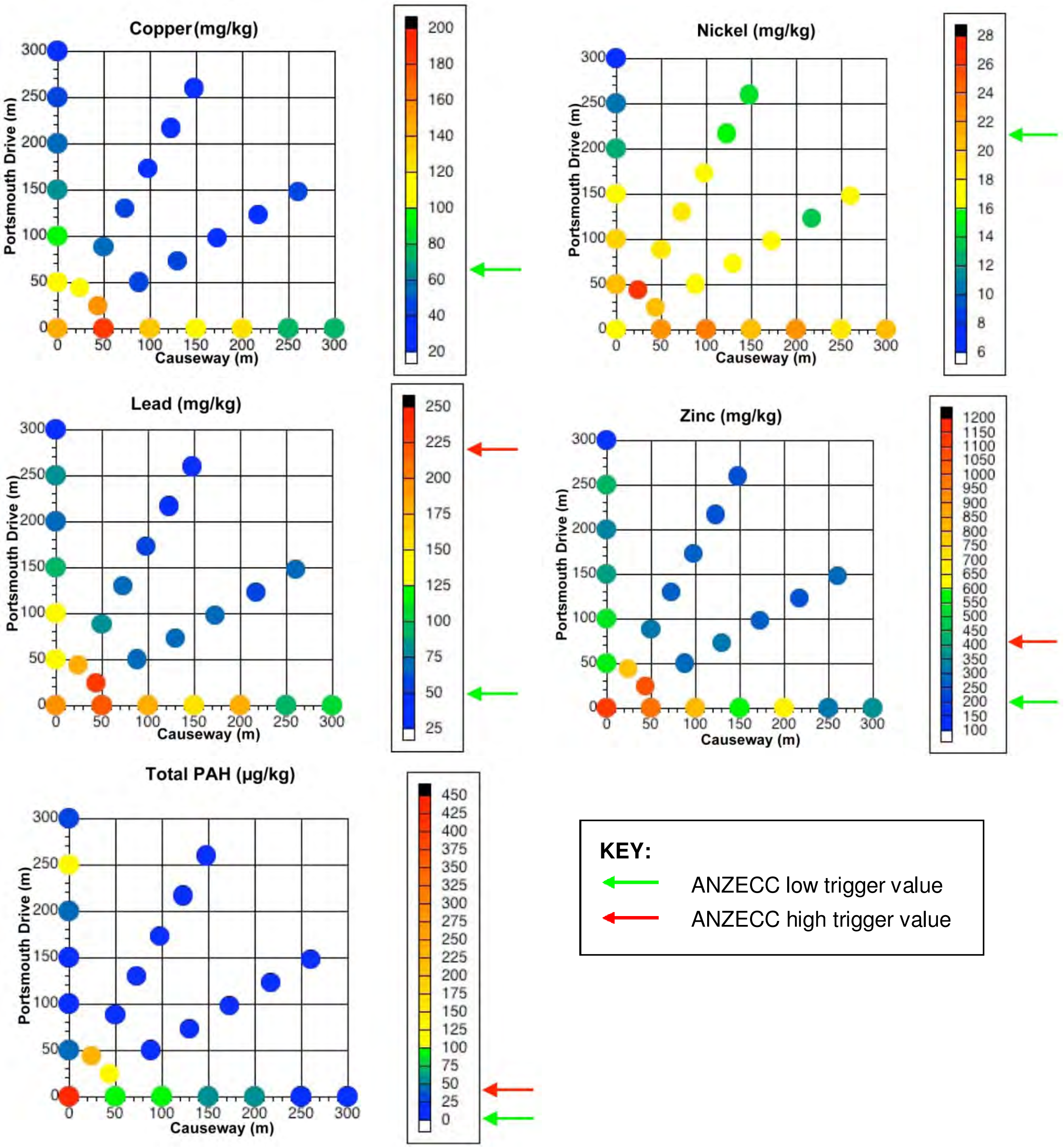


Figure 5-4: Sediment Contaminant Concentrations adjacent to the Portobello Road Outfall (from Ryder, 2005b)

5.2 Freshwater Receiving Environment

The South Dunedin catchment does not contain any open channels or watercourses; the stormwater network is fully piped, and discharges directly to the marine environment.

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

Contaminant	ANZECC Trigger Value[1]		Within 20m of Outfall				>20m	Comment
	Low	High	2007	2008	2009	2010	2010	
Arsenic (As)	20	70	29	23	24	15	15.6	All samples except 2010 exceed ANZECC low trigger value.
Cadmium (Cd)	1.5	10	1.8	1.8	2.0	1.5	0.8	All near-outfall samples exceed ANZECC low trigger value.
Chromium (Cr)	80	370	60.1	54	50	36	25	All samples at or below ANZECC low trigger value.
Copper (Cu)	65	270	169.3	160	190	123	72	All samples exceed ANZECC low trigger value.
Nickel (Ni)	21	52	20.43	18	26	19	14.3	One isolated exceedence of low trigger value, all other results below low trigger.
Lead (Pb)	50	220	306.33	330	290	193	99	All samples except 2010 exceed ANZECC high trigger value. 2010 results exceed ANZECC low trigger value.
Zinc (Zn)	200	410	1493	1400	1600	1040	520	All samples exceed ANZECC high trigger value.
PAHs	4	45	382.90	250.3	525.3	194.1	189.1	All samples exceed ANZECC high trigger value.
Enterococci*	-	-	727	170	< 2	< 3	24	Generally low numbers, within range of typical stormwater runoff.
Faecal Coliforms*	-	-	23	43	2	21	22	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:

Yellow	Exceeds Low ANZECC Trigger Value
Orange	Exceeds High ANZECC Trigger Value

6 Stormwater Quality

This section of the report provides a description of monitoring undertaken to date with respect to stormwater quality, and a characterisation of the stormwater quality being discharged from the South Dunedin catchment.

6.1 Stormwater Quality Monitoring

As part of the consent conditions the consent holder must undertake annual water quality sampling of the discharge. A number of samples have been taken in the catchment by Ryder (2007, 2008 and 2009, 2010), and others. These are discussed further below.

A water quality sampler was installed at the Portobello Pump Station in late 2008 for the purpose of collecting flow or time-proportional stormwater quality data over a storm event. A stormwater event on 19 March 2009 was sampled. The rainfall during this event was 6mm over 2.5 hours, with dry antecedent weather and a single storm peak. Figure 6-1 below displays the rainfall and suspended solids results from the event. It can be seen that the suspended solids concentrations are highest at the second sample taken, and show that after the initial small amount of rainfall, a 'first flush' effect is apparent. Following the first flush, suspended solids concentrations (and associated contaminant concentrations) decline. Median and average concentrations have been calculated for this event, and are as shown in Table 6-1 below.

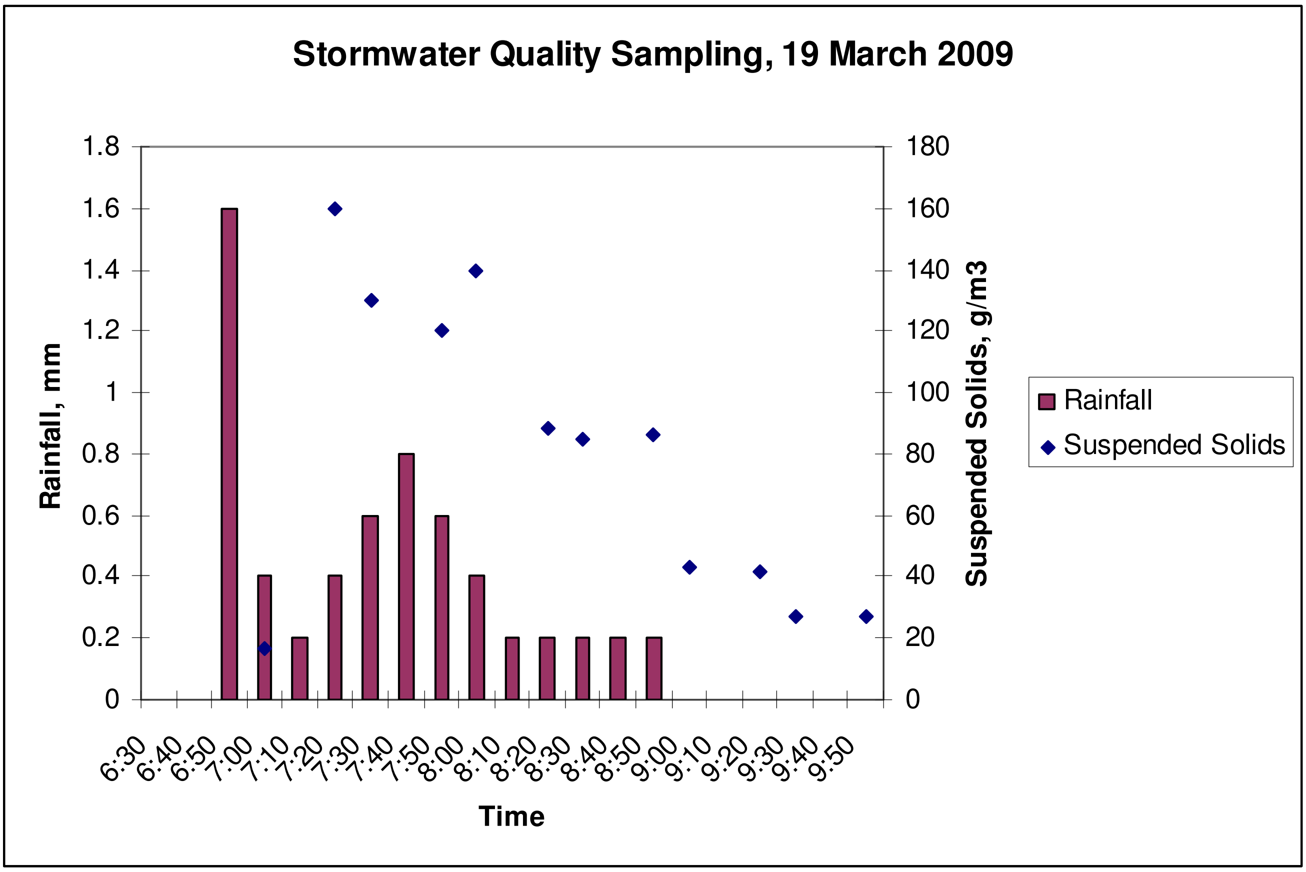


Figure 6-1: South Dunedin Stormwater Quality Sampling - Suspended Solids and Rainfall, March 2009

Table 6-1: South Dunedin Stormwater Quality Sampling, March 2009

Contaminant	Minimum	Maximum	Median	Average
Grease (g/m^3)	26	42	31	33.58
pH	7	7.67	7.1	7.19
Arsenic (As) (g/m^3)	0.0012	0.0052	0.0026	0.0029
Cadmium (Cd) (g/m^3)	0.000072	0.00041	0.00019	0.0002
Chromium (Cr) (g/m^3)	0.0011	0.0074	0.0041	0.0042
Copper (Cu) (g/m^3)	< 0.003	0.064	0.0395	0.036
Lead (Pb) (g/m^3)	0.0067	0.073	0.0305	0.037
Nickel (Ni) (g/m^3)	0.00083	0.0044	0.0024	0.0024
Zinc (Zn) (g/m^3)	0.23	0.84	0.365	0.45
Suspended Solids (g/m^3)	17	160	85.5	80
Polycyclic Aromatic Hydrocarbons (PAHs) (g/m^3)	0.00011	0.03458	0.00239	0.0077
Faecal Coliforms (cfu/100ml)	5400	20000	7650	8608
E.coli (MPN/100ml)	3900	14000	7100	7950

Prior to the DCC study described above, a number of water quality monitoring studies were undertaken in this catchment, (Brown and Peake, 2006, and Ryder, 2007, 2008, 2009 and 2010). Historical monitoring data were also provided by Ryder Consulting as the result of a literature review of all monitoring undertaken in the catchment prior to 2007.

Table 6-2 provides a summary of monitoring data collected to date. While the 2009 event captured represents a range over a full event, remaining data is from grab samples during a stormwater event. Where possible, the samples were gathered during the 'first flush' of stormwater events. What is apparent from the recent monitoring is that there is a large range of contaminant concentrations over an event.

Calculations of annual catchment yield of contaminants could be undertaken using an estimate of event mean concentration for each contaminant. This type of calculation has in the past supported consent applications. The recent flow based monitoring undertaken in the catchment, however, shows that due to the large variation of contaminant concentrations throughout an event, annual yield concentrations calculated using annual discharge volumes could be highly misleading.

Table 6-3 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 6-4 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.

TSS measurements taken in the catchment seem reasonably consistent for the grab samples taken by Ryder Consulting, and during historical monitoring. The value measured by Brown and Peake (2006) would appear to be an anomaly. However, the values measured in 2009 by DCC show that a wide range of sediment concentrations could appear throughout an event, and the timing of the sample is critical for TSS measurements (and presumably sediment associated contaminants).

Zinc (Zn) concentrations in the South Dunedin catchment fluctuate considerably, however appear to be at the high end when compared to 'mean' values for Australia, and the New Zealand data range. Major zinc sources include galvanised and zinc/aluminium roofs and car tyre wear. Some fluctuation exists in the measurements, however it is apparent that zinc concentrations in South Dunedin stormwater also appear to be high when compared with other sampling results in Dunedin.

Lead (Pb) concentrations appear to be reducing when the annual sampling results are reviewed, however the time-proportional monitoring samples contained a considerable range of lead concentrations. Values are not particularly high when compared to other data compared in Table 6-4.

There are large inconsistencies in the magnitude of measured PAH levels, and along with small amounts of data, this renders a median or mean value for South Dunedin to be of limited use. Road runoff is usually the principal source of PAHs in urban catchments, and the extent of the contamination depends on the road use intensity (i.e. the rate of vehicles per day (vpd)).

The large spike in PAH recorded by Stewart in 2008 was attributed to the defunct gas works in the catchment. Measurements taken in the catchment during the 1998 – 2000 period by Brown and Peake (2006) were also elevated, and the results were also attributed to the gasworks. Further investigation into the effects of the gasworks site on stormwater quality may be required to ensure that the high contaminant concentrations are anomalies, rather than typical.

PAHs with the greatest concentrations in South Dunedin stormwater during the 'spike' monitored in 2008 by Ryder Consulting were; Acepaphthylene, Anthracene, Biphenyl-d10, and Fluorene. Monitoring by Brown and Peake (2006) between 1998 and 2000 found that Fluoranthene and Pyrene dominated the PAH profiles in the stormwater, with lower levels of Phenanthrene/Anthracene than other stormwater sites sampled. Comparisons of stormwater with road debris in the South Dunedin catchment by Brown and Peake (2006) showed that road debris was the main contributor to PAHs in stormwater. However, different profiles in sumps sampled indicated that additional PAH sources in the catchment existed (potentially the disused gasworks site).

Stormwater samples were analysed for the presence of E.coli and faecal coliforms as part of the annual consent monitoring. The 2007 and 2008 results are in the same order of magnitude as the values reported during the monitoring event in March 2009 (Table 6-1). Typical stormwater is expected to have faecal coliform bacteria levels of between 1,000 and 21,000 cfu (Metcalf & Eddy, 1991), and the values reported during monitoring in this catchment lie within this range. Therefore, direct wastewater inflows are not apparent during the events that were monitored.

Table 6-2: Measured Stormwater Concentrations of Key Contaminants

Source / Reference		Concentrations (g/m^3)				
		TSS	Cu	Pb	Zn	PAHs
Portobello studies (Ryder Consulting, 2005, 2007, 2008, 2009 and 2010)	Historical	28	0.030	0.021	0.895	0.003
	2007	18	BDL	BDL	0.080	BDL
	2008	46	0.026	0.019	0.940	328
	2009	30	0.01	0.0067	0.64	0.00017
	2010	8.1	0.006	0.00055	0.153	0.00016
Portobello study (Brown & Peake, 2006)*	1998-2000	30	0.012	0.062	0.125	0.008
DCC South Dunedin monitoring (Range)	2009	17-160	0.003-0.036	0.007-0.073	0.23-0.84	0-0.03
All catchment studies (Ryder Consulting, 2009)	2009	7.4-100	0-0.059	0-0.033	0-0.64	LD
All catchment studies (Ryder Consulting, 2010)	2010	BDL - 240	BDL – 0.021	BDL – 0.0048	0.092-1.79	LD

BDL: Below detection limits; LD: Limited site data available; NR: Not reported / sampled
* Converted from dry weight measurement using estimate of TSS concentration

Table 6-3: 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 6-4: Comparison of South Dunedin 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]	South Dunedin 2010
	Residential / Industrial	Christchurch	Industrial	Residential	Australian sites	Highway	Urban	Residential / Industrial
TSS	8 - 330	33 - 200	124	5 - 49	164	142	-	8.1
Zinc	0.05 - 2.50	0.40	2.80	0.003 - 0.260	0.910	0.329	0.09 – 0.80	0.153
Copper	BDL - 0.23	0.05	0.08	0.002 - 0.031	0.08	0.054	0.015 – 0.110	0.006
Lead	BDL - 0.087	0.075	0.23	0.003 - 0.007	0.25	0.4	0.06 – 0.19	0.00055

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 South Dunedin catchment and stormwater network was developed to replicate the stormwater system performance, and to predict flood extents during a number of different scenarios. One modelling report was produced for DCC; the '*South Dunedin Model Report'* (URS, 2011c), 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; 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).

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.

Five short term flow monitors were installed in the catchment for calibration purposes. Confidence in the model output is considered to be moderate, due to difficulties calibrating the model (due to a suspected 'dynamic' blockage occurring at the pump station screens). 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 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.

Section 8 analyses the modelling results in order to identify key issues relating to system capacity and flooding. 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.

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: South Dunedin Catchment Model Results – Current Land Use

Hydraulic Performance Measure	ARI	Current Land Use
Percentage of manholes predicted to overflow	1 in 2[1] yr	18.3
	1 in 5 yr	30.1
	1 in 10 yr	43.5
Number of land parcels with flood depth potentially >= 300 mm	1 in 2[1] yr	0
	1 in 5 yr	1
	1 in 10 yr	8
	1 in 50 yr	31
	1 in 100 yr	40
Estimated flood extent (% of catchment area with flood depth >= 50 mm)[3]	1 in 2[1] yr	0.4
	1 in 5 yr	1.4
	1 in 10 yr	3.5
	1 in 50 yr	6.4
	1 in 100 yr	7.8
Modelled percentage (by number) of pipes surcharging	1 in 2[1] yr	91.0
	1 in 5 yr	96.0
	1 in 10 yr	98.1
Percentage of manholes predicted to be close to overflowing (free water level within 300 mm of cover)	1 in 2[1] yr	38.1
	1 in 5 yr	42.3
	1 in 10 yr	38.0

[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: South Dunedin 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	43.6	46.6	49.1	48.9	53.9
Number of land parcels with flood depth potentially >= 300 mm[1]	1 in 10 yr	8	15	15	15	25
	1 in 50 yr		38		40	
	1 in 100 yr					93
Estimated Flood Extent (% of catchment area with flood depth >= 50 mm)	1 in 10 yr	3.5	4.1	4.7	4.6	6.0
	1 in 50 yr		7.2		7.9	
	1 in 100 yr					11.9
Modelled percentage (by number) of pipes surcharging	1 in 10 yr	98.1	98.2	98.2	98.2	98.5
Percentage of manholes with free water level within 300 mm of cover	1 in 10 yr	38.0	36.3	35.1	35.1	31.9

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

Created with ESRI ArcGIS

DUNEDIN CITY COUNCIL

OPUS

URS

Dunedin 3 Waters Strategy

SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 7-1

South Dunedin Catchment Model Extent

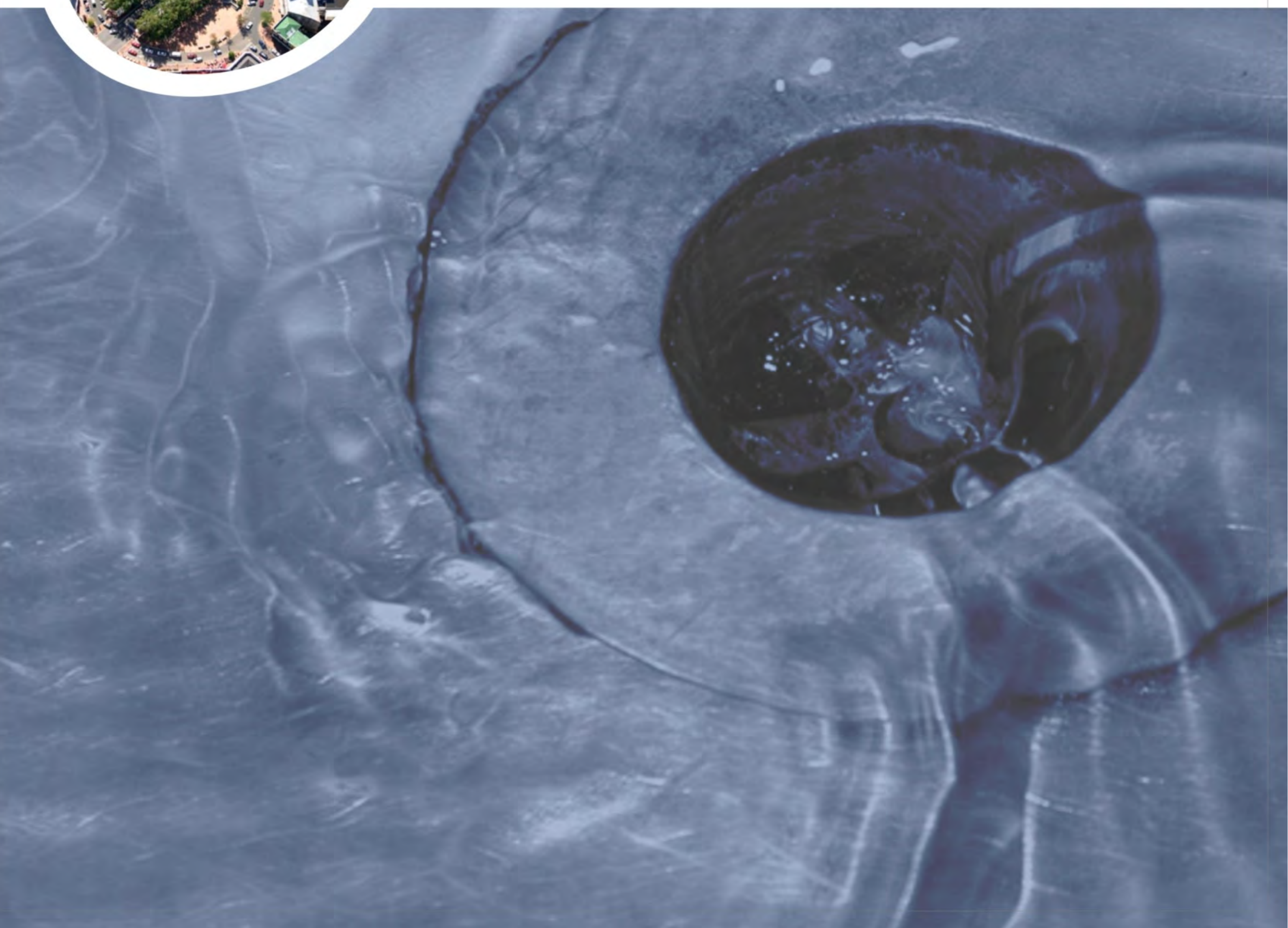
DISCIPLINE

Stormwater

Drawn: CO	Status: Final		
Checked: JH	Scale: 1:12,500	Plot Date: Sep 2011	
Approved: HS	Job. No: 42173227	Map No: Figure 7-1	Revision: -
Date: Sep 2011			

T:\Jobs\42173227\GIS\FIGURES\Kitchener St\K_Model_Extent.mxd   Original Size: A3

Part 3
Analysis



8 Assessment of Environmental Effects

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 car parks, 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 above, 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.

Each planning scenario modelled used a range of assumptions which are outlined in Section 7. A moderate level of calibration was achieved at the five flow monitors installed in the catchment, which provides a moderate to good level of confidence in the model's ability to broadly estimate the catchment response to extreme rainfall events.

The effects of stormwater quantity on the network within the South Dunedin 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 1 in 10 yr ARI rainfall event with current land use shows that approximately 56 % of the network in the South Dunedin catchment can accept a 1 in 10 yr ARI rainfall event without overflowing. However, results also show that almost the entire system (98 %) is fully surcharged during this event.

Approximately 18 % of catchment manholes are predicted to overflow during a 1 in 2 yr ARI rainfall event, and 91 % of the pipe network is surcharged during this event. Flooding effects are exacerbated with the introduction of any additional water through the application of climate change and future land use scenarios.

Predicted manhole overflows are identified in a number of different areas of the catchment, however are generally in smaller lateral pipes, away from the main pipelines running along Andersons Bay Road, Hillside Road, Macandrew Road and Bay View Road. An exception is the top end of Bayview Road, discussed further below.

Manhole overflows are likely to either be the result of pipes originally installed with a low level of service, downstream effects of surcharging pipes, or development in the catchment since the installation of the pipes (some of which are approaching 100 years old). Blockages or pipe defects are 'built in' to the current model, and the location and subsequent removal of these issues may produce some 'quick wins' with respect to localised system capacity. It is not anticipated, however, that this would increase the level of service significantly across the catchment.

A hydraulic bottleneck exists just upstream of the Portobello Pump Station, where three culverts with a total area of 7.4 m^2 discharge into two culverts with a cross sectional area total of 5.4 m^2 (refer Figure 8-1 below). This bottleneck may be influencing the flooding in Bay View Road, Hargest Crescent and the Ascot Street / Royal Crescent areas also described below. Figure 8-2 shows a hydrograph of the links on the main Portobello Road line, with those from the Royal Crescent and Bay View Road systems also shown. The backwater effect in the Royal Crescent and Bay View Road stormwater lines is clear from the graph.

Figure 8-1: Portobello Road Hydraulic Bottleneck

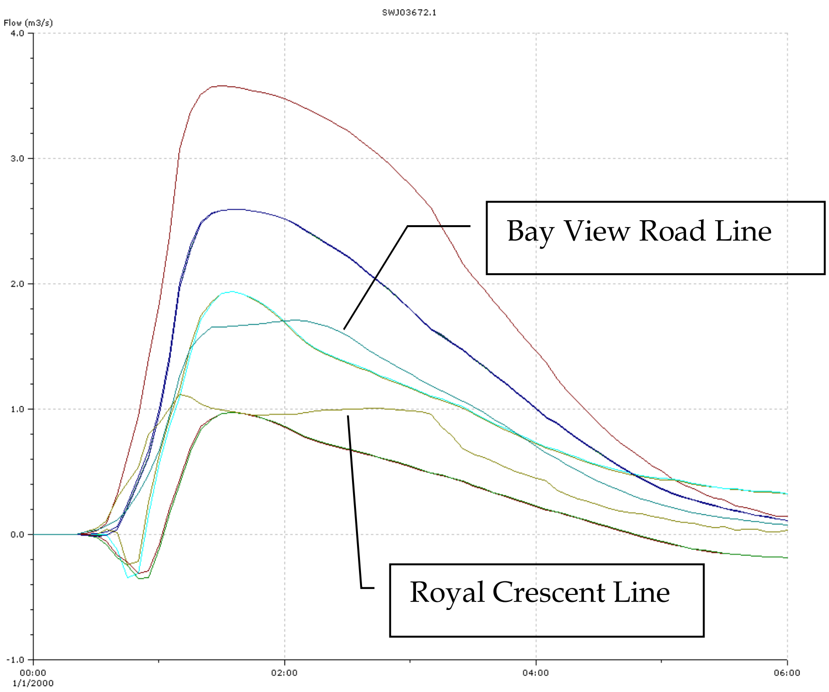


Figure 8-2: Discharge Hydrographs at Portobello Road

The modelled pump station operation for Portobello is based on the operation and design parameters recommended for the pump station, as recorded on the "as-built" drawings. Using these details, the pump station appears to operate as required, and have sufficient capacity for catchment stormwater, even for the higher return period events with extreme climate change. However, information from DCC indicates that the pump station is not being operated in a manner consistent with the design – it is not known whether this is resulting in improved, or reduced pumping capacity. Therefore, actual flooding in the catchment may be slightly different than the flooding predicted by the model. Nevertheless, regardless of pump station optimisation, a proportion of the system still has a low level of service; model results show that approximately 30 % of the catchment manholes overflow during a current 1 in 5 yr ARI rainfall event.

There is little flooding immediately upstream of the Tainui Pump Station, indicating that this pump station is able to accept design flows.

Due to the catchment currently being almost fully developed, future requirements for stormwater capacity in the South Dunedin area due to increased imperviousness are not expected to change significantly, as can be seen in the minimal difference between the current and future predicted flooding for a particular rainfall event. Requirements for system capacity will, however, increase should DCC want to accommodate increased rainfall due to climate change within the system.

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 rainfall 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, customer complaints, and observations made on the catchment walkovers.

The accuracy of the flood hazard maps cannot be fully relied on to depict secondary flow paths and flooding extent due to possible inaccuracies within the data. The flooding indicated should therefore be considered as indicative with respect to the exact extent of the flooding, with a higher level of confidence in the location of surcharging manholes and volume of stormwater leaving the pipe network.

Flooding in the South Dunedin catchment is predicted by the model to be widespread but generally shallow; a few areas are identified as being at risk of deep (habitable floor) flooding. Predicted flood hazard is generally 'low' with small areas predicted to have 'moderate' to 'significant' hazard in the extreme rainfall and climate change scenario.

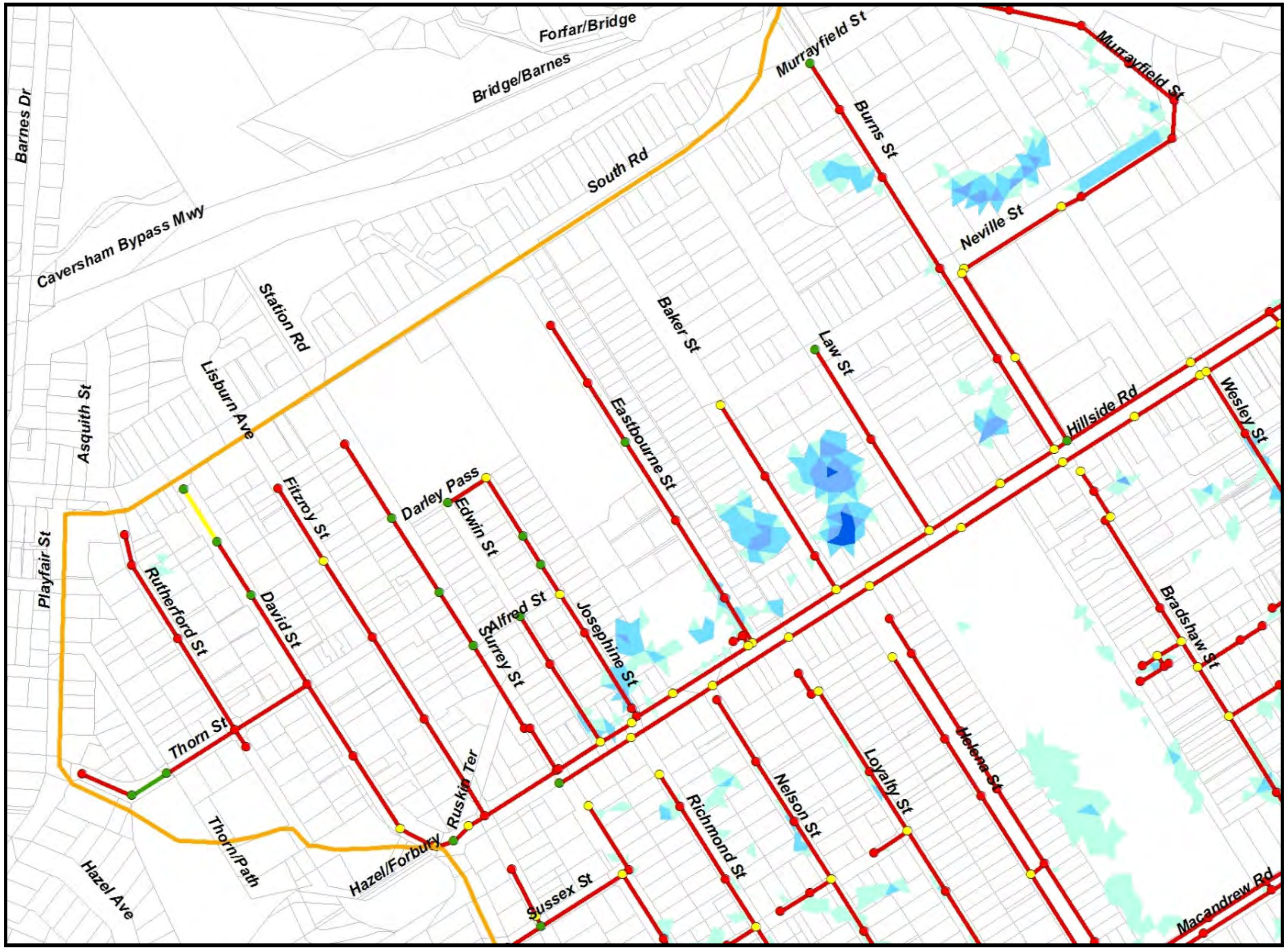
Predicted nuisance flooding, habitable floor flooding and flood hazard ratings within the catchment have been assessed, and are discussed in the following sections.

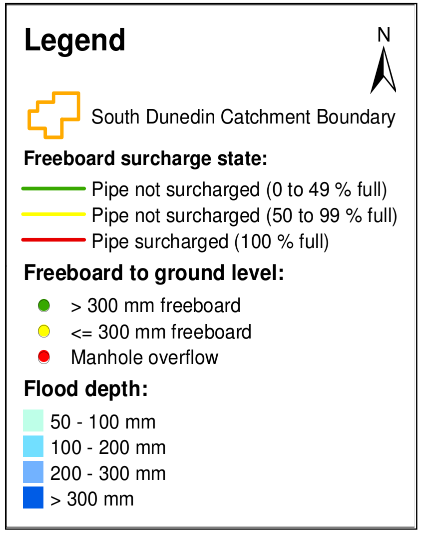
8.1.4.1 Nuisance Flooding

Using the modelling results, critical areas in the network resulting in flooding in events as small as the 1 in 2 yr ARI rainfall event, can be considered the most critical network issues. The location of these critical areas is tabulated in Table 8-1 below. Figure 8-3 – Figure 8-6 show the extent and depth of predicted flooding in these areas during a 1 in 10 yr ARI rainfall event. Flood complaints support the modelled flooding in all of these areas, with the exception of the predicted flooding in Carisbrook, which is unconfirmed.

Table 8-1: Predicted and Confirmed Nuisance Flooding (50 mm – 300 mm deep) – up to a 1 in 10 yr ARI Rainfall Event

Location	Description	Predicted Cause	Minimum Rainfall Event (ARI yr)
Hillside Road North	Low to significant flooding on Josephine Street, Eastbourne Street, Baker Street, Law Street, Neville Street and Burns Street. Complaints in the Burns Street area.	Northern-most stormwater main on Hillside Road predicted to surcharge and cause flooding via laterals.	1 in 2
Hillside Road South	Low to moderate along streets such as Glasgow Street, Reid Street and King Edward Street. Confirmed via customer complaints.	Southern-most stormwater main on Hillside Road predicted to surcharge and cause flooding via laterals.	1 in 5
Ascot Street / Royal Crescent	Moderate to significant flooding in Ascot Street, Ravelston Street, Royal Crescent and Normanby Street.	Hydraulic bottleneck at Ascot Street / Rugby Street Intersection, in addition to bottleneck and surcharging of main stormwater line along Portobello Road.	1 in 2
Tainui	Low to moderate flooding on Magdala Street and Botha Street.	Surcharge of local reticulation in area upstream of the Tainui Pump Station.	1 in 2
Bay View Road	Low to moderate flooding on western end of Bay View Road, overland flow from Bay View Road to the south.	Local bottleneck, also surcharge of local reticulation. General system restrictions may be influencing the flooding also.	1 in 2
Hargest Crescent	Nuisance flooding from manholes on stormwater laterals south of Hargest Crescent	Surcharged pipe along Hargest Crescent, through to its connection with the network along Portobello Road.	1 in 2





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.

Figure 8-3: Predicted Flooding due to Hillside North Trunk Main Surcharging during a 1 in 10 yr ARI Rainfall Event (Current Land Use)

Legend

N

South Dunedin Catchment Boundary

Freeboard surcharge state:

- Pipe not surcharged (0 to 49 % full)
- Pipe not surcharged (50 to 99 % full)
- Pipe surcharged (100 % full)

Freeboard to ground level:

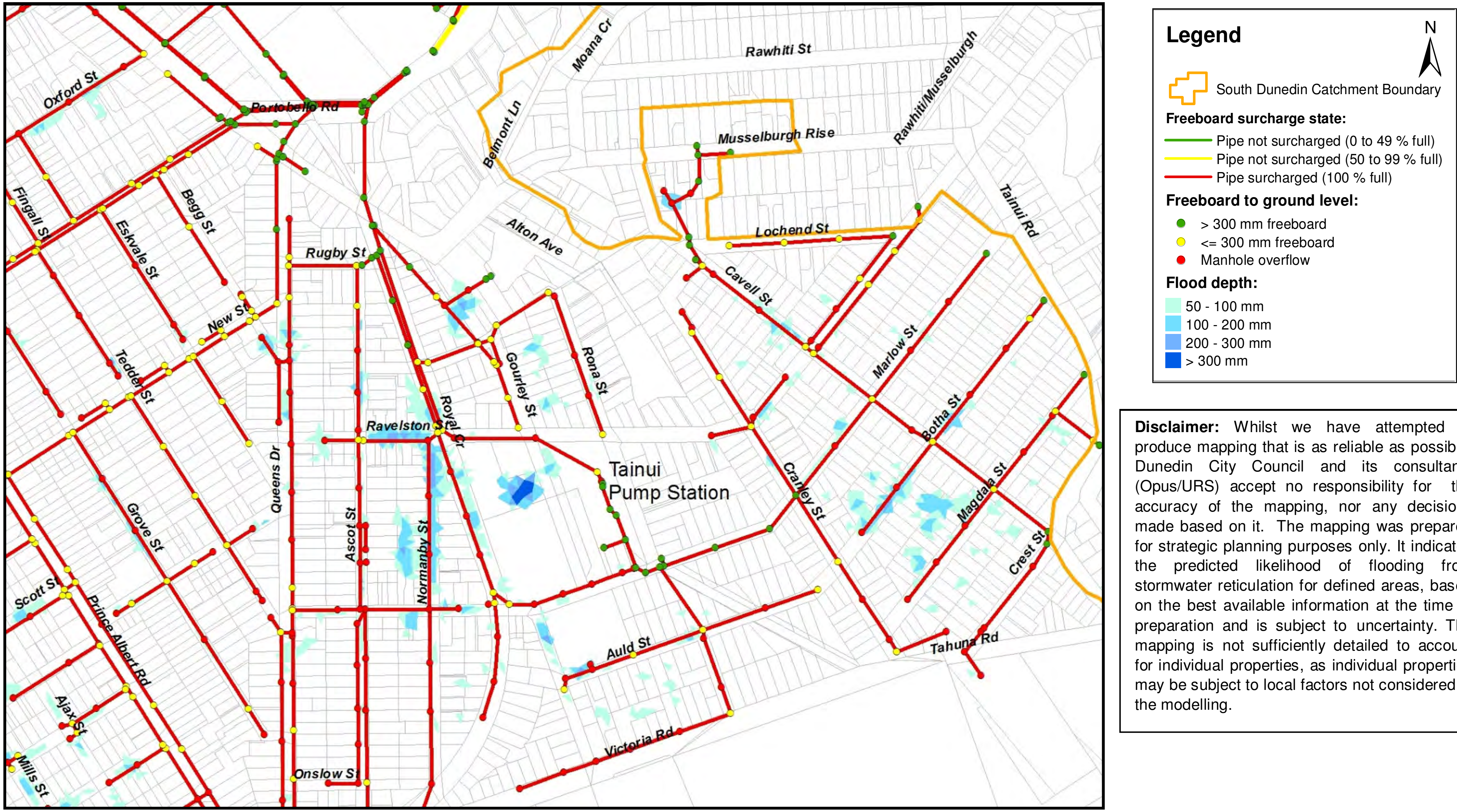
- > 300 mm freeboard
- <= 300 mm freeboard
- Manhole overflow

Flood depth:

- 50 - 100 mm
- 100 - 200 mm
- 200 - 300 mm
- > 300 mm

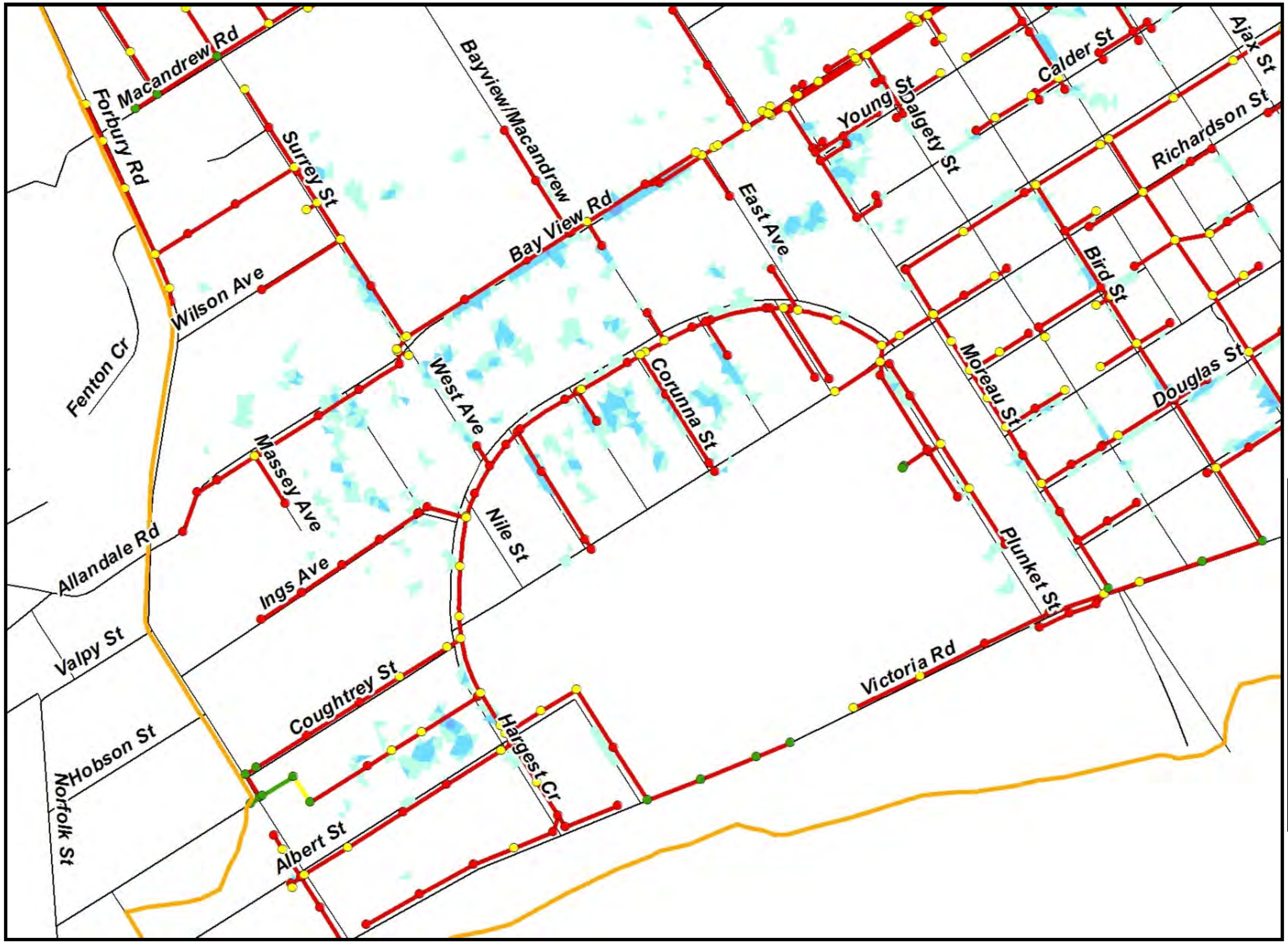
Disclaimer: Whilst we have attempted to produce mapping that is as reliable as possible, Dunedin City Council and its consultants (Opus/URS) accept no responsibility for the accuracy of the mapping, nor any decisions made based on it. The mapping was prepared for strategic planning purposes only. It 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.

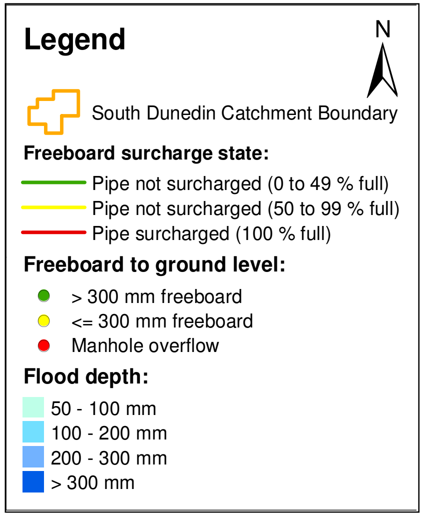
Figure 8-4: Predicted Flooding due to Hillside South Trunk Main Surcharging during a 1 in 10 yr ARI Rainfall Event (Current Land Use)



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.

Figure 8-5: Predicted Flooding - Ascot Street Area and Tainui, during a 1 in 10 yr ARI Rainfall Event (Current Land Use)





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.

Figure 8-6: Predicted Flooding due to Bay View Road, Hargest Crescent, and Portobello Road Main Surcharging, during a 1 in 10 yr ARI Rainfall Event (Current Land Use)

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.

During the 1 in 50 yr ARI rainfall events modelled, 31 properties are predicted to experience flooding on part of their parcel to depths greater than 300 mm for the current land use. Mean climate change and the maximum land use increased the number of properties affected to 40. It should be noted, however, that it is uncertain whether this flooding is likely to enter habitable floors, as no floor level survey has been undertaken, and a number of parcels are only predicted to experience flooding on part of the parcel.

Flood depths exceeding 300 mm are predicted on 8 parcels during a 1 in 10 yr ARI rainfall event, and on 1 property during a 1 in 5 yr ARI rainfall event. No properties are predicted to be at risk during a 1 in 2 yr ARI rainfall event.

The areas predicted to experience deep flooding are as follows:

Baker Street, Law Street, and Burns Street – properties in the block between Law Street and Baker Street, and on Burns Street near Hillside Road are predicted to be subject to deep flooding; flooding in the area is predicted during small events, and deep flooding (> 300 mm deep) is predicted on one property during a 1 in 5 yr ARI rainfall event, with up to 19 properties in this area potentially affected during a 1 in 50 yr ARI rainfall event (refer Figure 8-7). As identified in Table 8-1 above, surcharging of the stormwater main on Hillside Road North is resulting in manholes on lateral lines overflowing.

Neville Street – the current Carisbrook stadium is serviced by an undersized pipe system. Under the current land use scenario, deep flooding is predicted in this area. Due to the unconfirmed nature of future land use in this area, there is a relatively high level of uncertainty relating to flood risk predictions in this location. Refer Figure 8-7.

Cavell Street – Deep flooding is predicted to potentially affect a small number of properties at the north end of Cavell Street. This area is a topographical depression, and due to the surcharge state of the South Dunedin network, overflows occur from manholes in this area (refer Figure 8-8). This area of the catchment is also predicted to be affected by overland flow from system deficiencies in the Shore Street catchment, resulting in flooding which is potentially worse than that depicted when assessing the catchments individually. Flood complaints have been received from both Cavell Street and Musselburgh Rise.

Legend

N

South Dunedin Catchment Boundary

Freeboard surcharge state:

- Pipe not surcharged (0 to 49 % full)
- Pipe not surcharged (50 to 99 % full)
- Pipe surcharged (100 % full)

Freeboard to ground level:

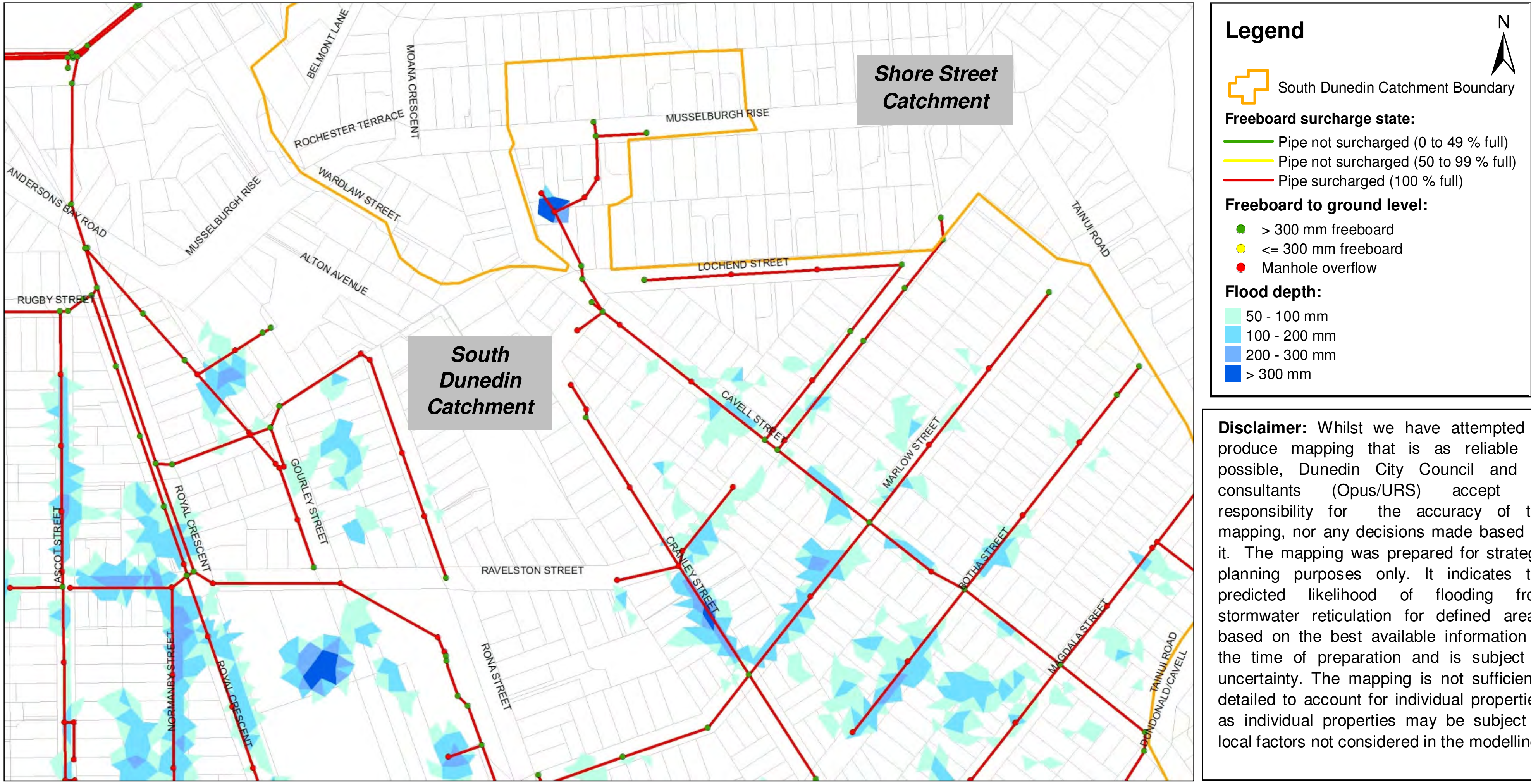
- > 300 mm freeboard
- <= 300 mm freeboard
- Manhole overflow

Flood depth:

- 50 - 100 mm
- 100 - 200 mm
- 200 - 300 mm
- > 300 mm

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.

Figure 8-7: Predicted Flooding, Neville Street, Burns Street, Law Street and Baker Street, during a Current 1 in 50 yr ARI Rainfall Event



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.

Figure 8-8: Predicted Flooding, Cavell Street, during a Current 1 in 50 yr ARI Rainfall Event

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 rainfall 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 8-2 below.

Table 8-2: Flood Hazard Rating

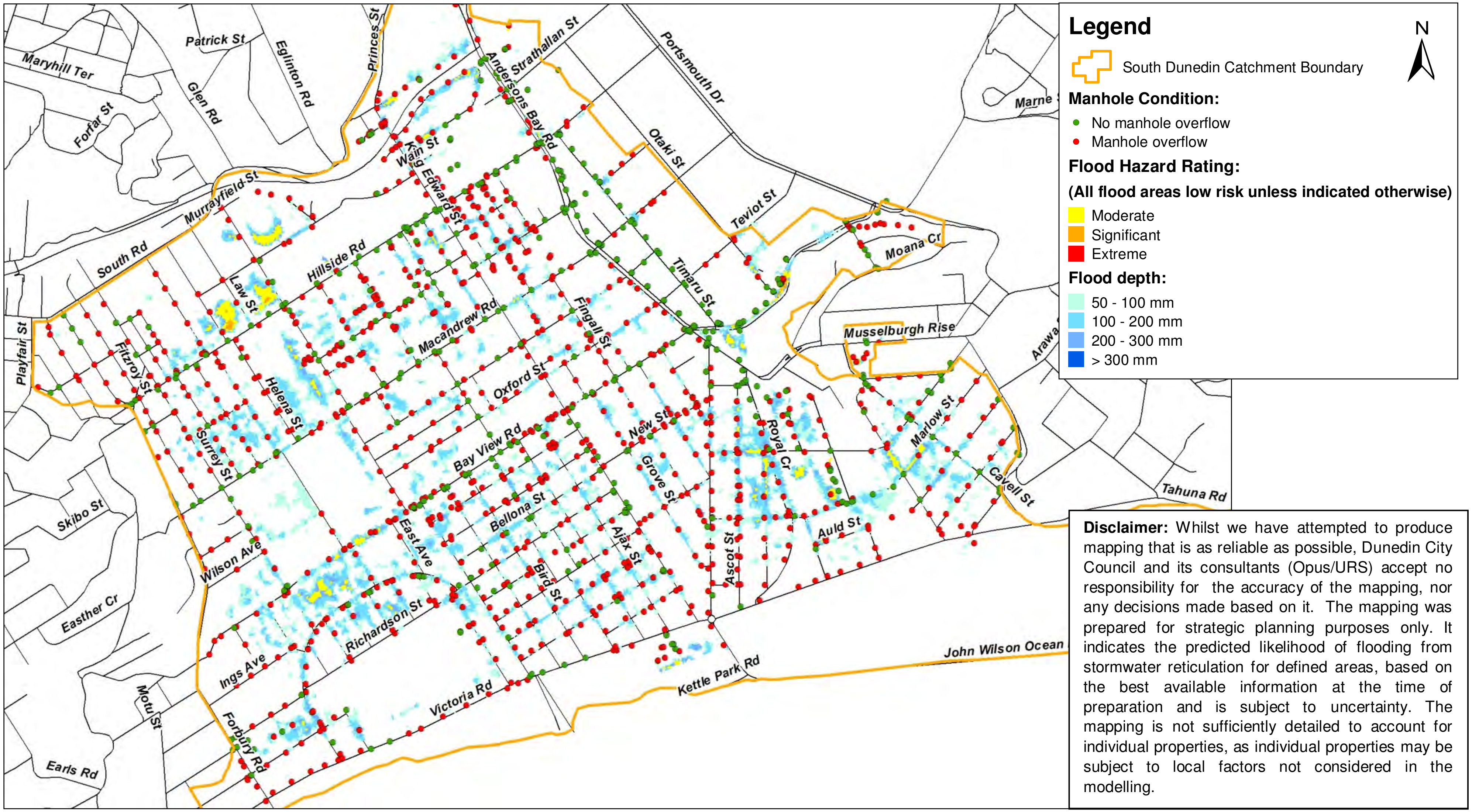
Flood Hazard Rating	Degree of Flood Hazard	Flood Hazard Description
< 0.75	Low	Caution – flood zone with shallow flowing water or deep standing water.
0.75 – 1.25	Moderate	Dangerous for some – (i.e. children). Flood zone with > 250 mm deep, or fast flowing water.
1.25 – 2.0	Significant	Dangerous for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

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 current and future 1 in 10 yr ARI rainfall event analysis of the current stormwater infrastructure indicates extensive under-capacity of the network and resultant extensive flooding predictions across South Dunedin. However, the flooding predicted is rarely above 100 mm deep, implying that most of the flooding would be "nuisance" flooding contained within the road prism. During the future extreme planning scenario with a 1 in 100 yr ARI rainfall event, only two areas are predicted to have a 'significant' flood hazard rating; the Burns Street, Law Street and Baker Street area, and the area downstream of the Portobello Road Pump Station, where gravity pipes from an adjacent industrial area connect with pressure pipelines from the pump station. A 'moderate' flood hazard rating has been calculated for other locations in the catchment subject to deep flooding. Figure 8-9 illustrates the modelled flood hazard within the catchment.

Discussed below are flood locations where moderate flooding is extensive or on sensitive sites, or areas where flooding is predicted to exceed 400 mm depth.

- Roads adjacent to, and the playing fields of Kings and Queens High School, and MacAndrew Intermediate school grounds.
- Portobello Road, in the vicinity of the pump station, and in the industrial area through to Teviot Street. Flooding in this area could restrict traffic movement to and from the Otago peninsula during a large flood event.
- Carisbrook Stadium may experience flooding in excess of 400 mm on the playing field. As this facility may be redeveloped with a most probable higher level of impermeability, a thorough investigation of the required stormwater services is imperative. Internal site drainage has not been included in the current hydraulic model, however, so flood estimates for this location are uncertain.
- West Avenue / Kings Avenue –properties in this low-lying area are predicted to experience flooding of up to 300 mm depth.
- Cavell and Cranley Streets – surcharging manholes between Ravelston and Cavell Streets may cause inundation of Marlow, Botha, Ravelston and Cranley Streets. Cranley Street is particularly affected with flooding deeper than 400 mm predicted by the model. The model indicates that adjacent properties may also be affected. Deep flooding in the northern section of Cavell Street is also exacerbated under this scenario.
- St Kilda Bowling Club - the bowling green is predicted to experience flood depths exceeding 400 mm during the future extreme event.



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.

Figure 8-9: 2060 Predicted Flood Hazard, 1 in 100 yr ARI Rainfall and 1 in 20 yr ARI Tide Level - Extreme Climate Change Event

8.1.5 Network Age, Operation and Maintenance

8.1.5.1 South Dunedin Catchment

Pump Station Intake Screens

Network flow monitoring shows the effects of pump station intake screen blocking, with a reduction in hydraulic efficiency of the network as a storm event progresses. DCC have recently improved the access to these screens for cleaning, and as a result, these screens are now safer to clean more frequently during storm events.

Pipe Network Age

Network age could be contributing to adverse effects on a number of levels; via under-sized reticulation causing flooding; poor condition increasing pipe roughness hence reducing conveyance capability; or breaks and cracks allowing contaminant or salt water ingress. However, there is insufficient information available on pipe network condition in this catchment to accurately quantify these effects.

An analysis of the South Dunedin pipe network indicates that a number of pipes are over 100 years old (the theoretical life of stormwater pipes). Of note are the pipe networks on Hargest Crescent, Queens Drive, Royal Crescent and the Bay View Road / Portobello Road intersection; all areas where flooding issues or hydraulic bottlenecks have been identified. .

Cross Connections

One wastewater / stormwater cross connection has been identified in the catchment, on the corner of Surrey Street and Hillside Road. This cross connection operates in a single direction, from wastewater to stormwater. During periods of high wastewater flows (wet weather driven), wastewater may enter the stormwater system, diverting wastewater contaminants to the harbour. A monitor has recently been installed in this overflow, to gauge volume and frequency of overflows.

Additionally, a study has been undertaken to better understand this cross connection, and reduce wastewater flooding in the Surrey Street area. The wastewater system is receiving a large amount of I&I from upstream catchments, resulting in significant pressure on the network. The investigation has resulted in the diversion of additional wastewater to the Green Island WWTP to temporarily relieve the pressure on the network, however a long term solution is still being developed. This will be investigated in conjunction with other strategic wastewater network options.

Water quality monitoring of South Dunedin catchment stormwater to date has not identified significant levels of contaminants that could be associated with wastewater contamination. However, the sampled events may have been too small to trigger surcharging of the wastewater system. Biological and sediment monitoring in the receiving environment has measured faecal contamination of cockles at the Portobello Road outfall. Results show that there is no indication that wastewater contamination is affecting the health of the ecosystem in this location. However, key stakeholder groups consider discharge of untreated wastewater to the environment unacceptable.

8.1.5.2 City-wide

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.

8.1.6 Culture and Amenity

Flooding in South Dunedin is predicted to be widespread but shallow; for the most part resulting in nuisance flooding. As identified above, a number of schools may have school grounds flooded, however survey is required in order to confirm whether floodwaters would enter buildings. In terms of the criticality assessment, Queens Drive contains a small number of sites with economic criticality, and Andersons Bay Road (crossed by the Bay View Road pipeline) is a highly trafficked road, hence of critical importance value. Flooding on Portobello Road next to the pump station may affect access to the Peninsula; however a number of alternative routes around the potentially flooded area exist.

8.1.7 Summary of Effects of Stormwater Quantity

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

- Confidence in the South Dunedin stormwater model is moderate due to difficulties calibrating the model near the pump station (pump station screen blockages).
- Flooding issues are well documented in the South Dunedin catchment.
- The current level of service for the network in this catchment varies across the catchment, but is approximately equivalent to a 1 in 2 yr ARI rainfall event.
- Most of the network is full during all rain events modelled, however manhole overflows result in primarily 'nuisance' flooding.
- Flood depths exceeding 300 mm are predicted on 1 property during a 1 in 5 yr ARI rainfall event, and 31 properties during the 1 in 50 yr ARI rainfall event.
- Deep flooding is predicted in two main areas; Law Street, and Cavell Street. Deep flooding predicted in the Carisbrook Stadium site is unconfirmed.
- Flood hazard is predicted in areas subject to deep flooding, however is not widespread throughout the catchment.
- A number of hydraulic bottlenecks in the catchment are restricting flow when capacity is available downstream. These have been identified in the following locations:
    - Hillside Road (north and south);
    - Portobello Road (just upstream of the pump station);
    - Ascot Street / Royal Crescent;
    - Tainui (Cranley, Marlow and Botha Streets); and
    - Bay View Road.
- Approximately 12 % of the stormwater network is considered to be beyond its theoretical life (100 years), and will be subject to assessment and possibly renewal in the short term.
- Information collated has indicated that the Portobello Road Pump Station is not being operated in accordance with original design. Sub-optimal operation of the station may be causing backflow issues through the network.
- A stormwater / wastewater cross connection has been identified in the Surrey Street area, and options have been investigated and short term management changes made to mitigate problems arising from this connection.
- South Dunedin receives overland flow from adjacent catchments (St Clair, Shore Street and Kitchener Street); in particular flows from the Shore Street catchment may be exacerbating flooding already predicted from the South Dunedin network in the Cavell Street area.
- A stormwater cross connection with the St Clair catchment may be contributing additional flow to the already surcharged South Dunedin network.

8.2 Stormwater Quality

Monitoring of stormwater quality, sediment quality and harbour ecosystems has been undertaken on an ad-hoc basis historically, with more regular sampling undertaken in recent years as part of current stormwater discharge consent conditions. Stormwater quality is discussed in detail in Section 6, and harbour sediment quality as part of Section 5. The results show a large range of contaminant concentrations have been measured, from which a 'best estimate' or 'event mean concentration' value would be misleading.

While the stormwater quality data collected in the South Dunedin catchment is more comprehensive than in other Dunedin city stormwater catchments, results from the monitoring must be viewed in the context of a small dataset and the limitations of the sampling method used for the more recent stormwater quality measurements (discussed below).

- TSS measurements taken in the catchment seem reasonably consistent with values used for typical urban stormwater catchments.
- Zinc concentrations in the South Dunedin catchment fluctuate considerably, however appear to be at the high end when compared to 'mean' values for Australia, and the New Zealand data range. Concentrations in the South Dunedin stormwater also appear to be high when compared with other sampling results in Dunedin.
- Lead concentrations remain within the typical range for urban stormwater, and appear to be at the lower end of that range.
- E.coli and faecal coliform values reported during monitoring in this catchment lie within the typical range expected of urban stormwater.
- PAH levels in stormwater from South Dunedin appear to fluctuate considerably. The conclusion reached by both Ryder Consulting and Brown and Peake (2006) is that point sources of PAH contaminants exist in the catchment.

Brown and Peak (2006), in a specific study including a South Dunedin catchment, identify the following:

- Road debris is a significant contributor to contaminants from the catchment;
- High levels of zinc in the stormwater could be attributed to a high proportion of zinc-galvanised roofing in the catchment (along with density of housing);
- High copper and lead levels may be the result of high traffic densities and the presence of light industrial land use.

Further sources of 'spike' PAH release, apart from contaminated sites (contaminants entering the stormwater system either directly or via damaged pipes) could be road works (coal tar used in road construction). Domestic fires can release PAHs into the air, which can be subsequently captured into stormwater. However, Ryder (2009) indicates that the dominant PAH types found in South Dunedin stormwater in 2008 (Anthracene and Biphenyl-d10) are components of coal tar, whereas domestic fires are more likely to release Benzo[a]pyrene, a constituent not present during winter monitoring events (2008 and 2009).

The most highly trafficked roads in the catchment are reported by DCC's roading department to be Andersons Bay Road, Hillside Road (high traffic flow), King Edward Street and MacAndrew Road (medium traffic flow).

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 rainfall event, the concentration of contaminants within the stormwater varies depending on the time since the start of the event. This is indicated in Figure 8-10 below.

The time, during the rainfall 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 rainfall 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.

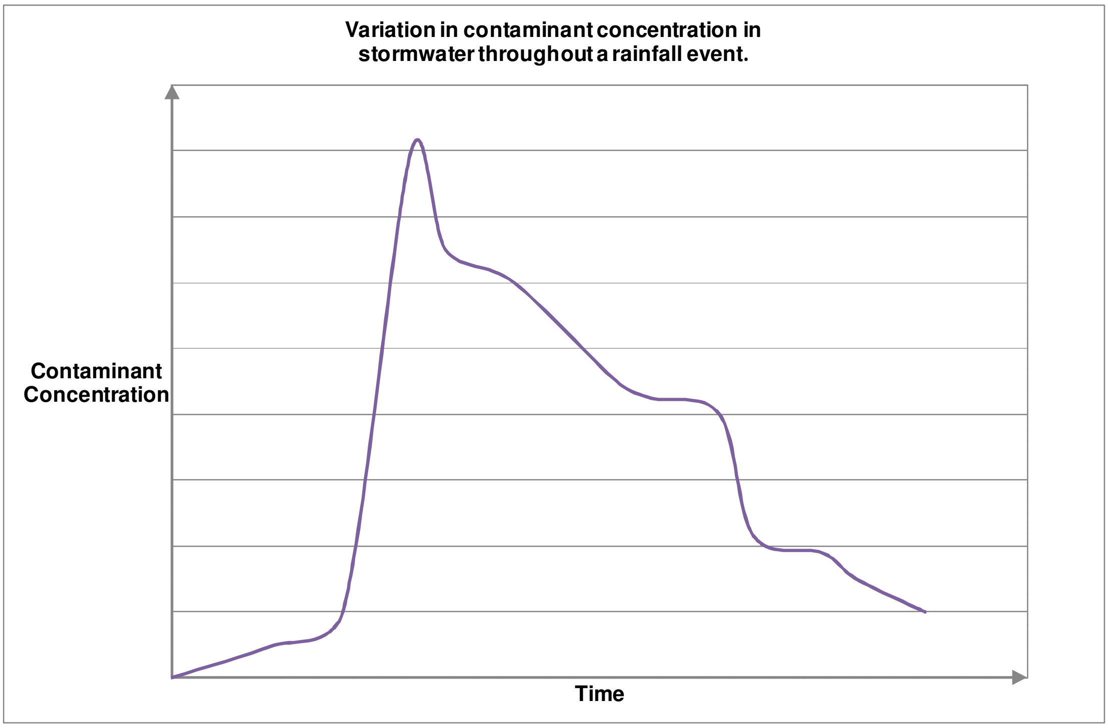


Figure 8-10: Concentration of Contaminants in Stormwater for Duration of a Rainfall Event
(Based on time-proportional sampling carried out in Dunedin)

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 outfalls and the quality of the water in the harbour.

While no national or international guidelines are available for stormwater discharge quality, ANZECC (2000) 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 monitoring would need to be undertaken alongside stormwater quality monitoring, and links established between stormwater discharge points and water quality in 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 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. This is 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 for adverse effects, any exceedence of the guidelines therefore, indicates only a potential for adverse effects.

ANZECC sediment quality guidelines (ANZECC, 2000) 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 South Dunedin Catchment

Contaminants sampled from sediments around the Portobello Road outfall show high levels of heavy metals and PAHs. Most of the heavy metals exceeded the ANZECC interim sediment quality guideline low trigger values, with the exception of chromium. Zinc, lead and PAHs exceed the high trigger value set by the ANZECC guidelines. Studies of the contaminant levels in sediments as a function of distance from the outfall show that contaminant levels reduce with increasing distance from the outfall, with the exception being high levels adjacent to busy kerbless roads running along the harbour's edge. Due to the location of the outfall in the corner of the upper harbour, sediments from adjacent outfalls are unlikely to be deposited in this location.

Sediment monitoring results indicate that severe historical contamination of sediments adjacent to the South Dunedin outfall has occurred (i.e. during the industrial development era). Some contaminant levels in more recently deposited sediments are potentially showing signs of slight decline. However, it is difficult to identify trends over the short period of time; within the 20 mm samples collected and analysed for monitoring purposes, there may be 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.

When compared with the other sediment sampling sites (Ryder, 2010b), the samples taken adjacent to the Portobello Road outfall usually contain the highest levels of contaminants, with the exception of Chromium and Zinc.

8.2.2.2 Harbour-Wide

Harbour-wide, trends in the levels of contaminants in the sediment throughout 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.

Contaminant results in harbour sediments could also be the result of contaminated groundwater. Contaminated sites in the catchment (such as the old gasworks) may be (currently or historically) releasing contaminants into the groundwater, and subsequently into the harbour. Groundwater monitoring results from bores in the catchment (including one in the gasworks site) show that PAH levels (at the gasworks site) are higher than those found in the stormwater samples (excluding the extremely high readings in stormwater on a small number of occasions), while heavy metal concentrations (lead, copper and zinc) are considerably lower. It is therefore considered unlikely that this site is contributing significantly to sediment contamination in the harbour via groundwater.

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

Historical data and the results of biological monitoring carried out harbour wide for DCC stormwater 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 general lack of diversity may be attributable to anthropogenic influences, including stormwater quality, but other factors such as freshwater inputs and exposure at low tide may also be contributing to the ecological health observed. It is not therefore possible to clearly link ecological health with stormwater quality.

Ecological monitoring shows some evidence of contaminant presence in flora and fauna near the South Dunedin catchment outfall. However, low diversity of benthic and infaunal communities cannot be attributed directly to stormwater discharges from South Dunedin. Heavy metals in cockles, mussels, fish and octopus are at higher levels near the South Dunedin outfall than other outfalls monitored, however, the levels are still within acceptable food standards. PAH levels are high compared with guidelines for human consumption (Canadian guidelines).

The biological monitoring results to date, harbour-wide, show 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).

8.2.4 Summary of Effects of Stormwater Quality

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

- Based on the information collated to date, it would appear that the contaminants of concern in the South Dunedin catchment stormwater are heavy metals and PAHs.
- In terms of heavy metals, Zinc and Copper values measured show an increased concentration in stormwater from South Dunedin than what might be expected in urban contaminants. PAH results in the stormwater monitoring for the catchment have been inconsistent.
- Sediment monitoring results classify heavy metal and PAH levels as 'high' around the South Dunedin outfall, and adjacent to harbour-side roads.
- Ecological information is not yet conclusive with respect to heavy metals and PAH levels, but so far indicates that PAH levels are of concern, but that heavy metals are not having a significant effect on the ecology of the area.
- Suspended solids concentrations in the stormwater appear to be consistent with typical urban runoff.
- Faecal contamination can be caused either from diffuse sources (bird litter etc.), or directly from wastewater overflows. Levels in South Dunedin stormwater are consistent with typical stormwater concentrations, and apart from the known cross-connection on Surrey Street (which is now being monitored), there is no evidence of other direct inflows of wastewater during storm events.
- A point source PAH discharge is suspected in the South Dunedin catchment, likely to be from a contaminated site.
- Due to uncertainties in harbour sediment deposition rates, it is difficult to distinguish between historic and recent sediment contaminant concentrations; studies have indicated that historical sediment contamination has occurred, however the rate at which 'cleaner' sediments are being deposited is uncertain.

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 South Dunedin catchment, and prioritised for action. These are discussed below, and indicated in Figure 9-1.

9.1 Stormwater Quantity Issues

9.1.1 Low Level of Service

The stormwater network in the South Dunedin catchment is estimated to have a capacity capable of conveying a rain event with an average return interval of approximately 1 and 2 years.

9.1.2 Hydraulic Bottlenecks

A number of hydraulic bottlenecks in the catchment are restricting flow when capacity is available downstream. These have been identified in the following locations:

- Hillside Road (north and south);
- Portobello Road (just upstream of the pump station);
- Ascot Street / Royal Crescent;
- Tainui (Cranley, Marlow and Botha Streets); and
- Bay View Road.

9.1.3 Nuisance Flooding

Widespread nuisance flooding occurs throughout the catchment, with depths increasing with larger rainfall events. In most instances, alternative routes are available, however a number of vulnerable locations may be affected. A significant number of complaints have been received in a number of areas regarding flooding, although many of these were during the February 2005 rainfall event, which had an extremely high intensity.

9.1.4 Deep Flooding

The flood hazard mapping undertaken for the South Dunedin catchment has identified two key areas where overland flow, ponding, and potential habitable floor flooding is predicted.

9.1.5 Overland Flow from other Catchments

Overland flow from the Kitchener Street, Shore Street and St Clair catchments has been predicted by other models, and corroborates with flood reports in South Dunedin. In particular, flooding predicted in the Cavell Street area may be exacerbated by flows from the Shore Street network.

9.1.6 Cross Connection with St Clair Stormwater Network

An identified high level bypass / overflow between the South Dunedin and the St Clair stormwater networks has the potential to transfer peak stormwater flows between the two networks.

9.1.7 Network Age and Condition

The age of the assets could be a concern for several reasons; impedance of flow (poor condition), leakage (in or out), and contaminant ingress (from pipes passing through contaminated sites).

9.1.8 Network 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. This has the potential to exacerbate or transfer flooding.

9.1.9 Blocking / Maintenance of Intake Structures

The Portobello Road Pump Station intake screens regularly block with stormwater transported debris. Stormwater monitoring during the model development for South Dunedin showed a 'dynamic blockage' over time as the screens blocked over an event. This presents an issue with respect to reduced effectiveness of the upstream stormwater system, and backwater effects extending up the catchment. Access to the screen has recently been improved, and more regular cleaning during storm events will be possible.

9.1.10 Pump Station Operation

Information collated has indicated that the Portobello Road Pump Station is not being operated in accordance with original design, but in response to inflow into the pumping station. The model suggests that the operation of the station may be causing backflow issues through the network, however it may be operating optimally, with the screen blockage having a greater effect on catchment flooding. Insufficient information was available to examine the pump station operation adequately (i.e. no pump station testing was undertaken).

9.2 Stormwater Quality Issues

It is clear that within the harbour there is historical sediment contamination likely to be from a combination of the stormwater outfall and other sources. Harbour-wide, there is potential for ongoing contamination of the sediment from stormwater, however the results are ambiguous and it has not been possible to establish a causal link from available data.

Harbour sediments adjacent to the South Dunedin catchment outfall show elevated levels of some contaminants, particularly heavy metals and PAHs. Stormwater quality measured at the outfall site is variable, but indicates that zinc and copper concentrations may be elevated. PAH measurements have occasionally been extremely high, and indicate a contaminant source within the catchment.

9.2.1 High Variability of Stormwater Quality Results

Time-proportional monitoring undertaken in the catchment has shown that the grab sample technique used for ongoing annual sampling of stormwater may not be providing sufficient information regarding stormwater quality. Based on historical information, some contamination of the stormwater from the South Dunedin catchment is suspected, however more information with respect to heavy metal levels is required.

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 Point-Source Contamination

Stormwater monitoring has indicated a point-source of PAH in the catchment. This is potentially linked to ongoing high levels of PAH measured in adjacent harbour sediments. Due to the presence of contaminated sites in the catchment (i.e. the disused gasworks site), this issue should be further explored.

9.2.4 Historical Harbour Sediment contamination

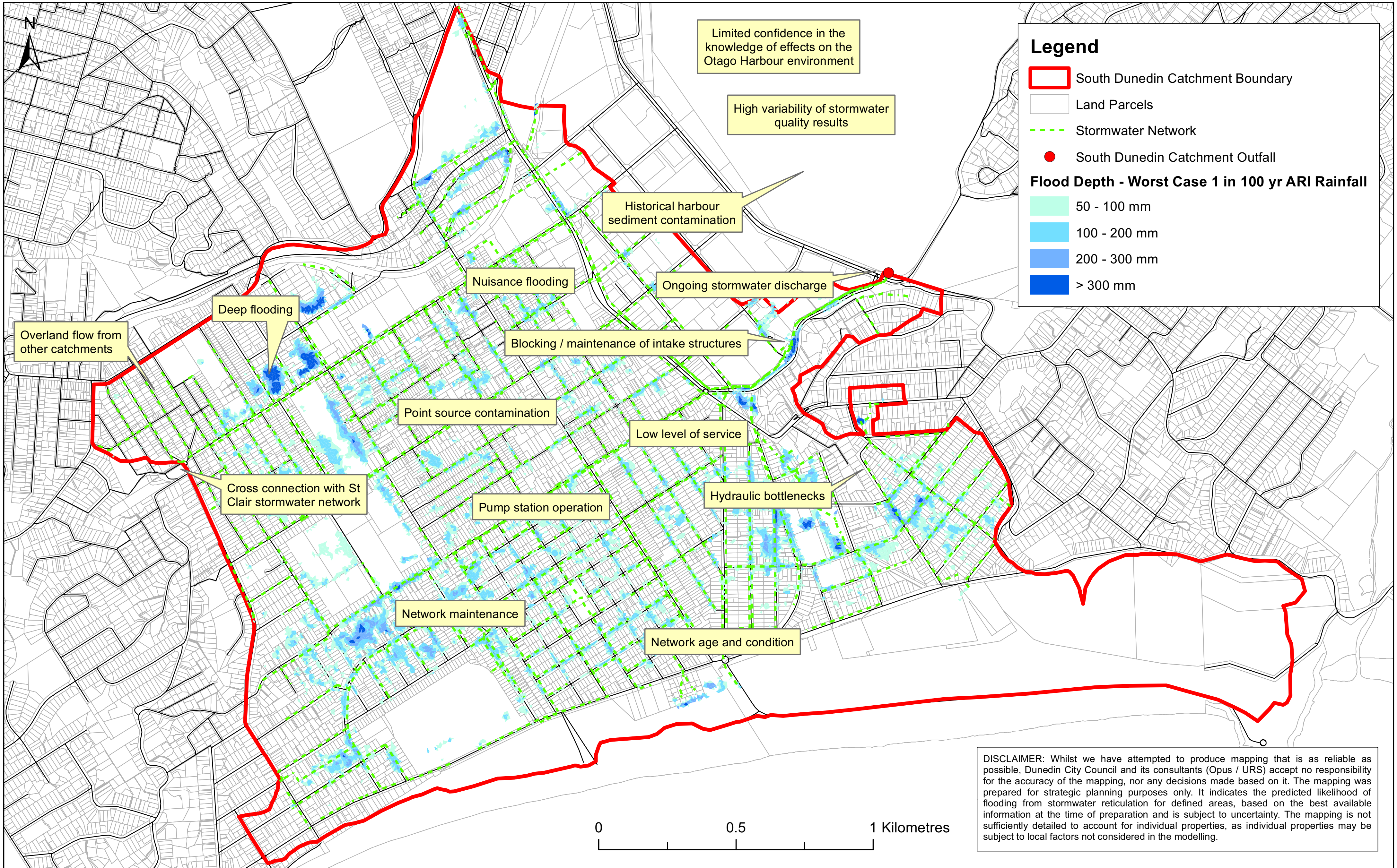
Historical sediment contamination in the harbour adjacent to the South Dunedin catchment outfall is believed to be the result of industrial land use in the catchment in the past. Primary contaminants of concern are heavy metals and PAHs.

9.2.5 Ongoing Stormwater Discharge

Harbour sediment contamination (likely to be as a result of stormwater discharges to the harbour) has been identified. Ongoing discharge of contaminants will result in the continuation of sediment contamination. Of particular concern are heavy metals and PAHs. While stormwater quality results are not entirely reliable, the following sources have been identified as being key contributors to ongoing stormwater contamination in the South Dunedin catchment:

- Heavy traffic use on roads;
- Light industrial land use; and
- Use of zinc-galvanised roofing products in the catchment.

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.



Created with ESRI ArcGIS

DUNEDIN CITY COUNCIL | OPUS | URS

Dunedin 3 Waters Strategy

SOUTH DUNEDIN INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 9-1

South Dunedin Catchment Issues

DISCIPLINE

Stormwater

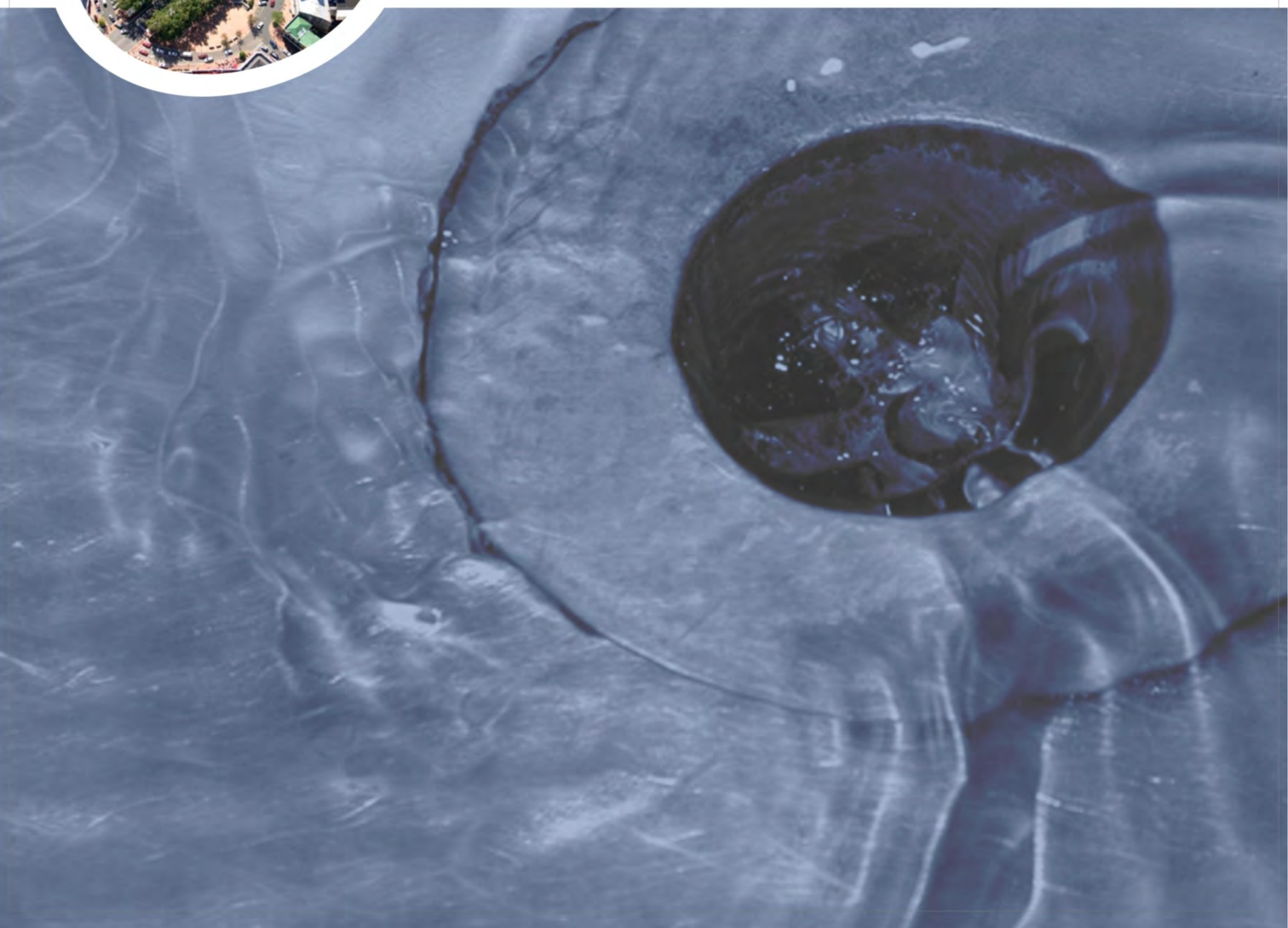
Drawn: CJO	Status: Draft		
Checked: HES	Scale: 1:12,500	Plot Date: Sep 2011	
Approved: HES	Job. No: 42173227	Map No: Figure 9-1	Revision: -
Date: Sep 2011			

T:\Jobs\42173227\GIS\FIGURES\Kitchener St\K_Catchment_Issues.mxd

Original Size: A3

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 South Dunedin 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 (Problem Description)	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Problem Management
Hydraulic Bottlenecks	40	5	Effect on a number of properties across the catchment. Threat currently occurring. Nuisance flooding predominant result.	200	Manage Actively
Blocking / Maintenance of Intake Structures	40	4	Pump station screens also potentially causing effect on hydraulics of system. Regular cleaning may be an ongoing solution, however the consequence of lapse in cleaning could be considerable.	160	Manage Actively
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
Ongoing Stormwater Discharge	40	4	Ongoing discharge of stormwater (and associated contaminants) to the harbour. The extent of contamination is unconfirmed, but available data indicates that contaminants discharged contain some key urban contaminants.	160	Manage Actively
Deep Flooding	40	3	Habitable floor flooding predicted in two main areas. Predicted on 1 property in a 1 in 5 yr ARI rainfall event, 8 properties in a current 1 in 10 yr ARI rainfall event, 31 properties in a current 1 in 50 yr ARI rainfall event. Limited knowledge of threat (no surveyed floor levels).	120	Manage Actively
Pump Station Operation	40	3	Pump station may not be operating optimally. Could be affecting operation of the system and subsequently flooding – whole catchment potentially affected. Moderate state of knowledge on the threat, and likelihood linked to storm events.	120	Manage Actively
Cross Connection with St Clair catchment Stormwater Network	40	3	Possible discharges between networks during extreme events. Poor state of knowledge regarding the discharge. Additional stormwater into South Dunedin catchment would exacerbate existing issues, and vice versa, although the extent to which this would occur is unknown.	120	Manage Actively

Issue (Problem Description)	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Problem Management
Overland Flow from Other Catchments	40	3	Overland flow entering the South Dunedin catchment from adjacent hillside catchments. Confirmed via models and complaints. Will be exacerbating existing flooding, as South Dunedin network has insufficient capacity to accept or convey additional flows.	120	Manage Actively
Point Source PAH Contamination	40	3	Sudden shock loading of PAH could cause major environmental damage. Suspected to occur. Requires further investigation. Key stakeholder (community) issue.	120	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. Based on historical information, some contamination of the stormwater from the South Dunedin catchment is suspected, however more information with respect to heavy metal levels is required.	120	Manage Actively
Low Level of Service	10	5	Level of service lower than DCC's design standards for new pipes. Threat is already occurring, however effects are minor. Hydraulic bottlenecks identified as separate issue.	50	Manage Passively
Flood Hazard – 1 in 100 yr ARI	40	1	Unlikely to be extreme damage due to shallowness of predicted flooding. Traffic disruption likely, however routes around 'significant' areas of risk available.	40	Manage Passively
Network Condition and Age	10	4	Consequence of failure of system linked to potential contaminated land and infiltration / cross contamination. Limited state of knowledge of network condition. Failures unlikely to be simultaneous throughout system.	40	Manage Passively
Historical Harbour Sediment Contamination	40	1	Major but recoverable ecological damage. Not expected to occur as good knowledge of threat, and major damage would only occur in exceptional circumstances. Long term target depends on actions undertaken elsewhere.	40	Manage Passively
Nuisance Flooding	10	4	Widespread nuisance flooding. DCC seek to avoid disturbance to private properties where practicable, however emphasis on avoiding increase due to new development. Currently occurring.	40	Manage Passively

Issue (Problem Description)	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Problem Management
Network Maintenance	10	3	Regular maintenance currently occurring. Consequence of poor maintenance is minor effects on environment, exacerbated short term flooding.	30	Manage Passively

11 Catchment Specific Targets and Approaches for Stormwater Management

Figure 11-1 below 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 (Section 8) has been used to identify the key stormwater management issues for the South Dunedin 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.

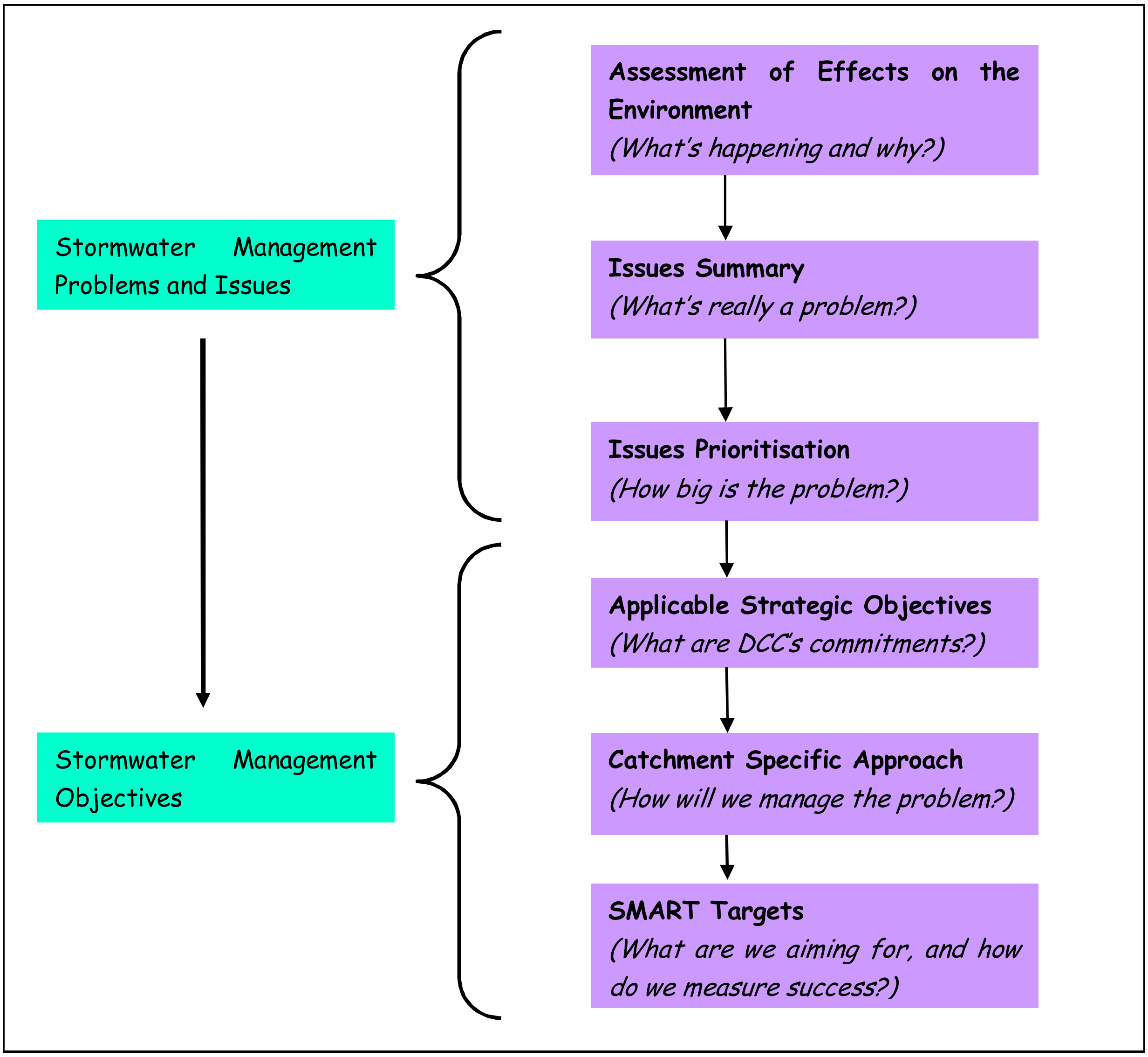


Figure 11-1: Target Development Process

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 outfalls discharging to the Otago 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 outline catchment specific approaches and SMART targets for each of the key stormwater issues identified in the South Dunedin catchment.

11.1 Stormwater Quantity Targets and Approaches

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

11.1.1 Hydraulic Bottlenecks

Customer complaints regarding the stormwater network correlate well with locations of hydraulic bottlenecks in the South Dunedin catchment, with the Hillside Road, Burns Street, Bay View Road and Tainui areas reporting multiple flood incidents.

The investigation of local upgrade options should be an approach for this significant issue, however the low level of service of the remainder of the network may result in 'shifting' of flood flows to alternative locations. Progressive network upgrades and coordination of works (renewal and upgrade) may enable the hydraulic bottlenecks to be resolved via infrastructural solutions, however local improvements and flood protection works may be required in the short to medium term.

11.1.2 Blocking / Maintenance of Intake Structures

The blocking of the Portobello Pump Station intake screens restricts flows to the pump station, potentially exacerbating flooding further up in the catchment. Recent work on access to the screens was aimed at improving access to enable more regular screen cleaning during storms. Targets for this issue involve coordination with the city-wide network maintenance recommendation for documentation of cleaning and maintenance responsibilities. Monitoring of the effectiveness of improved access on screen performance will be necessary, however, as further improvements may be required in the future to ensure the screen blockage does not impede flows from the catchment network.

11.1.3 Deep Flooding

The Building Act requires that habitable floors (or 'useful floor space' in relation to non-residential properties) should not be at risk of flooding during a 1 in 50 yr ARI rainfall event. The modelling predicts that currently, up to 31 land parcels may experience flood depths greater than 300 mm during a current 1 in 50 yr ARI rainfall event. During a 1 in 10 yr ARI rainfall event, 8 properties are estimated to be at risk.

Targets for this flood hazard seek to avoid habitable floor flooding under both current and future land use and climate change scenarios, for all events smaller than and including the 1 in 50 yr ARI rainfall event. It is also desirable to avoid any increases in surface flooding of private properties during this event.

Because the modelled flood extents indicate that in some cases, flooding may not actually enter buildings, parcels identified as potentially being subject to deep flooding during rainfall events with 1 in 50 yr ARI rainfall and smaller should be surveyed or a damage assessment undertaken to gauge the effects of deep flooding in the catchment, prior to detailed design of options.

'Land parcels' and 'properties' are both used to provide information in this context, however model results only provide information in terms of 'land parcels'. DCC's targets are focussed on avoiding habitable floor, or significant private property flooding, therefore actual numbers of properties / premises at risk is likely to be less than the number of land parcels reported.

Because deep flooding in the South Dunedin catchment is predicted to affect a number of habitable floors, it is categorised as manage actively. Options for mitigation of flood effects will be explored, in conjunction with the pipe renewals process which may have an influence on some areas.

11.1.4 Pump Station Operation

The key operation and maintenance tasks in the South Dunedin catchment relate to cleaning of the Portobello Road Pump Station intake screen, operating the pump station, and cleaning the catchpits. DCC's operations and maintenance team are committed to undertaking all of these tasks, however, there may be an opportunity for improvement or a shift to reducing the maintenance requirement in some areas. Investigations into procedures, or looking at some capital changes, may result in a system that is more effectively maintained.

11.1.5 Cross Connection with St Clair Network

While open cross connections between networks can provide relief during peak flows, they can potentially be transferring the issue by placing additional strain on the receiving network, particularly during extreme events. A good understanding of the flow regimes under which the bypass structure operates is required in order to accurately evaluate the effects of the flow transfers at this location.

Currently, knowledge of the interaction between the South Dunedin and St Clair stormwater networks via this cross connection is limited, however modelling has indicated that both networks are surcharged during high frequency rainfall events, indicating that any transfer of flows would exacerbate flooding in the receiving network. Therefore, the first target set for this issue is to develop a better understanding of the existing and predicted future overflows through the structure via further modelling. Following this, changes to the configuration of the bypass may be recommended in order to minimise overall surcharging of the two networks.

11.1.6 Overland Flow from Other Catchments

Overland flow is predicted to move into the South Dunedin catchment from the St Clair, Shore Street, Orari Street and Kitchener Street catchments during large storm events. To some extent, any proposed upgrades and renewals of the network in the catchments will reduce this overland flow, however the risk still remains during large events exceeding the capacity of the networks.

In particular, the St Clair and Shore Street catchment interactions result in flooding in areas where the South Dunedin network also predicts flooding. Flood mapping in the South Dunedin area will therefore be underestimating the extent or depth of flooding that may occur.

Combination of the models, based on areas of issue, would provide a method for assessing the risks, and assist in the development of solutions for mitigating the risk.

11.1.7 Low Level of Service

Despite South Dunedin's stormwater network having a low level of service (estimated to be somewhere between 1 in 2 and 1 in 5 yr ARI), flooding resulting from a 1 in 10 yr ARI rainfall event design storm is predicted to be predominantly 'nuisance' flooding (i.e. less than 100 mm deep, and mainly in roads).

The recommended targets and approaches 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 climate change alters weather patterns and sea levels.

A 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. The South Dunedin catchment lies within the 'South Dunedin' group of this survey.

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 the Dunedin Code of Subdivision and Development, and also with the Building Act.

11.1.8 Flood Hazard – Current and Future 1 in 100 yr ARI

Flood hazard issues in this catchment are considered to be fairly minor, with hazard being mainly restricted to the areas already predicted to have deep flooding during a number of events. As such, the approach to this issue is one of passive management; ensuring that there is no increase in flood hazard due to development or climate change.

Based on the modelling undertaken (which was not a detailed model of climate change effects on sea levels), effects predicted in the future are primarily due to climate change effects on rainstorm depths, rather than sea level rise, or land use development. The potential effects of climate change on this catchment will be considered by DCC's Climate Change Adaptation Plan (currently being developed).

Options pursued to address deep flooding in these areas, along with network renewals over time, are expected to resolve the majority of the flood hazard issues in the catchment.

The strategic direction provided by the 3 Waters Strategy 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 climate change alters weather patterns and sea levels. Because the existing network does not contain capacity for increased flows, flood mitigation options may need to be developed to allow for adaptation to climate change. The 3 Waters Strategy Direction Statement puts an emphasis on at-source options for stormwater management.

The 1 in 100 yr ARI rainfall event has been considered for emergency planning purposes. Targets for flood mitigation during this event focus on ensuring the population of South Dunedin is able to access main transport routes, and that flooding in the catchment is not exacerbated by future development or climate change effects.

11.1.9 Network Condition and Age

Because of the potential for groundwater infiltration (potentially contaminated), and the low pipe gradients in the catchment, the assessment of the ageing pipe network in the South Dunedin catchment should be prioritised as part of the DCC renewals programme. The extent to which the stormwater network is providing land drainage ('drawing down' the groundwater levels) in the catchment would, however, need to be examined with respect to the potential replacement of pipes – new pipes would result in less infiltration, and hence potentially raise the groundwater in some locations.

11.1.10 Nuisance Flooding

Nuisance flooding is predicted and confirmed across the South Dunedin catchment. This flooding is predominantly the result of the low level of service of the stormwater network, combined with a number of hydraulic bottlenecks in the system. Options pursued to resolve these issues will consequently reduce the nuisance flooding, along with planned network renewals. Ongoing review of customer complaints and the ROS would enable the success of renewals and options implemented to be gauged.

11.1.11 Network Maintenance

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.

Table 11-1: South Dunedin Catchment Management Targets: Stormwater Quantity

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Hydraulic bottlenecks	A number of 'bottlenecks' in the system may be exacerbating flooding. These also result in a lower overall level of service in the network.	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. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Actively*** Maintain or improve existing level of service in network. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes and hydraulic bottlenecks prioritised). Monitor customer complaints and / or undertake site visits to confirm locations of flooding. Investigate local upgrade options.	Feasibility studies undertaken of upgrades to relieve hydraulic bottlenecks by 2014. > 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Blocking / Maintenance of Intake Structures	Blocking of intake screen leads to backwater effects throughout catchment.	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.	***Manage Actively*** Reducing the backwater effect caused by blocking Portobello Pump Station intake screens. Prioritise Portobello screens for early and regular attention during storms.	Document cleaning and maintenance responsibilities for all stormwater inlet assets in the catchment by 2013. Develop consistent cleaning and maintenance criteria for all stormwater inlet assets (city-wide) by 2012. Specifically include action plan for cleaning the Portobello screens. Measure frequency and effectiveness of manual cleaning of screens.
Deep Flooding	Model results indicate 8 parcels affected by deep flooding during 1 in 10 yr ARI rainfall event; rises to 31 during 1 in 50 yr ARI rainfall event in current, and 40 land parcels in future planning scenarios.	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. 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 potential habitable floor flooding due to the stormwater system in events up to a 1 in 50 yr ARI rainfall event. Enhance understanding of effects of deep flooding, particularly on private property. Undertake pipe renewals programme as scheduled (with older pipes prioritised). Investigate options for reducing habitable floor flooding during frequent events.	< 31 properties at risk of deep flooding (> 300 mm) during a 1 in 50 yr ARI rainfall event by 2060. Undertake habitable floor survey and / or damage assessment of potentially flooded properties. > 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Pump Station Operation	Pump station operation is key to performance of infrastructure. There is an unknown level of optimisation. Future upgrades can only be made to network if pump station capacity and performance is optimised.	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. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Actively*** Ensure that the Portobello Road Pumping Station is running optimally, and has capacity to adjust for future flows, and potential upgrades to the overall South Dunedin network.	Ensure Portobello Road Pump Station is running optimally. Test Portobello Road Pump Station, and document capacity. Portobello Road Pump and Tainui pump stations to convey a 1 in 10 yr ARI rainfall event by 2060.
Cross Connection with St Clair Network	Limited knowledge of the effects of the cross connection due to independent modelling of catchments. Stormwater exchange between the South Dunedin and St Clair networks may be reducing the available capacity of the receiving network during extreme events.	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.	***Manage Actively*** Quantify and investigate effects of overflows through the bypass structure between the two networks.	Quantify and assess the effects of overflows from St Clair on South Dunedin, and / or vice versa by 2013. > 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Overland Flow from other Catchments	Overland flow is predicted to move into the South Dunedin catchment area ('the Flat') from the Shore Street, St Clair and Kitchener Street catchments. The effects of the Shore Street catchment are particularly significant.	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.	***Manage Actively*** Quantify and investigate the effects of overland flow from other catchments. Prioritise study into the effects of the Shore Street / South Dunedin / St Clair catchment interaction.	Quantify and assess the effects of overland flow from other catchments on South Dunedin, prioritising Shore Street and St Clair interactions. Prioritise or develop options for mitigating flooding effects by 2015.
Low Level of Service	44 % of the network cannot accept rainfall from a 1 in 10 yr ARI rainfall event, driving by network capacity. Manholes predicted to overflow throughout system. Network 99 % surcharged during a 1 in 2 yr ARI rainfall event.	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*** Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Use customer complaints and Resident's Opinion Survey to gauge satisfaction with the stormwater system performance.	> 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (ongoing).

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Flood Hazard – Current and Future 1 in 100 yr ARI	'Moderate' to 'significant' flood hazard predicted in both current and future scenarios. Mainly affecting properties already at risk of deep flooding. Due to flatness of catchment, high velocity flows not predicted.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Passively*** 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. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances).	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. Provide modelled flood predictions to agencies responsible for transport routes.
Network Condition and Age	The age of the assets could be a concern for several reasons; impedance of flow (poor condition), leakage (in or out), and contaminant ingress (from pipes passing through contaminated sites).	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.	***Manage Passively*** Undertake pipe renewals programme as scheduled (with older pipes prioritised).	> 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Nuisance Flooding	Nuisance flooding is predicted on a regular basis throughout the catchment due to hydraulic restrictions throughout the network.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Use customer complaints and ROS to gauge satisfaction with the stormwater system performance.	> 56 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (ongoing).
Network Maintenance	Flooding extents and durations in the South Dunedin catchment are potentially exacerbated by variations in the frequency and standards of catchpit and inlet screen 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. Use customer complaints and ROS to gauge satisfaction with the stormwater system performance.	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 the South Dunedin catchment requiring additional cleaning and maintenance checks by 2013.

11.2 Stormwater Quality Targets and Approaches

11.2.1 Stormwater Quality

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

Targets and approaches 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. Specific targets relating to discharges from the South Dunedin catchment are presented under issues for point source PAH contamination, and ongoing stormwater contaminant discharge.

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.

11.2.2 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.

Samples taken from the South Dunedin catchment discharge do indicate that a number of heavy metals may be present in levels above what may be typical for an urban catchment, however the variability in results means that further confirmation of this may be required.

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 – some sediment samples taken adjacent to the South Dunedin catchment outfall have shown relatively high levels of contaminants, particularly heavy metals and PAH. 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).

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 harbour wide, the data does not appear to be showing any trends. With 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 commitment to improve the quality of stormwater discharges to the harbour. 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.

- Dunedin Code of Subdivision indicates that at-source management of stormwater quantity is desirable and Low Impact Design methods are preferred.

11.2.3 Ongoing Stormwater Discharge

Despite the low confidence in the data relating to the stormwater quality and effects on the receiving environment, data is indicating that there may be elevated levels of zinc, copper and PAHs from the South Dunedin catchment.

Zinc discharge in stormwater from South Dunedin has been attributed to residential roof types in the catchment, and zinc, copper and PAH contamination is a feature of stormwater from heavily trafficked roads, of which there are several in the South Dunedin catchment.

Catchment specific approaches applied in other Dunedin catchments include the consideration of stormwater quality treatment when undertaking stormwater capital works, the use of source control by new developments, and education of owners of high contaminant producing sites to ensure there is no deterioration of stormwater quality due to land use change of development in the catchment.

Further to this, because of the elevated contaminants measured in the South Dunedin catchment stormwater, a target for confirming stormwater quality, and identifying the most likely sources of heavy metals and PAHs in the catchment has been set, with a view to undertaking work to eliminate contaminants at source, or implementing targeted stormwater treatment. In parallel, identifying the source of PAH contamination is discussed below.

11.2.4 Point Source PAH Contamination

Locating point source PAH contamination is also a specific target relating to ensuring contaminants are not being generated from the disused gasworks site in the catchment.

Point source PAH contamination of stormwater and harbour sediments appears to be occurring, and an approach based around locating and addressing point source discharge of PAH would be key to achieving DCC's strategic objective of reduction of contaminants in stormwater

11.2.5 Historical Harbour Sediment Contamination

Sediment quality may be improving over time due to the deposition of 'cleaner' sediments on top of historically contaminated sediments, however there is some uncertainty regarding sediment deposition rates in the upper harbour, and the extent to which wave action re-suspends and shifts sediment. Any trend may take some time to observe due to this slow deposition rate and re-suspension.

Due to high lead, zinc and PAH concentrations in sediments, DCC would like to set a target for the reduction of the concentrations of these contaminants in the sediment. However, due to the reported health of the ecology in the area, there is insufficient evidence to state that these sediments are currently having an adverse effect. In addition, the receiving environment in this area is highly modified via reclamation works, dredging and years of industrial discharges.

A target of lowering contaminants in sediments to below the ANZECC high trigger value within 20 years has been identified with respect to the sediment contamination. 20 years should be sufficient time to ensure that the depth of sediments being sampled have been generated while the stormwater management plan has been operative, and the selection of the high ANZECC trigger value is considered appropriate, rather than the low trigger, due to the observed current health of the ecosystem. Should ecosystem health deteriorate, or clear trends develop over time, this target would need to be reviewed. Because of the timeframes involved in measuring responses in sediment quality, this target would not be an appropriate short term indicator for stormwater management. The triggers developed as part of the revised monitoring programme would be used as a short term measure of success and improvement monitoring.

The approach to management of the catchment in order to achieve this target will be via the approaches for other options, involving the reduction in contaminants in current sediments. Investigations. Further information should also be sought, via the improved monitoring programme, in order to confirm sediment deposition rates in the harbour; this will enable the target to be adjusted to reflect the deposition rate.

Table 11-2: South Dunedin Catchment Management Targets: Stormwater Quality

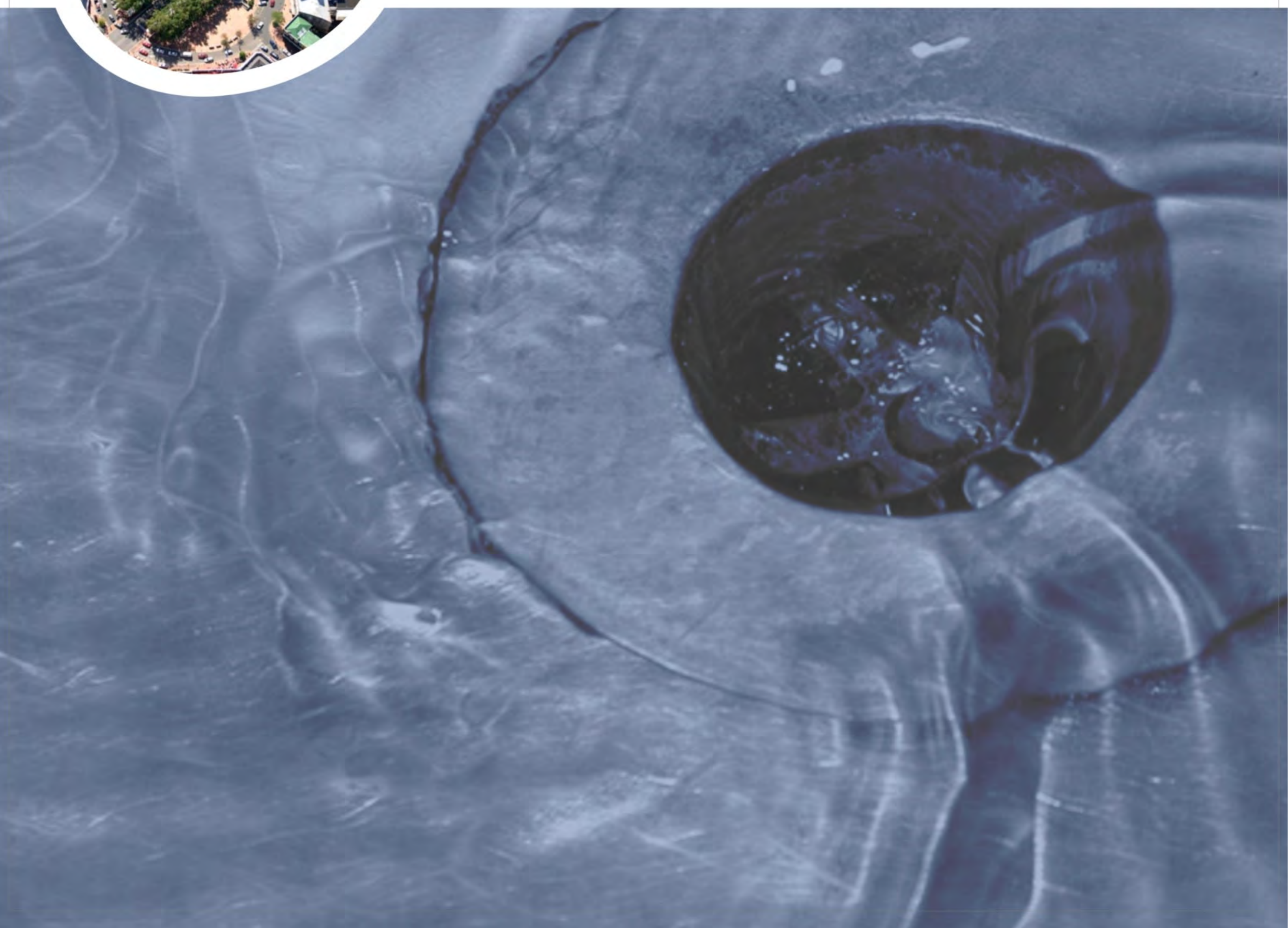
Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Limited Confidence in the Knowledge of Effects on Harbour Environment and Variability of Stormwater Quality Results	High variability of stormwater quality results, any trends in stormwater contaminant levels remain unclear, however results to date indicate moderately high contaminant concentrations in stormwater discharge. Poor information on actual effects of stormwater on harbour environment. Lack of data to assess linkages between pipe discharge and harbour environment quality.	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. Improve the quality of stormwater discharges to minimise the impact on the environment. 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 city-wide 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	Catchment Specific Approach	SMART Targets
Ongoing Stormwater Discharge	Could exacerbate historical contaminant issues in the harbour. Extent to which this is likely to occur is unconfirmed. Key stakeholder issue. Based on available data, there may be some ongoing contamination of stormwater.	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 Actively*** 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. Further characterise the stormwater quality from the catchment to confirm key contaminants. Undertake an investigation to identify the primary sources of key contaminants. Develop solutions to remove key contaminants at-source, or implement stormwater treatment.	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. Further characterisation of South Dunedin stormwater by 2012. Confirmation of key contaminants and primary sources by 2012. Implementation of measures to reduce contaminants in stormwater by 2013.

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Point Source Contamination	'Spikes' of high PAH in stormwater quality sampling, combined with historical (and potentially recent) PAH contamination of sediment indicates a point source may exist in the catchment. Old gasworks site in catchment. Additionally, ageing pipes may be allowing ingress of contaminated groundwater.	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 Actively*** Locate and remove point source Contamination of PAHs. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.	Lower the contaminant levels in sediment adjacent to the Portobello Road Outfall to below ANZECC 'high' trigger values within 20 years.

Issue (Problem Description)	Effects Summary	Strategic Objectives	Catchment Specific Approach	SMART Targets
Historical Harbour Sediment Contamination	Contaminated sediment adjacent to outfall at depths > 300 mm. Contaminant levels above ANZECC low and sometimes high guidelines. No clear significant adverse effects on ecology.	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. Ensure stormwater discharge quality does not deteriorate.	***Manage Passively*** 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.	Lower the contaminant levels in sediment adjacent to the Portobello Road Outfall to below ANZECC 'high' trigger values within 20 years.

Part 5
Solutions



12 Stormwater Management Options

12.1 Introduction

Options are presented below to manage the stormwater issues identified in the South Dunedin 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 11 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 identified.

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 South Dunedin 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 key stormwater management issues present in the South Dunedin 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 may be considered for further evaluation in Section 14, if more than one potential solution is available.

Some stormwater management issues have been grouped together where options for addressing the issues are linked or benefit more than one issue.

12.2.1 Hydraulic Bottlenecks – Manage Actively

Hydraulic bottlenecks have been identified in a number of locations, where they are causing manhole overflows, resulting in nuisance and deep flooding. Although the entire network has a low level of service, attention to these bottlenecks would most likely reduce the severity of flooding in the particular locations affected. A number of options have developed to reduce flooding and surcharging associated with these areas. These are described below.

12.2.1.1 Hillside Road North and South

In terms of reducing flooding in laterals connecting to the stormwater network mains running down the northern and southern sides of Hillside Road, a number of options were considered for removing the bottlenecks created by the surcharging main pipes. While some local options are specific to one of the mains, the majority of the options affect both pipelines. These are described below.

Option SD 1: Local Pipe Upgrades

The model was used to simulate upsizing the smaller pipes in the upstream part of the Hillside Road pipe section from 400, 475 and 600 mm to 1050 mm diameter to provide in-line storage and reduce the hydraulic grade line in the laterals. Increasing the size of the downstream part of the southern Hillside Road system between Reid Street and Andersons Bay Road was modelled.

Option SD 2: Create 'Dual' System

There is some uncertainty regarding the extent of cross connection between the Hillside Road north and south pipelines, and it is suspected that some unknown cross connections may occur that were not included in the model, potentially skewing results in this area. Regardless, the under capacity of the system still exists. An option to provide further capacity is to increase cross connections between the northern and southern pipelines down Hillside Road, creating more of a 'dual' system.

Option SD 3: Major Pipe Upgrades – In-line Storage

This option provides in – line storage by increasing the size of the Southern Hillside stormwater main (approximately 1.5 km long) from diameter 375 mm to a larger pipe (diameter 600 mm or 1050 mm), with connections in place between the two systems as per Option SD 2 above.

Option SD 4: Diversion

Diverting the northern Hillside Road system to a new outfall, or the existing Orari Street outfall, was simulated by ‘disconnecting’ the pipe network at Andersons Bay Road (Figure 12-1). This did not result in a significant reduction in the flood extent in the area, indicating that the flat grade of the system, combined with the size of the pipes, did not provide local conveyance necessary to relieve flooding.

Option SD 5: Pumping

Further to the consideration of diversion of stormwater to an alternative outfall, a pump station would be required to divert flows, and was simulated at the Andersons Bay Road end of Hillside Road (refer Figure 12-1).

Figure 12-1: Modelled Diversion of Hillside Road Stormwater

Option SD 6: Detention

A detention pond was simulated in Bathgate Park, with a volume equal to the stormwater volume from a current 1 in 10 yr ARI rainfall event, upstream of the park. Figure 12-2 below shows the modelled pond location, and the diverted network.

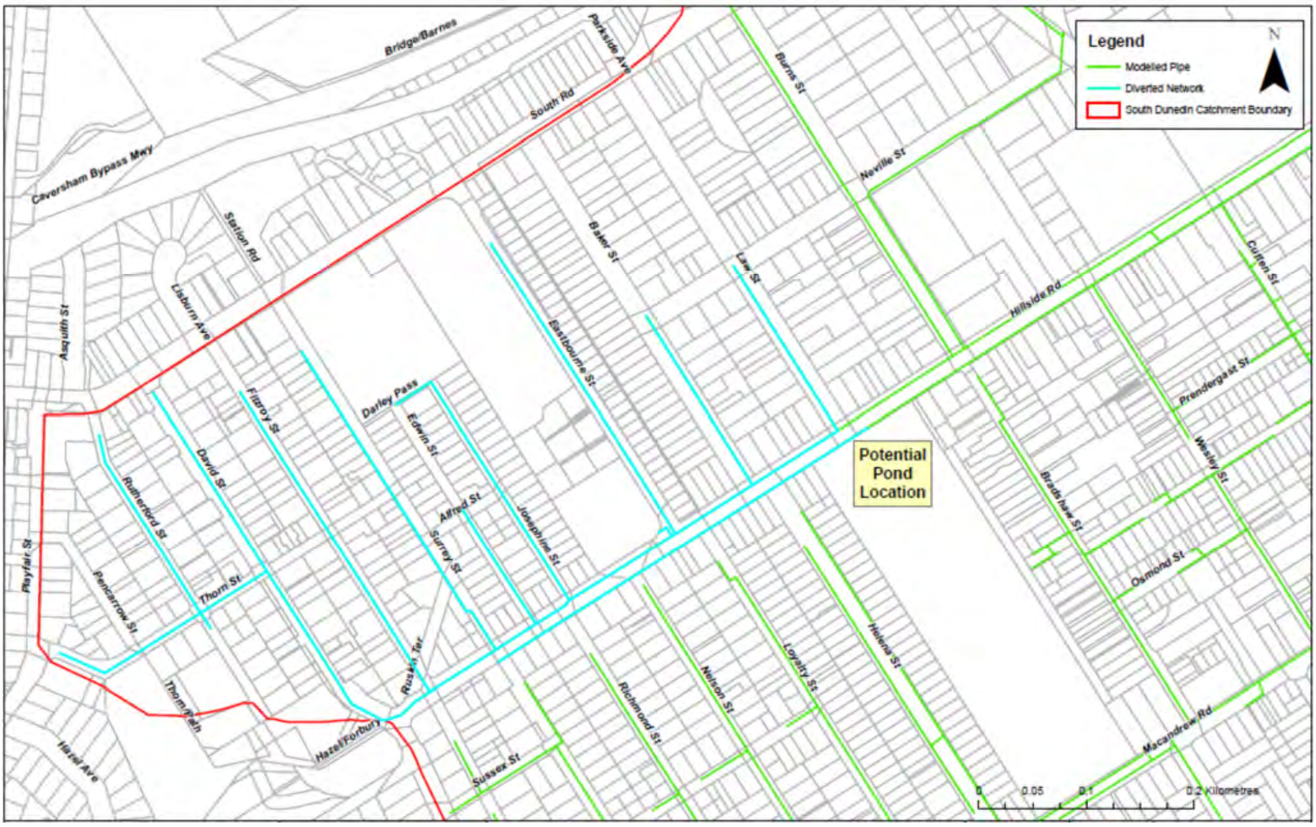


Figure 12-2: Modelled Pond Storage at Bathgate Park

12.2.1.2 Portobello Road

A number of options are presented for reducing the hydraulic grade line at Portobello Road, hence reducing the backwater effect up the tributary links and throughout the catchment. The blocking of the inlet screen is also identified as an issue, and options to alleviate the effects of the blockage will almost certainly contribute to altering the flow dynamics at this location. Consequently, options for inlet screen modification are also presented below. Figure 12-3 below identifies the locations of each option.

Option SD 7: Create Cross Connections

As the hydraulic grade line along Bay View Road is in part driven by the full receiving pipeline on Portobello Road, some modifications could be made to the network at this point.

Providing cross connections between the three pipes prior to the confluence with the Bay View Road inflow was simulated to provide flow balancing.

Option SD 8: Install Additional Link to Pump Station

The addition of a third link to the pump station would provide additional capacity for water coming from Royal Crescent, Bay View Road, and the remainder of the catchment to enter the Portobello Road system, without backflow.

The modelled new pipeline also has the influence of a debris screen, presented as a ‘blockage’ in the pipe.

Option SD 9: Modification of Inlet Screens

The modelling of this option is essentially to determine the effect of the screens, and the influence they have on the flooding in the catchment. Modification of the screen (i.e. installation of a sloping screen or increase in the mesh / bar gap) would have a similar result to this option, however, these options cannot be hydraulically modelled with the current model.

Option SD 10: Enlarge Chamber Prior to the Screen

Providing additional storage prior to the screen may lower the hydraulic grade line upstream of the screens.

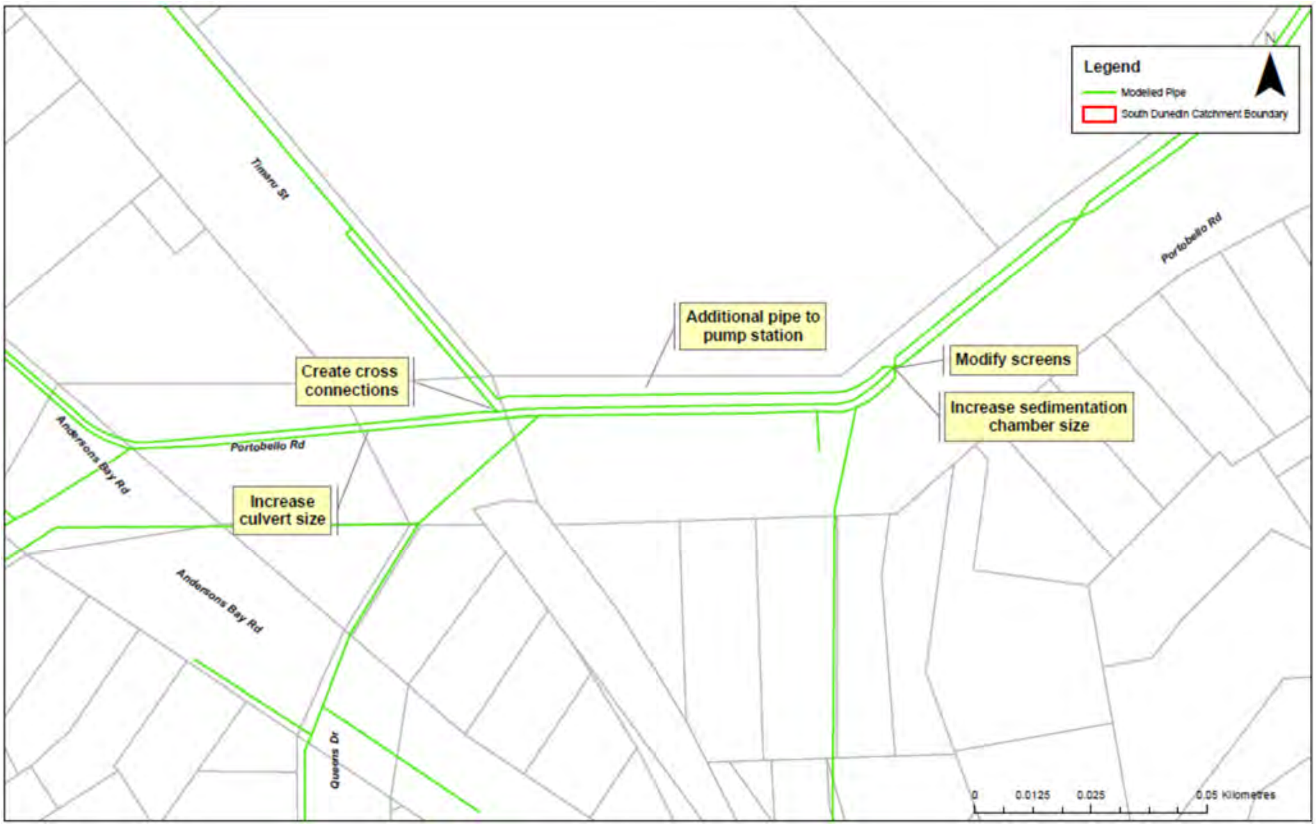


Figure 12-3: Potential Options for Portobello Road Network

12.2.1.3 Ascot Street / Royal Crescent Area

Flooding in the Ascot Street / Royal Crescent area is most likely to be driven by a combination of undersized local pipes and the hydraulic grade line from the confluence of the system with the Portobello Road stormwater lines. Local options are identified below. Options relating to the Portobello Road stormwater system are discussed in Section 12.2.1.2 above. Also, an option to divert the Bay View Road network (Section 12.2.1.5) would also potentially relieve flooding in this area.

Option SD 11: Remove Ascot / Rugby Street Bottleneck

The pipe system in Ascot Street, currently 300 mm diameter, was increased in size to 600 mm diameter, in order to remove a hydraulic bottleneck.

Option SD 12: Remove Gourley Street Bottleneck

The pipe system in Gourley Street, currently 225 or 200 mm diameter, was increased in size to 400 mm diameter, in order to remove a hydraulic bottleneck.

Option SD 13: Upsize Queens Drive Pipes

The Queens Drive pipeline, which is due to be assessed under the pipe renewals programme, was modelled with an increased pipe size; increased from 300 mm diameter to 750 mm diameter. The Royal Crescent pipeline was also increased in size to 850 mm (from 600 mm).

12.2.1.4 Tainui

Flooding upstream of the Tainui Pump Station appears to be the result of local network issues.

Options for resolving flooding in this area are largely dependent on options implemented downstream in the Royal Crescent / Ascot Street area and below at the confluence with the Portobello Road system, and therefore extensive modelling of this issue has not been undertaken. If capacity is available downstream (which is not the case currently), infrastructural options may be considered. However, if the downstream issues cannot be resolved, local solutions will be necessary. Options to consider would be as follows:

- Local upgrades (in line storage);
- Formal detention (ponds);
- Bioretention (swales and / or rain gardens); or
- Individual property protection.

12.2.1.5 Bay View Road

A hydraulic bottleneck exists on Bay View Road, where a dual system has a ‘choke’ in place to restrict flows back into the main network. It is assumed that this system was developed as in-line storage; release of this choke does not result in any improvement in the flooding in the area.

Flooding in this area may also be alleviated by options considered for the Portobello Road Hydraulic Bottleneck. Resolution of this issue would be required prior to local upgrades being considered, unless detention options (as per Hillside Road option SD6) were implemented.

Option SD 14: Diversion

The Bay View Road and New Street systems were disconnected from the current network, and diverted directly to the Portobello Road Pump Station.

12.2.2 Blocking / Maintenance of Intake Structures – Manage Actively

Blockage of the Portobello Road Pump Station intake screens is explored under the hydraulic bottleneck issue; modifications of the screens are considered.

In the first instance, however, targets for this issue revolve around monitoring the screen cleaning effectiveness, now that the screen access has been improved. As part of the option presented for network maintenance, monitoring of the screen performance should be undertaken to support stormwater structure inventory information collected across the city.

12.2.3 Deep Flooding – Manage Actively

A number of properties in the South Dunedin catchment are predicted to flood during the 1 in 50 yr ARI rainfall event. Thirty one (31) of the properties are at risk of habitable / commercial floor flooding under the current scenario, with a further nine at risk under the future scenario. For future developments, there is a strategic objective to prevent this floor flooding during a 1 in 50 yr ARI rainfall event. DCC's target with respect to this flooding is to ensure that the risk is not increased in the future, as development occurs and climate change is taken into account. Additionally, planned pipe renewals will increase system capacity and potentially reduce predicted habitable floor flooding.

In order to fully understand the risk of habitable / useful space floor flooding, properties identified as being at risk will require building footprint confirmation and floor level survey to determine whether flood depths of 300 mm or greater would in fact enter the building. A damage assessment of affected properties which are commercial or industrial premises is often also useful in terms of identifying particularly vulnerable businesses. This assessment would consider the use of the premises, and estimate the likely loss of equipment or stock during a flood event, based on surveyed levels and information from the property owner.

Resolution of hydraulic bottlenecks via infrastructural changes in the South Dunedin network is difficult, and the benefits to individual properties are not clear given the hydraulic complications in the network. Retrofit of rain gardens, swales, and increases in catchment perviousness could be considered to lower the amount of stormwater entering the network to reduce stress on the network. The perviousness of the catchment at present is very low, and high groundwater levels and poorly drained soils produce fairly fast runoff from pervious surfaces. Options for incorporating swales and rain gardens would require careful design to maximise detention of stormwater.

Option SD 15: Development Controls

The use of the Dunedin Code of Subdivision and Development, and the Building Act requirements would ensure that future development or subdivision would not increase the number of habitable floors at risk.

Using data supplied by DCC from its Residential Capacity Study, five lots identified as being suitable for 'infill' development would potentially be in the an area at risk of habitable floor flooding (> 300 mm deep) for a 1 in 50 yr ARI rainfall event. The flooding of habitable floors in these five sections would therefore be avoided via controls in place through the Building Act and Dunedin Code of Subdivision and Development.

Option SD 16: Capital Works

The reduction in potential habitable floor flooding is used as an option evaluation criteria (Section 14) for capital works options developed to relieve flooding and surcharging through the system (mainly due to hydraulic bottlenecks). Weighting of the criteria in favour of achieving flood risk targets is a mechanism for ensuring progressive reduction in potential habitable floor flooding over time as capital works are implemented.

Option SD 17: Swales

A number of streets were selected throughout the catchment and dedicated as swales. In reality, this option assumes that swales would be incorporated into a large number of streetscapes across the catchment. 20 hectares of swales were added to the catchment model.

Option SD 18: Catchment-wide Reduction in Stormwater Runoff

A reduction in imperviousness was incorporated into the hydraulic model of the network. This could represent the use of rain tanks on individual properties, swales along roads, rain gardens, green roofs, or stricter planning rules (for re-development). Three options were investigated; reduction by 5 %, 10 % and 20 %.

Option SD 19: Individual Property Flood Mitigation Works

With DCC's target set at maintaining the risk of flooding at current levels, nine properties that do not flood to deep levels under the current scenario are predicted to be at risk of habitable floor flooding under the maximum future scenario.

An option available to DCC is to review the flood situation at these properties, with a view to undertaking flood mitigation works on an individual property basis. Depending on the location and depth of the flooding, and the property layout and situation, the following options might be available:

- Use of swales to create overland flow paths;
- Local flood protection (e.g. bunding);
- Raising of house floor levels; or
- Purchase of house.

The last option, house purchase, could also potentially be combined with detention pond construction (i.e. using the low lying area for detention instead of housing), to reduce flood risk elsewhere in the catchment.

12.2.4 Pump Station Operation – Manage Actively

Because the whole of the South Dunedin catchment drains to the Portobello Road Pump Station prior to discharge to the harbour, the efficient and optimal running of the Portobello Road Pump Station is a key factor in ensuring the network is providing the best level of service possible. Additionally, the Tainui Pump Station is running for long periods to transfer flood flows from the upper catchment; an assessment of these pumps may also improve pump station operations. Only one option is presented for this issue, as further information is required to determine whether the pump stations require modification. Should the pump stations be considered to be undersized, information confirming their current capacity would be imperative for development of future changes.

Option SD 20: Pump Station Testing and Optimisation

Information collated has indicated that the Portobello Road Pump Station is not being operated in accordance with original design, but in response to inflow into the pumping station. The model suggests that the operation of the station may be causing backflow issues through the network, however it may be operating optimally, with the screen blockage having a greater effect on catchment flooding. Insufficient information was available to examine the pump station operation adequately (i.e. no pump station testing was undertaken).

Additionally, flow data obtained from the flume entering the Portobello Road Pump Station may not be as accurate as required for pump station optimisation; DCC are currently investigating alternative monitoring for the pump station.

Modelling of pump station performance using InfoWorks CS is adequate for the purposes of this ICMP. However this option involves a more detailed investigation into the pump station operation and controls in order to either confirm the current configuration, or to develop a control sequence that optimises performance.

12.2.5 Cross Connection with St Clair Stormwater Network – Manage Actively

Due to uncertainties regarding the amount of water transferred between the St Clair and South Dunedin networks at the north end of Forbury Road, the recommended approach for this issue is to quantify and investigate effects of overflows through the bypass structure between the two networks.

Because both the St Clair and South Dunedin networks are surcharged during reasonably small rainfall events, it is likely that the cross connection is exacerbating flooding in one or other of the catchments, however the timing of network flows, as well as the location of predicted manhole overflows needs to be explored further.

As the South Dunedin and St Clair hydraulic models have been built using an identical methodology, the merging of the two models would enable this issue to be better understood. Potential for network upgrades that would benefit both catchments could also be examined; the South Dunedin network is very hydraulically constrained, and upgrades in the St Clair network may assist in alleviating flood issues on The Flat.

12.2.6 Overland Flow from Other Catchments – Manage Actively

Modelling, supported by DCC Network Management and Maintenance staff comments, indicates that some of the flooding experienced in South Dunedin is caused by stormwater flowing overland from the Orari Street, Shore Street, St Clair (and a small amount from Kitchener Street) catchments.

Additional modelling, in the form of combination of part of the St Clair and Shore Street catchment models with the South Dunedin model, may be necessary to quantify the risk, particularly in the Forbury Road area and Cavell Street area. This modelling may also lead to options investigations that could improve the performance of the networks in the catchments.

12.2.7 Low Level of Service – Manage Passively

Hydraulic modelling of the South Dunedin network has indicated that approximately half of the pipe network provides a relatively low level of service, compared with current design requirements for levels of service. This issue has been categorised as requiring passive management. It is likely that this issue will be resolved over time as other works in the catchment are undertaken to support development, relieve hydraulic bottlenecks and resolve flood hazard issues, and planned renewals occur. Fifty five percent (55 %) of the stormwater pipes in the South Dunedin catchment are due for assessment as part of the renewals programme within the timeframe of this document. The renewals process includes inspection and condition assessment, and potentially extends the useful life of a stormwater asset beyond 100 years, if it is in good condition. However where capacity is an issue, and level of service is compromised, renewals will be necessary.

The catchment specific approach for this issue is to maintain or improve the existing level of service in the network as follows:

- Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances).
- Undertake pipe renewals programme as scheduled (with older pipes prioritised).
- Use customer complaints and 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.

Where appropriate, upgrades will be planned in hydraulic bottleneck locations to provide a 'quick win' in terms of increased network performance. Relieving the effect of hydraulic bottlenecks will then change the hydraulic performance of the system from 'downstream control' to 'upstream control', resulting in enhanced effectiveness of at-source control or local network upgrades. Pump station optimisation is also essential to ensure that the network is operating effectively.

Customer complaints and the ROS can also be used to gauge satisfaction with the stormwater system performance. In 2010, 63 % of the respondents in the South Dunedin sector of the ROS were either satisfied or very satisfied with the stormwater collection service.

Table 12-1: Stormwater Design Criteria

Function	AEP %	Return Period (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

Identification of critical pipes is currently underway via the criticality project being developed by DCC (refer Section 4.7.3). Preliminary analysis of the areas defined as 'critical' show that there are a small number of locations in the South Dunedin catchment where the pipe network intersects a critical property parcel. Predominantly the 'critical' pipes are likely to be in the vicinity of Andersons Bay Road, which is identified as economically critical as it is a major transport route. This information affects the scheduling of pipe network upgrades, or renewals. Prioritisation of these pipes would increase the network level of service in the location of the new pipe. However, as hydraulic analysis discussions later in this section will indicate, little benefit will be gained elsewhere in the South Dunedin network.

12.2.8 Flood Hazard (Current and Future) – Manage Passively

Flooding during the 1 in 100 yr ARI rainfall event is predicted to be widespread in the South Dunedin catchment. Because of the low capacity of the network, flooding of properties and roads during an event this large is unavoidable. Some benefits will 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 no increase in number of properties predicted to flood in a 1 in 100 yr ARI rainfall event between the current and future scenarios.
- 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.
- Ensure transport routes around flooding areas are available.

Option SD 21: Develop Emergency Response Plan

The flatness of the South Dunedin catchment results in relatively shallow, slow-moving flood waters. This decreases the risk to public health and safety, and provides an opportunity to manage the response to flooding.

Because of South Dunedin's grid road network, and a number of entrance and exit points to the catchment (with the exception of access to the peninsula), an emergency response plan could be prepared to ensure that evacuation from flooded areas was possible during a large storm event. Re-direction of bus routes and major transport routes would also be possible.

An emergency response plan could also include the identification of vulnerable households and premises such as retirement villages and schools, and provide a specific evacuation plan for these.

Option SD 22: Protect Critical Infrastructure

A number of areas with critical infrastructure have been identified as at risk during the 1 in 100 year flood event. These include areas of Andersons Bay Road, Kings and Queens High School, MacAndrew Intermediate School, and the roads in the Portobello Road Pump Station area.

This option may involve the use of protection, detention or conveyance methods to reduce flood levels in these critical areas. A number of options may be available at each location, including the following:

- Surface Detention – redirecting flows using overland flow paths and bunds, using either nearby parks or fields (in the case of the schools), or sacrificing car parking areas of commercial premises (for Andersons Bay Road) for storage of floodwaters.

- Network improvements and / or storage – increasing the network capacity in particular areas to convey large flows away from the critical areas. Given the low capacity of the South Dunedin network, this would result in flooding downstream. This may be manageable if sacrificial flood areas are available. In the case of the Portobello Road Pump Station area, it may be possible to direct excessive flows into the Otago Harbour to avoid floodwaters restricting access to the peninsula.

- Property flood-proofing – modification to vulnerable buildings might include amendments to electrical equipment, provision of 'safe' areas, and moveable fittings. This would reduce the consequence of a major flood event.

Because this issue has been prioritised for passive management, it is anticipated that the emergency response planning undertaken on a city-wide basis as a part of the climate change adaptation process, would provide guidance in terms of managing this issue in the South Dunedin catchment.

12.2.9 Network Condition and Age – Manage Passively

There are a large number of older pipes in the South Dunedin catchment. Age is, however, not the only indicator of criticality, and DCC are currently undertaking a criticality assessment of the stormwater system city-wide. The objectives with respect to pipe condition are to use the criticality assessment as the driver for pipe replacement, and also to ensure that new pipes meet the design level of service for new pipes. Pipe upgrades, as discussed above, will also need to be designed to adapt to climate change if this cannot be managed at-source.

Upgrading these pipes to a 1 in 10 year design level of service would provide additional capacity in these areas, although it is likely that these works would need to proceed in conjunction with further works downstream. This would relieve hydraulic bottlenecks to ensure the additional flows could be conveyed to the pump station without exacerbating flooding.

As will be discussed below under stormwater contamination, CCTV survey could be undertaken in contaminated sites to review the condition of pipes, and the likelihood of contaminant ingress.

12.2.10 Nuisance Flooding – Manage Passively

Nuisance flooding in the South Dunedin catchment is predicted to be widespread, due to the low level of service provided by the stormwater system, coupled with the flatness of the catchment. 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.

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 and conveyance up to a 1 in 10 yr ARI rainfall event (as outlined in Table 12-1). It is likely that this, along with planned pipe renewals, will somewhat relieve the frequent nuisance flooding in the catchment over time. Additionally, the main areas experiencing nuisance flooding are being investigated under hydraulic bottleneck issues – nuisance flooding will therefore also abate if capital works or flood management options are implemented in these locations.

12.2.11 Network Maintenance – Manage Passively

Flooding extents and durations in the South Dunedin catchment could potentially be exacerbated should critical catchpits not be adequately cleaned. Silt build up in the pipes is also a risk, due to the flatness of the pipe gradients.

The cleaning of the intake screen has a clear effect on catchment hydraulics. Therefore when assessing flood risk, consideration should be given to the extent of screen blockage. A clearer understanding of the regularity and effectiveness of screen cleaning would provide greater confidence in the catchment modelling.

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 the South Dunedin catchment, the inlet screen to the pumping station would be included, along with catchpits in locations where hydraulic bottlenecks exist, to ensure that floodwaters return to the network as quickly as possible.

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

The stormwater quality data collected to date indicates that stormwater from the South Dunedin catchment may have slightly elevated levels of some contaminants (refer Section 12.2.13 below for options relating to this issue).

Information collected to date city-wide indicates that 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 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.

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:

Option SD 23: 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 sediment 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.

12.2.13 Ongoing Stormwater Discharge – Manage Actively

Targets for contaminant discharge look to reduce the contaminant load in stormwater discharges occurring as related to new development. Currently, DCC are unable to set a target for total contaminant discharge from the catchment, due to insufficient data relating to effects on the environment and the extent of contamination within the water column in the Otago Harbour (as identified in Option 12.2.12 above).

Catchment specific approaches applied in other Dunedin catchments include the consideration of stormwater quality treatment when undertaking stormwater capital works, the use of source control by new developments, and education of owners of high contaminant producing sites to ensure there is no deterioration of stormwater quality due to land use change of development in the catchment.

Further to this, because of the elevated contaminants measured in the South Dunedin catchment stormwater, a target for confirming stormwater quality, and identifying the most likely sources of heavy metals and PAHs in the catchment has been set, with a view to undertaking work to eliminate contaminants at source, or implementing targeted stormwater treatment. In parallel, identifying the source of PAH contamination is discussed in Section 12.2.14.

With respect to future development, increased stormwater contamination due to new developments is unacceptable to DCC. While targets for stormwater discharge quality are still to be determined, it is essential that new development does not increase the concentration of contaminants in the stormwater.

Management of existing (and new) industrial stormwater discharges should be highlighted as important in this catchment, and can be undertaken via a number of mechanisms, as follows:

- Development controls – DCC have preference for at-source management and low impact stormwater design in the code of subdivision and development.

- District Plan Rules – permitted activity rules for industrial land use could specify stormwater treatment or set standards for discharge quality.

- Trade Waste Bylaws – following on from the definition of permitted activities, trade waste discharge permits would be required for discharges not permitted by the district plan. The use of trade waste permits in South Dunedin would remove some contaminated stormwater from the harbour discharge, and divert it to the WWTP. Standards set in a trade waste bylaw would reflect treatment capabilities at the WWTPs.

- Education and Assistance – Inspections of industrial premises could be undertaken to ensure that adequate site management practices are in place. Assistance could be provided by DCC to help achieve higher stormwater quality.

Option SD 24: Confirmation of Heavy Metal Sources and Development of Targeted Stormwater Treatment

Because end of pipe, catchment based treatment requires significant land investment, targeted stormwater treatment would possibly be an effective alternative in the South Dunedin catchment.

Heavily trafficked roads and kerbless roads adjacent to the harbour should be key targets for stormwater treatment. Options for consideration for road treatment include the installation of catchpit filters along heavily trafficked roads, and / or the installation of swales along heavily trafficked roads, and adjacent to kerbless roads.

Zinc discharge in stormwater from South Dunedin has been attributed to residential roof types in the catchment. Options for the removal of zinc from the stormwater system at source, or treatment on a catchment wide basis will need to be explored in order to target zinc removal, should stormwater targets be developed that require a reduction in zinc.

Additionally, industry in the area should be encouraged to avoid generation of contaminants, or treat stormwater at-source.

The first step in the development of this option would be further stormwater monitoring to confirm the likely source of contaminants in the catchment; further to this, contaminant-specific stormwater management approached can be developed.

Option SD 25: Installation of Catchment-based Stormwater Treatment

The installation of catchment or sub-catchment based stormwater treatment could be undertaken by DCC, and developer contributions sought to fund part of the facility. Potential infill and development lots are scattered throughout South Dunedin, with a few areas of more intense possible future development. The majority of the potential infill areas are in the area between Bay View Road and Queens Drive. Catchment-based stormwater treatment for this area would therefore need to be located near the intersection with Andersons Bay Road. Options for treatment could include proprietary devices, wetlands, ponds, or swale / rain garden systems.

12.2.14 Point Source PAH contamination – Manage Actively

PAH contamination of stormwater and harbour sediments is a key issue for the South Dunedin catchment. The catchment management approach based around locating and addressing point source discharge of PAH is vital to achieving the strategic objective of reduction of contaminants in stormwater. An alternative option is to provide stormwater treatment at the base of the catchment. This would have an additional benefit of removing other contaminants from the stormwater, however with respect to PAH removal, a more targeted approach is warranted. Catchment based stormwater treatment is identified as an option under the above issue relating to ongoing stormwater contaminant discharge (Section 12.2.13).

Option SD 26: Confirmation of PAH Sources

It is suspected that a point source PAH discharge exists in the catchment. In order to confirm this, further monitoring of the stormwater quality in the area may be required in conjunction with the location and CCTV inspection of pipelines intersecting known contaminated sites. Evidence of PAH contamination within pipelines and catchpits may be found to provide further evidence. Following from the confirmation of a PAH source, options for removal of the contaminant from stormwater at source could be developed. These could include the remediation of contaminated sites, containment of the contaminants, or diversion of stormwater around the sites.

12.2.15 Historical Harbour Sediment Contamination – Manage Passively

A target of lowering contaminants in sediments to below the ANZECC high trigger value within 20 years has been identified with respect to the sediment contamination. This will, however, need to be confirmed and reassessed once further monitoring has been undertaken to confirm sediment deposition rates in the harbour (Refer Section 12.2.12).

Ryder Consulting undertook a study in 2006 entitled 'Remediation of Contaminated Sediments off the Portobello Road Stormwater Outfall: a proposed course of action'. This study investigated the extent of contamination, both in distance from the outfall, and in depth of sediment. There was some evidence that contamination is limited do depths of less than 300 mm in harbour sediments, but further information would be required to gain more certainty. A number of remediation options were outlined. However, invasive options such as removal of contaminant sediment from the harbour, or covering sediment with clean sediment or concrete, are considered deal breakers. These options do not fit with the 'manage passively' prioritisation, and also may cause greater negative environmental impacts than the 'do nothing' option by disturbing and releasing contaminants into the harbour environment.

Option SD 27: Monitored Natural Recovery

Options developed to reduce stormwater contaminant discharge into the harbour should increase the overall quality of the harbour sediment. Stormwater quality is likely to be better than that discharged historically, and it is likely that a layer of cleaner sediment will cap the historical contaminated sediment, resulting in older sediments which contain the highest levels of contaminants being less likely to be disturbed by wave action, or accessed by sea life.

Other processes involved are natural transformation processes, which convert the contaminants to less toxic forms. Ongoing monitoring of harbour contamination and ecological health would confirm or otherwise, that the contaminated harbour sediment was becoming less available, and ecological health was improving over time. Risks of the issue could be re-assessed on the basis of monitoring data.

Further sediment analysis could be undertaken in the harbour to detail the extent, depth and composition of the contaminated sediment. Ryder (2006) suggests that Whole Effluent Toxicity Tests (WETT) could be undertaken to determine toxicity of the sediments, and also that finer increments of samples over a larger area could be taken (other than 300 mm and 500 mm depths sampled to date) to determine changes in sediment composition over time (historically), and further detail the extent of contamination in the upper harbour. The results from this study may provide more confidence in the targets set for sediment remediation.

13 Integration

13.1 General

A key driver for the 3 Waters Strategy Project and indeed for the re-organisation of the DCC Water and Services 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. One such issue has been identified for investigation in this ICMP.

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, however none are known to exist in the South Dunedin catchment. 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.

The most critical trunk wastewater sewer is the main intercepting sewer (MIS), which begins at Harrow Street in North Dunedin and conveys wastewater through South Dunedin to the Musselburgh Pump Station.

The most critical pump station in Dunedin is the Musselburgh Pump Station, which is in the South Dunedin catchment, as all wastewater is conveyed from this pump station to the Tahuna WWTP. Capital investment is scheduled for the improvement of screens and/or bypass at Musselburgh Pump Station.

Some historical customer complaints and operational issues were recorded for the Surrey Street area of South Dunedin catchment. In general, these relate to a combination of wastewater and stormwater flooding. This has been investigated recently as a capital works project, with options identified for better management of wastewater and stormwater flows in the area to reduce the likelihood of wastewater network surcharge.

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.

Table 14-1: Option Assessment Criteria and Scoring System

QBL (weighting)	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 yr ARI event.	Replicates or reduces current flow patterns up to 1 in 10 yr ARI event.	Replicates or reduces current flow patterns up to a 1 in 100 yr ARI 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 (weighting)	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 (weighting)	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 yr ARI 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.

14.2 Shortlist of Infrastructural Options

Options for the manage actively flood related issues developed in Section 12 have been preliminarily evaluated using the hydraulic model and a qualitative assessment to determine technical feasibility and likelihood of meeting the targets set for this catchment.

Areas of potential habitable floor flooding are located throughout the catchment, with the majority in the following two areas during small events:

1. Hillside Road – Burns Street / Law Street / Baker Street and Glasgow Street;
2. Royal Crescent area – Cavell Street.

Hydraulic modelling of a number of options was used to assess the likely effectiveness of the options for reducing flooding. The one-dimensional component of the InfoWorks CS model was used to calculate 'flood volume', or the amount of water leaving the pipe network during the 1 in 10 year storm event. The two-dimensional model was not run for all option scenarios due to long run times and result extraction.

Table 14-2 presents the calculated flood volume for each modelled option, and provides a percentage reduction when compared to the 'do nothing' option. During the hydraulic analysis, it was discovered that due to the flatness and layout of the pipe network, it is difficult to isolate effects of any particular option to one area. Flood volume comparisons were therefore assessed on a whole network basis.

Further to the one-dimensional analysis, the two-dimensional model was run for a number of options to determine if there would be an effect on predicted property flooding. Results from two of the options (SD17 – Swales, SD14 – Bay View Diversion) showed that reduction in predicted property flooding was almost imperceptible. During the development of the options, it became clear that the low capacity of the network throughout the catchment meant that the removal of hydraulic bottlenecks did not provide any significant gain in terms of predicted property flooding.

Infrastructural options would therefore always require extensive detention, or major upgrades of one or more of the main laterals down Hillside Road, Macandrew Road, Bay View Road, as well as Andersons Bay Road. It was therefore decided that the infrastructural solutions would be grouped together for comparison with non-infrastructural options.

Table 14-2: Modelled Preliminary Options; One-Dimensional InfoWorks Model

Area	Option Number	Description	Flood Volume (m^3)	% Flood Volume Reduced Catchment-wide	Comment
Whole network	0	No Change – Existing network.	34847		
Hillside Road North and South	SD1a	Upsize the northern Hillside Road from 400, 475 and 475 to 1050 mm.	34591	< 1 %	Local infrastructure options. Grade lines did not show improvement due to downstream control.
	SD1b	SD1a and southern Hillside Road upsized from Reid Street and Andersons Bay Road to 1050 mm.	33863	3 %	
	SD2	Addition of 6 cross connections to divert water between the northern and southern Hillside Road systems.	34832	0 %	No effect on flood volumes.
	SD3	Upsize the Southern Hillside Road main from 375 mm to 1050 mm.	33627	4 %	Hydraulic grade line not reduced significantly therefore flooding of laterals still features.
	SD4	Northern and Southern Hillside Road mains disconnected from the system (free outfall).	31355	10 %	Not technically feasible to provide a gravity line to a new outfall.
	SD5	Northern and Southern Hillside Road mains disconnected from the system and pumped out with 3 pumps.	31339	10 %	Assumes rising main can be connected to the Orari Street outfall, or new outfall constructed.
	SD6	Detention Pond in Bathgate Park.	32828	6 %	Local solution.
	SD6a	Combination of SD5 and SD6.	30665	12 %	Detention pond may be required to provide capacity in existing Hillside Road system.

Area	Option Number	Description	Flood Volume (m^3)	% Flood Volume Reduced Catchment-wide	Comment
Portobello Road	SD7	3 cross connections that divert water from the western Andersons Bay Road line into the eastern line.	34312	2 %	Little effect on upstream hydraulics.
	SD8	Add a third link along Portobello Road to the pump station.	33274	5 %	May provide extra capacity to enable upgrades upstream.
	SD9	Removal of screen.	33110	5 %	Removal of screen not possible, however modifications to screen could improve network performance.
	SD10	Enlargement of the chamber prior to the screen.	34843	0 %	No effect on flood volumes.
Ascot Street / Royal Crescent	SD11	Remove of bottleneck along Ascot Street: pipes increased from diameter 300 mm to 600 mm.	34655	< 1 %	May provide local relief, but dependent on works undertaken downstream.
	SD12	Remove of bottle neck along Gourley Street: pipes increased from diameter 200 mm and 225 mm to 400 mm.	34823	< 1 %	Resolves flooding in 1 in 3.8 yr ARI rainfall event, reduces grade line slightly in 1 in 10. Design could be modified to resolve 1 in 10 year flooding, however downstream capacity would need to be provided.
	SD13	Queens Dr pipes upsized from diameter 300 mm to 750mm and Royal Crescent pipes from 600 mm to 850 mm.	34316	2 %	May provide local relief, but dependent on works undertaken downstream.
Bay View Road	SD14	Add a third line that collects the water from the Bay View Road and New Street and discharges into Portobello PS (7 pumps).	30300	13 %	Removes large part of the network from Portobello Road bottleneck. Under capacity of system upstream still causes flooding.

Area	Option Number	Description	Flood Volume (m^3)	% Flood Volume Reduced Catchment-wide	Comment
Whole Network	SD17	20 ha of swales throughout network.	32657	6 %	Implementation of swales fits well with DCC's preferred approach. Little effect on catchment flooding.
	18a	5 % imperviousness reduction.	34559	< 1 %	Catchment pervious areas have low perviousness values due to high groundwater and low drainage potential.
	18b	10 % imperviousness reduction.	34277	2 %	
	18c	20 % imperviousness reduction.	33714	3 %	
Tainui	n/a	Wet well added, and 2 rotodynamic pumps included in addition to the 3 existing axial pumps.	34808	< 1 %	Shows that flooding issues upstream are not pump station related.
Pump Station Optimisation	SD20a	Switch on levels decreased to below invert of incoming pipes (eliminates backwater).	34690	<1 %	Optimising pump station will ensure water is leaving catchment; eliminates downstream control so allows for upstream options to be implemented.
	SD20b	SD20a plus additional pumps in pump station.	34577	< 1 %	

14.3 Options Comparison

Potential options for stormwater quantity and stormwater quality issues are outlined and evaluated below. In some cases, only a single option has been presented (for example with respect to the variability of stormwater quality results), therefore option comparison has not been necessary.

14.3.1 Stormwater Quantity Options

The modelling indicates that there is little opportunity for localised network upgrades in the South Dunedin catchment which could provide quick wins in terms of reducing flood risk. Major upgrades across the catchment are required to provide the network capacity for the large events that cause the majority of the flood risk.

The benefits of stormwater quantity options affect both flood hazard risk as well as network operation targets. From the preliminary options identified, four alternatives have been identified:

- Infrastructural – network upgrades across the whole catchment;
- Operational – modification of intake screens, pump station optimisation and network maintenance;
- Planning – amendments to council plans and design guidelines, development of action plans; and
- Individual – Targeted at critical infrastructure or individual or groups of at-risk properties.

As each of these options is very different in terms of the detail and scale of implementation, using the QBL criteria developed above would not provide a valuable comparison. If further detailed options are developed, then the criteria could be used for direct comparison (for example to compare solutions at a specific location). At this scale, broad QBL assessment is undertaken as detailed in Table 14-3, with +10 and +5 indicating strong and moderate positive effects, 0 indicating a neutral score, and -5 and -10 moderate and strong negative effects, respectively. Criteria in Table 14-1 above have been used as guidance for scoring.

Table 14-3: Stormwater Quantity Options Evaluation

Option Assessment Criteria (weighting)	Infrastructural Options	Operational modifications	Plans and guidelines modification	Individual Property and critical infrastructure Protection
Environmental (e.g. contaminant management opportunities) (10)	+5 Infrastructural options have an opportunity to incorporate contaminant management.	0 Neutral – operational modifications to pump station and screens not related to contaminant targets.	+5 Provides an opportunity to include contaminant management and volume control at source in all future development..	+5 At-site contaminant management possible to incorporate as part of property flood mitigation.
Social (e.g. disruption during construction, community support) (10)	+5 Major disruption to traffic and residents during construction. Some support likely.	0 Making best use of current resources.	+5 Support as low cost and using existing tools.	+ 5 Some support. Minor disruption to traffic and residents as localised work.
Cultural (e.g. fit with iwi values, consideration of heritage sites) (10)	-5 Large infrastructure not preferred options for iwi.	+5 Improving on whole of catchment management by operating current assets well.	+5 Good fit with cultural values by encouraging at-source management.	0 Could incorporate at-source options. Targeted approach not consistent with whole of catchment management.
Implementation Risk (risk of operational failure) (20)	+10 Proven technology.	+5 Possible risk, due to tinkering with currently operating system.	+10 Already utilised.	0 Possibly complicated technology.
Economic (capital cost, risk of cost escalation) (10)	-10 Major cost (> $ 10m)	+5 Minor cost (< $ 1m)	+10 Low cost (< $ 500k)	-5 Moderately large cost ($ 2 - $ 10m)
Effectiveness (risk reduction) (30)	+10 Major benefits catchment wide with respect to flood mitigation and network level of service.	0 Minor improvements.	0 Future proofing with respect to flood mitigation. Limited opportunities as small number of sites open to development.	+10 Able to meet flood mitigation targets for habitable floors.
Weighted Score:	**450**	**200**	**400**	**350**

14.3.2 Stormwater Quality Options

Because a number of the stormwater quality targets are yet to be set (dependent on analysis of the effects of the discharge on harbour water quality), a limited set of options are presented here for comparison and evaluation.

Of the 'manage actively' stormwater quality issues, only the issue of ongoing stormwater discharge has more than one option: confirmation of heavy metal sources and development of targeted stormwater treatment, or installation of catchment based stormwater treatment. The options evaluation criteria outlined in Table 14-1 has been used to compare these options, with the removal of the wastewater connections and I&I criteria due to non-relevance. Table 14-4 presents this comparison, with an equal weighting given to each QBL category.

Table 14-4: Ongoing Stormwater Discharge Options Comparison

QBL Assessment Criteria	Category Weighting	Sub-weighting	Option		
			SD24 - Targeted SW Treatment	SD25 - Catchment-Based Treatment	Comment
Removal of known wastewater cross connections	10	N/A	N/A	N/A	Not Applicable.
Contaminant Reduction		1.67	5	0	Targeted treatment likely to remove more contaminants, assuming sources identified and manageable.
Use of Source Control / LID		1.67	0	-5	Site-based in-line treatment, vs. end of pipe.
I&I reduction		1.67	5	-10	Some inflow points may be identified during on-site investigations.
Construction effects		1.67	5	5	Minimal / controlled disturbance by either method.
Replication of current flow patterns		1.67	-5	-5	At-site control more likely to replicate current flow paths than treatment device for larger area, however treating smaller area.
Option flexibility		1.67	5	0	Both can be staged, however more flexibility with at-source controls.
Interest / support of community / social interest groups	10	10	5	5	Likely to be support for either option.
Fit with Māori cultural values	10	10	5	0	LID recommended approach.

QBL Assessment Criteria	Category Weighting	Sub-weighting	Option		
			SD24 - Targeted SW Treatment	SD25 - Catchment-Based Treatment	Comment
Risk of operational failure	20	20	0	5	Catchment based treatment ensures DCC control; on site vested in property owner.
Estimated Capital Cost - order of magnitude (note does not allow for internal costs)	10	2.5	0	-5	Catchment based option likely to be more expensive as treating larger flows.
Risk of cost escalation due to construction unknowns		2.5	5	-5	Fewer alternatives with catchment-based treatment.
Risk of land availability		2.5	5	-5	Land must be purchased for catchment based treatment; existing land used for site based.
Risk of protracted consent process with authorities		2.5	5	0	Larger works require more complex consents.
Risk Reduction	30	7.5	5	5	Both systems would be designed to reduce risk.
Deep flooding 1 in 50 yr future-current		7.5	0	0	Catchment based treatment provides attenuation at end of pipe; targeted treatment may provide detention further up catchment. Depends on options implemented.
Manholes overflowing 1 in 10 yr - future-current		7.5	0	0	
Improvement in level of service		7.5	5	0	
Weighted Total Score:			**238**	**125**	

15 Option Selection

15.1 Approaches for Active Management

Comparison of options for stormwater quantity management in the South Dunedin catchment ranks the alternative approaches for active management of stormwater quantity issues as follows:

1. Infrastructural Options;
2. Plans and Guidelines Modifications;
3. Individual Property and Critical Infrastructure Protection; and
4. Operational Modifications.

It should be noted that while Option 1 has scored the highest in terms of the QBL assessment, implementation of Options 2 and 4 would provide an opportunity to improve overall catchment network levels of service. Prior to the commencement of infrastructural upgrades, flood level surveys should be undertaken to confirm the extent of potential habitable floor flooding. Additionally, the pipe renewals programme should be run in conjunction with the recommended upgrades, to maximise investment benefits.

Further to this comparison, the following options are recommended for adoption, with no alternatives being presented:

- Further modelling, combining the South Dunedin hydraulic model with the St Clair, Shore Street, Orari Street and potentially Kitchener Street models, to better understand the linkages between the catchments.
- Undertaking pipe condition assessment as part of the pipe renewals process, to ensure that critical pipes are targeted for renewal.

The following options are also highlighted as being acceptable options for pursuit in terms of stormwater quality management:

- Redesign and implement the city-wide framework for stormwater quality and harbour environment monitoring.
- Educate owners of high-risk land uses with respect to contaminant generation, to encourage at-site mitigation.
- Locate and manage suspected point-source PAH discharge.

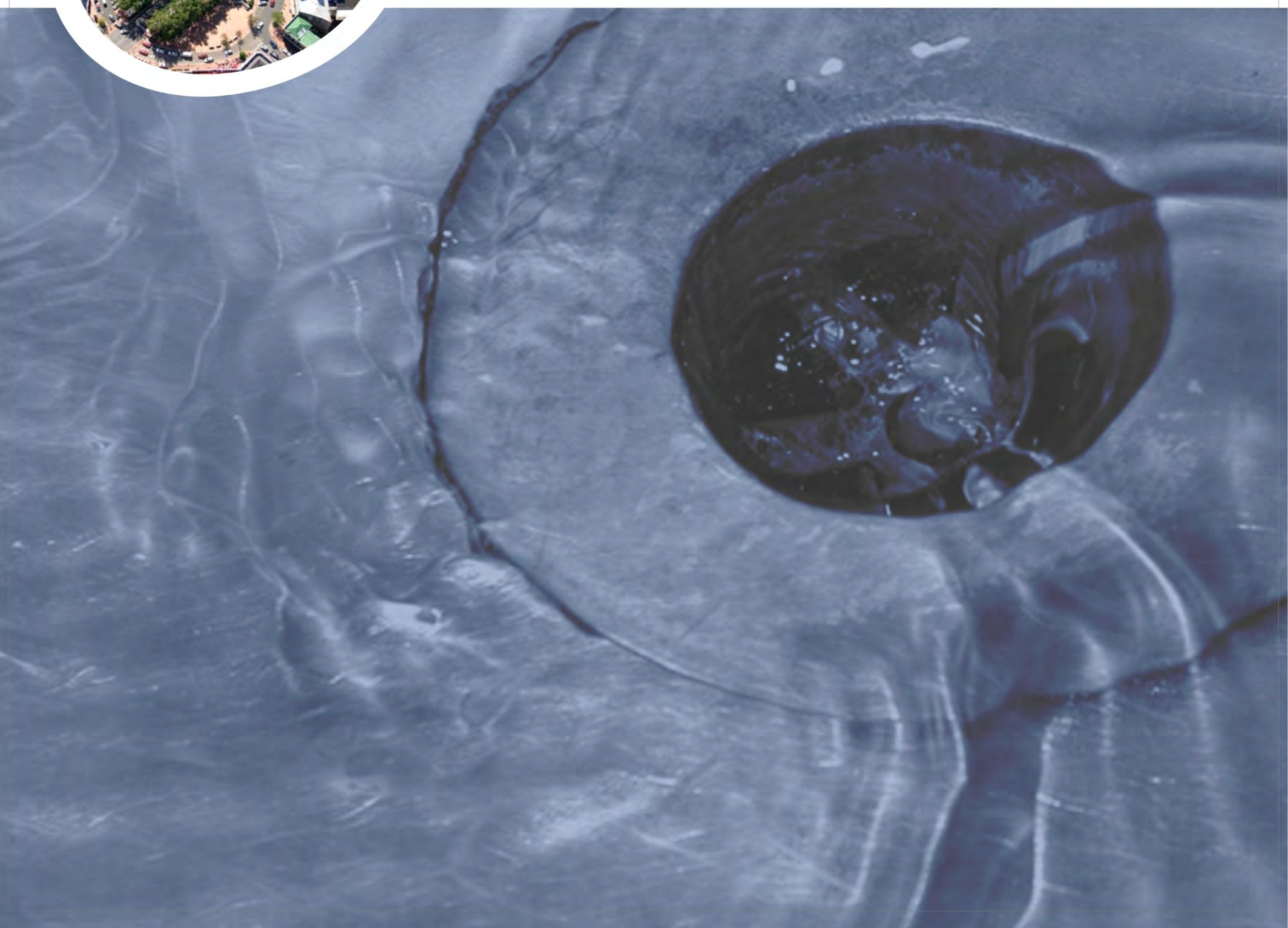
A comparison between targeted at – source stormwater management and catchment based stormwater treatment was made in order to identify the best option for managing ongoing stormwater discharge in the catchment (with indications of unacceptable levels of some contaminants). Targeted stormwater treatment / management scored the highest, however investigations will be required to identify likely sources of contaminants. For example, roof inspection might assist in identifying zinc sources, and an analysis of highly trafficked roads would lead to stormwater treatment in particular areas being targeted. Monitoring to identify heavy metal sources could be combined with recommended monitoring to track PAH discharges.

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.
- Utilise ROS information to continuously gauge customer satisfaction with the stormwater service.
- Provide information regarding predicted future flooding to the climate change adaptation team.
- Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.

Part 6
Way Forward



16 Recommendations

The following tables provide a list of recommendations relating to stormwater management in the South Dunedin catchment, and provides an indicative cost and work period for each recommendation. The recommendations are listed in order of priority, relating to the risk matrix score assigned to each issue during 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, capital works, and operation and maintenance 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
160	Undertake further stormwater monitoring to investigate the extent of potential PAH and heavy metal contamination and likely sources within the catchment.	$ 100 k	12 months
120	Combine the South Dunedin, Shore Street, Orari Street and St Clair 1-D and 2-D stormwater models.	$ 40 k	6 months
120	Identify and undertake floor level survey and damage assessment of properties potentially internally affected by deep flooding (up to a 1 in 50 yr ARI).	$ 20 k	3 - 6 months
50	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
160	Work with ORC to develop a plan for education programmes in relation to best practice site management of industrial premises.	$ 20 k	6 months
50	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	$ 0	2 months
40	Contribute information to a city-wide climate change adaptation plan.	$ 0	6 - 12 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
160	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance.	$ 20 k	3 - 6 months
160	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	$ 20 k	2 months
50	Ensure planned renewals are designed to accommodate a 1 in 10 yr ARI rainfall event and incorporate allowances for climate change.	$ 0	Annual

Table 16-4: Capital Works Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
200	Progressively develop and implement infrastructural upgrades to reduce critical location flooding in 1 in 10 yr ARI through to 1 in 50 yr ARI events.	tba	tba

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 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 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 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 targets have been established for discharge stormwater quality, the PAH source has been located, and potential habitable floor surveys are complete;
2. When targets are adjusted (i.e. due to changes in climate change predictions); and
3. As monitoring data is collected and reviewed for trends. The following regular monitoring and reporting would provide feedback with respect to the targets set for this catchment;
    - Harbour sediment monitoring;
    - Stormwater discharge quality monitoring; and
    - Flood complaints.

18 References

Australian and New Zealand Environment Conservation Council (2000). *Australia and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 1: The Guidelines.* National Water Quality Management Strategy – Paper No. 4.

Auckland Regional Council (2005). *Sources and loads of metals in urban stormwater.* Auckland Regional Council Technical Publication No ARC04104, based on report prepared for ARC by NIWA, June 2005.

Bishop, D.G. and Turnbull, I.M. (comp) (1996). *Geology of the Dunedin area.* Institute of Geological & Nuclear Sciences 1:250,000 geological map 21. Lower Hutt, New Zealand.

Brown, J.N. and Peake, B.M. (2006). *Sources of heavy metals and polycyclic aromatic hydrocarbons in urban stormwater runoff.* Science of the Total Environment **359**:145-155

Christchurch City Council (2003). *Waterways, Wetlands and Drainage Guide. Part B: Design.* Christchurch, New Zealand.

Dunedin City Council (2007). *Rainfall and Flooding Event of 30 July 2007.* Internal DCC report by Asset Management and Development Team Leader, September 2007.

Grove, S.L and Probert, P.K (1999). *Sediment macrobenthos of upper Otago Harbour, New Zealand.* New Zealand Journal of Marine and Freshwater Research, **33**: 469-480.

Käi Tahu ki Otago Ltd (2005). *Cultural Impact Assessment Discharges of Stormwater Otago Harbour and Second Beach.* Report prepared for Dunedin City Council, October 2005.

Metcalf & Eddy (1991). *Wastewater Engineering: Treatment, Disposal and Reuse.* 3rd Edition. McGraw Hill Education.

MWH (2005). *7 February 2005 Flood Event.* Client report prepared for Dunedin City Council, April 2005.

MWH (2006). *April 2006 Storm Reporting.* Client report prepared for Dunedin City Council, June 2006.

Otago Regional Council (2009). *Regional Plan: Coast for Otago.* Dunedin, New Zealand.

Ryder Consulting (2010a). *Ecological Assessment of Dunedin's Marine Stormwater Outfalls.* Dunedin 3 Waters Strategy. Client report prepared for Dunedin City Council, June 2010.

Ryder Consulting (2010b). *Compliance Monitoring 2010. Stormwater Discharges from Dunedin City. ORC Resource Consents 2002.080 – 2002.110 and 2006.222.* Client report prepared for Dunedin City Council, July 2010.

Ryder Consulting Ltd. (2009). *Compliance Monitoring 2009. Stormwater Discharges from Dunedin City*. ORC Resource Consents 2002.080 – 2002.110 and 2006.222. Client report prepared for Dunedin City Council, July 2009.

Ryder Consulting Ltd. (2008). *Compliance Monitoring 2008. Stormwater Discharges from Dunedin City*. ORC Resource Consents 2002.080 – 2002.110 and 2006.222. Client report prepared for Dunedin City Council, July 2008.

Ryder Consulting Ltd. (2007). *Compliance Monitoring 2007. Stormwater Discharges from Dunedin City*. ORC Resource Consents yet to be granted. Client report prepared for Dunedin City Council, July 2008.

Ryder Consulting Ltd. (2006). *Remediation of Contaminated Sediments off the South Dunedin Stormwater Outfall: A proposed course of action*. Client report prepared for DCC, December 2006.

Ryder Consulting Ltd. (2005a). *Characterisation of Dunedin's Urban Stormwater Discharges & Their Effect on The Upper Harbour Basin Coastal Environment*. Client report prepared for DCC, February 2005.

Ryder Consulting Ltd. (2005b). *Spatial Distribution of Contaminants in Sediments off the South Dunedin Stormwater Outfall*. Client Report prepared for DCC, October 2005.

Smith, A.M and Croot, P.L (1993). *A flushing time for Upper Otago Harbour, Dunedin, New Zealand.* A report to the Otago Regional Council. Department of Marine Science, University of Otago, Dunedin, New Zealand.

Smith, A.M (2007). *Marine Sedimentation and Coastal Processes on the Otago Coast.* Report to the Otago Regional Council. Department of Marine Science, University of Otago, Dunedin.

URS (2008). *Dunedin 3 Waters Strategy, Stormwater Catchment Prioritisation Framework.* Client report prepared for DCC.

URS (2011a). *Dunedin City Imperviousness, Dunedin 3 Waters Strategy*. 8 August 2011.

URS (2011b). *Dunedin Integrated Catchment Management Plans: Rainfall and Tidal Analysis Report, Dunedin 3 Waters Strategy*. 8 August 2011.

URS (2011c). *Dunedin 3 Waters Strategy, South Dunedin Model Report.* Client report prepared for DCC.

U.S Department of Transportation Federal Highway Administration (1990). *Pollutant loadings and impacts from highway stormwater runoff Volume 1: Design Procedure.*

Van Valkenhoed, B, and Wright, A (2009). *Salt Water Intrusion Investigation November 2008 – February 2009.* Internal DCC report.

Wendelborn, A., Mudde, G., Deletic, A., and Dillon, P. (2005). *Research on Metals in Stormwater for aquifer storage and recovery in alluvial aquifers in Melbourne, Australia.* ASMAR Aquifer Recharge 5th international symposium, 10-16 June 2005, Berlin.

Zollhoefer, J (2008). *Brookhaven wetland swale, Christchurch: Stormwater Analysis and Ecological Assessment.* Technical report prepared for Christchurch City Council, Eliot Sinclair & Partners Limited, July 2008.