Dunedin 3 Waters Strategy

Halsey Street Integrated Catchment Management Plan

Halsey Street Integrated Catchment Management Plan 2010-2060

Contract No. 3206
Dunedin 3 Waters Strategy

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Executive Summary

The Halsey Street 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 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 stormwater effects on the harbour's receiving environment.

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 Halsey Street catchment is relatively large, covering an area of approximately 390 ha, characterised by relatively low lying flat land in the lower reaches with increasing steepness towards the head of the catchment. The catchment is predominantly urban with areas of residential, commercial and industrial land use as well as areas of bush cover and grass playing fields. It incorporates the areas of Roslyn, Maori Hill, parts of the university campus and Woodhaugh and a portion of the Harbourside.

The natural stream network in this catchment comprises three streams with natural channels located within the Town Belt. The stream channels are piped upstream receiving flow from an urban residential area. Downstream, at the edge of the Town Belt, the flow within the stream channels diverted via pipework to an outfall discharging to six outfalls in the Otago harbour.

The Otago Harbour is the receiving environment for the stormwater discharges from this catchment. It also receives stormwater and other discharges, at various points throughout the upper harbour. The harbour is 23 km long and has been heavily modified by reclamation, transport causeways and dredging. There are a number of stormwater and other discharge points into the upper harbour, carrying a variety of contaminants. The harbour is considered an important area for recreation and tourism and is of great significance to Māori and others.

Monitoring of the harbour environment has been carried out annually in accordance with the conditions of resource consent for DCC stormwater discharges. To date four rounds of biological, and stormwater quality monitoring have been undertaken (2007 to 2010). Variability in monitoring results and small datasets makes it difficult to establish stormwater quality and identify a link between the stormwater quality and the health of the receiving environment.

A linked 1 and 2-dimensional hydrological and hydraulic model of the Halsey Street catchment and stormwater network was developed to replicate the stormwater system performance, and to predict flood extents during a number of different land use, storm event and climate change scenarios.

Flow monitoring was undertaken for this catchment and the model calibrated to replicate the observed flow, depth and velocity data as well as was possible, confidence in the model is considered to be moderate to high.

An assessment of environmental effects, based on the interpretation of the outcomes of the stormwater network hydraulic modelling; marine and stream 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.

Stormwater issues were prioritised, and management targets and catchment specific approaches were developed for the Halsey Street 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 Halsey Street.

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.

Of all of the issues identified in the catchment, the following were identified as requiring active management:

- Nuisance flooding;
- Blocking / maintenance of intake structures;
- Flood hazard (current and future) (1 in 100 yr Average Recurrence Interval (ARI));
- High variability of stormwater quality results and undefined effects on the Otago harbour environment; and
- Potential wastewater contamination.

The remaining issues were categorised as requiring passive management. This is predominantly due to the location, short duration, or shallow depth of predicted flooding in the catchment.

For the majority of the issues identified in this catchment a limited number of management options were available when taking into account the catchment specific approach and targets set. This resulted in recommendation of all options presented, with a priority placed in according to issue prioritisation.

Tables ES-2 to ES-5 below outline the recommendations, split into further studies, planning and education, operation and maintenance, and capital works 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: Halsey Street Catchment Issues, Approach and Targets Summary

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Potential Wastewater Contamination	High microbial contamination of stormwater, particularly in 2007, 2009 and 2010, may be cause for concern.	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*** Undertake targeted monitoring to enable better understanding of potential catchment contamination. Investigate potential sources of wastewater contamination. Develop appropriate management options to remediate problem where necessary.	Improve data relating to levels microbial contamination and potential sources of contamination within the catchment by 2012. Implement management options to remediate problem where necessary.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Limited Confidence in the Knowledge of Effects on Harbour Environment and Variability of Stormwater Quality Results	High variability of stormwater quality results, any trends in stormwater contaminant levels remain unclear. Poor information on actual effects of stormwater on harbour environment. Lack of data to assess linkages between pipe discharge and harbour environment quality.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. No recorded breaches of the Resource Management Act. Ensure stormwater discharge quality does not deteriorate.	***Manage Actively*** Redesign DCC's monitoring programme to ensure stormwater quality and receiving environment data is collected within a robust framework. Include Halsey Street as a priority catchment in the monitoring programme. 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 and Targets	Catchment Specific Approach	SMART Targets
Nuisance Flooding	Nuisance flooding is predicted on a regular basis in a number of locations in due to hydraulic restrictions throughout the catchment and tidal influence on the lower catchment. Of significance are the effects on London Street and in the central city (vicinity of St Andrew Street). Nuisance flooding may pose a risk to building interiors on George Street. Affects 0.05 % of catchment during 1 in 2 yr ARI rainfall events, and 0.8 % of catchment during a 1 in 10 yr ARI rainfall event.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Actively*** 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). Prioritise the renewals programme to focus on poorly performing areas of the catchment	< 0.05 % of catchment surface area predicted to flood during a 1 in 2 yr ARI rainfall event by 2060. Undertake survey of property owners to determine any occurrence of flooding during high frequency events. > 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.

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

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Flood Hazard – Current and Future 1 in 100 yr ARI	Areas of significant flood hazard in roadways, including State Highway, mostly in central city, predicted during current event. Significant flood hazard in roadways in central city, with increased flood extent, predicted in the future (2060) event predominantly due to tidal inundation, exacerbated by predicted climate change effects.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Actively*** Ensure new development does not increase the number of properties predicted to flood due to the stormwater system in a 1 in 100 yr ARI rainfall event. Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply etc.) from flood hazard. Avoid development of vulnerable sites / critical infrastructure in flood prone areas. Ensure transport routes around flooding areas will be available. Develop a better understanding of the likely effects and magnitude of climate change.	Develop a catchment specific emergency response plan by 2012. Provide modelled flood predictions to DCC Climate Change Adaptation Group to ensure information is taken into account during the development of a city-wide climate change adaptation plan.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Network Maintenance	Flooding extents and durations in Halsey Street 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.	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 Halsey Street catchment requiring additional cleaning and maintenance checks by 2013.
Low Level of Service	16 % of stormwater network cannot accept rainfall from a 1 in 10 yr ARI, driven by both network capacity and tidal influence. Manholes predicted to overflow with pipes flowing full throughout approximately 57 % of system. This low level of service is currently occurring with no capacity for climate change effects. Flooding results in certain locations during a current 1 in 10 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*** Maintain or improve existing level of service in network – ensure no increase in the number of stormwater manholes predicted to overflow in a 1 in 10 yr ARI rainfall event. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Use customer complaints and residents' opinion survey (ROS) to gauge satisfaction with the stormwater system performance.	> 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. < 16 % manholes predicted to overflow during a 1 in 10 yr ARI rainfall event by 2060. < 0.8 % of catchment surface predicted to flood during 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 and Targets	Catchment Specific Approach	SMART Targets
Ongoing Stormwater Discharge	Could exacerbate existing / historical contaminant issues. Extent to which this is likely to occur is unconfirmed. Key stakeholder issue. Based on available data, consequence currently believed to be minor.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	***Manage Passively*** Include Halsey Street as a priority catchment in the monitoring programme. Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high-contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.	No deterioration of stormwater quality due to land use change or development in the catchment. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Deep Flooding	Model results indicate 2 land parcels affected by deep flooding during 1 in 5 yr ARI rainfall event; rises to 32 parcels during 1 in 50 yr ARI rainfall event in current and 56 parcels in future planning scenarios. Large number of properties affected during extreme climate change scenario. A proportion of the deep flooding predicted during high frequency events is predicted exterior to buildings (although surveys not yet undertaken).	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 Passively*** 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. Reduce the number of properties predicted to flood during a current 1 in 10 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).	< 32 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. > 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.

Table ES 2: Further Study Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
200	Undertake further stormwater monitoring to investigate the extent of potential wastewater contamination and likely sources within the catchment.	$ 20 k	6 - 8 months
160	Redesign the city-wide framework for stormwater quality and harbour environment monitoring.	$ 20 k	3 - 6 months
120	Improve quality of stormwater network data through (level survey, GIS (geographic information system) confirmation, CCTV (closed circuit television)).	$ 0	Ongoing
120	Undertake feasibility study to enable preparation of an action plan of stormwater capital works in the catchment.	$ 100 – $ 150 k	tba
40	Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service.	$ 0	Ongoing
30	Identify and undertake floor level survey and damage assessment of properties potentially affected by deep flooding up to a 1 in 50 yr ARI event. (Include properties in George Street commercial area).	$ 20 k	3 - 6 months

Table ES 3: Planning and Education Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
120	Review the education / advice provided to property owners responsible for watercourses to ensure adequate information and assistance is provided.	$ 0	3 - 6 months
70	Develop a city-wide climate change adaptation plan, including ongoing monitoring of climate change predictions, incorporating damage assessment of the vulnerable infrastructure.	$ 0	6 - 12 months
70	Develop an emergency response plan for the catchment to ensure evacuation from flooded areas is possible during a large storm event.	$ 0	6 - 12 months
40	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	$ 0	2 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
120	Ensure damaged screens and / or intake structures on open channels and watercourses are replaced or repaired.	tba	Ongoing
50	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
50	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	$ 20 k	2 months

Table ES 5: Capital Works Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
120	Include additional or improved catchpits in all stormwater capital works.	tba	Ongoing

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, and 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; and
- 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 Halsey Street Integrated Catchment Management Plan (ICMP) 2010-2060 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 (five 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 consents granted for the Halsey Street catchment (via six individual outfalls). Each consent (Consents No. 2002.098, 2002.099, 2002.100, 2002.101, 2002.102, and 2002.103) has a condition which states the following:

> *"In consultation with the Consent Authority, the consent holder shall prepare and forward to the Consent Authority within four years of the commencement of this consent, a Long Term (35 year) Stormwater Catchment Management Plan for the Halsey Street 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 ten largest stormwater catchments discharging to the harbour was undertaken, and identified South Dunedin as the highest priority catchment in terms of stormwater issues (refer *'Dunedin 3 Waters Strategy, Stormwater Catchment Prioritisation Framework'*, URS 2008). Following the development of the ICMP for South Dunedin, the remaining stormwater catchments were re-prioritised, whereby the economic, social, cultural and environmental aspects of the catchments'' assets were gauged based on 12 QBL indicators. The four QBL 'wellbeings' (categories) and 12 indicators were each defined and weighted in consultation with DCC Water and Waste Business Unit 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 remaining nine catchments were then scored against the indicators on a scale of zero to five (zero representing 'no issue' and five, a 'significant issue'), thus producing a final weighted score and ranking of the catchments. The results of this QBL prioritisation assessment are presented in Table 1-1 and further details can be found in the report: *'Phase 2 Stormwater Catchment Prioritisation Framework'* (URS, 2009). The Halsey Street stormwater catchment was ranked first out of nine by this prioritisation, particular issues elevated for this catchment were reported quality and flooding incidents and the potential for stormwater / wastewater interaction.

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: Phase 2 Catchment Prioritisation

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

1.3 Overview

This ICMP comprises six parts:

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.

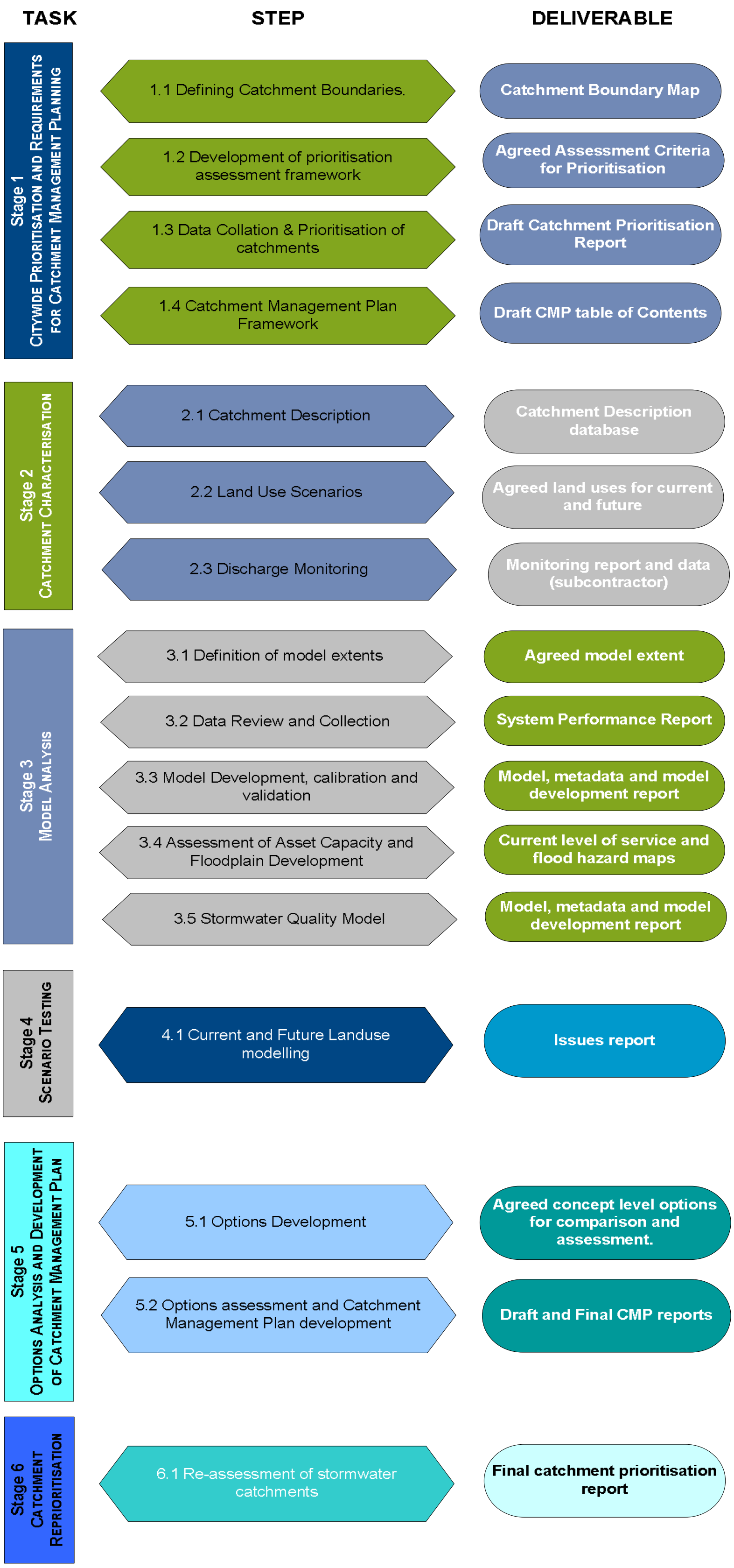


Figure 1-1: Scope of Work

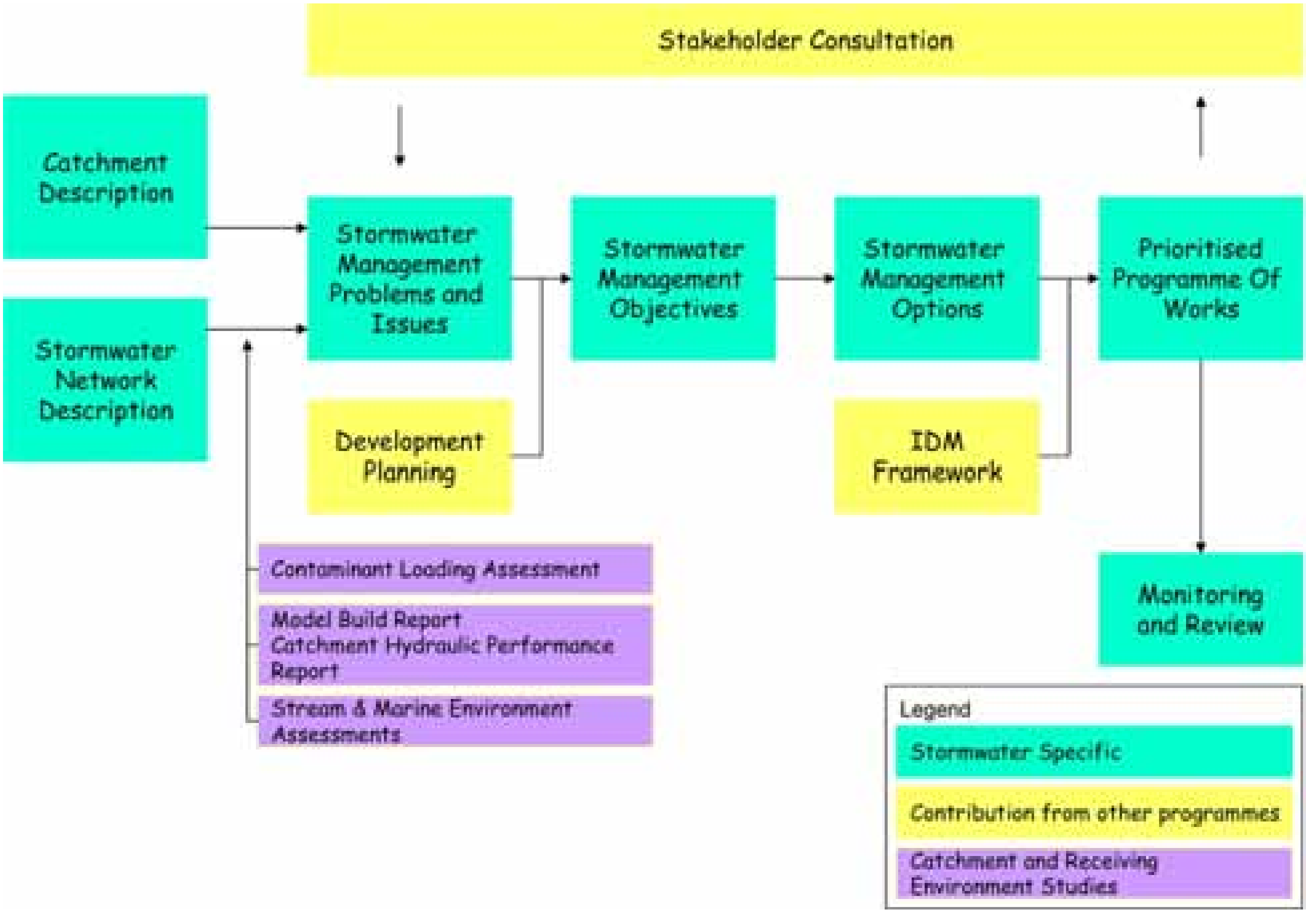


Figure 1-2: ICMP Development Process

2 Planning and Statutory Background

2.1 Planning Framework

An ICMP and any stormwater development undertaken where the ICMP is applied needs to 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 – 2.7. It is important to note that these documents are subject to change and review. Therefore, the ICMP needs to be flexible enough to endure variations to these documents while remaining relevant. In some cases the ICMP may provide direction to these variations.

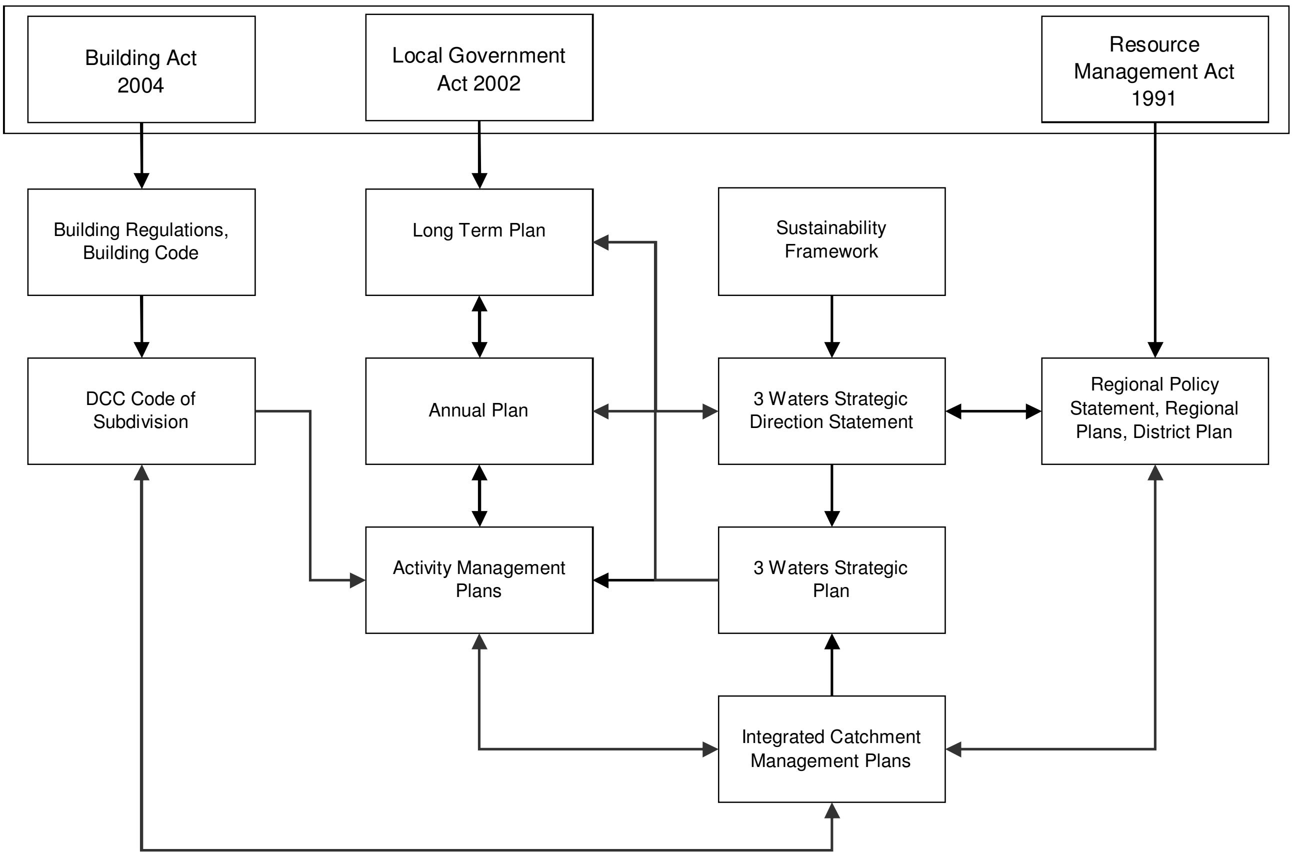


Figure 2-1: Legislative and Planning Document Hierarchies

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 in further detail below.

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

2.2.1 Long Term Plan (LTP)

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

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

2.2.2 Annual Plan

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

2.2.3 Performance Measures

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

2.2.4 Trade Waste Bylaw

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

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

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

2.3 Resource Management Act (1991)

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

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

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

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

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

i) The setting of any maximum or minimum levels or flows of water; 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 which is consistent with the purpose and principles of the RMA, will allow for the identification of in-catchment values, such as drainage patterns and sensitive receiving environments. Management recommendations are then made based on the best practicable option, to ensure that the natural and physical environment within a stormwater catchment and its receiving environment are managed sustainably. This approach helps to ensure that the natural and physical resources within Dunedin's stormwater catchments are used in a way that provides for the community's social, economic and cultural wellbeing.

2.3.1 The New Zealand Coastal Policy Statement (2010)

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

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

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

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

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

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

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

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

The Halsey Street catchment discharges into the Otago Harbour, which links with the Pacific Ocean, therefore the NZCPS must be considered when developing and implementing the ICMP. The ICMP provides a detailed assessment of the effects of current land use and development within the Halsey Street 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 regarding stormwater management options such as source control, treatment devices, low impact design, and community education will ensure that the adverse effects of stormwater runoff on the coastal environment will be avoided, remedied or mitigated.

2.3.2 Marine and Coastal Area Act (2011)

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

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

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

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

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

2.3.3 National Environmental Standards

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

2.3.4 The Otago Regional Policy Statement (1998)

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

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

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

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

2.3.5 The Regional Plan: Coast for Otago

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

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

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

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

2.3.6 The Regional Plan: Water for Otago

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

Policies 7.7.3, 7.7.4, 7.7.5 and 7.7.7 outline matters which need to be considered when assessing resource consents for discharges including cumulative effects, the sensitivity of the receiving environment and any relevant standards. Policies 7.7.10 and 7.7.11 address stormwater systems directly, identifying required outcomes for new systems and requiring the progressive upgrade of older systems. These policies provide both general and specific guidance for any stormwater system or associated discharge within the Halsey Street 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 Otago Regional Plan: Coast for Otago and the NZCPS.

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

The Dunedin City District Plan also uses land use zoning as a method of regulating activities under DCC jurisdiction. These land uses will play an integral part in determining the quantity and quality of any stormwater runoff. The Halsey Street catchment consists of Industrial 1 and 2 (In1, In2), Port 2, Campus, Residential 1, 3 and 4 (R1, R3, R4), Central Activity (CA), Large Scale Retail (LSR) and Local Activity Zone 1 (LA1) land use.

Careful consideration will need to be given to the Industrial 1, Port 2, Central Activity, Local Activity 1 and Large Scale Retail land use zones when looking at management options under the ICMP, as these land uses are likely to produce different stormwater quantities and quality outputs to the residential zones. Activities which are permitted to occur within the Industrial 1 zone include: industrial activity, service activity, retail activity specific to and complimentary to industrial or service activity, recreational activity, service stations, vehicle and boat yards and garden centres. The Port 2 zone also permits industrial, service and related retail activities along with activities specific to a port such as the unloading and storage of cargo.

The small Industrial 2 zone is an area of historically mixed land use, and includes some high technology based industries. The purpose of this zone is to enable the development of activities which generate few adverse effects in areas close to sites such as the University or to allow activities to operate alongside what may normally be considered incompatible land uses. Activities in this zone are likely to have a higher stormwater quality than traditional industrial land uses.

It may 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 Halsey Street 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 are 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 also help shape the future direction of the Code.

2.6.3 The Dunedin City Council Sustainability Framework

The DCC Sustainability 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 this ICMP and any recommendations with regard to future capital works.

2.6.4 3 Waters Strategic Direction Statement and 3 Waters Strategic Plan

The purpose of the 3 Waters Strategic Direction Statement is to align the management of Dunedin's three waters activities with the city's sustainability principles. This document provides direction for the detailed 3 Waters Strategic Plan which will be largely influenced by the content of all 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 Regional Water and Coastal Plans which are relevant to the activities likely to occur under the ICMP.

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

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

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

Stormwater discharge from the Halsey Street catchment is unlikely to comply with the conditions of rule 10.5.3 due to the catchment containing industrial or trade land uses. 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 Regional Plan: Water for Otago classify the discharge of stormwater and the discharge of drainage water to water.

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

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

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

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

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

2.8 Objectives of Stormwater Management

2.8.1 Strategic Objectives

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

Table 2-1: Strategic Stormwater Management Objectives

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

2.8.2 Activity Management Plan / LTP Objectives and Targets

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

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

Table 2-2: Activity Management Plan Measures and Targets

Objective	Performance Measure	2010 / 2011 Target	2021 Target
Stormwater Quality	Residents' satisfaction with the stormwater collection service	≥ 60 %	≥ 70 %
	Number of blockages in the stormwater network per 100 km of mains per annum	< 15	< 10
	Number of beach closures	0	0
Service Availability	Percentage of customer emergency response times met (Stormwater)	≥ 95 %	≥ 95 %
Demand Management	Completion of stormwater catchment management plans	as plan	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.

3 Consultation

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

3.1 3 Waters Strategy Consultation- Stakeholder Workshops and Community Survey

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

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

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

Views Relating to Quality

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

Views Relating to Volume

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

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

- Legislative changes, e.g. changing planning or building consents standards to further reduce the impact of new developments on stormwater;
- Passive changes, e.g. increasing the use of swales and soakholes to better manage storm events; using landscaping to reduce the visual pollution of outfalls;

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

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

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

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

3.2 Resource Consent Submissions

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

3.2.1 Käi Tahu Cultural Impact Assessment

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

The report details historical use of the Otago Harbour by Käi Tahu and their 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 Käi Tahu values and beliefs. These adverse impacts are associated with effects on the spiritual value of water, mahika kai, aquatic biota and water quality.

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

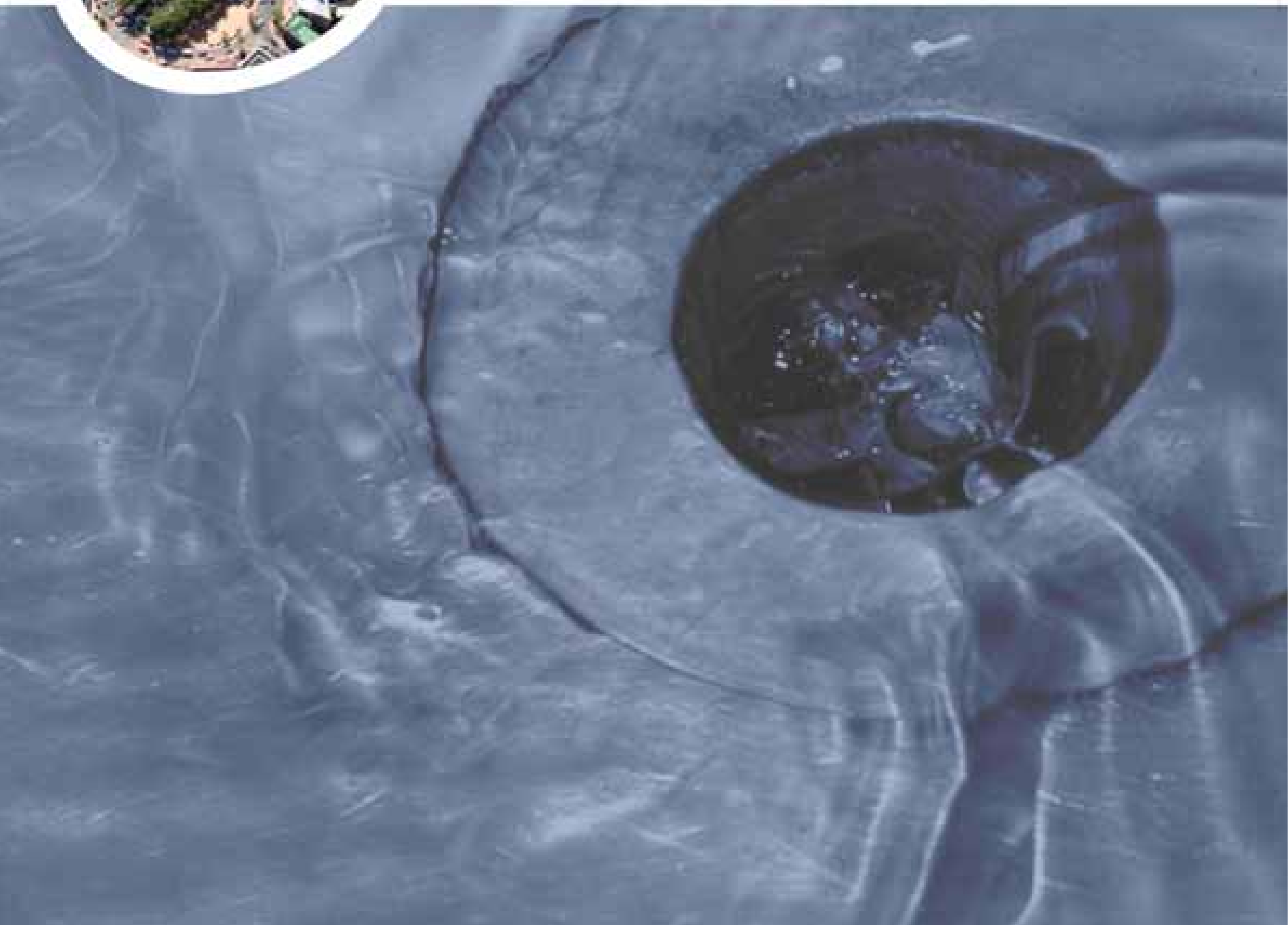
- Reducing the area of impervious land;
- Use of grass swales to filter stormwater;
- Covering car-parking areas and other areas where increased contaminants may be found;
- Sediment/grease traps to be installed at all industrial premises, petrol stations and car parks;
- Management plans for industrial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

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

3.3 Annual Plan Submissions

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

Part 2
Baseline



4 Catchment Description

4.1 Catchment Location

The Halsey Street stormwater catchment is approximately 390 ha and is one of the larger stormwater catchments in Dunedin. Figure 4-1 shows the location of the catchment.

The catchment includes a large part of the central commercial and industrial area in Dunedin, north and east of the Octagon, as well as the residential suburbs of Littlebourne and Maori Hill. The Town Belt runs through the catchment in the west. The catchment is generally bounded by the waterfront to the south-east, Stuart Street, York Place and Kilgour Street to the south-west, Highgate Street to the north-west and Drivers Road and St David Street to the north-east. There is also an area to the north-east of the main catchment encompassing a section of Bullock Track and Malvern Street, draining to the main catchment via a piped network along Great King Street North.

The catchment boundary has been determined for stormwater management purposes as based on the area served by the pipe network, and where the catchment boundary traverses sections of reserve or bush, by overland flow paths.

4.2 Topography and Geology

Figure 4-2 provides a contour map of the Halsey Street stormwater catchment based on 2 m contours. The catchment is characterised by low lying relatively flat areas in the eastern areas which are occupied by commercial and industrial land uses, with topography increasing in steepness towards the west of the catchment. The head of the catchment has an elevation of approximately 165 m above mean sea level.

Figure 4-3 provides a geological map for a majority of the Halsey Street stormwater catchment (Bishop and Turnbull, 1996, revised 2004). The topography of the upper catchment has been created by volcanic laval flows which occurred in the mid to late Tertiary period, with the predominant geology in the west of this catchment being Md2e basalt. This rock material typically provides variable infiltration capacity. Geology in the centre of the catchment is dominated by type Q2af gravel, which has been deposited by the waters of the Leith over time. This material will also have variable permeability, due to the presence of silts, sand, and clays interspersed with more permeable gravel.

The flat area at the base of the catchment adjacent to the harbour is reclaimed land, identified as geologic unit Q1an. This material consists predominantly of unconsolidated and unsorted material from a variety of sources that were deposited on the shoreline to reclaim seabed. The deposits include gravels, sands, marine silts and clays, most likely combined with anthropogenic materials from industrial and domestic waste, and including material from the Bell Hill cutting. Drainage capabilities of this material will be variable, depending on the specific materials used in different areas of the reclamation.

4.3 Surface Water

Runoff generated in the upper areas of the Halsey Street catchment is collected via a series of small reticulated networks which in turn discharge to a series of small gullies that run through the Town Belt (refer Figure 4-9 later in this report). Some of these gullies are piped, whilst some are open channels with a mix of concrete channels and natural stream channels. An assessment of streams undertaken by Ryder Consulting Ltd. in 2010 identified three streams suitable for sampling within the catchment; all of which are located within the Town Belt near Queens Drive. Below the Town Belt the streams are piped until they discharge to the harbour.

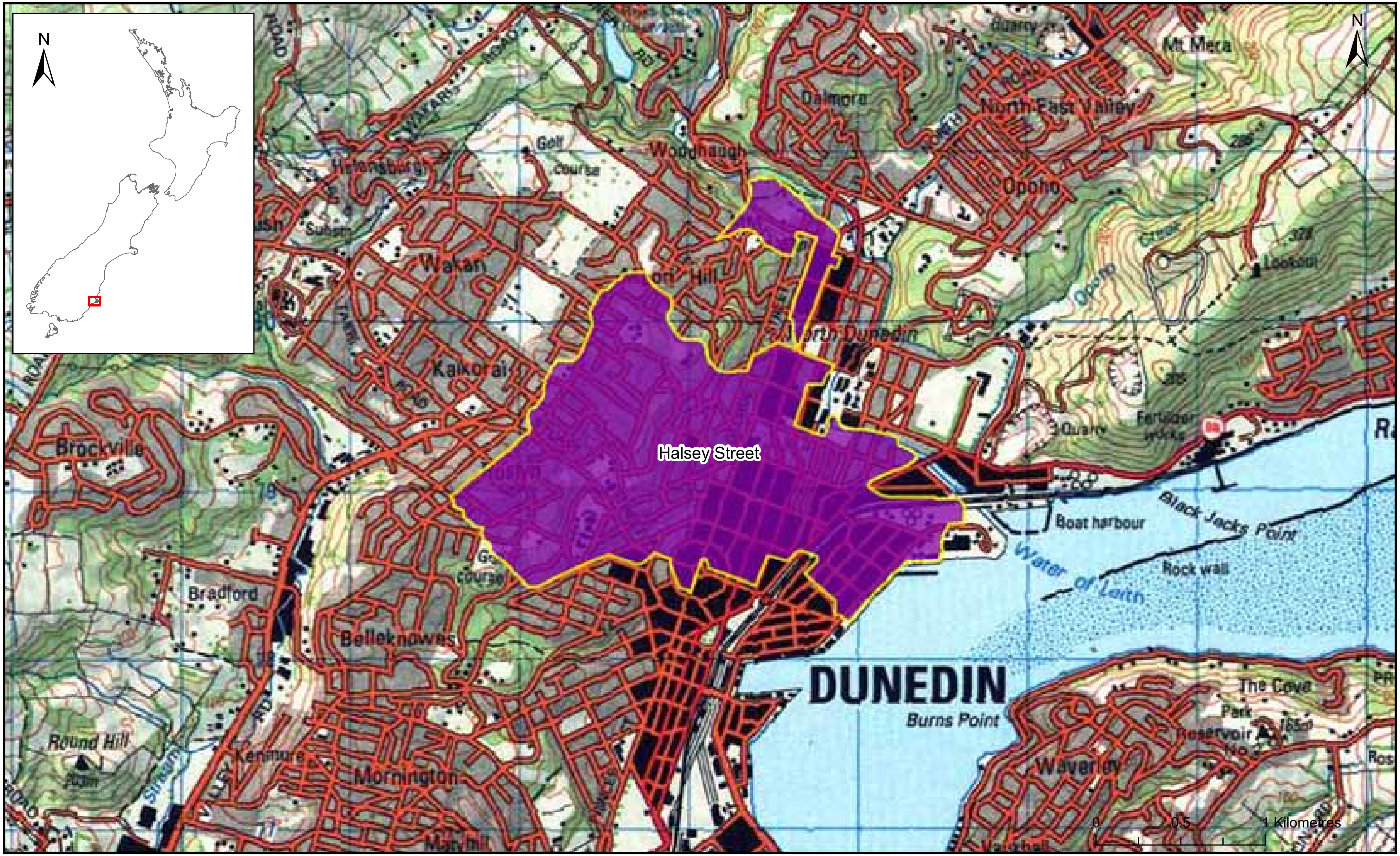
The three streams sampled by Ryder Consulting can generally be characterised as shallow (between 2 and 40 cm deep) and relatively narrow with all streams having a wetted width of less than 1.2 m. Section 5 of this report contains a description of the freshwater environment in this catchment.

4.4 Groundwater

There is limited information relating to groundwater surface levels in the Halsey Street catchment, and over much of the Dunedin urban area adjacent to the harbour. ORC do not currently require groundwater monitoring in the area for consent purposes. However, based on the site geology, a conceptual understanding of the groundwater system has been developed.

The basalt which makes up the majority of the catchment may contain a fractured rock groundwater system. However, as there are no wells drilled in the catchment area, it is difficult to ascertain the extent of any fractured rock groundwater. Nevertheless, water that infiltrates the basalt is expected to move vertically down through fractures until it intercepts the quaternary groundwater system.

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



Dunedin 3 Waters Strategy	HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-1 Halsey Street Catchment Location	DISCIPLINE Stormwater

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Approved: SDH	Job. No: 42173227	Map No: Figure 4-1 / Revision: -
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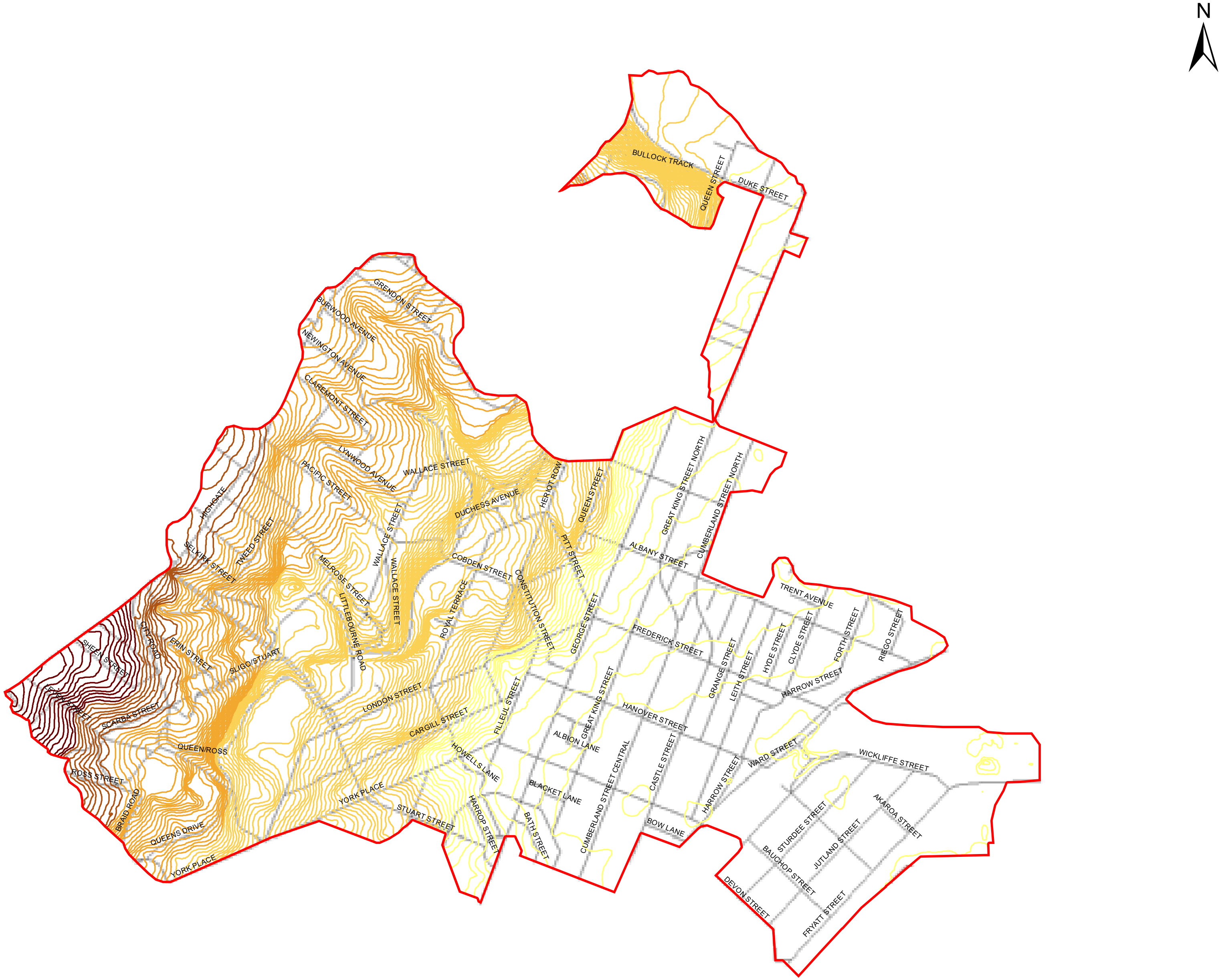

Legend

Halsey Street Catchment Boundary

Contour (m)

- <30
- 30-110
- 111-155
- 156-170
- >170

0 0.3 0.6 Kilometres

DUNEDIN CITY COUNCIL / OPUS / URS	Dunedin 3 Waters Strategy	HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-2 Halsey Street Catchment Contour Map	DISCIPLINE Stormwater	Drawn: KC Checked: HES Approved: SDH Date: Sep 2011	Status: Final Scale: 1:12,500 Job. No: 42173227 Plot Date: Sep 2011 Map No: Figure 4-2 Revision: -

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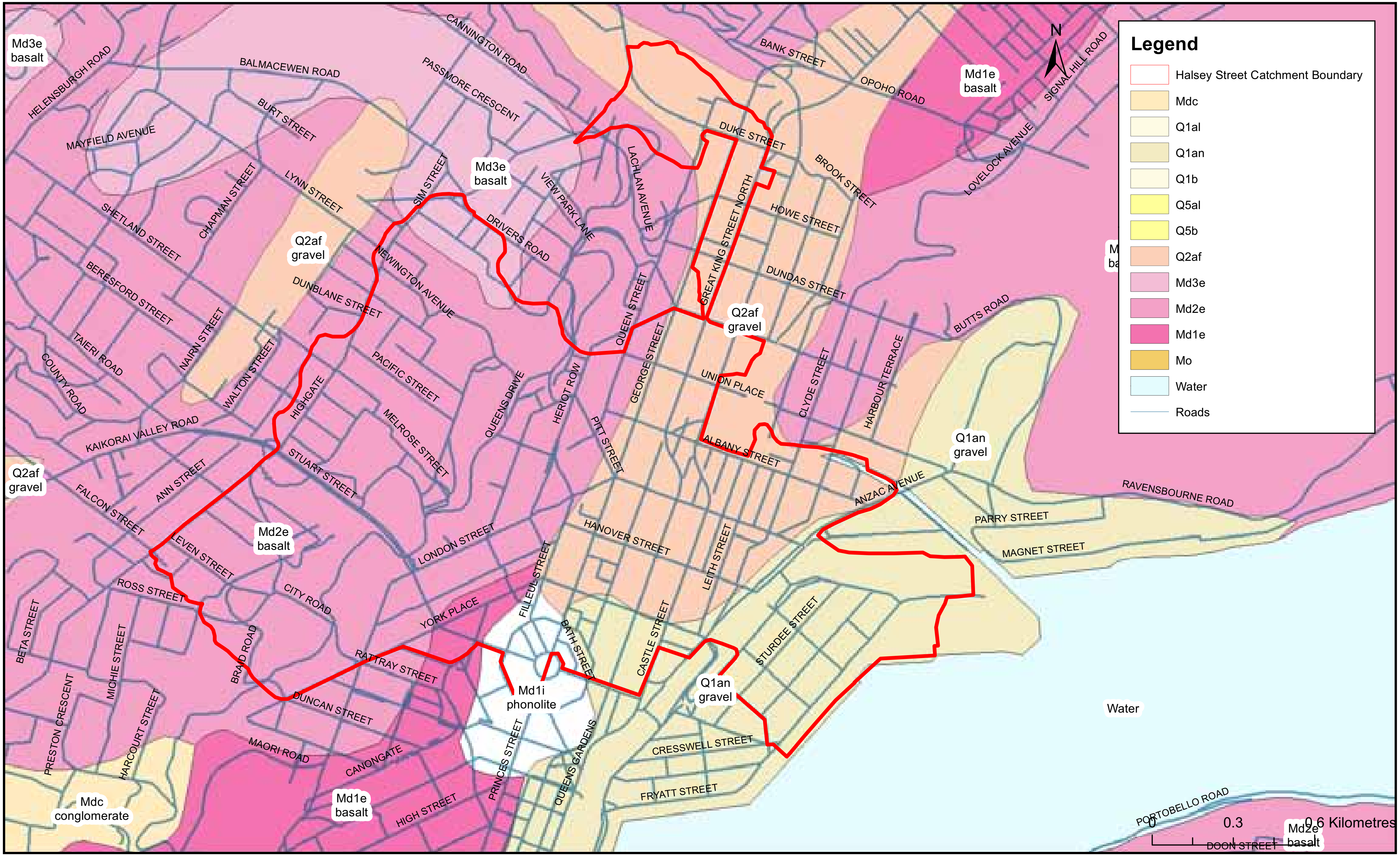

Dunedin 3 Waters Strategy	HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-3 Halsey Street Catchment Geology Map	DISCIPLINE Stormwater	Drawn: KC	Status: Final	
			Checked: HES	Scale: 1:12,500	Plot Date: Sep 2011
			Approved: SDH	Job. No: 42173227	Map No: Figure 4-3 / Revision: -
			Date: Sep 2011		

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4.5 Land Use

4.5.1 Historical and Current Land Use

Table 4-1 and Figure 4-4 describe the current land use in the Halsey Street catchment. Current land use reflects, to a large extent, historic land use in the area.

The Halsey Street catchment includes part of the city centre and harbour side, and parts of the residential suburbs of Littlebourne, Roslyn and Maori Hill.

Residential development has occurred over time, but commenced on the city side of the Town Belt in the late 19th century. There are four types of residential zones within the catchment, each with slightly different characteristics. The main differentiating factor in relation to stormwater is the building site coverage. Residential 1 is characterised by low site coverage (25 %), Residential 3 has medium to high site cover (45 %) and Residential 4 has high site cover (60 %).

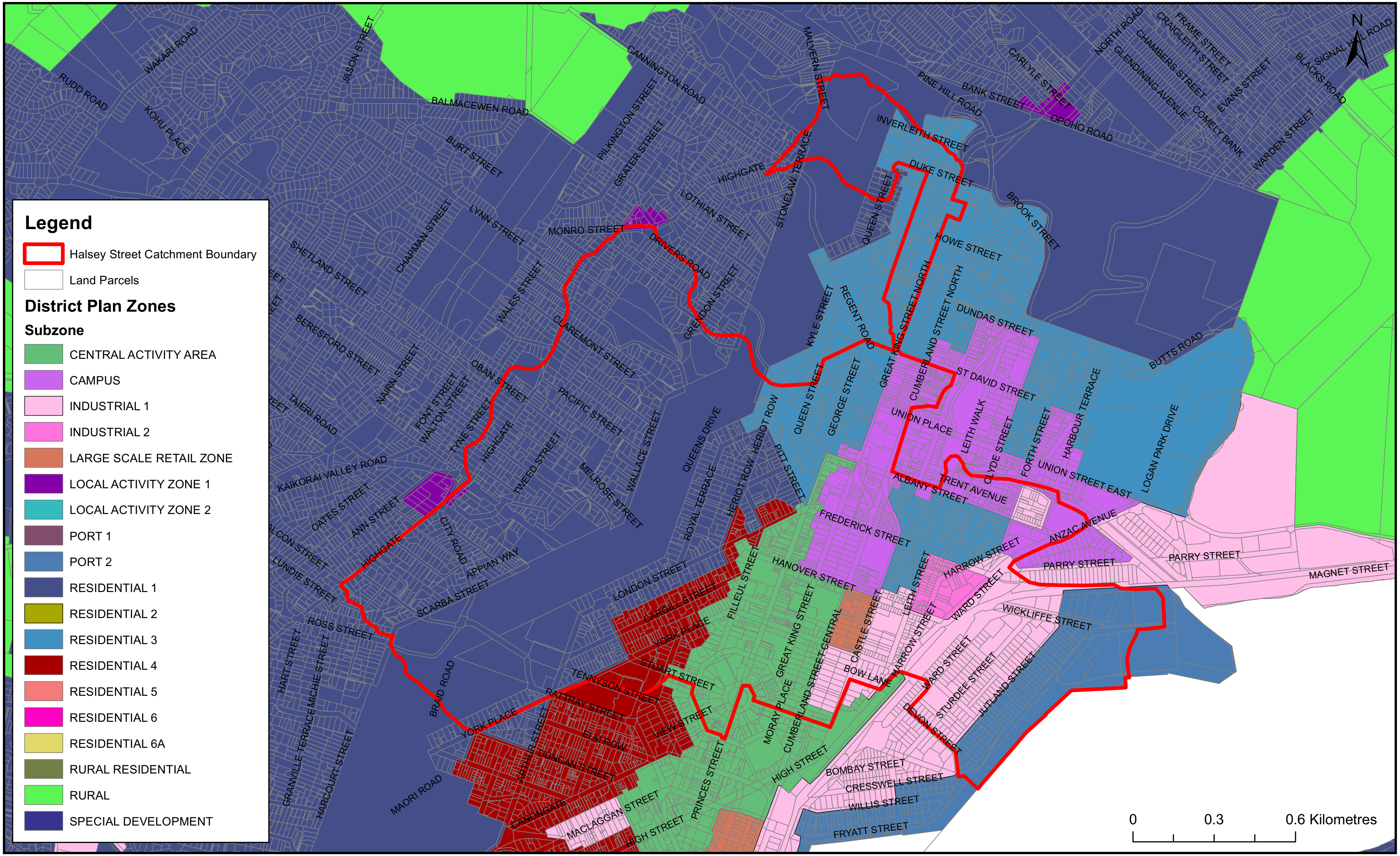
Most of the Octagon lies in the Halsey Street stormwater catchment (with the remainder in the Mason Street catchment), and this central commercial area of Dunedin was created when swampland was drained in the late 19th century. State Highway 1 runs through the centre of the catchment.

The harbour side area is reclaimed, much of it with material from the cutting of Bell Hill (commenced in 1858). This area is used for industrial and Port purposes, and has both the railway (laid in 1878) and main transport route to Port Chalmers running through it.

The University of Otago was founded in 1869, and the south campus is located within the Halsey Street catchment; this contains the school of medicine, Dunedin Hospital, and School of Dentistry, amongst other university buildings. The Otago Museum is also in this area.

Table 4-1: Current Land Use in the Halsey Street Catchment

DCC Zone	Proportion of Catchment
Residential 1	78 %
Residential 3	4 %
Residential 4	3 %
Industrial 1	10 %
Industrial 2	<1 %
Campus	2 %
Central Activity	2 %
Local Activity Zone 1	< 1 %
Large Scale Retail	< 1 %
Port 2	2 %



Dunedin 3 Waters Strategy	**HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN** **Figure 4-4** **Halsey Street Catchment Land Use Zones**	**DISCIPLINE** **Stormwater**	Drawn: KC Checked: HES Approved: SDH Date: Sep 2011	Status: Final Scale: 1:12,500 Plot Date: Sep 2011 Job. No: 42173227 Map No: Figure 4-4 Revision: -

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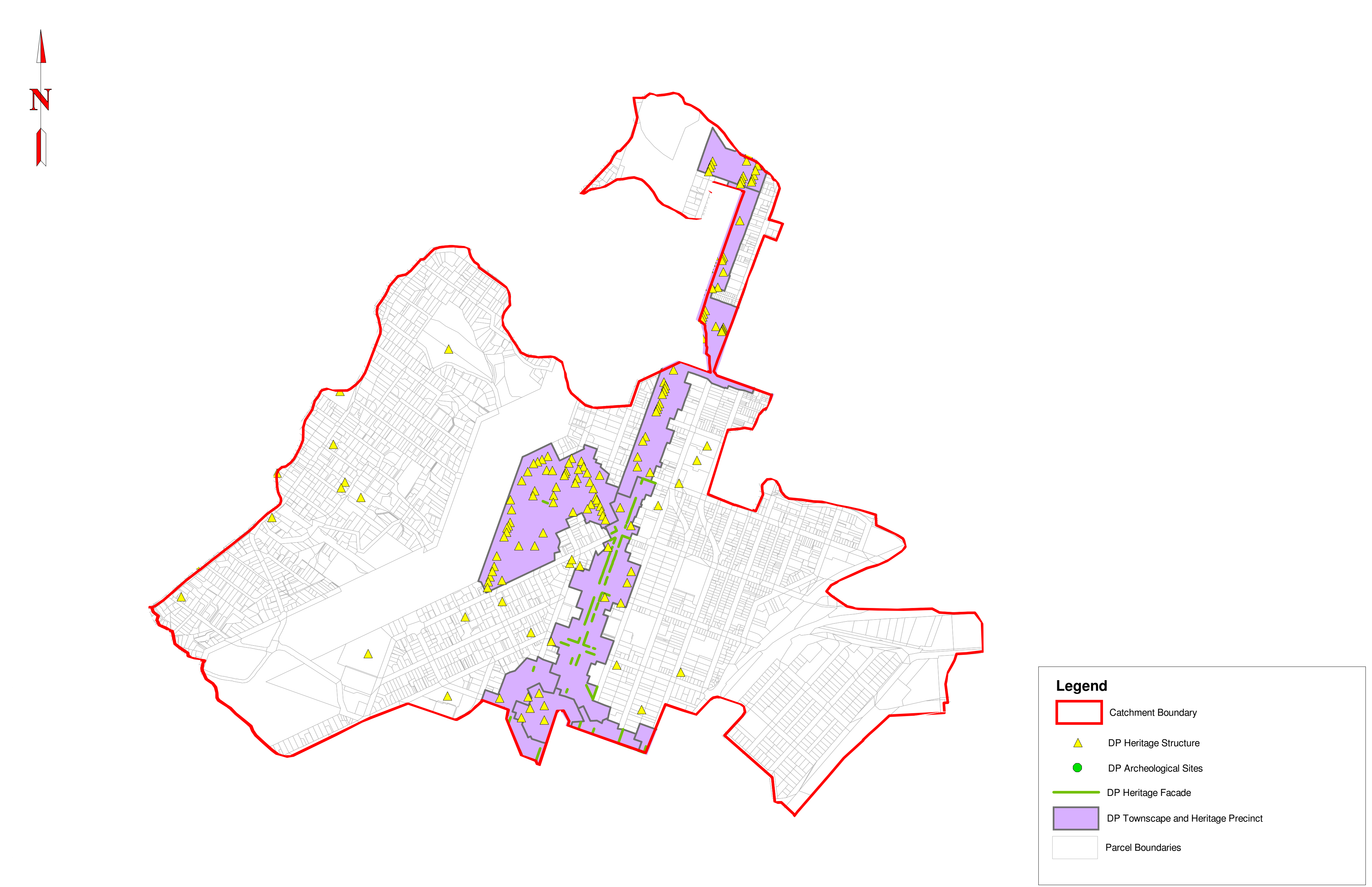
4.5.2 Cultural / Heritage Sites and Designations

According to DCC records of significant archaeological and heritage sites within Dunedin city, the Halsey Street catchment contains a number of Townscape and Heritage Precincts, as well as many heritage structures, several of which are contained within the various precincts.

Many of the heritage structures in the catchment are commercial buildings and houses spread along George Street within the Octagon Townscape Precinct and the George Street Commercial Heritage Precinct. Many other heritage structures (houses) are clustered in the Royal Terrace/Pitt Street/Heriot Row Heritage Precinct. Other heritage buildings, such as the Cadbury Factory and Fire Station, are scattered throughout the catchment.

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



Dunedin 3 Waters Strategy

HALSEY ST INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-5
Halsey Street Catchment Archaelogical and Heritage Sites

Discipline:

Stormwater

DRAWN BY MG	STATUS Final		
CHECKED LB	SCALE NTS	PLOT DATE February 11	
APPROVED HS	JOB NO. 3-d1040.07	DWG. NO.	REVISION
DATE February 11			

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4.5.3 Resource Consents and Designations within the Catchment

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

A number of consents have been granted, by ORC and DCC, within the Halsey Street catchment. However, there are no significant resource consents granted relating to stormwater management.

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

A number of District Plan Designations exist within this catchment. Some are for transport purposes and include the existing Main South Railway in the southeast of the catchment and the Harbourside Arterial Link (State Highway 88) and State Highway 1. There are also three electricity substations, located at the northern end of Great King Street North, at Smith Street, and near Hanover Street, between Cumberland Street and Castle Street.

An area of land in the east of the catchment is designated for the construction and operation of an arterial road corridor, known as the Harbourside Arterial Link. DCC proposes to realign and extend the road corridor to connect to Ravensbourne Road. The physical works include the widening and realignment of the route north of Willis Street, construction of a new corridor, new road crossings of the railway corridor, a new bridge across the Water of Leith and a new entrance into the Boat Harbour. At the time this plan was completed, this area was underdevelopment and the road realignment yet to be completed.

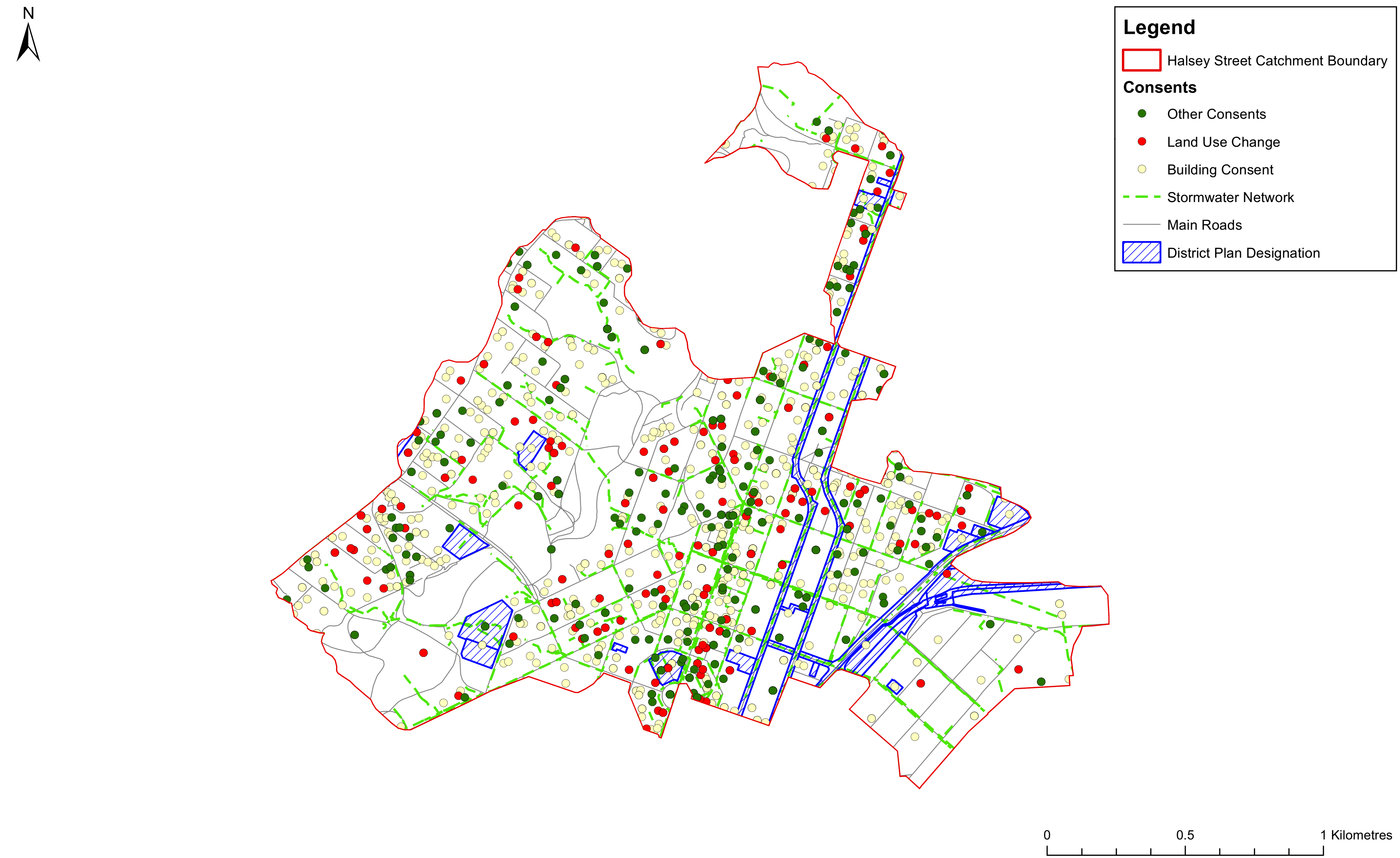
Figure 4-6 provides the location of the resource consents granted by DCC and District Plan designations within the Halsey Street catchment.

4.5.4 Contaminated Land

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

There are a number of contaminated sites within the catchment. Most are associated with petroleum storage, with the exception of one remediated site on Fryatt Street, which had been used for bitumen storage. Most of the sites are considered to be ‘managed’ although the site of Wickcliffe Street (Shell Depot) is considered to be ‘contaminated’.

Figure 4-7 provides the location of the known contaminated land sites within the Halsey Street catchment.



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Dunedin 3 Waters Strategy	HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-6 Halsey Street Catchment Recent Consents and Designations	DISCIPLINE Stormwater	Drawn: KC	Status: Final	
			Checked: HES	Scale: 1:12,600	Plot Date: Sep 2011
			Approved: SDH	Job. No: 42173227	Map No: Figure 4-6 / Revision: -
			Date: Sep 2011		

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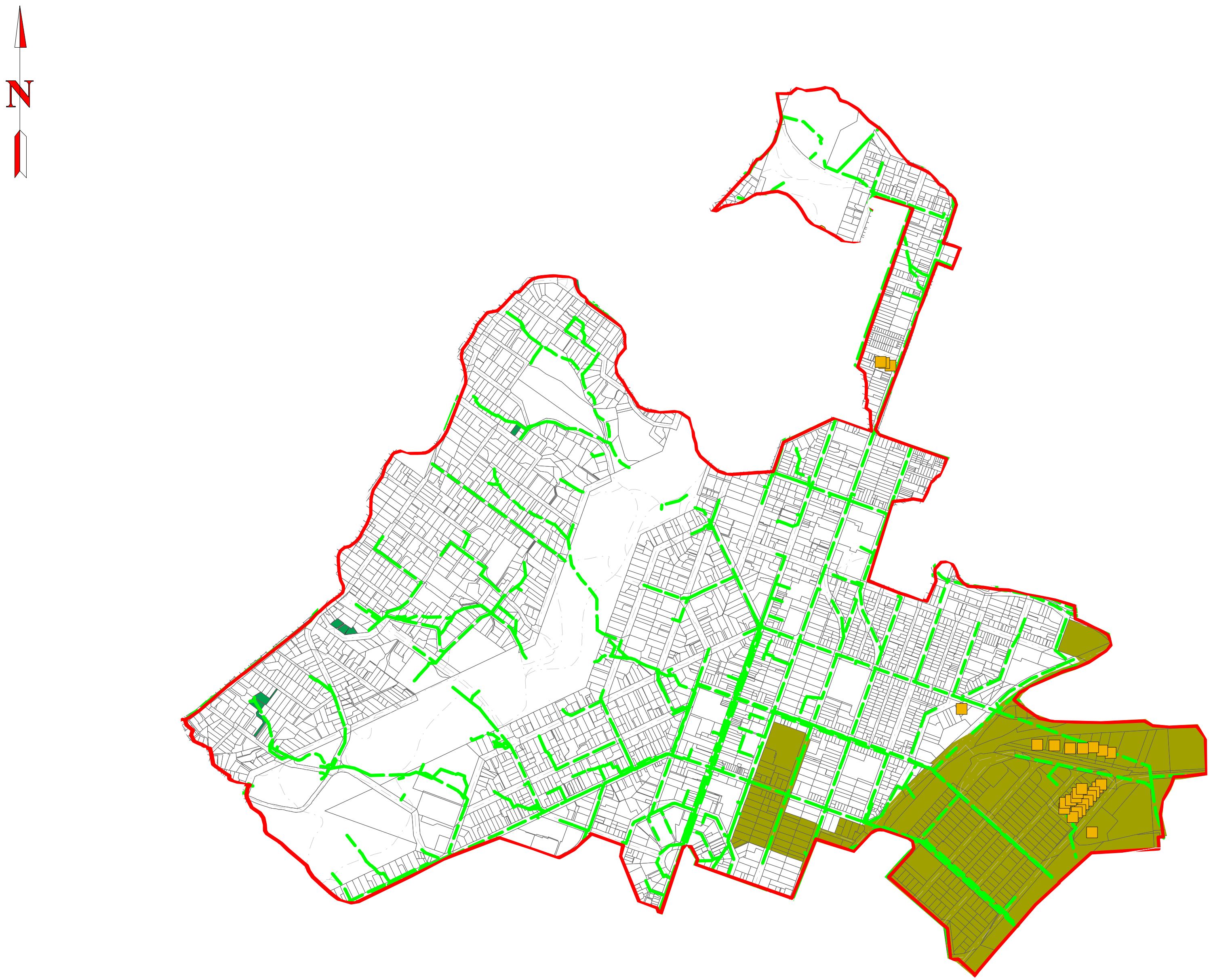

Legend

- Catchment Boundary
- Stormwater Network
- Road
- Parcel Boundaries
- Contaminated Site
- Landfill
- Reclamation
- Reclaimed Land
- ORC Contaminated Sites

Dunedin 3 Waters Strategy

HALSEY ST INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-7
Contaminated Land Sites

Discipline:

Stormwater

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APPROVED	HS
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STATUS	Final
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4.5.5 Future Land Use

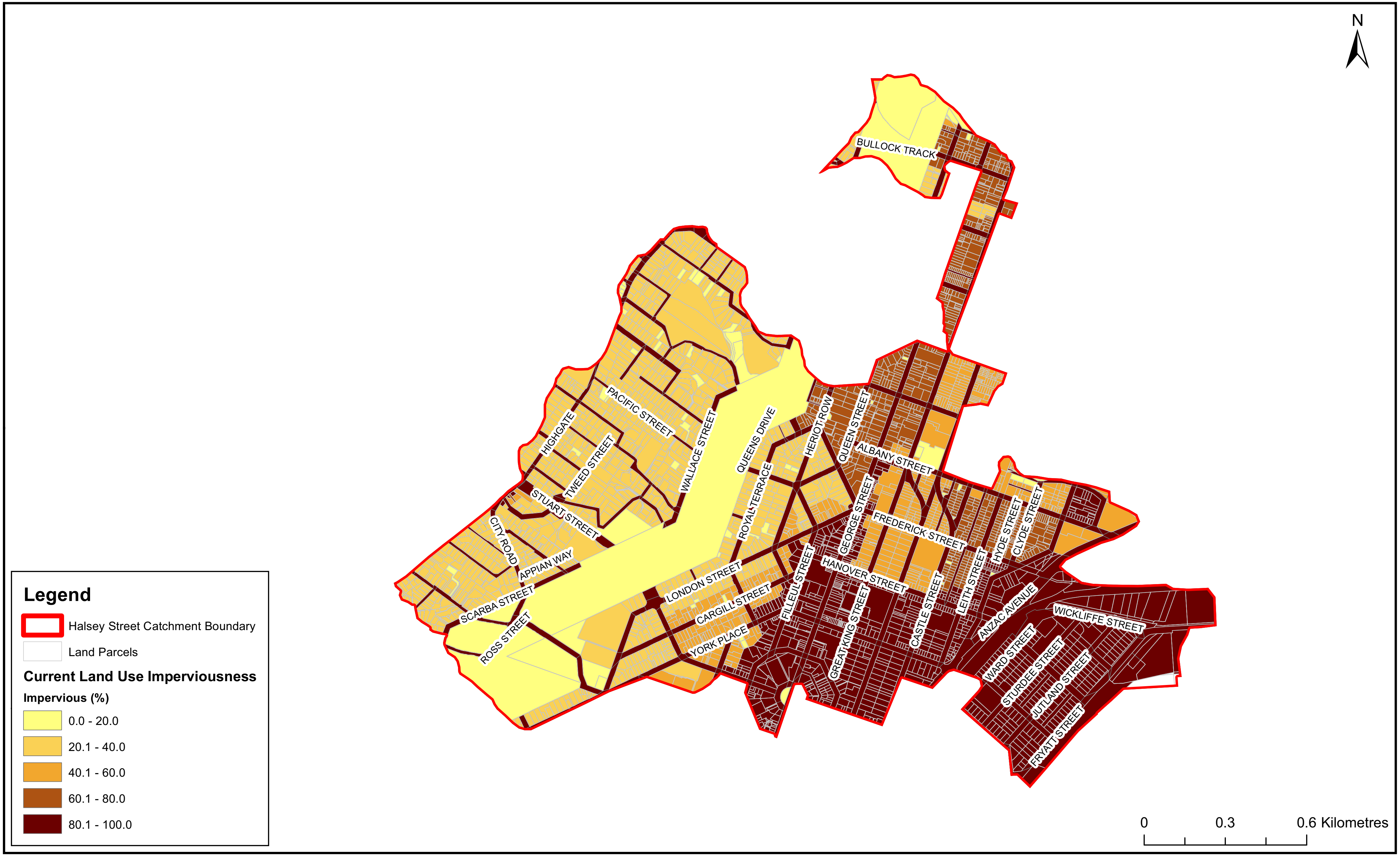
Three future land use scenarios are being considered within the DCC 3 Waters Strategy along with the current situation. The scenarios are; 2008 (current), 2021, 2031 and 2060. For the purposes of stormwater modelling, the 2031 scenario contains the maximum allowable imperviousness for each zone, consistent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

The Halsey Street catchment has some opportunity for in-fill housing within the residential zones, and re-development within the industrial zones, although as discussed in Section 2, re-development in the Industrial 2 Zone is limited to particular low-impact industries.

4.6 Catchment Imperviousness

Figure 4-9 provides a map of current imperviousness for the Halsey Street catchment (refer Appendix B for calculation methods). The imperviousness throughout the catchment is highly variable, with the Town Belt being highly pervious, and the harbour side almost entirely impervious. Overall, the imperviousness of the Halsey Street catchment is estimated to currently be approximately 60 %.

For the Halsey Street catchment, there is expected to be very little change in impervious between now and the planning horizon of 2060. Future imperviousness trends from 2021 to 2060 have been based on projected growth for each of the suburbs within this catchment. While there is some in-fill development expected in built up areas, imperviousness is already estimated to be at or above the maximum allowable by the DCC district plan for these areas due to the majority of zoning being Residential 2, or Commercial/Industrial.



Dunedin 3 Waters Strategy

HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-8

Halsey Street Catchment Current Imperviousness

DISCIPLINE

Stormwater

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

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4.7 Stormwater Drainage Network

4.7.1 Network Description

Figure 4-10 provides details of the stormwater network in the catchment. Runoff generated in the upper areas of the catchment is collected via a series of small reticulated networks which in turn discharge to a series of small gullies that run through the Town Belt. Some of these gullies are piped; whilst some are open channels with a mix of concrete lined and natural stream channels. These channels convey stormwater towards the lower areas of the town belt before being piped through the town centre to discharge via six outfalls to the harbour.

Several of the mains running through the lower areas of the catchment have sealed manholes enabling the system to become pressurised during periods of high flow, increasing flow capacity. A parallel gravity system provides local drainage in this area. Overland flows from adjacent catchments (for example an area on Maori Hill) also contributes stormwater to the Halsey Street catchment network during large events. This has been taken account of within the hydraulic modelling of the system.

The ability of the reticulated system to intercept these open channel flows and direct them to the harbour is key to the system's operation, as failure to intercept the flows could result in overland flows and associated flooding in the area below. Key network features have been identified as follows:

- Gully intakes in the Town Belt – there are several gullies which collect stormwater from the upper catchments and convey flows through the Town Belt.
- Harbour outfalls – six outfalls discharge stormwater to the harbour. All of these outfalls are tidally influenced, they outfalls are referred to as follows:
    - Outfall 1 - Frederick Street outfall (1050 mm diameter);
    - Outfall 2 - Akaroa Street outfall (300 mm diameter);
    - Outfall 3 - Halsey Street gravity outfall (1800 mm x 1950 mm culvert);
    - Outfall 4 – Halsey Street pressure outfall (1800 mm x 1325 mm culvert);
    - Outfall 5 – St Andrews / Bauchop Street outfall (1350 mm diameter); and
    - Outfall 6 – Bauchop Street outfall (450 mm diameter).
- Tidal weir – in the stormwater main on Bauchop Street, adjacent to Fryatt Street, there is a brick wall constructed to prevent tidal ingress.
- Pressure system – sealed manholes result in the stormwater pipes along York Place, Filleul Street, Frederick and Hanover Street to the harbour operating under pressure.

Figure 4-9 provides the frequency distribution of the pipe diameters in the Halsey Street catchment. The diameter of the pipes within the network varies significantly, with the majority of the pipes being 600 mm diameter or less.

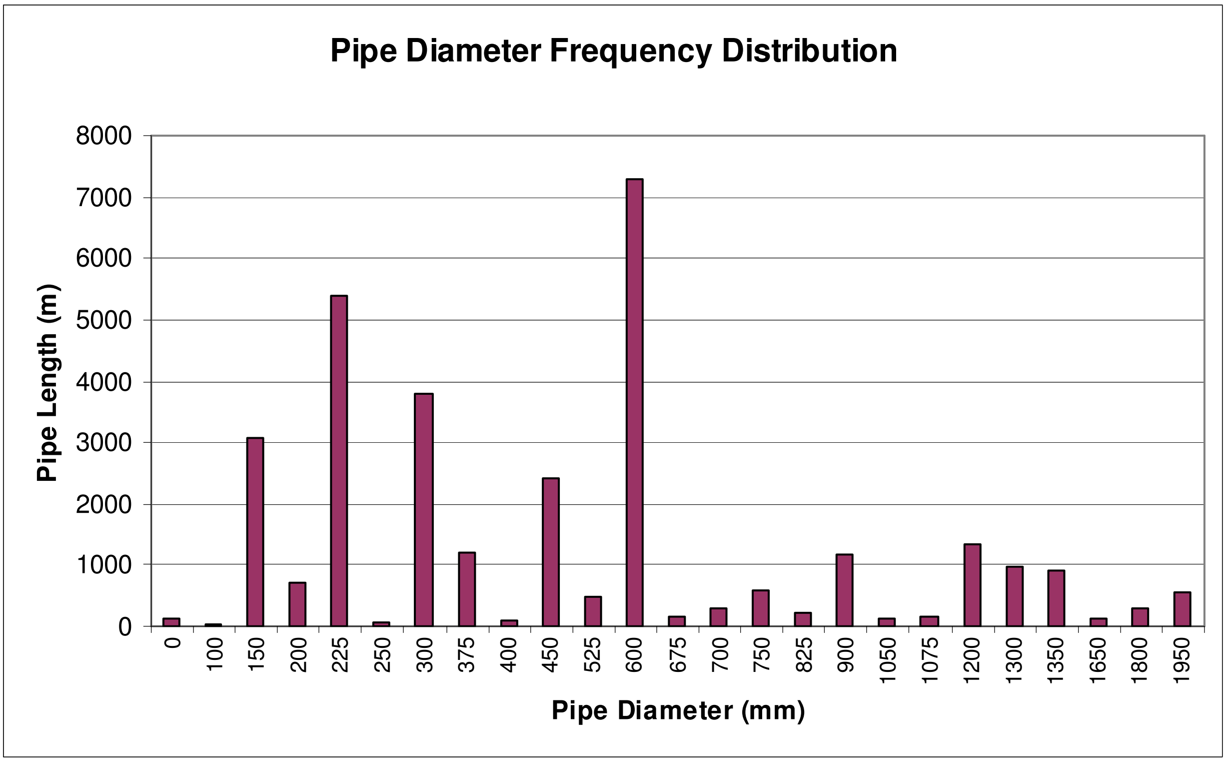
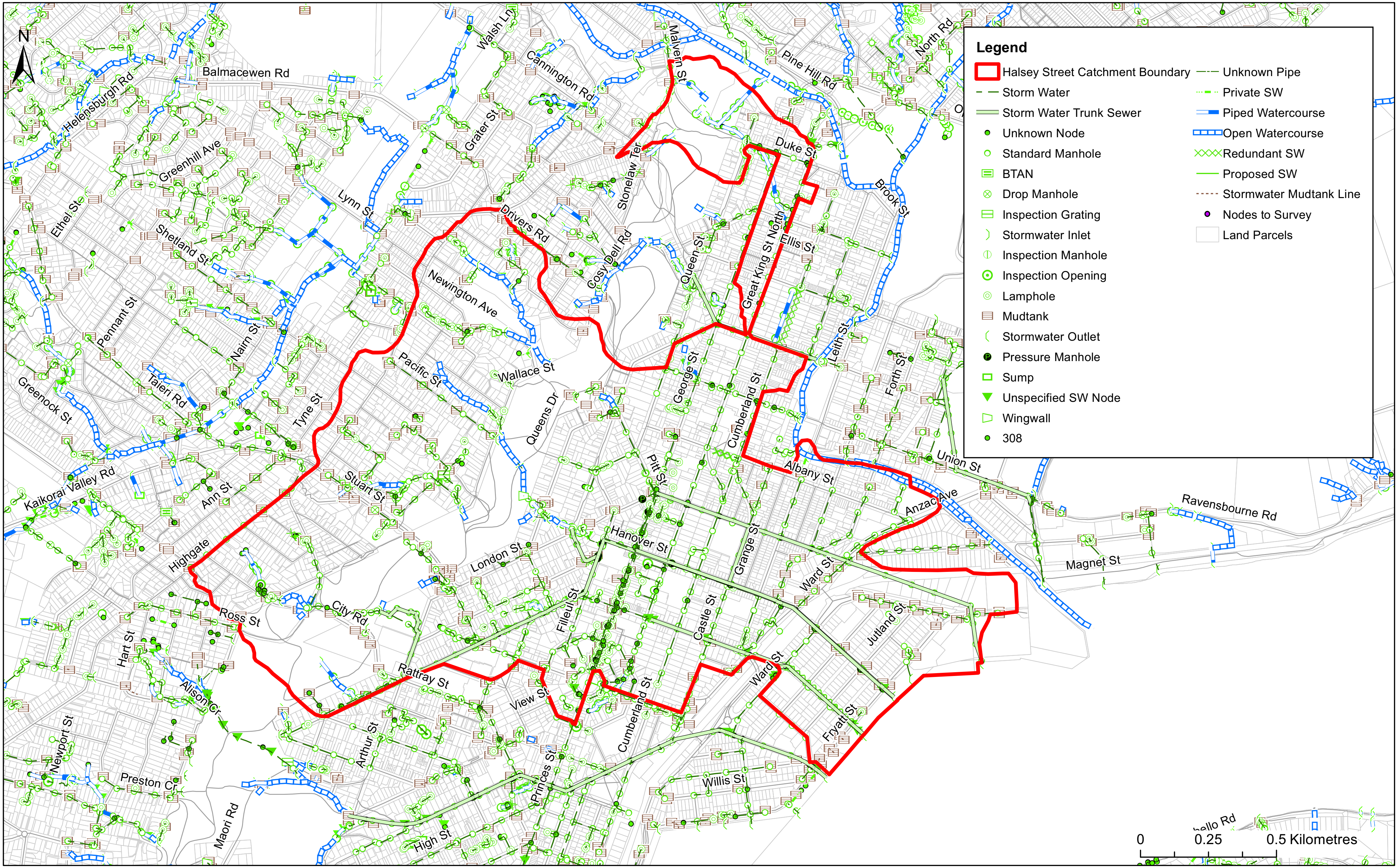


Figure 4-9: Pipe Diameter Frequency Distribution



Created with ESRI ArcGIS	Dunedin 3 Waters Strategy	**HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN** **Figure 4-10** **Halsey Street Catchment Stormwater Drainage Network**	**DISCIPLINE** **Stormwater**	Drawn: KC Checked: HES Approved: SDH Date: Sep 2011	Status: Final Scale: 1:12,500 Job. No: 42173227	Plot Date: Sep 2011 Map No: Figure 4-10 Revision: A

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4.7.2 Network Age

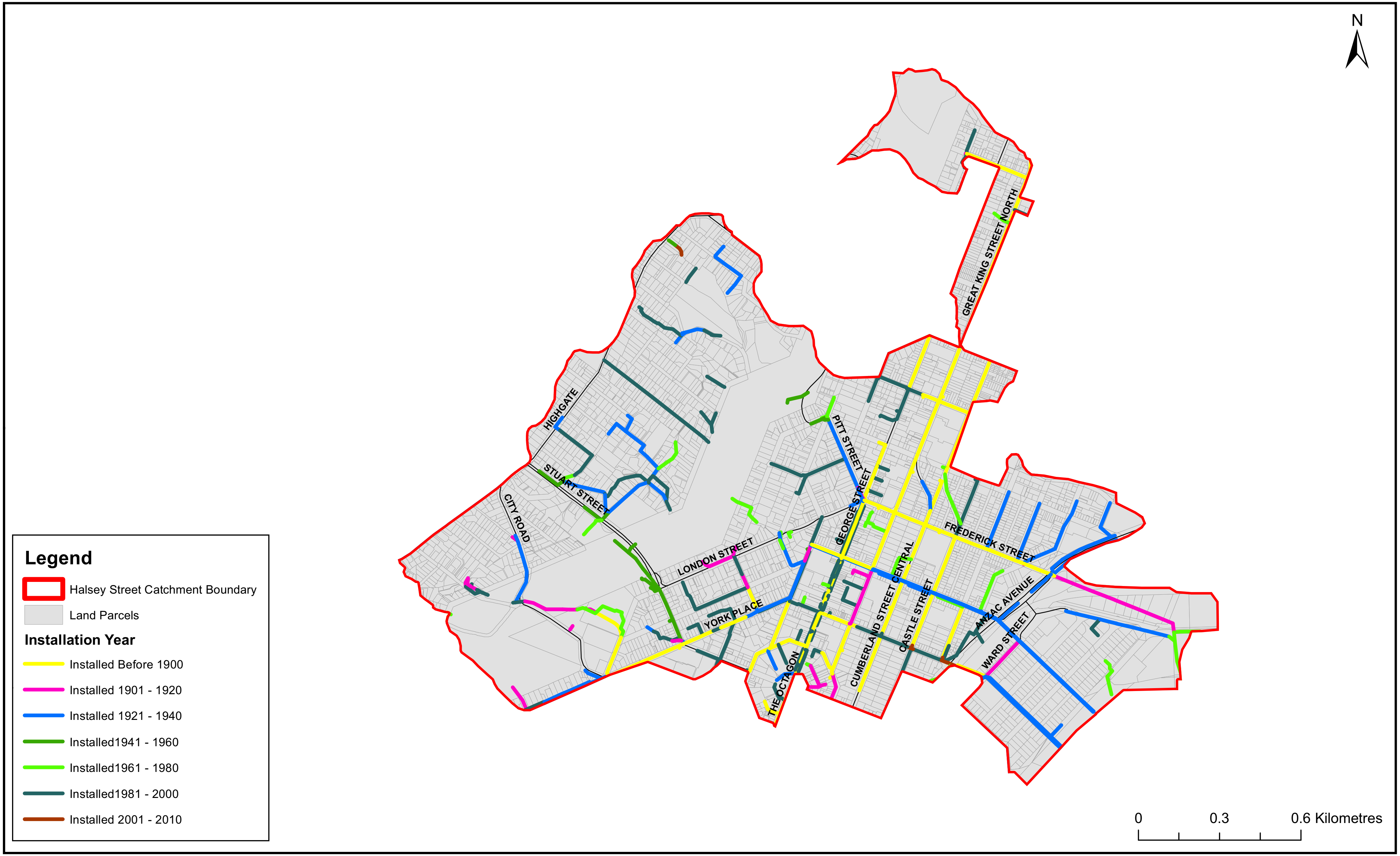
Table 4-2 below provides a breakdown of pipe age in the Halsey Street catchment. Figure 4-11 provides a map of pipe age based on location.

The data shows that the majority of the stormwater network in the central commercial area of Dunedin is likely to be original, with close to 30 % of the network was installed prior to 1900. Some of this pipe work appears to have been upgraded or supplemented with new infrastructure during the 1980 and 1990s, however, which may assist in providing capacity and reliability.

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, 66 % 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 4-2: 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	219	8475	27
Installed 1901 to 1920	90-110 years	57	2035	6
Installed 1921 to 1940	70-90 years	178	9103	29
Installed 1941 to 1960	50-70 years	38	1283	4
Installed 1961 to 1980	30-50 years	81	2402	8
Installed 1981 to 2000	10-30 years	287	7620	24
Installed 2001 to 2009	< 10 years	28	857	3



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Dunedin 3 Waters Strategy	HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-11 Halsey Street Catchment Pipe Network Ages	DISCIPLINE Stormwater

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Checked: HES	Scale: 1:12,500	Plot Date: Sep 2011	
Approved: SDH	Job. No: 42173227	Map No: Figure 4-11	Revision: -
Date: Sep 2011			

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4.7.3 Asset Condition and Criticality

A condition assessment has not been undertaken of the Halsey Street stormwater network.

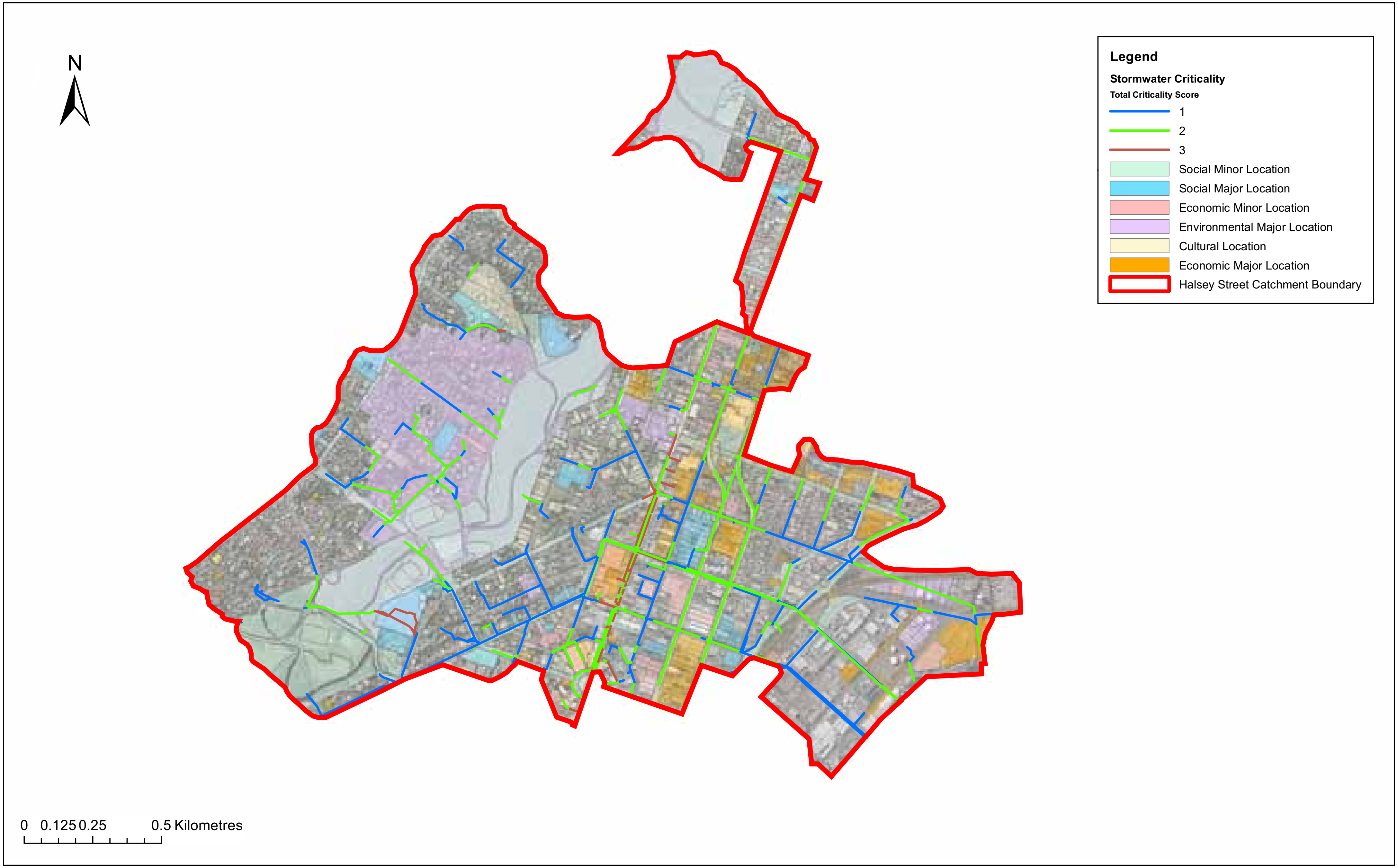
DCC has developed and applied a first cut criticality assessment to all water, wastewater, and stormwater network assets across the city. The criticality score has been calculated based on three weighted criteria: extent, cost, and location. For the full version of the methodology used, the DCC methodology document (available on request) should be referred to. Table 4-3 summarises the first cut version used for stormwater assets as at 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 4-12 shows a map of the Halsey Street catchment, with criticality and the four well-being locations identified. This map shows pipe criticality only. The figure shows that much of the stormwater network along George Street has a criticality score of 3, due to the roadway itself being classified as a minor economic asset, as well as a large number of culturally significant sites being identified in the area. The area has also been identified as being of social importance.

Table 4-3: 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	HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-12 Halsey Street Catchment Stormwater Network Criticality	DISCIPLINE Stormwater	Drawn: MM	Status: Final	
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			Date: Sep 2011		

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4.7.4 Salt Water / Saline Groundwater Intrusion

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

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

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

Some wastewater pipes in the Halsey Street catchment (mainly in the area east of the railway lines) have recently been rehabilitated to reduce saline intrusion.

4.7.5 Operational Issues

Discussions were held with DCC operations personnel during the catchment walkover (November 2009) in order to identify known operational issues or locations of historical flooding. Further discussions were held during a workshop with DCC Water and Waste Business Unit staff in November 2010. Discussions highlighted the following issues:

- Overtopping of inlet screens in the Town Belt, resulting in overland flow;
- General lack of maintenance work leading to blocking of catchpits (further discussed below in Section 4.7.6);
- Widespread flooding in the town centre during the February 2005 rainfall event;
- Flooding at the London Street / Heriot Row intake structure, which has previously resulted in property flooding; and
- Flooding at the intake structure in Cosy Dell Road which has previously resulted in property flooding (overland flow from Cosy Dell Road which is outside the Phase 2 stormwater catchments, enters the Halsey Street catchment).
- Confirmation of property flooding (Heriot Row and Filleul Street) due to overland flows Network Maintenance.

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

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

Network Management

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

- Check access to the site in respect to Health and Safety requirements.
- Check the screen intake to ensure screen is 95 % or more clear.
- Check upstream channel is clear of debris (approximately first 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 Highway, which are the responsibility of the New Zealand Transport Agency (NZTA)).

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

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

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

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

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

Community and Recreation Services

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

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

4.8 Customer Complaints

Based on DCC customer complaints information collated between 2005 and 2010, there were a number of reported flooding incidents in the Halsey Street catchment. Figure 4-13 provides a map of the stormwater complaints received, and Figure 4-14 displays the wastewater complaints received in this five year period.

Stormwater complaints in the catchment are most numerous at the northern and southern ends of George Street, with a large number of complaints during the February 2005 storm event. This event resulted in significant property damage, and was an extremely high intensity storm event, much larger than the design capacity of the stormwater network. Catchpits in the stormwater network could not accept such high intensity flows, and therefore overland flows through the city were significant. Hydraulic modelling undertaken for this catchment included a validation exercise using the February 2005 rainfall event, in order to compare model predictions with reported flooding, thereby providing increased confidence in model outputs. Complaints during other storm events have also been received in this area, however, indicating that frequent stormwater issues arise.

Wastewater flooding and infrastructure complaints have been received across the catchment on numerous different occasions; however the majority appear to have been in the centre or south-west of the catchment.

Of note is the area on George Street, immediately north of the Octagon, where numerous stormwater and wastewater complaints have been received during the five years recorded.

Legend

Halsey Street Catchment Boundary

Stormwater Flooding Complaints

Year

- Undated
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010

Exact Location Known (Full Address)

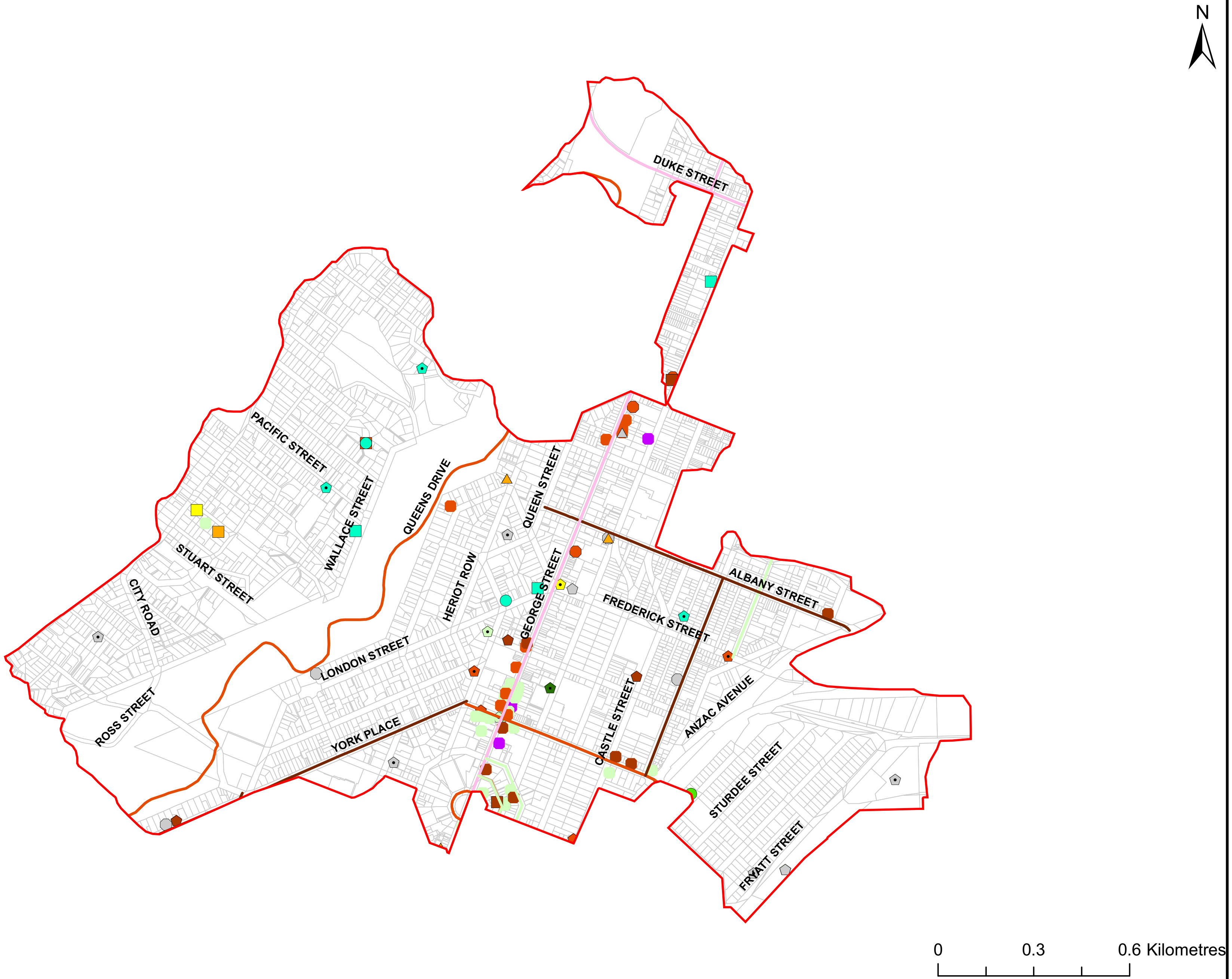
Problem Description

- Complaints
- Floodgate Outlet Damaged
- Pollution Spill
- Stormwater Channel Screen Blocked
- Stormwater Channel Screen Damaged
- Stormwater Overflowing - Into my basement or garage
- Stormwater Overflowing - Onto my property
- Drain - Boundary trap overflow
- Lamphole - Overflowing
- Sewer Blocked
- Sewer Collapsed
- Sewer Leaking
- Sewer Overflowing
- Sewer Manhole - Overflowing

Exact Location Unknown (Road Name Only)

Problem Description

- Complaint
- Stormwater Channel Screen Blocked
- Stormwater Channel Screen Damaged
- Stormwater Overflowing - Into my basement or garage
- Stormwater Overflowing - Onto my property
- Sewer Blocked
- Sewer Leaking
- Sewer Overflowing
- Sewer Manhole - Overflowing
- Land Parcels



Dunedin 3 Waters Strategy	**HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN** **Figure 4-13** **Halsey Street Catchment Reported Stormwater Flooding**	**DISCIPLINE** **Stormwater**	Drawn: KC	Status: Final	
			Checked: HES	Scale: 1:12,500	Plot Date: Sep 2011
			Approved: SDH	Job. No: 42173227	Map No: Figure 4-13 / Revision: -
			Date: Sep 2011		

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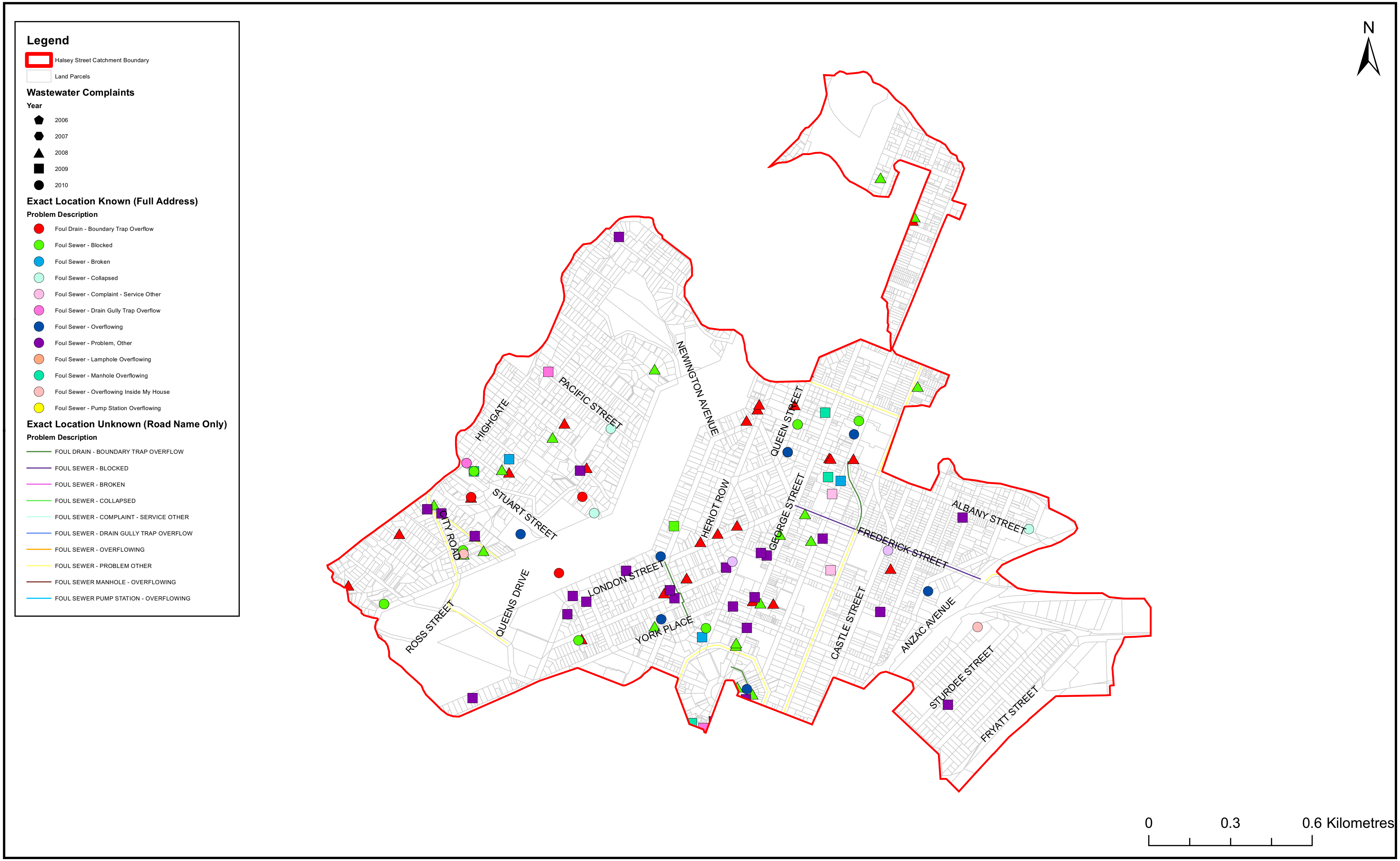

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DUNEDIN CITY COUNCIL · OPUS · URS	Dunedin 3 Waters Strategy	HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-14 Halsey Street Catchment Reported Wastewater Flooding	DISCIPLINE Stormwater	Drawn: KC Checked: HES Approved: SDH Date: Sep 2011	Status: Final Scale: 1:12,500 Job. No: 42173227	Plot Date: Sep 2011 Map No: Figure 4-14 Revision: -

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4.9 Water and Wastewater Systems

Figure 4-15 provides a layout of the three waters networks in the Halsey Street catchment.

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

4.9.1 Water Supply System

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

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

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

The water for the Halsey Street catchment is supplied from the North End reservoir, located to the north of the catchment in north Dunedin. There are approximately 60 km of water supply pipes within the Halsey Street catchment, with pipe diameters ranging from 15 mm to 500 mm diameter. The majority of the supply pipes in this catchment are constructed from cast iron.

The Halsey Street catchment is within the 'CBD' areas of the treated water supply. Leakage in the CBD has been identified as being higher than the average for Dunedin. Higher leakage in CBD areas is expected, due to difficulties in locating and repairing leaks. The higher leakage in the area may have a potential to infiltrate into the stormwater network. The performance of the pipework in the catchment area has been assessed, and no issues other than the high leakage have been identified.

DCC's Water Upgrade Plan identifies water mains review in Royal Terrace and a condition assessment in Moray Place planned for 2010/11.

4.9.2 Wastewater System

The main areas of investigation into the Dunedin City wastewater system during Phase 1 of the 3 Waters Strategy Project were system capacity, hydraulic performance, wastewater overflows and pumping stations. Current and future anticipated issues within the system at a macro level were identified. Flow survey and modelling from Phase 1 revealed a strong wet weather influence on the wastewater system city-wide, caused by both direct and indirect entry of stormwater via storm induced inflow and infiltration (I&I). This indicated that the Dunedin City wastewater system remains at least partially combined with a clear and significant response to rainfall. A number of wastewater manhole overflows were also predicted by the modelling whereby wastewater may then enter the stormwater system via curb and channel and stormwater catchpits and contribute to stormwater flows. Investigations also revealed that a number of wastewater overflows to the natural environment have been found to operate during rainfall events within Dunedin City.

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

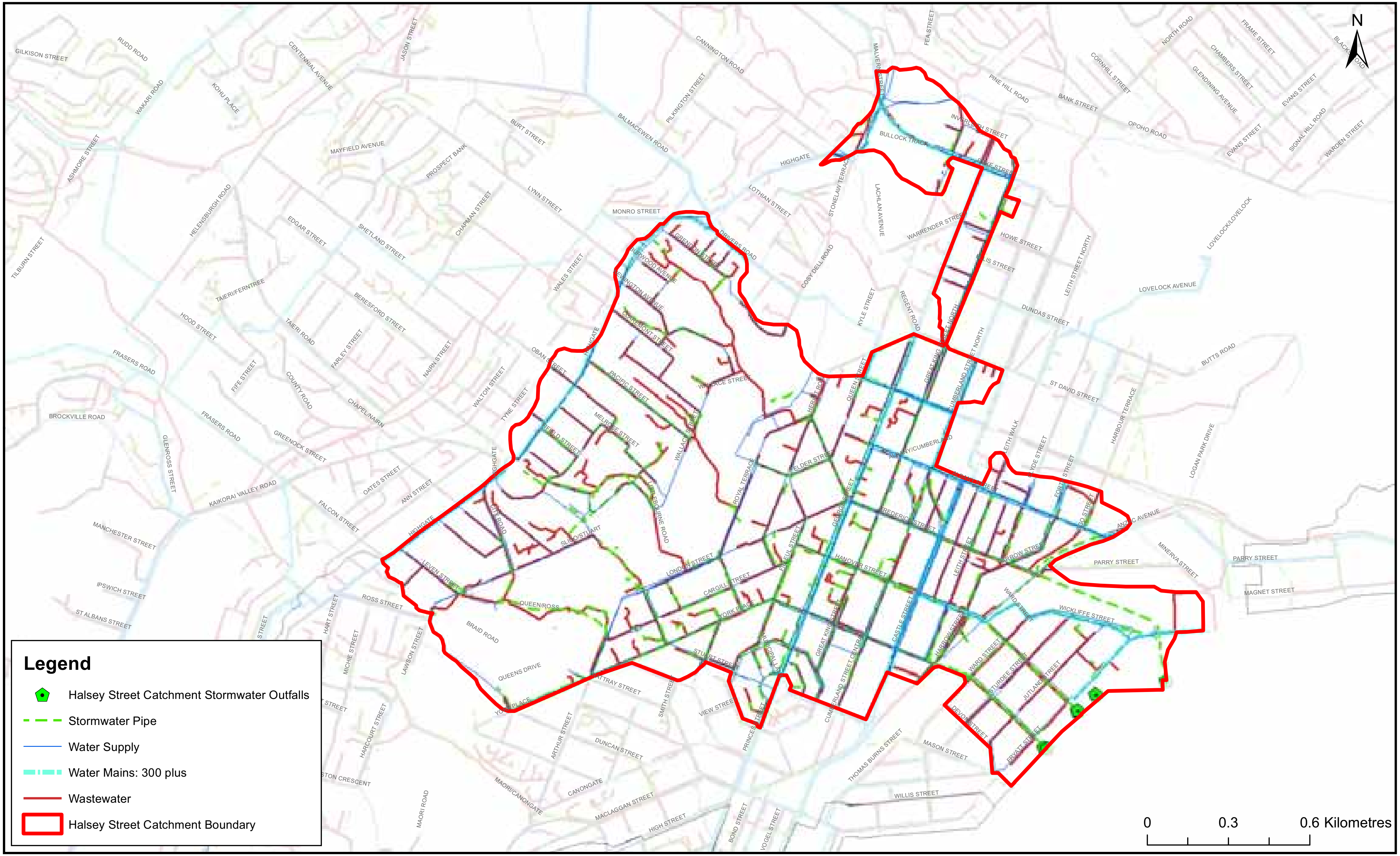
The wastewater system within Halsey Street catchment is part of the Dunedin Metropolitan Scheme. The Metropolitan Scheme provides wastewater services to the urban area of Dunedin, West Harbour communities, Ocean Grove and the Peninsula down to Portobello. The main interceptor sewer (MIS) is the main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

The system within the Halsey Street catchment comprises approximately 47 km of wastewater pipeline, approximately 80 % of which are between 150 mm and 300 mm in diameter.

The MIS runs through the Halsey Street catchment along Harrow Street and Anzac Avenue. Flows from Roslyn, central Dunedin, Harbourside and north Dunedin are conveyed to the MIS which in turn conveys the flows to the Musselburgh pumping station and ultimately the Tahuna WWTP.

There are two manually operated valve controlled cross connections between the wastewater and stormwater systems within the Halsey Street catchment. One is located at the junction of Harrow Street and St Andrew Street, and the other at the junction of Frederick Street and Harrow Street. In emergency situations these could be opened allowing flows to be transferred between the stormwater and wastewater systems.

As discussed in Section 4.7.4, a number of wastewater pipes in the lower catchment were rehabilitated during 2011, to reduce sea water infiltration into the network.



HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN	DISCIPLINE	Drawn: KC	Status: Final	
Figure 4-15	Stormwater	Checked: HES	Scale: 1:12,500	Plot Date: Sep 2011
Halsey Street Catchment Three Waters Networks		Approved: SDH	Job. No: 42173227	Map No: Figure 4-15 / Revision: -
		Date: Sep 2011		

Dunedin 3 Waters Strategy

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5 Receiving Environment

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

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

The stormwater network in the Halsey Street catchment discharges directly to the marine environment at the north-eastern shore of the Otago Harbour basin via six outfalls. This includes three main outfalls at Wickliffe Street, Halsey Street and Bauchop Street and minor outfalls at Halsey Street, Mason Street and Fryatt Street. The location of the outfalls, relative to other DCC stormwater outfalls and the Otago Harbour receiving environment, is shown in Figure 5-1.

There are three natural streams in the Halsey Street catchment, the locations of which are indicated in Figure 5-3. The watercourses are generally a combination of piped and natural sections, and receive discharges from the stormwater network as well as direct runoff from surrounding land.

5.1 Marine Receiving Environment

Monitoring of the harbour environment is undertaken on an annual basis in accordance with the conditions of consent for DCC's stormwater discharges. To date, four rounds of monitoring have been undertaken (2007, 2008, 2009, and 2010). The annual monitoring 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).

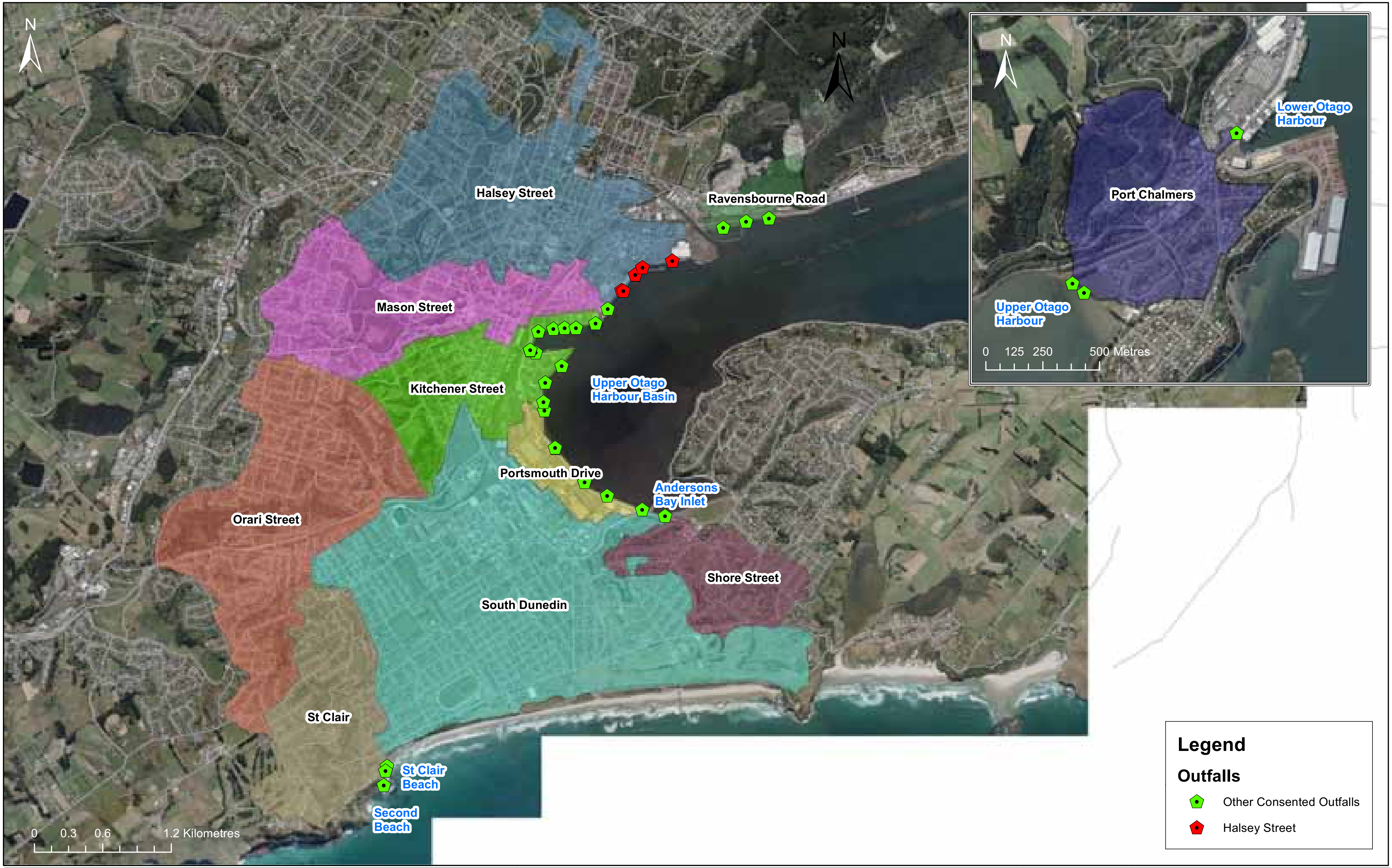
- Sediment monitoring: Replicate samples are collected from the top 200 mm of sediment within 20 m of each outfall monitored. The sediment is analysed for a suite of contaminants including heavy metals, bacteria and PAHs. In addition to the annual sampling, sediment is also analysed from four transects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

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.



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

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5.1.1 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 5-1.

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

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

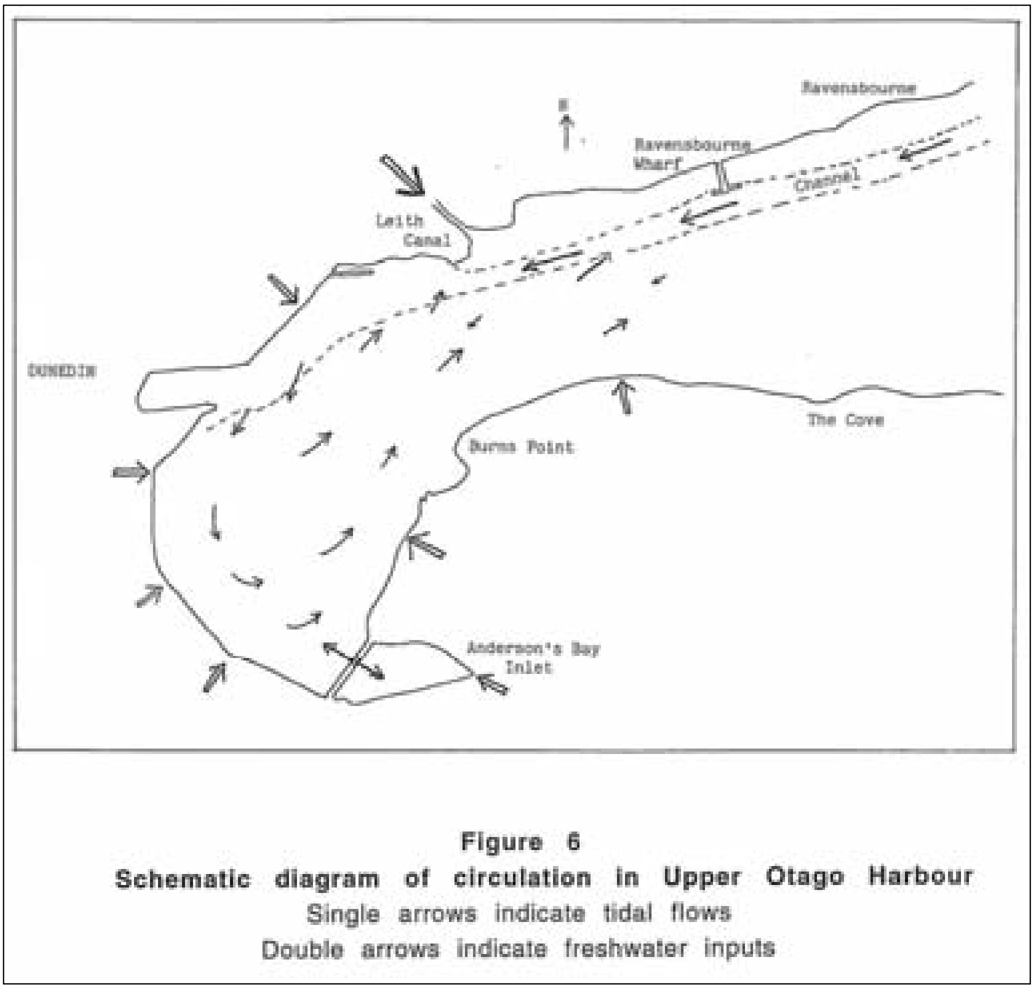


Figure 5-2: Circulation of Water in the Upper Otago Harbour (Smith and Croot, 1993)

5.1.2 Recreational and Cultural Significance

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

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

5.1.3 Harbour Ecology

The resource consents associated with the outfalls of the Halsey Street catchment (Bauchop Street outfalls) have conditions requiring biological monitoring. Whilst the outfalls of the Halsey Street catchment discharge into deep water and biological assessment of the benthic communities of the intertidal zone is not possible, the resource consents require that sampling of fish (spotties or triplefins) occurs within 50 m of the confluence of the outfall and the water's edge at low tide. The weight and length of fish is recorded and the flesh is analysed for a number of contaminants. The discharge consent for the Mason Street catchment (directly adjacent to Halsey Street); also has requirements for fish sampling. As the fish sampled will have a relatively wide range within the harbour, a single annual sample of fish in the vicinity of these catchments has been undertaken. The results of the fish sampling for Halsey Street catchment therefore mirrors that for the Mason Street catchment.

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

It is difficult to distinguish between the ecological effects of stormwater discharge and other influences. Harbour ecology is likely to be affected by a number of factors in addition to stormwater inputs, such as other discharges and freshwater input to the harbour (for example the Water of Leith) and historical sediment contamination.

Table 5-1: Sources of Stormwater Contaminants

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

The results of the biological monitoring (fish) for the Halsey Street consent requirements 2007 to 2010, can be summarized as follows:

- Fish: The monitoring results indicate that the mean weight and length of fish sampled increased between 2007 and 2010. The results for the contaminant concentrations in the flesh samples are variable between years and show no clear trend. The results for 2009, however, generally indicate higher contaminant levels than other monitoring years. The results are shown in Table 5-2.

- The Australia New Zealand Food Standards Code 2004 (the Code), sets out maximum levels (MLs) of specified contaminants in nominated foods. The contaminant concentrations measured in the fish flesh samples (2007 to 2010) were all below the MLs, for specified contaminants in fish.

The 2010 monitoring report notes that in general, 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).

Table 5-2: Contaminant Levels Measured in Fish Flesh Adjacent to the Halsey Street Outfall

Contaminant	Level in Fish Flesh mg/kg				ANZ Food Standards Code ML
	2007	2008	2009	2010	mg/kg
Arsenic (As)	1.9	1.6	1.9	1.6	2.0
Cadmium (Cd)	0.0047	0.0047	0.0110	0.0091	-
Chromium (Cr)	0.05	BDL	0.14	BDL	-
Copper (Cu)	0.54	0.52	1.20	0.38	-
Nickel (Ni)	BDL	BDL	< 0.095	BDL	-
Lead (Pb)	0.140	0.120	0.430	0.140	0.500
Zinc (Zn)	21	20	21	18	-
PAHs	0.0056	0.0023	0.0060	0.0150	-

BDL – Below Detectable Limits.

5.1.4 Harbour Sediments

The resource consents associated with the outfalls in the Halsey Street catchment have no sediment monitoring requirements. However, as part of the DCC annual monitoring programme, in order to gain a clearer picture of sediment contamination in the upper harbour basin, sediments have been collected, when the tide was suitable, on an annual basis, from less than 5 m from the outfalls at a number of sites harbour wide. Included in this sampling regime is a site adjacent to the Wickliffe Street outfall. This is within the Halsey Street catchment and therefore the results of this monitoring are discussed in this section.

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.

The upper harbour bed has been classified, in general, as muddy sands/sandy muds, with varying proportions of fine gravels (Ryder, 2005b). Sediments at the Wickliffe Street outfall are generally black and anoxic and smell strongly of hydrogen sulphide.

A range of historic data is available regarding contaminant levels within the harbour sediments. 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.

The stormwater catchments and associated outfalls into the Otago Harbour are located close together, and a certain amount of dispersion and mixing occurs in the harbour environment. It is difficult to associate any sediment contamination with any one outfall, and 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.

The sediment analysis results for consent monitoring 2007-2010 at the Wickliffe Street outfall are presented in Table 5-3 alongside Australian and New Zealand Environment and Conservation Council (ANZECC 2000) sediment quality guidelines and discussed below.

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

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

Contaminant levels in much of the harbour have been found to be highly variable but are generally higher closer to the outfalls than further away. However, this is not true for all contaminants or for all outfalls in any given year (Ryder, 2010b). For example, in 2010 copper and zinc levels were found to increase with distance from the Kitchener Street outfall (Kitchener Street catchment).

The monitoring results presented in Table 5-3 shows variability in contaminant levels between the years monitored. In general, lead and PAHs have been monitored at levels above ANZECC low trigger values and zinc has been consistently monitored above ANZECC high trigger values. Copper has also exceeded the low trigger values in earlier samples (2007 and 2008).

The contaminant concentrations in the 2010 sampling show that contaminant concentrations are generally similar to the previous year's sampling, or slightly elevated and the ANZECC low trigger values were still found to be exceeded by lead and PAHs and the high trigger values were again exceeded by zinc.

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

Table 5-3: Marine Sediment Guideline Values and Measured Contaminant Levels (within 20 m of Outfall)

Contaminant	ANZECC Trigger Value[1]		Wickliffe Street Outfall				Comment
	Low	High	2007	2008	2009	2010	
Arsenic (As)	20	70	17.3	11.0	6.9	9.0	All samples at or below ANZECC low trigger value.
Cadmium (Cd)	1.5	10	0.6	0.7	0.8	0.7	All samples at or below ANZECC low trigger value.
Chromium (Cr)	80	370	38.0	34.0	16.0	27.0	All samples at or below ANZECC low trigger value.
Copper (Cu)	65	270	121	68	50	58	Early samples exceeded the ANZECC low trigger value.
Nickel (Ni)	21	52	19.2	23.0	13.0	17.0	One isolated exceedence of low trigger value, all other results below low trigger.
Lead (Pb)	50	220	76.1	140	77	92	All samples exceed low trigger value.
Zinc (Zn)	200	410	412	740	810	740	All samples exceed high trigger value.
PAHs	4	45	9.2	1.2	7.3	7.2	Most samples exceed low trigger value.
Enterococci*	-	-	580	>1600	330	<3	Very low concentrations except 2008 result.
Faecal coliforms*	-	-	2	540	33	540	Very low concentrations.

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

KEY:

Exceeds Low ANZECC Trigger Value

Exceeds High ANZECC Trigger Value

5.2 Freshwater Receiving Environment

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

The assessment of stream health indicates, in part, the effect of ongoing stormwater discharges into the watercourses. The three streams in the Halsey Street catchment receive flows from the stormwater network. They have been receiving stormwater from urban development (both diffuse and concentrated) since the late 1800s; as a result, DCC's stormwater collection network has evolved around these natural flow corridors. Figure 4-10 shows the extent of open channel and piped network within the catchment.

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

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

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

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

Three streams with natural channels were identified as suitable for assessment in the Halsey Street catchment. A total of four sites were assessed in June 2010. The locations of the streams and assessment sites are shown in Figure 5-3.

Only one survey site was selected in two of the streams (Halsey Street 1 and 2), with two sites (upstream and downstream) being surveyed in the third (Halsey Street 3).

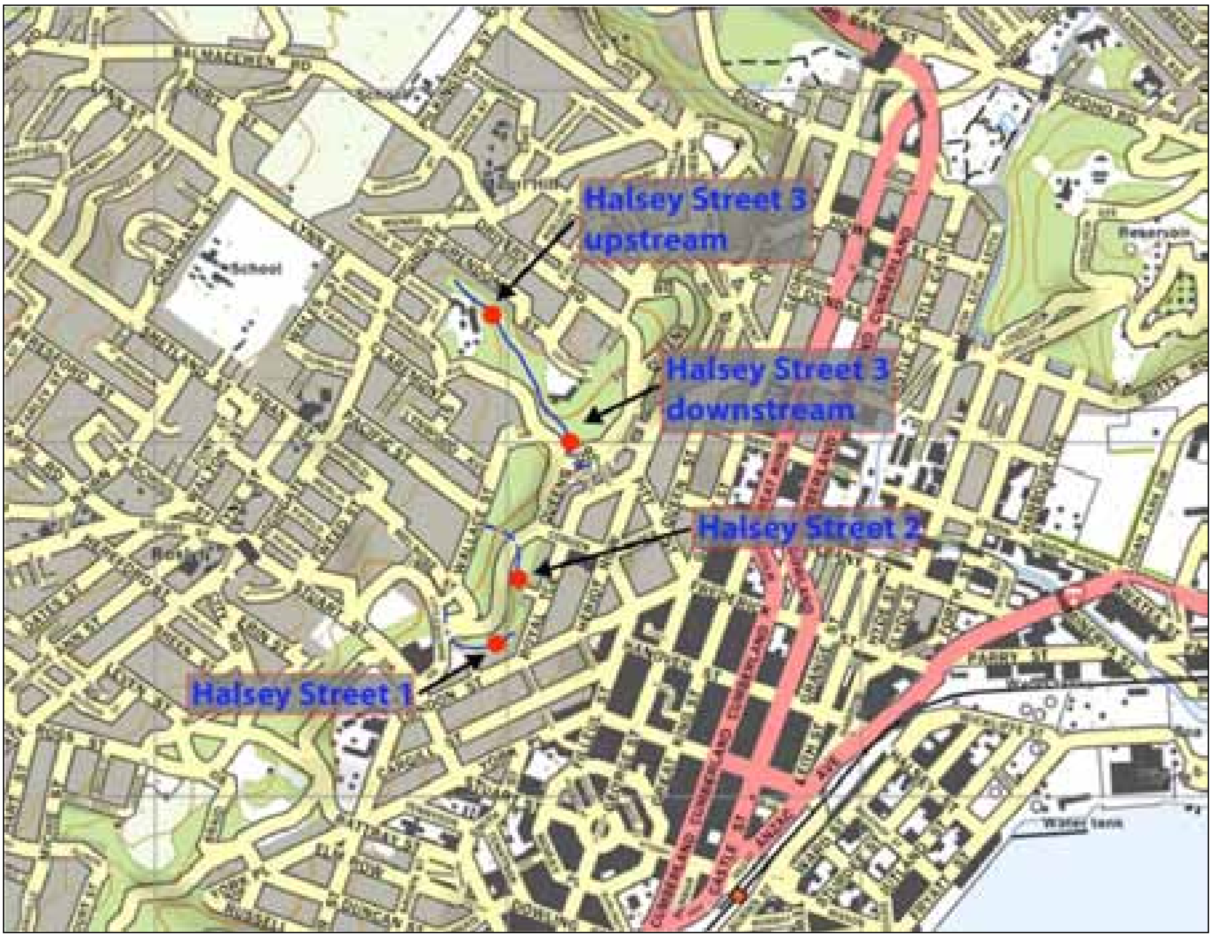


Figure 5-3: Freshwater Receiving Environment

5.2.1 Habitat Characteristics

The habitat characteristics of the streams, at the four sites assessed, are summarised in Table 5-4 and the following text.

Table 5-4: Assessment Site Characteristics

Characteristic	Halsey Street 1	Halsey Street 2	Halsey Street 3 - Upstream	Halsey Street 3 - Downstream
Length	60 m	100 m	80 m	40 m
Channel width	2-3 m	0.5-1.0 m	0.5-1.0 m	1-2 m
Channel depth	3-40 cm	2-40 cm	2-30 cm	3-30 cm
Bank height	2 m	0.5 m	0.5 m	0.5-1.5 m
Bank stability	High (boulders) / Low (clay)	High (gently sloping banks) / Low (steep banks)	Generally high	Very high
Wetted width	1-2 m	0.2-0.5 m	0.2-0.5 m	0.2-0.5 m
Dominant riparian vegetation	Native forest and leaf litter	Native forest and ivy	Garden and lawn	Native forest and ivy
In-stream characteristics	Shallow riffles with runs and small pools	Shallow riffles, with runs and small pools	Shallow runs, with some small riffles and pools	Shallow runs and pools, with some riffles
Bed substrate	Cobbles with sediment, gravels, small boulders and some clay-like material	Fine sediments, clay-like substrate, gravels. Steeper downstream end contained gravels, cobbles and small boulders	Gravels and cobbles, with some areas of fine sediments	Cobbles, boulders and bedrock
Other	Woody debris, moss and leaves - common	Some woody debris, moss and leaves	Some woody debris and moss. Leaves – common	Woody debris, moss and leaves were common

<u>Halsey Street 1</u>

The upper reaches of this stream flow from stormwater pipes into a natural channel, before re-entering pipes under Melrose Street and Queens Drive. Downstream of Queens Drive the stream enters a natural channel in a forested gully, this is the location of the sampling site.

The stream is contained within a gully with no public access and is not generally visible from adjacent roads, therefore no amenity values were identified.

Figure 5-4: Halsey Street 1 - Assessment Site

Halsey Street 2

The stream originates from stormwater pipes before flowing through a mixture of concrete channels, pipes and natural channels. Land use in the immediate catchment is reserve land, while the wider catchment is predominantly urban).

The only amenity value identified was a small walking track along the true left side of the stream floodplain and a partial view of the stream from Queens Drive.

Figure 5-5: Halsey Street 2 - Assessment Site

Halsey Street 3 upstream

The stream is a natural channel at the sampling site which is located between Newington Avenue and Grendon Street. The land use in the surrounding catchment is predominantly urban.

No public amenity values were observed because the site was located on private land.

Figure 5-6: Halsey Street 3 - Upstream Assessment Site

Halsey Street 3 downstream

The stream flows through a natural channel at the sampling site before entering a section of channel with historic artificial cobble substrate, upstream of Queens Drive. Downstream of Queens Drive the stream enters a concrete channel and stormwater pipes. Land use in the adjacent area is reserve and residential land.

The only amenity values identified were partial views from a walkway from Queens Drive to Newington Avenue and from Queens Drive itself.

Figure 5-7: Halsey Street 3 Downstream - Assessment Site

5.2.2 Water Quality

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

Conductivity levels were low at all sites. A higher conductivity indicates higher levels of nutrient enrichment.

Dissolved oxygen levels were below the minimum standard of 80 % for lowland river environments at Halsey Street 2 and Halsey Street 3 upstream. Dissolved oxygen levels of 52 % and 70.3 % were recorded at Halsey Street 2 and 3 downstream respectively. The Third Schedule of the RMA (1991) states that a dissolved oxygen (DO) level of 80 % is an acceptable minimum standard for lowland river environments in New Zealand.

5.2.3 Stream Ecology

The ecological assessment of the streams involved the survey of aquatic plants, benthic macroinvertebrates and fish.

A survey of the benthic algal cover and aquatic plants was undertaken and the relative abundance and diversity of species assessed.

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

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

The results of the stream ecological assessment are summarized below:

- Aquatic Plants: Low levels of algal cover were seen with generally only thin algal mats or films present on larger substrate surfaces. These mats consisted of several diatom taxa and filamentous algae.

- Macroinvertebrates: A total of 21 different taxa were observed within the Halsey Street streams. However, the average number of taxa per sample, at any given site, was below the national average of 14 (as determined in a nation-wide survey by Quinn and Hickey 1990).

- Macroinvertebrate communities were dominated by oligochaete worms with a high abundance of freshwater pea clams at Halsey Street 3 upstream. Other taxa observed were found in low abundances. This included a large adult crayfish seen at Halsey Street 1 during spotlighting.

- Macroinvertebrate community health index scores were very low throughout the catchment, and indicative of a ‘poor’ quality habitat (using narrative terminology of Stark and Maxted 2004).

- Fish: No fish were caught or observed in the three streams surveyed in this catchment.

5.2.4 Summary

The following summarises the freshwater receiving environment within the Halsey Street catchment. Further to the use of national classification systems, the different habitat and ecosystem features of the streams surveyed in the Dunedin stormwater catchments as part of this study, have been interpreted relative to each other to summarise the receiving environment within the catchment. The features have been given an overall value of between ‘poor’ and ‘excellent’, based on the findings of the site assessments. This is shown in Table 5-5.

The aquatic ecosystems of the stream sites within the catchment were generally of poor quality, with low dissolved oxygen levels, especially at Halsey Street 2 and Halsey Street 3 upstream sites, poor quality invertebrate communities and an absence of fish. However, in-stream habitat was found to be of good quality.

The presence of an individual crayfish at Halsey Street 1 site indicates that conditions are suitable for a large crustaceans and potentially other organisms as crayfish are a suitable indicator species for good quality environment. However, the absence of juvenile crayfish indicates that the population may be in decline and not self-sustaining. Further monitoring would be required to confirm this.

There are currently no relevant National Policy Statements or National Environment Standards relating to freshwater systems. There is a Proposed National Environmental Standard on Ecological Flows and Water Levels however the focus of this is on setting ecological flows and water levels in relation to water abstraction.

Whilst the stream quality is not good compared to a pristine, wilderness environment, the habitat quality of streams in the Halsey Street catchment vary, but are as to be expected for modified urban streams.

Table 5-4: Summary of Habitat and Ecosystem Quality in the Shore Street Catchment
(Values are 'poor', 'good', and 'excellent')

Feature	Halsey Street 1	Halsey Street 2	Halsey Street 3	
			Upstream	Downstream
Riparian vegetation	Excellent	Good	Good	Good
Bank stability	Good	Good	Good	Excellent
Flow variability	Good	Good	Good	Good
Bed substrate	Good	Good	Good	Excellent
In-stream cover	Excellent	Good	Good	Good
Water quality	Good	Poor	Good	Excellent
Invertebrates	Poor	Poor	Poor	Poor
Fish	Poor	Poor	Poor	Poor

6 Stormwater Quality

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

6.1 Stormwater Quality Monitoring

Annual water quality sampling of the stormwater discharges in this catchment is required as a condition of the discharge consents. Three outfalls in the Halsey Street catchment have been included in this sampling regime. They include the Bauchop Street, Halsey Street and Wickliffe Street outfalls.

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

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

Three time-proportional stormwater quality samples have also been taken across Dunedin as part of the 3 Waters Strategy; one at South Dunedin (2009), one at Bauchop Street (2009), and one at Port Chalmers (2010). These three sites provide stormwater quality representing industrial/residential, commercial/residential, and residential land uses respectively. The Bauchop Street time-proportional monitoring site is within the Halsey Street catchment and therefore gives further information regarding the range of stormwater contaminants discharged from this catchment during a rainfall event.

6.2 Stormwater Quality Results

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

Table 6-1 presents the results of the annual monitoring at the Halsey Street catchment outfalls, which is undertaken via a grab-sampling technique, providing a ‘snapshot’ of stormwater quality during a storm event.

Table 6-2 shows the results of the time proportional sampling in Dunedin. The results provide an indication of the variations in contaminant concentrations throughout the duration of a rainfall event for catchments with differing urban land uses. The results from the Halsey Street catchment (Bauchop Street), are highlighted in this table.

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

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

The 2010 stormwater grab samples were collected 23rd April, during a 2.6 mm rainfall event following eight days of dry weather.

The contaminant levels measured within the stormwater from grab samples in this catchment are highly variable across the four monitoring years and between outfalls. However, majority of contaminant levels measured in these samples were within, or below, the range typically observed in urban stormwater. This is true across all sampling years, when compared with stormwater data from the variety of sources listed in Table 6-3, with several being below detectable limits, particularly in 2010. The exception to this is the level of microbial contamination, which is discussed further below.

The levels of E.coli and faecal coliforms, measured in the annual monitoring grab samples, have fluctuated over the four monitoring years. However, over the four year sampling period, there have been multiple recordings of faecal coliform concentrations exceeding the typical range for urban stormwater (1,000 – 21,000 MPN/100 ml) (Metcalf & Eddy, 1991), notably, for all monitoring years in the stormwater from the Wickliffe Street outfall and in 2009 and 2010 in stormwater from the outfall on Halsey Street.

The presence of FWAs within the stormwater can be an indication of human waste contamination within the stormwater, however, the fluctuations measured in E.coli and faecal coliforms does not correspond with measured fluctuations in the FWA level and therefore it cannot be concluded that the microbial levels within the stormwater are as a result of human waste contamination.

There are two manually operated valve controlled cross connections between the wastewater and stormwater systems within the Halsey Street catchment (refer Section 4.9). In emergency situations these could be opened allowing flows to be transferred between the stormwater and wastewater systems. However, there is no record of this occurring in recent years.

There are a number of wastewater complaint records for this catchment, in particular for 2008 and 2009. However, it is unclear from most of the records whether the incidents recorded resulted in wastewater flooding within the catchment and therefore causing peaks in microbial contamination in the stormwater.

The potential source of the microbial contamination in the stormwater is therefore difficult to distinguish.

The time-proportional monitoring of stormwater from the Bauchop Street outfall (2009) indicates the range of contaminants in the stormwater throughout a rainfall event. The results are in contrast to the annual monitoring and indicate that, during the event sampled, the range of suspended solids, zinc and copper were at or above the range typically observed from when compared with stormwater data from the variety of sources listed in Table 6-3.

The Halsey Street catchment is predominantly commercial and residential land use with some industrial activities and there are a number of areas where older buildings are prevalent. As the Central Activity Zone is within the catchment and State Highways 1 and 88 run through the catchment, it is also an area of high vehicular traffic. The contaminant levels measured in the stormwater may be reflecting the land uses of the catchment with potential sources of contaminants being building materials and motor vehicles.

A single time-proportional sample, whilst giving an indication of the range of contaminants in a single event, is not sufficient to give a clear picture any trends in stormwater contaminants over time to be assessed.

Table 6-1: Stormwater Quality Consent Monitoring Results –Halsey Street Catchment Outfalls

Year	Contaminant												
	pH	As	Cd	Cr	Cu	Ni	Pb	Zn	TSS	Oil and Grease	FWA	E.Coli	Faecal Coliforms
		g/m^3									µg/l	MPN/ 100ml	cfu/ 100ml
Bauchop Street Outfall													
2007	7.6	0.03	BDL	BDL	0.029	0.01	0.01	0.23	44	4	2.028	2200	2200
2008	7.8	BDL	BDL	0.0015	0.0096	BDL	0.0035	0.12	16	BDL	4.92	400	400
2009	8.1	0.021	BDL	BDL	BDL	BDL	BDL	0.13	13	BDL	0.031	3000	3000
2010	7.4	BDL	0.00049	BDL	0.0026	BDL	BDL	0.121	53	BDL	0.067	7900	35000
Halsey Street Outfall													
2007	7.3	0.03	BDL	BDL	0.024	0.009	0.021	0.12	119	9	BDL	9000	9000
2008	7.3	BDL	0.00022	BDL	0.0043	BDL	0.0022	0.033	35	BDL	0.004	1700	1700
2009	7.2	0.01	BDL	BDL	0.021	0.0035	0.0097	0.3	27	BDL	0.011	70000	70000
2010	6.8	0.0044	0.00026	BDL	0.0016	BDL	0.0021	0.136	50	BDL	0.061	17000	92000
Wickliffe Street Outfall													
2007	7.7	0.03	BDL	BDL	0.01	0.01	0.006	0.1	35	6	0.024	25000	30000
2008	7.5	BDL	BDL	0.0017	0.013	BDL	0.0084	0.2	27	9.5	0.003	10000	10000
2009	8.0	0.003	0.00052	0.0076	0.059	0.0042	0.033	0.53	100	9.5	0.021	220000	220000
2010	7.3	BDL	0.00078	0.00157	0.0058	BDL	BDL	0.24	86	BDL	0.048	35000	54000

BDL = Below detection limits

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

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

BDL = below detection limit

Table 6-3: Comparison of Halsey Street Catchment Stormwater Quality with Other Stormwater Quality Data

Contaminant (g/m^3)	Time Proportional Dunedin	Christchurch Recommended Provisional Mean Values[1]	Pacific Steel, Auckland[2]	Brookhaven Subdivision[3]	Australian Stormwater Mean[4]	Urban Highway, USA[5]	New Zealand Data Range[2]	Halsey Street 2010
	Residential / Industrial	Christchurch	Industrial	Residential	Australian sites	Highway	Urban	Mixed Use
TSS	8 - 330	33 - 200	124	5 - 49	164	142	-	50 - 86
Zinc	0.05 - 2.50	0.40	2.80	0.003 - 0.260	0.910	0.329	0.09 - 0.80	0.136 - 0.24
Copper	BDL - 0.23	0.05	0.08	0.002 - 0.031	0.08	0.054	0.015 - 0.110	0.00162 - 0.0058
Lead	BDL - 0.087	0.075	0.23	0.003 - 0.007	0.25	0.4	0.06 - 0.19	BDL - 0.121

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

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

- Two alternative catchment imperviousness figures; one for the current land use, and one for the future, representing the likely maximum imperviousness.
- Seven different high tide situations; current 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 yr, 1 in 5 yr, 1 in 10 yr, 1 in 50 yr and 1 in 100 yr 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 Halsey Street catchment model was calibrated against a single flow monitor installed at the base of the catchment, and validated using stormwater flooding complaints. 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 (light detecting and ranging) survey data were also incorporated into the model. Catchment hydrological (runoff) parameters were estimated based on the calibrated model built for the pilot catchment, South Dunedin, and adjusted during calibration.

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

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

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

Table 7-1: Halsey Street Model Results – Current Land Use

Hydraulic Performance Measure	ARI	Current Land Use
Percentage of manholes predicted to overflow	1 in 2[1] yr	2
	1 in 5 yr	11
	1 in 10 yr	16
Number of land parcels with flood depth potentially >= 300 mm[2]	1 in 2[1] yr	0
	1 in 5 yr	2
	1 in 10 yr	20
	1 in 50 yr	32
	1 in 100 yr	64
Estimated flood extent (% of catchment area with flood depth >= 50 mm)	1 in 2[1] yr	0.05
	1 in 5 yr	0.28
	1 in 10 yr	0.81
	1 in 50 yr	2.62
	1 in 100 yr	3.64
Modelled percentage (by number) of pipes surcharging	1 in 2[1] yr	27
	1 in 5 yr	42
	1 in 10 yr	57
Percentage of manholes predicted to be close to overflowing (free water level within 300 mm of cover)	1 in 2[1] yr	5
	1 in 5 yr	16
	1 in 10 yr	22

[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: Halsey Street 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	17	20	21	21	27
Number of land parcels with flood depth potentially >= 300 mm[1]	1 in 10 yr	19	20	23	26	27
	1 in 50 yr		48		56	
	1 in 100 yr					177 [2]
Estimated Flood Extent (% of catchment area with flood depth >= 50 mm)	1 in 10 yr	0.83	1.38	1.62	1.74	2.38
	1 in 50 yr		3.16		3.55	
	1 in 100 yr					8.43
Modelled percentage (by number) of pipes surcharging	1 in 10 yr	58	66	67	68	73
Percentage of manholes with free water level within 300 mm of cover	1 in 10 yr	23	27	30	30	38

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

[2] Includes 1 in 20 yr ARI storm surge (model run 14), which inundates 30 % of the catchment under dry weather conditions.

URS

Dunedin 3 Waters Strategy

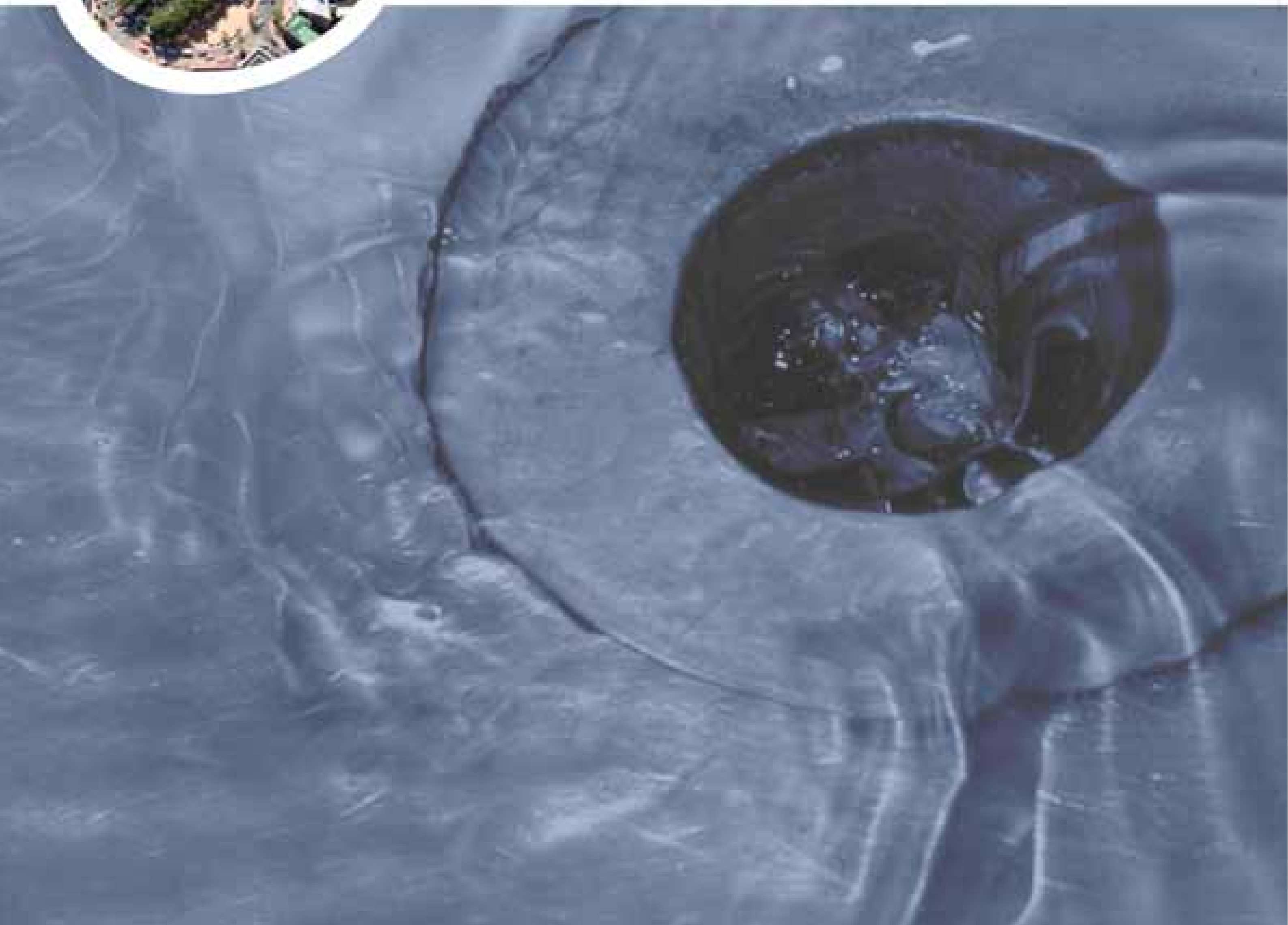
HALSEY ST INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 7-1
Halsey Street Stormwater Catchment Model Extent

Discipline:
Stormwater

MH	Final		
MG	NTS	January 11	
WB	3-d1040.07		
February 11			

Part 3
Analysis



8 Assessment of Environmental Effects

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

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

8.1 Stormwater Quantity

8.1.1 Benefits of the Stormwater Network

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

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

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

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

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

8.1.2 Stormwater Quantity Effects

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

Each planning scenario modelled used a range of assumptions which are outlined in Section 7. Flow monitoring was undertaken in this catchment and the model calibrated to replicate observed flow, depth and velocity data as well as possible. A historical rainfall event (February 2005) was also simulated, and model results compared with reported flooding information for the same event in order to validate the model. Due to adequate calibration and validation, confidence in the model is considered to be moderate to high.

It should be noted however, that even with a moderate to high level of confidence, there are still some uncertainties in the model. Assumptions regarding the catchment's hydrology represent the highest area of uncertainty, particularly in the Town Belt, with additional uncertainties due to interpolation of missing GIS data, LiDAR data limitations, the simplistic replication of open channel dimensions within the Town Belt, and the omission of small pipes elsewhere.

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

8.1.3 Infrastructure Capacity

The network analysis and flood mapping undertaken for the current land use show that the predicted level of service provided by the stormwater network in the Halsey Street catchment is variable (refer Table 7-1, 7-2). Overall, it is predicted to be approximately equivalent to a 1 in 10 yr ARI rainfall event in most of the catchment, with a few areas of exception having a lower level of service. These are discussed below.

In general, DCC are particularly concerned with the point at which a manhole is predicted to overflow and cause flooding (particularly to potential habitable floors); however the pipe surcharge state, and manholes that are 'almost' overflowing are also of relevance when considering available capacity in the system.

Based on the results presented in Section 7 (manholes overflowing), the model of the stormwater network estimates that the percentage of the network able to accept stormwater flows is as follows:

- 98 % of the network can accept a 1 in 2 yr ARI rainfall event;
- 84 % of the network can accept a 1 in 10 yr ARI rainfall event; and
- 64 % of the network can accept a 1 in 100 yr ARI rainfall event.

It should be noted however, that whilst the stormwater system is able to accept the flows, they may not immediately be conveyed by the network. For example, during a current 1 in 2 yr ARI rainfall event combined with a MHWS tide, some surcharging across the modelled network is predicted, with approximately 27 % of the pipes having no spare capacity and approximately 2 % of all manholes in the catchment predicted to overflow.

There are some system restrictions in the upper catchment during a 1 in 2 yr ARI rainfall event; current modelling indicates that manhole overflows are predicted due to insufficient network capacity. However, the majority of system restrictions are predicted to occur on the flat land of the lower catchment. Several of the pipes are predicted to be flowing full and manhole overflows are also predicted. Pipe surcharging in the lower catchment during this event is primarily due to tidal influence on the stormwater network reducing capacity. The six outfalls discharge below the high tide water level and so the tide forms a backwater effect causing surcharging of the pipes upstream. The tidal influence extends up the system until approximately Filleul Street/York Place. This is shown in Figure 8-1, with tidally influenced pipes showing a surcharge state.

Figure 8-1: 2010 1 in 2 yr ARI Rainfall Event (Model Results)

Further to overflows during the 1 in 2 yr ARI event, the number of manhole overflows in the catchment during a 1 in 5 yr ARI rainfall event is estimated to be 44 (an increase from 9 in the 1 in 2 yr ARI event), and one of the intake structures at City Road is also predicted to overtop; this is primarily due to design (the intake comprises a double catchpit, which is particularly prone to blockage), and as such the structure does not efficiently convey stormwater flows. However, the predicted flooding during this event is considered insignificant.

During a 1 in 10 yr ARI rainfall event, with a MHWS tide, further pipe surcharging is predicted in the lower catchment, and additional manholes overflows are predicted in the upper and lower catchment. This is shown in Figure 8-2. The model predicts that approximately 16 % of the manholes in the catchment will overflow and approximately 57 % of the modelled network is predicted to be flowing full. Flooding resulting from manhole overflows is discussed in the following sections, along with the anecdotal evidence provided by DCC Network Management and Maintenance staff.

Workshop discussions revealed that the blockage of intake structures in the catchment is known to significantly reduce the efficiency of the structures and, during significant rainfall events, may cause the intake screen to overtop, contributing to catchment flooding. Similarly, catchpit blockage was highlighted as another factor contributing to a reduction in the capacity of the network. Catchment flooding is discussed further in the following sections and network maintenance is discussed further in Section 8.1.4.

Workshop discussions also confirmed that network capacity problems, resulting in manhole overflows have been observed at the lower end of York Place particularly at the junction with Haddon Place and Filleul Street/St Andrew Street.

As this catchment is almost fully developed, with the exception of the Town Belt, future land use changes are unlikely to be significant. Imperviousness is already estimated to be at or above the maximum allowable by the DCC District Plan; this means that projected growth will not significantly reduce the level of service provided by the stormwater system, and any future increase in flooding predicted by the model is almost entirely as a result of projected climate change effects.

The number of manholes overflowing in the Halsey Street catchment during a 1 in 10 yr ARI rainfall event is predicted to increase from 16 % currently, to 21 % when a 2060 mean climate change scenario is modelled.

Figure 8-2: 2010 1 in 10 yr ARI Rainfall Event (Model Results)

8.1.4 Flooding

The hydraulic model has been used to indicate areas within the catchment potentially at risk of flooding during a variety of planning scenarios. This includes a range of storm events, current and future land use scenarios and climate change projections, generally modelled with a MHWS tide condition (adjusted for climate change where necessary). These predictions have been validated, where possible, with anecdotal evidence from DCC Network Management and Maintenance staff, and observations made on the catchment walkovers. As outlined in Section 4.8, a number of flood complaints have been made by the public in the catchment in recent years.

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

8.1.4.1 Nuisance Flooding

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

Nuisance flooding is predicted within the catchment at a number of locations, the effects and significance of this flooding is described below.

Significant nuisance flooding occurs on the flat land of the lower catchment, within the central city, or the slopes of the middle catchment where overland flows contribute to nuisance flooding in the lower catchment.

Table 8-1 presents the most significant locations affected in the Halsey Street stormwater catchment during events up to 1 in 10 yr ARI rainfall event; the identification of these locations is based on model outputs combined with confirmation from customer complaints and/or DCC Network Management and Maintenance staff. Figure 8-3 shows the significant nuisance flood extents and surcharging manholes contributing to flooding within the catchment.

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

Location	Description	Predicted Cause	Minimum Rainfall Event (ARI yr)
London Street / Heriot Row Intake structure	Stormwater flows across property immediately downstream of intake onto London Street. Building at risk of interior flooding. High velocity flows (up to 2 m/s) across Heriot Row / Scotland Street intersection and down embankment to 84 Filleul Street resulting in flooding around building, > 300 mm deep, building at risk of flooding. Flows contribute to overland flows down Filleul Street and St Andrew Street	Intake structure and pipework immediately downstream of limited capacity causing significant hydraulic restriction. Flooding exacerbated when intake screen blocked.	1 in 10
York Place	Manhole overflows lower end of York Place. High velocity flows (up to 1 m/s) downhill contributing to overland flows and nuisance flooding on St Andrew Street.	Inadequate capacity in local network and backwater effect from main stormwater line on St Andrew Street resulting in manhole overflows. Hydraulic bottleneck upstream of pressure line on York Place resulting in manhole overflows.	1 in 5
St Andrew Street / George Street	High velocity flows at the top end of St Andrew Street, contributed to by overland flows from York Place and Filleul Street. Some stormwater predicted to flow into, and pond on George Street, the remainder contributing to flooding downhill. Flood depths of less than 300 mm may present a risk to building flooding on George Street. Manhole overflows at intersection with St Andrew Street and Castle Street, Leith Street and Cumberland Street. Flooding across the full width of the road at Castle Street intersection. Significant ponding (> 200 mm deep) at Cumberland Street intersection. Traffic passing through can cause bow wave onto pavement. Overland flows downhill arriving at intersection with Leith Street contribute to manhole overflows in the locality.	Main stormwater line on St Andrew Street flowing full and manhole overflows result primarily due to tidal influence on the network in the lower catchment.	1 in 5

Figure 8-3: 2010 1 in 10 yr ARI Rainfall Event (Model Results) - London Street / Filleul Street / York Place / St Andrew Street

The areas most affected by nuisance flooding in this catchment include busy parts of the city with significant vehicular and pedestrian traffic. The effects of the nuisance flooding are considered to be significant and can be summarised as follows:

- High velocity flows predicted (1-2 m/s) in a number of locations presenting risk to the public in areas of high pedestrian traffic.
- Nuisance flooding predicted to result in ponding extending the full width of the road (St Andrew Street), with traffic causing bow waves onto the pavement.
- Heightened sensitivity of property owners and the public to flooding in this location following the significant effects of the February 2005 rainfall event.
- Risk of flooding to commercial premises (George Street), even at flood depths less than 300 mm.
- A number of economic and social wellbeing locations and historic buildings may be affected (refer Sections 4.5.2 and 4.7.3).

Furthermore, a significant number of flood complaints have been made for this part of the catchment, notably along George Street and St Andrew Street. Most of the complaints recorded relate to the 2005 event, and include several instances of flooding entering buildings.

Further to the areas indicated in Table 8-1, the model predicts that a number of other areas may experience nuisance flooding in small events (and consequently more severe flooding in larger events), as described in Table 8-2 below. These events are unconfirmed by customer complaints or anecdotal evidence.

Table 8-2: Modelled Flood Areas (Unconfirmed)

Area	Location	Predicted Flooding
Upper Catchment	Bute Street / Duchess Avenue	Moderate flooding in the vicinity of the Bute Street intake structure due to the screen overtopping, resulting in deep flooding (> 300 mm) around the intake. Due to a backwater effect resulting from a small diameter pipe causing a hydraulic restriction downstream of the intake.
	City Road Intake Structure / Queens Drive	Low to moderate flooding around the intake structure with some overland flows through the Town Belt predicted. Manhole overflows downstream of intake are predicted to contribute to overland flows. Flooding exacerbated by intake blockage.
	Claremont Street	Low to moderate flooding in the gardens of properties on Claremont Street and overland flows across Hamel Street/Newington Avenue intersection and into a gully in the Town Belt. Due to undersized pipe and therefore manholes overflowing.
Lower Catchment	Anzac Avenue / Parry Street	Moderate to significant flooding on Anzac Avenue close to/with the intersection with Parry Street. Shallow ponding across full width of road on Parry Street. Surcharging of mainline due to tidal influence causes a backwater effect in stormwater pipes on Anzac Avenue. Manhole overflows result.
	Frederick Street	Low to moderate flood flows along the kerb-line of Frederick Street, to the south of the intersection with Clyde Street, ponding at the intersections with Anzac Avenue and Harrow street. Flows contribute to manhole overflows from Anzac Avenue (see above). Due to tidal influence on mainline on Frederick Street, manhole overflows result.
	Akaroa Street	Low flooding along the kerb of Akaroa Street. Due to an undersized pipe, manhole overflows result.

The nuisance flooding and effects described are predicted to worsen when future planning scenarios are applied to the model. However, as future land use changes in the catchment are unlikely to be significant the future increase in flooding predicted is almost entirely as a result of projected climate change effects.

8.1.4.2 Habitable Floor Flooding

Predicted 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, analysis of a variety of rainfall events is undertaken in order to assess the risk of flooding.

It should be noted that although the model predicts that a number of land parcels will experience deep flooding (> 300 mm), particularly during a 1 in 50 yr ARI rainfall event, some may result due to limitations in the LiDAR data and the model may therefore incorrectly predict flooding in certain locations. Not all buildings are included in the ground model and the model may incorrectly predict flooding of building footprints. Additionally, flood predictions in gully areas are usually related to stream channels, and therefore do not pose a flooding risk to properties. Information gathered on catchment walkovers, data analysis and engineering judgement has been applied in these situations, as well as model analysis, and those areas within the catchment that are considered at risk of deep flooding are described below.

During a current 1 in 50 yr ARI rainfall event approximately 32 land parcels are predicted to experience flood depths of greater than 300 mm, an increase of 12 from the 1 in 10 yr ARI event. Future land use with the application of 2060 mean climate change could result in approximately 56 properties experiencing flooding on part of their land parcels to depths greater than 300 mm. It is uncertain however, whether this flooding is likely to enter habitable floors as no floor levels surveys have been undertake. Furthermore, a number of properties are only predicted to experience flooding on part of the land parcel or the land parcels are away from buildings (for example, within the Town Belt).

The model predicts that two land parcels will experience deep flooding (>300 mm) during a 1 in 5 yr ARI rainfall event, and approximately 20 land parcels during a 1 in 10 yr Ari rainfall event.

The most significant locations that deep flooding is predicted, posing a risk to habitable floor flooding during the current 1 in 50 yr ARI rainfall event, are shown in Figure 8-4 and are as follows:

- Former Smith City site (84 Filleul Street);
- George Street;
- Harrow Street / St Andrew Street / Anzac Avenue intersection; and
- London Street / Heriot Row intake structure.

Workshop discussions have verified the locations of the predicted deep flooding. Furthermore, a significant number of flood complaint records exist in the catchment, predominantly for George Street, St Andrew Street, and Filleul Street, many of which describe significant flooding to the interior of buildings. However, the complaints were recorded following the February 2005 rainfall event, which is considered to have a peak intensity in excess of the design capacity of a new stormwater network.

There are no complaints records relating to Harrow Street / St Andrew Street / Anzac Avenue and analysis of aerial photographs indicates that the predicted deep flooding is unlikely to reach the buildings on the properties in this location.

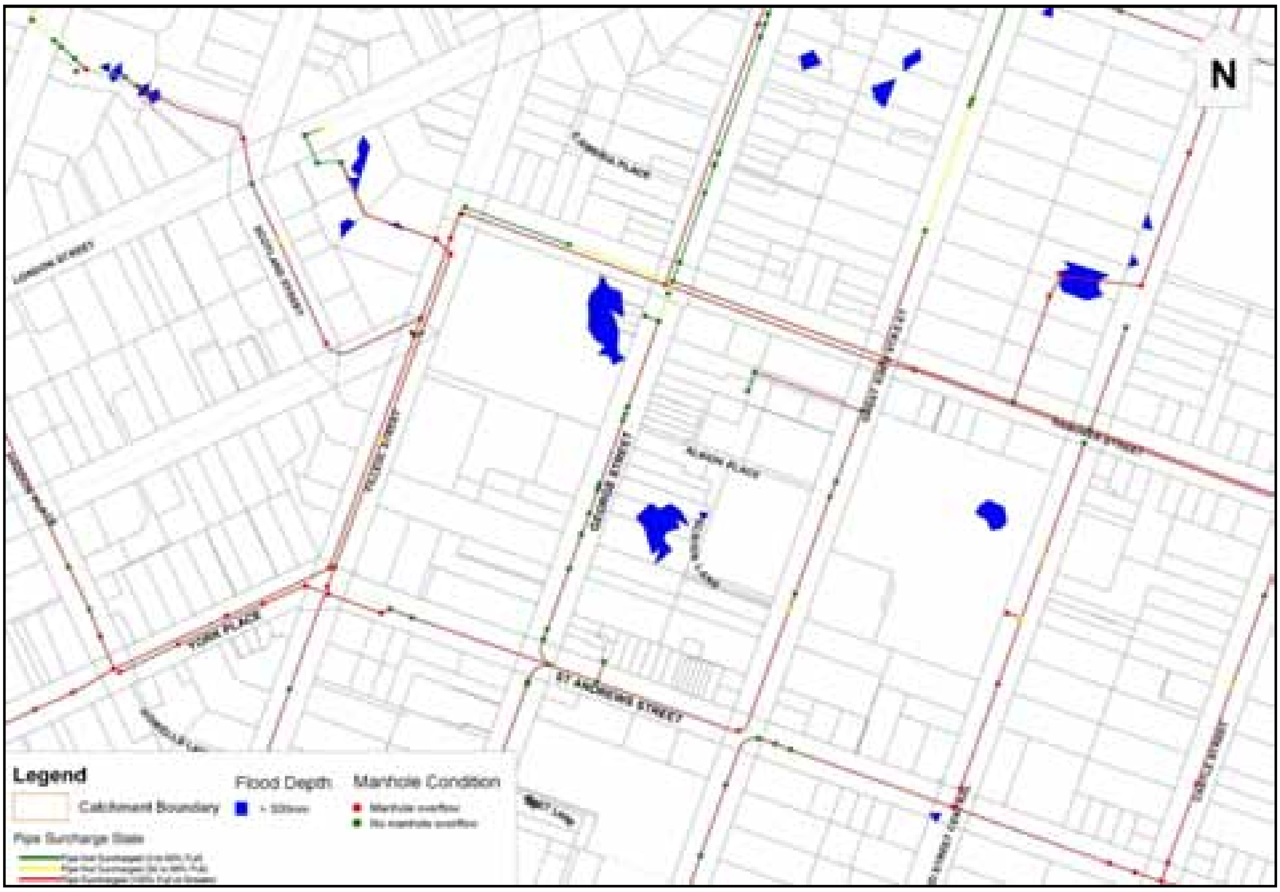


Figure 8-4: 2060 1 in 50 yr ARI Rainfall Event (Model Results)

8.1.4.3 Flood Hazard

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

A predicted flood hazard rating has been calculated for the current and future (extreme) planning scenario during a 1 in 100 yr ARI event. A flood hazard rating is a factor of velocity and depth calculated from the hydraulic model results. It indicates the likely degree of flood hazard for a given area and the associated risk to the public. A definition of each Rating can be found in Table 8-3.

Table 8-3: 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

The maximum flood hazard rating for the catchment during a current 1 in 100 yr ARI rainfall event is 'significant', the main locations being London Street (in the vicinity of the intake structure), St Andrew Street, Pitt Street and Rattray Street in the Town Belt. Of significance to the flood hazard rating in these locations is the high velocity of flows predicted during this event (Figure 8-5).

Figure 8-5: 2060 1 in 100 yr ARI Rainfall Event (Model Results)

During a future 1 in 100 yr ARI rainfall event when the extreme planning scenario is applied, it is predicted that the total flood area will comprise approximately 8 % of the catchment, mostly on the flat land of the lower catchment. Much of the predicted flooding in the lower catchment, predominantly to east of the railway is associated with the extreme tide level and storm surge applied to the model. During this event the maximum flood hazard rating is ‘extreme’ around the wharf on Fryatt Street with further areas of ‘significant’ flood hazard rating predicted in the Central Activity Zone, with the areas of greatest risk being in the vicinity of St Andrew Street. This is shown in Figure 8-6.

It is predicted that during this future event transport routes, particularly within the central city, would be significantly disrupted. Several sections of road are predicted to become impassable, notably State Highway 1 (Cumberland Street and Castle Street), State Highway 88 (Anzac Avenue) and St Andrew Street. In addition, the majority of the flooding predicted within the central city, with a concentration around the central Activity Zone would be of significant depth (> 300 mm) and high velocity flows would occur in several locations which would therefore pose a risk to the public.

It is beyond the scope of this ICMP to detail or manage the effects of sea level change, however it is of importance that the stormwater network will not function as designed at these extreme sea levels and that flood hazard risk may develop in the future should current climate change predictions eventuate.

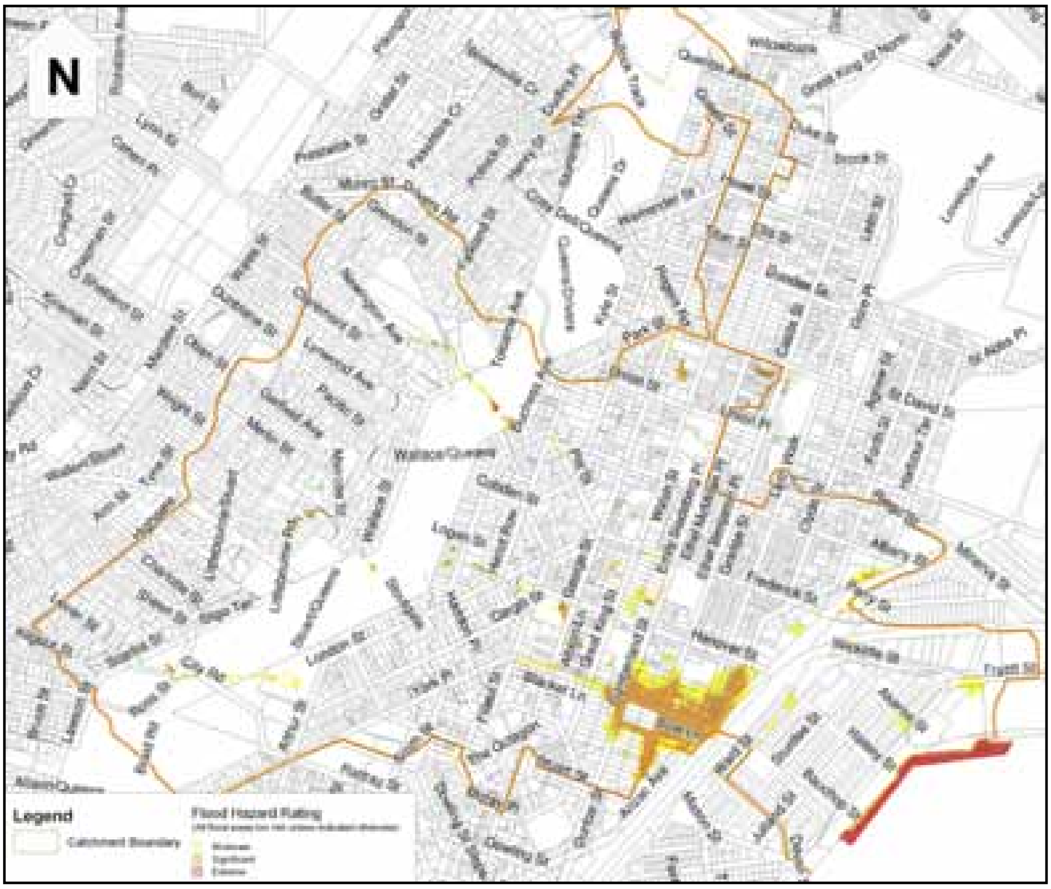


Figure 8-6: 2060 Extreme Flood Hazard 1 in 100 yr ARI Rainfall Event

8.1.5 Network Age, Operation and Maintenance

8.1.5.1 Halsey Street Catchment

A number of operational issues relating to flooding have been identified by DCC Network Management and Maintenance team and are described in the sections above. Further catchment specific issues relating to network operation and maintenance are described below.

Intake Structures

It has been advised by DCC Network Management and Maintenance staff that during autumn months in particular, heavy rainfall can result in debris blocking stormwater catchpits and inlet screens. Of particular importance in this catchment are the inlet screens at London Street, City Road and Logan Street. A further intake structure, outside the catchment, located to the rear of a property on Cosy Dell Road was also highlighted by Network Management and Maintenance staff as being significant.

During catchment walkovers the level of blockage observed at the London Street/Heriot Row intake structure was not significant (Figure 8-7). However, results from the model indicate that hydraulic capacity may be an issue at this location which would be further exacerbated by the accumulation of debris. DCC Network Management and Maintenance staff confirms that this intake screen is considered to be poorly maintained and prone to blockage; overtopping of this screen causing flooding in the property immediately downstream and significant overland flows onto London Street has been observed in the past. Workshop participants were unclear where the responsibility for maintenance of this structure lay and it was suggested that it may lie with the property owner.

The main intake structure on City Road, comprising a double catchpit, was found to be almost completely buried under debris during catchment walkovers. Overtopping of this structure would result in the first instance in ponding in-situ, the impact of which is considered to be minor due to its location within the Town Belt. However, should the structure overtop then overland flows through the Town Belt may result.

The Logan Street intake structure was not predicted to overtop during a 1 in 10 yr ARI rainfall event. Although high levels of blockage would increase the likelihood of this occurring. Based on visual inspection during catchment walkovers, it is thought that any flows overtopping the structure may enter the adjacent property approximately 15 m downstream.

The intake structure on Cosy Dell Road accepts flows from an open channel and conveys them under a property and into the piped network. This structure is outside of the Halsey Street catchment boundary (and any of the 3 Waters Phase 2 stormwater catchments) and the associated stormwater system is not part of the Halsey Street network. During a 1 in 10 yr ARI rainfall event, the model does not predict any significant problems with the intake structure. However, should the intake structure become blocked then flooding would result in overland flows down Regent Road and into the Halsey Street catchment. DCC Network Management and Maintenance staff confirmed that this screen is known to become blocked regularly. This results in flows overtopping the structure. Reports have been received of stormwater flow through the property on such occasions in the past. Overland flows down Regent Road were also confirmed.

However, due to the topography in this location, any flooding issues associated with this structure would result in overland flows into the Halsey Street catchment.

Figure 8-7: London Street / Heriot Row Intake Structure

Catchment Outfalls

The model results demonstrate that the stormwater outfalls in this catchment are tidally influenced, affecting the capacity of the network in the lower catchment by causing a backwater effect during high tides. Only the outfalls located on Halsey Street were able to be inspected during catchment walkovers. At this time they were fitted with flap valves but at the time of writing had been removed for repair.

Flow monitoring undertaken in the catchment recorded a tidal depth response in the stormwater pipes and it is therefore concluded that the outfalls either have no flap valves or that they were not functioning. They were therefore were not modelled. However, the presence of flap vales is unlikely to change the system's performance during rainfall events when the pipes are flowing full as any stormwater discharges through the flap valve would generally be small due to the significant hydraulic head required to force the flap valve open in these events. It is unlikely that therefore that the backwater effect upstream would be alleviated.

Hanover Street Pump Station

The Hanover Street pump station, located near the intersection of Hanover Street and Harrow Street, is understood to serve a small local sub-catchment near Anzac Avenue. However, its hydraulic performance has not been assessed as no information was available regarding this asset at the time of building the model. DCC Network Management and Maintenance staff have indicated that there are no known issues with pump station. The pump station may have a beneficial effect in certain storm events by collecting overland flows arriving from the wider catchment and pumping them to the Hanover Street pressure main (provided spare capacity is available in the particular storm event).

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

The predicted nuisance and habitable floor flooding in this catchment are predicted to occur in the central city, and affect Heritage Precincts in the District Plan. Further to this, a variety of locations are listed as wellbeing locations; with major and minor economic and social wellbeing locations common throughout the Central Activity Zone in this catchment (see Figure 4-12). These areas are also predicted to be affected by flooding.

8.1.7 Summary of Effects of Stormwater Quantity

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

- The modelling results indicate that 84 % the stormwater network in Halsey Street has the ability to accept rainfall from a 1 in 10 yr ARI event during MHWS tide conditions, with some areas having less capacity.

- Network capacity restrictions in the upper catchment are predicted in events as small as a 1 in 2 yr ARI rainfall event and some areas in the lower catchment have restricted levels of service due to tidal influence.

- Between a 1 in 5 yr and a 1 in 10 yr ARI rainfall event, nuisance flooding is predicted in a number of locations predominantly in the lower catchment. This is not considered significant however as due to the shallow depths, this poses little risk to the public and is unlikely to significantly disrupt traffic.

- During a current 1 in 10 yr ARI rainfall event, the network capacity is further constrained due to a number of hydraulic pinch points and tidal influence in the lower catchment. This results in high velocity overland flows and significant nuisance flooding in the lower catchment, notably around St Andrew Street.

- Further to the nuisance flooding during a current 1 in 10 yr ARI rainfall event, deep flooding (> 300 mm) is predicted, and verified on 2 properties, and certain buildings in the Central Activity Zone (George Street) may be at risk of habitable floor flooding when flood depths are less than 300 mm.

- During a current 1 in 50 yr ARI rainfall event, approximately 32 land parcels are predicted to be at risk of deep flooding (>300 mm). Many of these parcels are within the Town Belt away from properties, therefore the risk of habitable floor flooding of buildings is considered to be low in these instances.

- Predicted deep flooding during a current 1 in 50 yr ARI event poses a risk of habitable floor flooding of buildings, notably on Filleul Street, George Street and London Street. In some locations the occurrence of habitable floor flooding has been verified by flood complaints records and anecdotal evidence.

- Inconsistencies in the standard and frequency of cleaning and maintenance of stormwater structures could exacerbate or transfer predicted flooding, and regular blockage of the London Street and City Road inlet screens currently occurs.

- During a current 1 in 100 yr ARI rainfall event, predicted maximum flood hazard rating for the catchment is 'Significant', affecting locations on St Andrew Street, Pitt Street, in the Town Belt and the vicinity of the London Street/Heriot Row intake structure. Of significance to the calculated Rating is the high velocity of flows predicted through the centre of the catchment during this event.

- During a future 1 in 100 yr ARI rainfall event, with the application of an extreme climate change scenario with sea level rise and storm surge, the model predicts that an 'extreme' flood risk develops around the wharf on Fryatt Street with further areas of 'significant' risk predicted in central city (including the Central Activity Zone), with the greatest risk being in the vicinity of St Andrew Street. Approximately 8 % of the catchment is inundated, mostly the flat land of the lower catchment. Despite the network being tidally influenced, significant proportion of this flooding is, however, the result of tidal inundation directly onto low lying land predominantly to the south east of the railway, and not the performance of the stormwater network.

8.2 Stormwater Quality

Stormwater quality is discussed in detail in Section 6. Annual monitoring of the quality of the stormwater discharged from the Halsey Street catchment, conducted using a grab-sample technique, has been undertaken (2007 to 2010) with a time-proportional sample set also collected from the Bauchop Street network in 2010.

The following is a summary of the annual stormwater monitoring results. The observations must be viewed in the context of a very small dataset and the limitations of the grab-sampling method (discussed below).

- The levels of the majority of contaminants in the stormwater from the outfalls in this catchment are typical of stormwater quality from similar catchments, with the exception of faecal coliforms, which at times are high.
- Microbial contamination (E.coli and faecal coliforms), has fluctuated over the monitoring years with several instances where levels have been recorded above the typical range for urban stormwater.
- FWA fluctuations do not correspond with fluctuations in the levels of microbial contamination.
- The results show variability between years and to date, due to both the sampling method, and an insufficient number of samples to establish trends.

The potential source of microbial contamination in the stormwater from this catchment is difficult to distinguish.

Measured peaks in levels of FWAs, an indicator of human wastewater contamination, do not correspond with peaks in the microbial contamination of the stormwater. Therefore contamination by human wastewater cannot be concluded with any certainty.

There are a number of wastewater complaint records for this catchment, they appear to be isolated events occurring only in a single year. The location and number of complaints varies throughout the monitoring years and it is difficult to draw parallels between the number of complaints in a given year and the varying microbial contamination levels. Furthermore, some information available regarding the wastewater complaints does not allow any conclusions to be drawn regarding the nature of the problem and the potential to affect stormwater quality. For example, many complaints are recorded as 'Foul Sewer – Problem Other' or 'Foul Sewer – Blocked'.

Whilst there are two manually operated, valve controlled, cross connections between the wastewater and stormwater systems in this catchment (junction of Harrow Street/St Andrew Street and junction of Frederick Street/Harrow Street), there is no record of these being operated in recent years. There are other known issues in this catchment, relating to the wastewater system (refer Section 4.9).

Further investigations may be required to reveal the potential sources of the microbial contamination within this catchment.

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

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

The time, during the storm event, that grab samples are taken can significantly affect the results. While stormwater samples taken were targeted at sampling the ‘first flush’, and consent conditions detailed required storm size and antecedent conditions, it is not known when, during a rainfall event, the stormwater monitoring grab samples were taken for each monitoring year. It is possible that they were taken at differing times during rainfall events, hence the data variability and lack of clear trends.

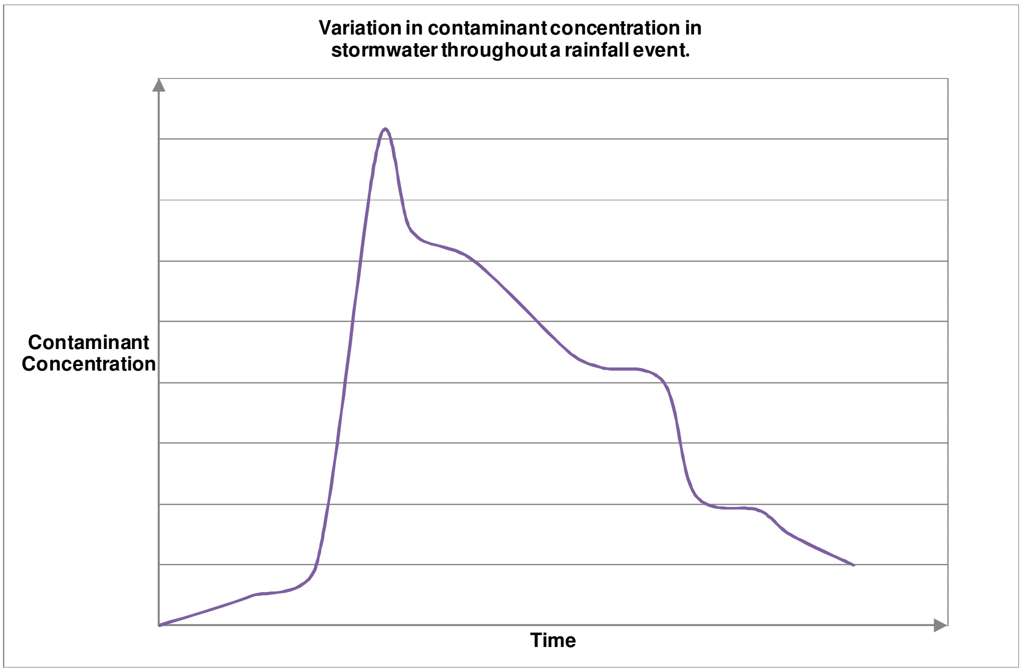


Figure 8-8: Concentration of Contaminants in Stormwater for Duration of a Rainfall Event
(Based on time-proportional sampling carried out in Dunedin)

Time proportional monitoring of stormwater quality yields results that provide a more accurate profile of contaminant concentrations within the stormwater from the catchment.

A single time-proportional sample of the stormwater discharged from the Bauchop Street outfall was taken in 2009. The results of this sampling indicated the following:

- The range of suspended solids, zinc and copper included concentrations at or above the range typically observed from when compared with stormwater data from the variety of sources. (Microbial contamination was not measured in these samples).
- The contaminant levels measured in the stormwater may be reflecting some of the land uses of the catchment.
- The results are in contrast to the annual grab samples taken throughout the annual monitoring period (2007-2010) which did not indicate any significantly elevated levels of stormwater contaminants, with the exception of E.coli and Faecal coliforms.

The results of the time-proportional sampling may indicate high levels of particular contaminants in the stormwater from this catchment. However, a single time-proportional sample, whilst giving an indication of the range of contaminants in a single event, is not sufficient to enable any trends in stormwater contaminants over time to be assessed. Furthermore, as with the grab samples, time-proportional results are also influenced by factors such as such as the time since the previous rainfall event within the catchment, and the intensity and distribution of rainfall can significantly affect the results. As such, a series of results of time-proportional samples taken for several rainfall events over time may give a clearer description of the quality of stormwater discharged from this catchment.

8.2.1 Harbour Water Quality

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

While no national or international guidelines are available for stormwater discharge quality, ANZECC (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 marine water quality within the harbour. Further clarity with respect to longer term environmental effects could then be established using sediment quality information.

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

8.2.2 Harbour Sediment Quality

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

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

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

8.2.2.1 Halsey Street Catchment

Measurement of marine sediment contaminant levels is not required under the resource consent consents conditions for the stormwater discharge from this catchment. However, sediments have been collected from within 5 m of the Wickliffe Street outfall from 2007 to 2010. The contaminant levels within the sediments adjacent to the Wickliffe Street outfall in the Halsey Street catchment are discussed in detail in Section 5.

To summarise, the levels of contaminants in the marine sediments have generally been variable between the years monitored. In general, lead and PAHs have been monitored at levels above ANZECC low trigger values and zinc consistently monitored above ANZECC high trigger values. Contaminant concentrations measured in the 2010 samples were generally similar to previous years, or slightly elevated in comparison.

Whilst the results of the annual stormwater monitoring (grab samples) do not correspond with the levels of contaminants in the marines sediments, with no elevated levels of lead or zinc, the results of the single time-proportional sample from the Bauchop Street outfall do show slightly elevated zinc levels in the stormwater.

It should be noted however, that the Bauchop Street outfall is approximately 500 m from the Wickliffe Street outfall (sediment sample site). Furthermore, only a single time-proportional sample exists for the Bauchop Street outfall, and may not be representative of stormwater contaminant levels/trends over time. The sediment results are therefore, are not necessarily reflecting the effects of the stormwater discharge from Bauchop Street.

Whilst is possible that the stormwater discharges are contributing to the contaminant levels in the sediments. It remains unclear however, in the absence of baseline data, a control site for comparison or samples from a more distant location from the outfall, the extent to which sediment contamination is as a result of historic land uses and activities within the catchment and what proportion can be attributed to current stormwater discharges. Further study is required to ascertain any temporal trends in marine sediment quality.

8.2.2.2 Harbour-Wide

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

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

Further monitoring of the sediments harbour-wide is required to better understand the levels of contamination and establish whether any long term trends exist. It should be noted that the Halsey Street catchment outfalls discharge into deep water and sediment re-suspended from elsewhere in the harbour, by wave action and periodic dredging, may accumulate in this location.

8.2.3 Marine Ecology

There are no consenting requirements for biological monitoring associated with the stormwater discharges from this catchment. However, the discharge consent for the neighbouring Mason Street catchment does require that fish are sampled and the flesh analysed for contaminants. These results are considered relevant to the Halsey Street catchment as the fish will have a reasonable range in the harbour and likely to be influenced by the sediments and stormwater from neighbouring catchments.

The biological monitoring results to date to not indicate significantly high levels of contaminants within the fish samples and where applicable (for lead and cadmium), concentrations have been consistently below the MLs as outlined in Australia New Zealand Food Standards Code (2004). The results indicate that the fish communities at this location are not being exposed to significantly high levels of contaminants.

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.

It should be noted that fish sampled in this location are likely to have a range and will be influenced by contaminants in the harbour marine environment outside of the Halsey Street catchment and the biological communities generally will also be influenced by contamination from sources other than stormwater. Therefore, whilst the ecological health analysed at this location was not found to be poor, it is difficult to draw any parallels between the ecology and the contaminants.

Determining the ecological effects of contamination in the harbour environment is difficult. Unless contamination levels are very high within the sediments it is difficult to distinguish between the potential adverse effects of contamination from stormwater, contamination from other sources, and the effects of other environmental variables.

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 Freshwater Habitat Quality

There are three streams in the Halsey Street catchment (refer Figure 5-3). All were assessed in 2010. The stream habitat health varied depending on the stream sampling location.

Habitat and water quality varied throughout the catchment, and was generally found to be good, with Halsey Street 1 and Halsey Street 3 (downstream) sites having some habitat features of ‘excellent’ quality. However, ecological quality was generally ‘poor’ despite the presence of an individual crayfish at the Halsey Street 1 sampling location. This is discussed further in Section 8.1.11.

The streams are located within an urban residential area. They run through a mixture of private land, and road reserve and alternate between natural channel and stormwater pipes. Most of the catchment is developed (except for the Town Belt), so water entering the stream will consist of runoff from hardstand areas (such as roads and driveways where contaminants such as heavy metals accumulate), roofs, lawns and gardens.

Surrounding land use significantly effects affects the quality of a stream. Investigations by Auckland Regional Council (ARC) found that the quality of urban streams is related to the density of urban development and that in the Auckland region urban stream quality was consistently poor in streams with a contributing catchment imperviousness of greater than 25 % (ARC, 2004). Although Dunedin has many different environmental characteristics relating to urban streams, the relationship between imperviousness and stream quality may still apply. The contributing catchment to the streams assessed in the Halsey Street catchment are urban residential and have an imperviousness of approximately 40 %. This suggests that the quality of the streams assessed in the Halsey Street catchment is as expected.

Watercourses running through private property are considered to be private drainage assets. Whilst private maintenance of streams sometimes works acceptably in rural areas, in the urban context, private property owners often lack resources to carry out stream maintenance. High flows, and fast response to rainfall means that the ongoing maintenance of urban streams, clearing of intake structures, and provision of overland flow oaths is vital to the flood protection provided by the stormwater network.

8.2.5 Freshwater Ecology

The aquatic ecology within the streams in this catchment was found to be poor at all sampling sites with below national average levels of benthic invertebrates and no fish caught or observed. However, a single freshwater crayfish was observed at the Halsey Street 1 site, indicating that conditions are suitable for such species. However, the absence of juvenile crayfish indicates that the population may be in decline or not be self-sustaining.

As the generally habitat quality of the streams was found to be good with some 'excellent' habitat features in certain locations, it is unlikely that the poor ecology is a result of habitat quality, however fish passage is likely to be obstructed by the piped stormwater network. Whilst water quality was generally found to be good, the assessment was based on levels of dissolved oxygen and conductivity only, with no measures of chemical parameters.

Whilst the causes of poor ecological values remain inconclusive, it may be due to contamination of the freshwater, from sources such as diffuse runoff from properties (gardens, roofs hardstand etc.) or stormwater from the upstream piped network. It could also be a result of modifications to the stream systems (concrete channels, pipe network) up and downstream of the open channel sections reducing the extent of available habitat and preventing the migration of species up and downstream.

8.2.6 Culture and Amenity

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

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

To date there is no evidence to suggest that the quality of the harbour continues to deteriorate significantly or that the quality of stormwater from the Halsey Street catchment is significantly contributing to any deterioration of the harbour. However, the high levels of faecal coliforms observed in the stormwater from the catchment could indicate some contribution to contamination and should be explored further.

8.2.7 Summary of Effects of Stormwater Quality

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

- The levels of contaminants within the stormwater discharged from the Halsey Street catchment varied throughout the monitoring years (2007-2010) with no clear trend emerging. The majority of contaminant levels measured were not significantly different from levels considered to be typical from residential/commercial catchments from annual monitoring samples with the exception of microbial contaminant levels. High levels of E.coli and faecal coliforms were measured from one or more of the outfalls in 2007, 2009 and 2010. This may be related to isolated wastewater flooding incidents but the evidence for this remains inconclusive.

- The results of the single time-proportional monitoring from the Bauchop Street outfall were in contrast to the annual monitoring indicating that suspended solids, zinc and copper were measured at or above the range typically observed from when compared with stormwater data from the variety of sources. This may be a reflection of the land uses of the catchment, however further monitoring may be required before any links can be made.

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

- Lead and PAH levels in sediments sampled near the Wickliffe Street outfall have in general, been measured above ANZECC low trigger values, whilst zinc has been measured above ANZECC high trigger values across all monitoring years. It appears that some of the sediment contamination could be historical or due to re-suspension and settlement of sediments from elsewhere in the harbour, as the high levels of certain contaminants, with the exception of zinc, measured in the sediment does not correspond with contaminant levels within the stormwater.

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

- There was poor freshwater ecology at all three streams within the catchment. These results may be attributable to the piping of sections of the streams, runoff from surrounding properties or general contamination of the freshwater.

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

9 Catchment Problems and Issues Summary

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

9.1 Stormwater Quantity Issues

9.1.1 Low Level of Service

Hydraulic restrictions in the upper catchment create overflows in events as small as a 1 in 2 yr ARI rainfall event, while some areas in the lower catchment have levels of service restricted to a 1 in 5 yr ARI rainfall event due to tidal influence. However, the modelling results indicate that the majority (84 %) of the stormwater network the stormwater in the Halsey Street catchment has the ability to accept rainfall from a 1 in 10 yr ARI event during MHWS tide conditions. In those areas where the network capacity is less, nuisance flooding effects are predicted in some cases.

9.1.2 Nuisance Flooding

Nuisance flooding (between 50 mm and 300 mm deep) is predicted in the road at a number of locations in the catchment with high velocity overland flows and significant effects at locations on London Street, Filleul Street, York Place and St Andrew Street during rainfall events of a 1 in 10 yr ARI or greater.

9.1.3 Deep Flooding

Deep flooding (>300 mm deep) occurs at a number of locations and may present a risk to properties during events as small as a 1 in 10 yr ARI rainfall event, with a threat to building interiors. The number of land parcels predicted to be at risk of habitable floor flooding increases with rainfall events of increasing recurrence interval. However, in some locations the risk to building interiors is considered to be low. This is because the flooding is predicted within the Town Belt, away from buildings, or because there are anomalies in the ground model used to predict flow paths.

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

The model shows that during a 1 in 100 yr ARI rainfall event, with MHWS tide conditions, York Place, St Andrew Street, Hanover Street, Leith Street and Harrow Street are predicted to have flooding across the full width of the road, with deep flooding (> 300 mm) predicted on parts of St Andrew Street, Hanover Street, and Harrow Street. High velocity overland flows are predicted on London Street, Pitt Street, York Place and Rattray Street, and in the Town Belt. A 'significant' flood hazard rating has been assigned to these locations. With the extreme climate change scenario applied (with a storm surge) the area of 'significant' flood hazard increases to encompass a large proportion of the lower catchment, predominantly the central city to the east of the railway. This is mainly due to tidal inundation.

9.1.5 Blocking / Maintenance of Intake Structures

Maintenance of intake structures is critical to the optimal operation of the hydraulic network. Several intake structures in the catchment are predicted (and in some cases verified) to be prone to blockage and exacerbate overland flows.

Overflows from the London Street / Heriot Row intake structure are sensitive to blockage of the screen. Blockage of the City Road intake structure is predicted to increase overland flows into the Town Belt and high levels of blockage at the Logan Street intake structure may present a risk of nearby property flooding.

9.1.6 Network Maintenance

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

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 outfalls and other sources. Although there is potential for ongoing contamination of the sediment from stormwater, to date, the monitoring results are ambiguous and it has not been possible to establish a causal link from available data.

At the Wickliffe Street outfall, within the Halsey Street catchment, sediment data collected over a four year period has indicated low levels of a number of contaminants (when compared with ANZECC sediment quality guidelines). However, in general lead and PAHs have been present in moderate amounts (above ANZECC guideline low trigger levels), whilst zinc has been consistently measured in elevated levels (above ANZECC guideline high trigger levels).

Stormwater quality may be contributing to poor ecological health in the streams of the Halsey Street catchment. Whilst the causes of poor ecological values remain inconclusive, it may be due to contamination from sources such as diffuse runoff from properties (gardens, roofs hardstand etc.) or from stormwater from the upstream piped network. It could also be a result of modifications to the stream systems (concrete channels, pipe network) up and downstream of the open channel sections reducing the extent of available habitat and preventing the migration of species up and downstream.

9.2.1 High Variability of Stormwater Quality Results

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

Whilst the annual stormwater monitoring results do not indicate any contaminants of concern, the single time-proportional sample from the Bauchop Street outfall (2009), showed elevated levels of suspended solids, zinc and copper, above the range typically observed in urban stormwater. These are common contaminants from residential roofs and vehicles.

A single time-proportional sample is insufficient to determine with any certainty contaminants of concern or to indicate any trends in the stormwater quality over time. Additional time-proportional monitoring may highlight, with further certainty, contaminants of concern from this catchment.

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

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

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

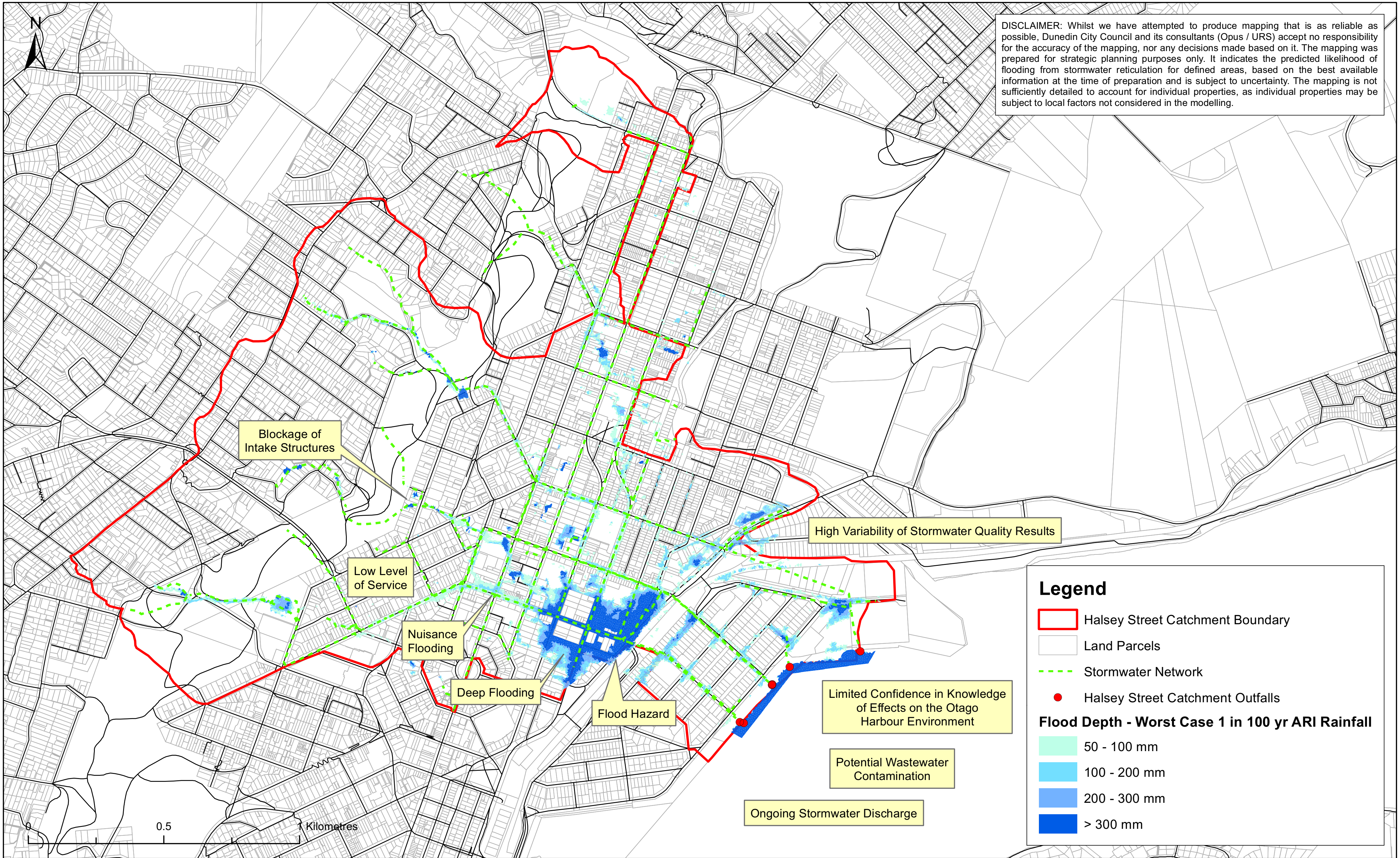
9.2.3 Ongoing Stormwater Discharge

Stormwater quality monitoring indicates that the stormwater quality discharged from the Halsey Street catchment appears to be largely typical of an urban, mixed land use, catchment with some contaminants elevated in some of the quality monitoring carried out (see Section 9.2.1). Indications from recent monitoring do not show that current stormwater discharges are having an obvious adverse effect on the receiving environment, however as discussed above, there is limited confidence in some of this information, and further data is required to validate this.

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.

9.2.4 Potential Wastewater Contamination

Stormwater quality monitoring (2007-2010) indicates high levels, at or above the upper limit typical for stormwater, of microbial contamination in the Halsey Street stormwater discharges. The results indicate significantly high levels of E.coli and faecal coliforms in the stormwater from one or more of the outfalls in 2007, 2009 and 2010. This suggests that there may be wastewater ingress into the stormwater system at one or more locations.



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.

Dunedin 3 Waters Strategy

HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 9-1

Halsey Street Catchment Issues

DISCIPLINE

Stormwater

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

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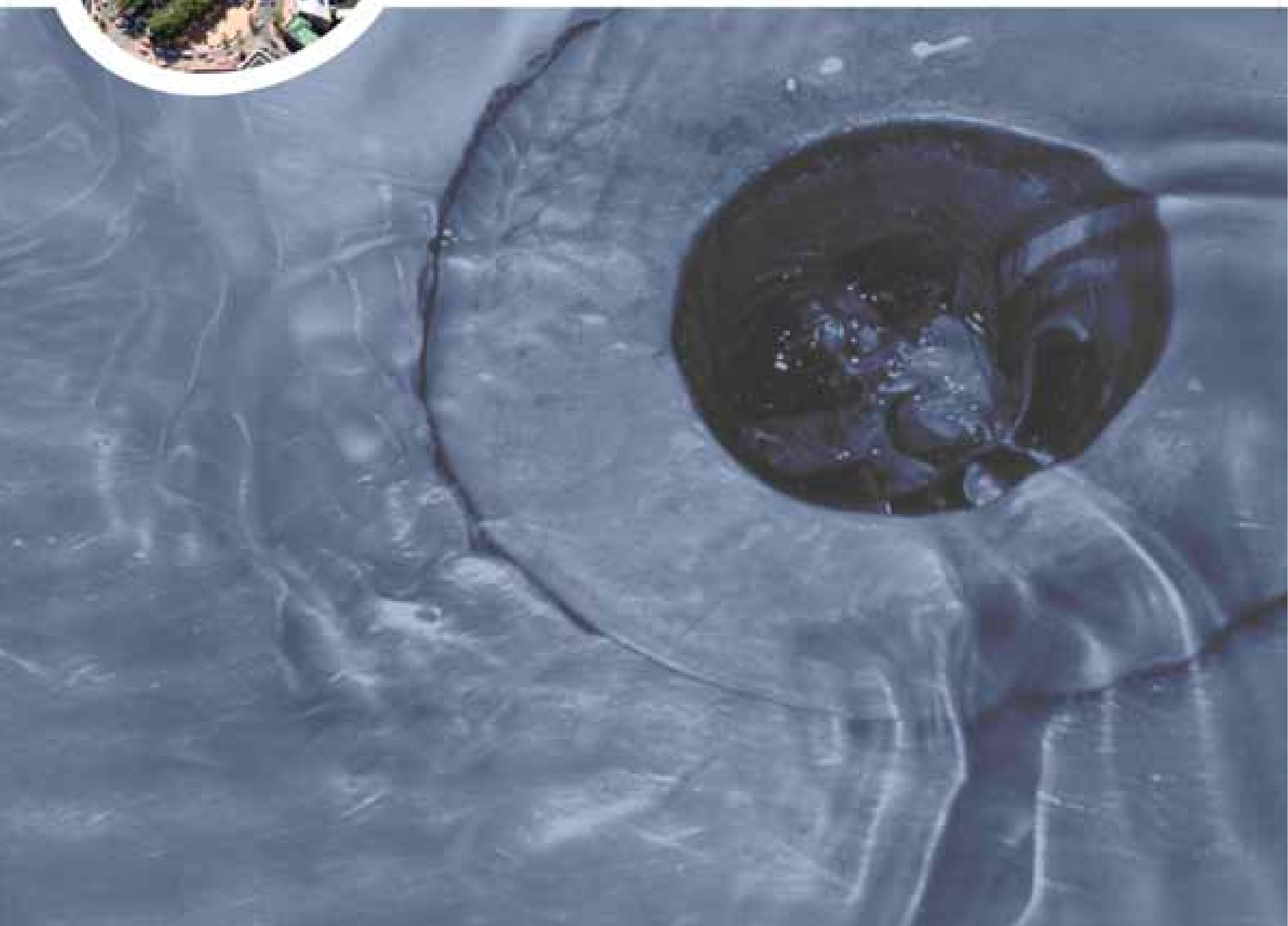
Part 4
Targets



10 Issues Prioritisation

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

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

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

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

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

Table 10-1: Issues Prioritisation

Issue	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Management Approach
Potential Wastewater Contamination	40	5	High microbial levels, above typical levels measured in stormwater. 2007, 2009 and 2010 results particularly high, potentially indicating wastewater contamination. Major Stakeholder issue. Confidence in data is relatively low / moderate and without better knowledge difficult to establish a source and significance of the threat.	200	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
High Variability of Stormwater Quality Results	40	3	Stormwater quality monitoring could be made more robust. Relatively low / moderate confidence in data. Without better knowledge, underpinned by good quality data, DCC cannot reliably meet its strategic objectives.	120	Manage Actively
Nuisance Flooding	40	3	Flooding predicted in a number of locations, predominantly in road corridor but also in properties around the central city. High velocity overland flows are predicted in parts of the catchment. Likely to increase in future, predominantly due to projected climate change. Currently occurring and during high frequency events (1 in 10 yr ARI) effects are considered to be significant.	120	Manage Actively
Blocking / Maintenance of Intake Structures	40	3	Intake structures prone to blockage, overland flows significantly increased, particularly at London Street/Heriot Row structure. Property at risk of flooding. Blockage at other locations could result in overland flow. Risk of disruption to properties. Likely to occur during significant rainfall.	120	Manage Actively

Issue	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Management Approach
Flood Hazard – Current and Future 1 in 100 yr ARI	70	1	Areas of significant flood hazard currently in roadways. Deep flooding predicted in locations within the central city under current conditions. Future extreme climate change effects pose significant potential threat. It is predicted that by 2060 during extreme weather and tide events there will be a significant hazard across a large part of the lower catchment. The extent of the threat is uncertain as it is predominantly driven by tidal influence, rather than being a stormwater issue. There is unknown certainty around climate change predictions.	70	Manage Actively
Network Maintenance	10	5	Inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures. Potential to exacerbate or transfer flooding effects.	50	Manage Passively
Low Level of Service	10	4	The current level of service is below DCC's target for new infrastructure, as a result of both tidal influence and inadequate network capacity. However, the majority of the network (84 %) can convey a 1 in 10 yr ARI rainfall event, in those parts which are unable to convey this event, adverse effects are predicted in some cases (management approaches for the effects will be set under the nuisance flooding issue). Effects of low level of service will be exacerbated by climate change therefore adaptation is required in order to meet future long term objectives of no increase in properties at risk of flooding due to climate change.	40	Manage Passively
Ongoing Stormwater Discharge	10	4	Ongoing discharge of stormwater (and associated contaminants) to the harbour. The extent of contamination is unconfirmed, available data indicates that contaminants discharged are typical of land use, but some may be at elevated levels. Uncertainty regarding data and trends in contaminant levels. Current discharges not believed to be as significant an issue as historical contaminant issues from a variety of sources.	40	Manage Passively

Issue	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Management Approach
Deep Flooding	10	3	Deep flooding predicted in a small number of locations. Occurs at high frequency events (1 in 5 yr ARI rainfall event) but in locations away from buildings. Risk to building interiors predicted to increase with lower frequency events (1 in 10 yr ARI and 1 in 50 yr ARI). However, scoring reflects limited knowledge and uncertainty of extent of threat (data anomalies and no damage assessment of buildings undertaken). Number of properties at risk is likely to increase under future scenarios.	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 has been used to identify the key stormwater management issues for the Halsey Street catchment. These issues have been prioritised and ranked, according to DCC's risk matrix, which looks at the consequence and likelihood of each issue.

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

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

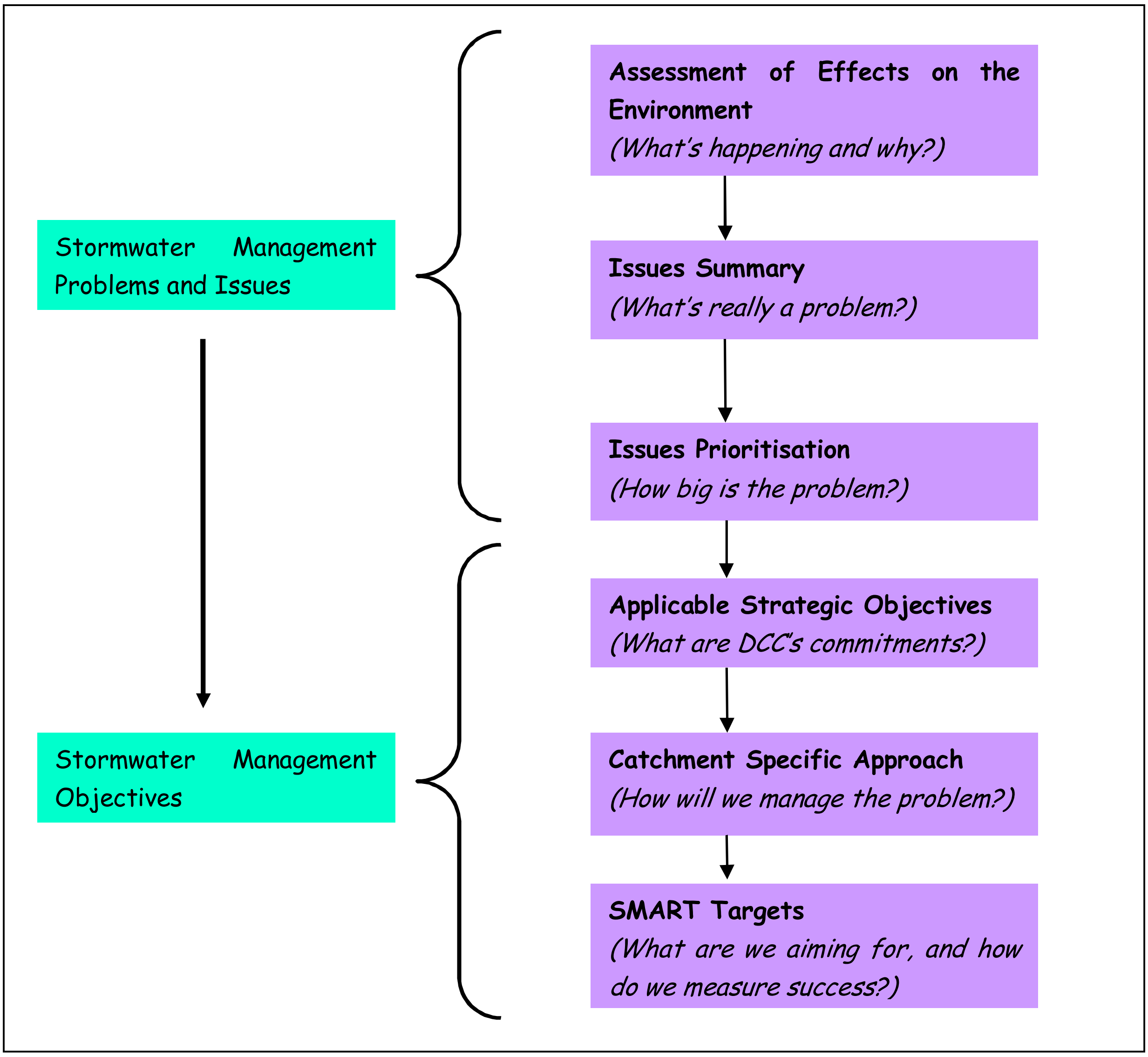


Figure 11-1: Target Development Process

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

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

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

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

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

Tables 11-1 and 11-2 outline catchment specific approaches and SMART targets for each of the key stormwater issues identified in the Halsey Street catchment. These are discussed further below.

11.1 Stormwater Quantity Targets and Approaches

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

11.1.1 Nuisance Flooding

The nuisance flooding in the Halsey Street catchment has been prioritised as a 'manage actively' issue as it is predicted to have considerable adverse effects. These include high velocity overland flows presenting a risk to the public, significant ponding in roads of the central city, and a risk of flooding to the floors of commercial buildings even at depths of less than 300 mm during a 1 in 10 yr ARI rainfall event. Furthermore, the flooding occurs in an area of the city where there are large numbers of pedestrians, with an expectation of high amenity. Property owners and the public may also have heightened sensitivity to flooding following the significant flooding experienced during the February 2005 rainfall event.

The nuisance flooding is caused by network capacity restrictions in the catchment at a number of locations during a 1 in 10 yr ARI rainfall event, along with tidal influence on the network in the lower catchment.

The recommended targets and approaches with respect to the stormwater network performance focus on improving the existing level of service under current and 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.

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.

Currently, 84 % of the pipes modelled in the catchment can accept stormwater during a 1 in 10 yr ARI rainfall without causing manhole overflow; however the 57 % of the pipes are highly surcharged. Based on the age of the network, the pipes in the Halsey Street catchment will be prioritised for assessment under the DCC pipe renewals programme; 27 % of the network is currently overdue for renewal, with a further 6 % requiring renewal within the next ten years. By 2060, 66 % of the pipes in the network (including some already at the desired level of service) will have been assessed under the pipes renewal programme, and either had their life expectancy increased, or will have been replaced (with new pipes designed to convey the 1 in 10 yr ARI rainfall event).

A number of complaints records exist for this catchment, however, in most cases the size of the storm event during which the complaints were made is not known and the historical data collection methods used for customer complaints logging has resulted in variable information on complaints. Improvements in complaints recording will result in a clearer picture of customer satisfaction in the future.

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 Halsey Street catchment lies within the Dunedin City group of this survey. The results of the 2010 survey indicate that 64 % of respondents were either 'very satisfied' or 'satisfied' with the stormwater collection service.

11.1.2 Blocking / Maintenance of Intake Structures

The blocking of the intake structure at London Street is known to exacerbate overland flows (volume and velocity) across the property at 61 London Street, over London Street and down into a property on Filleul Street, contributing to overland flows in the Central Activity Zone. Blocking of this structure is predicted to compound the effects of nuisance flooding as described above.

Other intake structures in the catchment are reported to have blockage issues, which would lead to deep ponding or overland flows, causing disruption to properties.

City-wide network maintenance is discussed as a separate issue, however a number of the approaches will be common to this issue; establishing criteria for intake cleaning and inspection is vital, as is identifying and advising those responsible for maintenance.

In the Halsey Street catchment this issue has been prioritised due its influence on catchment flooding; DCC may need to take a more active role in ensuring that intake structures on privately owned watercourses are of a required standard and well maintained. Initially inspections of the drainage channels in the catchment could be undertaken to identify critical structures. Following this, options for structure improvement / optimisation can be considered along with options for managing and maintaining the watercourses.

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

Flood hazard is present in the Halsey Street catchment as a result of high velocity overland flows and deep flooding. In large events (e.g. 1 in 100 yr ARI rainfall events), flood hazard predominantly affects transport corridors (including State Highways) and commercial areas of the central city, including the Central Activity Zone.

As the flood hazard is predicted to be occurring currently, the recommended targets have been established to ensure that adequate emergency response measure are developed for the catchment to ensure public health and safety in a low frequency event.

As the flood hazard is predicted to increase in the future, under the extreme climate change scenario (2060), it is appropriate that the potential effects of climate change on this catchment be considered by DCC's Climate Change Adaptation Plan (currently being developed). Note that much of the significant flooding predicted during the future (extreme) climate change scenario modelled is due to direct tidal inundation (sea level rise plus storm surge), rather than the response of the stormwater system to the rainfall and tide boundaries.

11.1.4 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.

11.1.5 Low Level of Service

The current level of service in some parts of the catchment is below DCC's target for new infrastructure, as a result of both tidal influence and inadequate network capacity. However, the majority of the network (84 %) of the network has the ability to accept rainfall from a 1 in 10 yr ARI event during MHWS tide conditions. As such this issue has been prioritised as 'manage passively'.

The recommended targets and approaches with respect to the stormwater network performance focus on improving the existing level of service under current and 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.

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.

Historical data collection methods used for logging customer complaints has resulted in variable information on complaints. Improvements in complaints recording will result in a clearer picture of customer satisfaction in the future. The ROS has been running since 2003, and gauges Dunedin city residents' overall satisfaction with the stormwater collection service, amongst other council services. The Halsey Street catchment lies within the Dunedin City group of this survey.

11.1.6 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 model predicts that 20 land parcels in the Halsey Street catchment are estimated to be currently at risk of flood depths exceeding 300 mm during a 1 in 10 yr ARI rainfall event, rising to 32 during a 1 in 50 yr ARI rainfall event. Deep flooding predicted during the current 1 in 100 yr ARI rainfall event is estimated to increase the depth and extent of flooding in already identified flood areas, frequently in conjunction with significant or high flood hazard.

Because the modelled flood extents indicate that in many cases, flooding may not actually enter buildings (due to flooding being in the Town Belt, or in the road) this issue has been prioritised as 'manage passively'.

Targets for this particular issue seek to avoid habitable floor flooding under both current and future land use and climate change scenarios. It is also desirable to avoid any increases in surface flooding of private properties during this event.

'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.

The modelled flood extents do indicate that flooding has the potential to enter some buildings; this has been verified in some cases by workshop discussions and also during larger rainfall events (February 2005) through media reports, photographs, eye-witness accounts and flood complaints records. However, it is still necessary that parcels identified as potentially being subject to deep flooding during storm 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.

It should be noted that the network capacity problems causing nuisance flooding effects are also the predominant cause of potential habitable floor flooding. As such, management options developed to alleviate nuisance flooding issues will also address deep flooding issues within the catchment.

Table 11-1: Halsey Street Catchment Management Targets: Stormwater Quantity

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Nuisance Flooding	Nuisance flooding is predicted on a regular basis in a number of locations in due to hydraulic restrictions throughout the catchment and tidal influence on the lower catchment. Of significance are the effects on London Street and in the central city (vicinity of St Andrew Street). Nuisance flooding may pose a risk to building interiors on George Street. Affects 0.05 % of catchment during 1 in 2 yr ARI rainfall events, and 0.8 % of catchment during a 1 in 10 yr ARI rainfall event.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Actively*** 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). Prioritise the renewals programme to focus on poorly performing areas of the catchment	< 0.05 % of catchment surface area predicted to flood during a 1 in 2 yr ARI rainfall event by 2060. Undertake survey of property owners to determine any occurrence of flooding during high frequency events. > 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.

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

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Flood Hazard – Current and Future 1 in 100 yr ARI	Areas of significant flood hazard in roadways, including State Highway, mostly in central city, predicted during current event. Significant flood hazard in roadways in central city, with increased flood extent, predicted in the future (2060) event predominantly due to tidal inundation, exacerbated by predicted climate change effects.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Actively*** Ensure new development does not increase the number of properties predicted to flood due to the stormwater system in a 1 in 100 yr ARI rainfall event. Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply etc.) from flood hazard. Avoid development of vulnerable sites / critical infrastructure in flood prone areas. Ensure transport routes around flooding areas will be available. Develop a better understanding of the likely effects and magnitude of climate change.	Develop a catchment specific emergency response plan by 2012. Provide modelled flood predictions to DCC Climate Change Adaptation Group to ensure information is taken into account during the development of a city-wide climate change adaptation plan.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Network Maintenance	Flooding extents and durations in Halsey Street 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.	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 Halsey Street catchment requiring additional cleaning and maintenance checks by 2013.
Low Level of Service	16 % of stormwater network cannot accept rainfall from a 1 in 10 yr ARI, driven by both network capacity and tidal influence. Manholes predicted to overflow with pipes flowing full throughout approximately 57 % of system. This low level of service is currently occurring with no capacity for climate change effects. Flooding results in certain locations during a current 1 in 10 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*** Maintain or improve existing level of service in network – ensure no increase in the number of stormwater manholes predicted to overflow in a 1 in 10 yr ARI rainfall event. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Use customer complaints and ROS to gauge satisfaction with the stormwater system performance.	> 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. < 16 % manholes predicted to overflow during a 1 in 10 yr ARI rainfall event by 2060. < 0.8 % of catchment surface predicted to flood during 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 and Targets	Catchment Specific Approach	SMART Targets
Deep Flooding	Model results indicate 2 land parcels affected by deep flooding during 1 in 5 yr ARI rainfall event; rises to 32 parcels during 1 in 50 yr ARI rainfall event in current and 56 parcels in future planning scenarios. Large number of properties affected during extreme climate change scenario. A proportion of the deep flooding predicted during high frequency events is predicted exterior to buildings (although surveys not yet undertaken).	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 Passively*** 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. Reduce the number of properties predicted to flood during a current 1 in 10 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).	< 32 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. > 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.

11.2 Stormwater Quality Targets and Approaches

Table 11-2 presents a summary of the key effects, relating to stormwater quality, and catchment specific targets set for the Halsey Street catchment. Approaches and targets developed for ‘active’ and ‘passive’ management of stormwater quality issues in the catchment are discussed in more detail below.

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

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

11.2.1 Potential Wastewater Contamination

The stormwater monitoring results for the Halsey Street catchment show microbial contaminant levels to be at or above the upper level that is typical of urban stormwater, with the 2007, 2009 and 2010 data sets showing elevated levels. However FWA levels (an indicator of human wastewater contamination) were measured at their highest levels when microbial levels were measured at low levels. However, it is acknowledged that there is low confidence in the current monitoring data at this time.

Furthermore, as there are no known issues with the wastewater network in this catchment the potential source of contamination is unknown and it is unclear whether isolated incidents have contributed, and as such the level of threat remains inconclusive.

The approach and targets for this issue are related to actively identifying the levels of microbial contaminants in the stormwater and investigating potential sources of any problems. This will ensure any management options in the catchment, should they be required, are developed appropriate to the issue.

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. The differing results between the annual grab-samples and single time-proportional sample from this catchment highlight this issue.

Four annual cycles of sediment monitoring have 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. However, it remains unclear whether the contaminant levels observed are as a result of historic contamination or current discharges (from either stormwater or other sources). For this reason, the sources of contamination are difficult to identify, as are any links with the quality of DCC stormwater discharges. High concentrations in sediments sampled adjacent to the Halsey Street catchment have been measured for certain contaminants, notably lead, zinc and PAHs. However, although high in the single time proportional monitoring round undertaken, these contaminants were not found to be significantly elevated in all of the stormwater discharges from the catchment, so contamination of the sediment could be attributed to sources outside of the Halsey Street catchment.

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

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

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

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

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

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

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

- Use data to contribute to the stormwater management programme for Dunedin. This will include the identification of stormwater management actions to improve stormwater quality where required and enable specific city-wide, targeted annual monitoring protocol to be established where necessary, including quality indicators, which can be used to trigger further action as required.

Due to the high concentrations of some contaminants measured in the stormwater discharged from the Halsey Street catchment, it is likely that this catchment will be highly prioritised for extensive monitoring,

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

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

11.2.3 Ongoing Stormwater Discharge

The annual monitoring results (grab sample) to date in general, do not indicate that the levels of contaminants in stormwater from the Halsey Street catchment are significantly high, with the exception is relatively high microbial contamination which is addressed as a separate issue (Section 11.2.2). However, results from a single time-proportional sample (2009) indicate elevated levels of suspended solids, zinc and copper in the stormwater.

However, it is acknowledged that there is low confidence in the current annual monitoring data and a single time-proportional sample is insufficient to give a clear indication of stormwater quality or trends over time. As such, this issue is prioritised as ‘manage passively’.

As there is a risk that they may be contaminants of concern within the stormwater discharged from this catchment, the approach and targets for this issue are related to the outcomes of the targets set for confidently identifying the levels of contaminants in the stormwater and any resulting effects on the harbour environment (refer Section 11.2.1), with the Halsey Street catchment set as a priority catchment in the redesigned monitoring programme.

Following the outcomes of the proposed monitoring and stormwater management prioritisation targets, the approach to stormwater management in this catchment will be revised and catchment specific targets, where appropriate will be applied.

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

Table 11-2: Halsey Street Catchment Management Targets: Stormwater Quality

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Potential Wastewater Contamination	High microbial contamination of stormwater, particularly in 2007, 2009 and 2010, may be cause for concern.	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*** Undertake targeted monitoring to enable better understanding of potential catchment contamination. Investigate potential sources of wastewater contamination. Develop appropriate management options to remediate problem where necessary.	Improve data relating to levels microbial contamination and potential sources of contamination within the catchment by 2012. Implement management options to remediate problem where necessary.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Limited Confidence in the Knowledge of Effects on Harbour Environment and Variability of Stormwater Quality Results	High variability of stormwater quality results, any trends in stormwater contaminant levels remain unclear. Poor information on actual effects of stormwater on harbour environment. Lack of data to assess linkages between pipe discharge and harbour environment quality.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. No recorded breaches of the RMA. Ensure stormwater discharge quality does not deteriorate.	***Manage Actively*** Redesign DCC's monitoring programme to ensure stormwater quality and receiving environment data is collected within a robust framework. Include Halsey Street as a priority catchment in the monitoring programme. 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 and Targets	Catchment Specific Approach	SMART Targets
Ongoing Stormwater Discharge	Could exacerbate existing / historical contaminant issues. Extent to which this is likely to occur is unconfirmed. Key stakeholder issue. Based on available data, consequence currently believed to be minor.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	***Manage Passively*** Include Halsey Street as a priority catchment in the monitoring programme. Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high-contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.	No deterioration of stormwater quality due to land use change or development in the catchment. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.

Part 5
Solutions

12 Stormwater Management Options

12.1 Introduction

Options are presented below to manage the stormwater issues identified in the Halsey Street 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; and
- 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 then evaluated against the QBL evaluation criteria outlined in Section 14, with the most favourable stormwater management option selected.

Following the identification of options for each stormwater management issue, and options evaluation using QBL methodology, a prioritised programme of capital works and additional investigations recommended in the Halsey Street 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 catchment. Option 'deal breakers' are eliminated and feasible options are described in further detail. Where an issue has been prioritised as 'manage passively', management options are discussed in more general terms, although planning based options may be presented where applicable. Where an issue is prioritised as 'manage actively', where available, a number of alternative options will be considered for further evaluation in Section 14.

12.2.1 Nuisance Flooding – Manage Actively

The effects of the flooding are considerable during a 1 in 10 yr ARI rainfall event when flooding extents comprise approximately 0.81 % of the catchment area. The effects of the nuisance flooding during this rainfall event include:

- High velocity overland flows (1-2 m/s) in a number of locations presenting risk to the public in areas of high pedestrian traffic;
- Ponding extending the full width of the road, with traffic causing bow waves onto the pavement;
- Deep flooding posing a risk to property interiors'; and
- Risk to flooding to commercial premises (George Street), even at flood depths less than 300 mm.

The effects are observed in areas close to/within the Central Activity Zone and as such may impact on a number of economic and social wellbeing locations and historic buildings. Furthermore, the effects are predicted in areas where there are large numbers of pedestrians, with an expectation of high amenity. There may also be a heightened sensitivity, of property owners and the public, resulting from the flooding experienced during the 2005 rainfall event in these locations.

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

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

To fully understand the flood risk to properties on George Street and whether flooding of the property interior would occur during high frequency events, building footprint confirmation and floor level surveys would be required to determine whether flood depths of less than 300 mm would in fact enter the building. It is recommended that this would form part of the surveys recommended under the deep flooding issue.

Twenty seven percent of the pipes in this catchment were laid more than 100 years ago, and are due to be assessed (and potentially upgraded) by the DCC renewals programme, with a further 33 % due to be assessed in the next 10 years. This, however, may only go some way to alleviating the adverse effects predicted and verified during a current 1 in 10 yr ARI rainfall event. Several management options have therefore been developed to alleviate the effects of current and future nuisance flooding and the risk of habitable floor flooding during a rainfall events of 1 in 10 yr ARI or greater. These preliminary options are as follows:

H1: York Place Upgrade

An upgrade of both the local catchment and the greater upstream catchment pipelines in York Place comprised of approximately 30 m of 900 mm diameter pipe immediately upstream of the pressure pipe system from the recorded 600 – 750 mm pipe, and upgrading 250 m of 225 – 375 mm pipe to 450-900 mm pipe. This will provide greater pipe capacity and reduce overland flows into St Andrew Street.

H2: Upgrade Scotland Street and London Street/Heriot Row Intake

Upgrade the London Street/Heriot Row intake screens to improve inlet conditions and upgrade the pipeline in Scotland Street to approximately 900 mm diameter to reduce overland flow volumes along London Street reduce the flood risk to the former Smith City building, and reduce overland flows into Filleul and George Streets.

H3: Realign Pipe Work at the Former Smith City Entranceway

Alter the piped discharge point at the former Smith City site from the pipeline in Filleul Street to a pipeline in Hanover Street (approximately 27 m of 450 mm diameter pipe).

H4: Upgrade Catchpits at Intersections of St Andrew Street and George Street

Construct double catchpits and oversized leads at the St Andrew / George Street intersection to intercept a greater volume of overland flow and reduce overland flow down St Andrew Street.

H5: High Level Connection St Andrew Street and George Street

By providing further high level interconnectivity between the catchments in the St Andrew / Hanover Streets block, there is potential to make use of any spare capacity within pipe sections, reducing manhole overflows.

H6: St Andrew Street Pipe Upgrade

Upgrade 925 m of pipe work along St Andrew Street from Great King Street to the ocean outfall to increase capacity and potentially reduce surface flooding.

H7: Connection to Additional Railway Culvert

By providing a connection between the main piped network along St Andrew Street and an existing parallel higher level culvert and pipeline under the railway line, there is potential to make use of the spare capacity within pipe sections, reducing manhole overflows.

H8: St Andrew Street Pipe Upgrade Combined with Additional Railway Culvert Connection

Combination of Options H6 and H7 to utilise the existing additional railway culvert and spare pipeline capacity to reduce the size of the St Andrew Street upgrade.

H9: Off-line Detention Device Upstream London Street / Heriot Row Intake

Provide an off-line detention pond or tank adjacent to the open channel upstream of the London Street / Heriot Row intake to store flood flows above the level that the current pipe network can currently convey, to contain flood flows and reduce manhole overflows and overland flows across London Street / down Scotland Street.

H10: Raise Levels of Flood Prone Buildings

Elevate the buildings that currently flood, and are predicted to flood in the 1 in 50 yr ARI future growth scenarios.

The locations of these options are shown in Figure 12-1. Section 14 contains further information relating to the options, the preliminary analysis and shortlisting.

Further catchment-wide management options are presented for this issue, they are not presented as alternatives, but rather to be considered to assist with both the renewals programme and further design and development of capital works within the catchment to maximise the potential to alleviate flooding issues.

Improve quality of Stormwater Network Data

To assist with both the renewals programme and the further design and development of stormwater management options in the catchment, there would be benefit in improving the quality of data relating to the stormwater network. To augment the information gathered during the city-wide CCTV inspection programme (in progress at the time of writing this plan), improvements in GIS asset data would be beneficial.

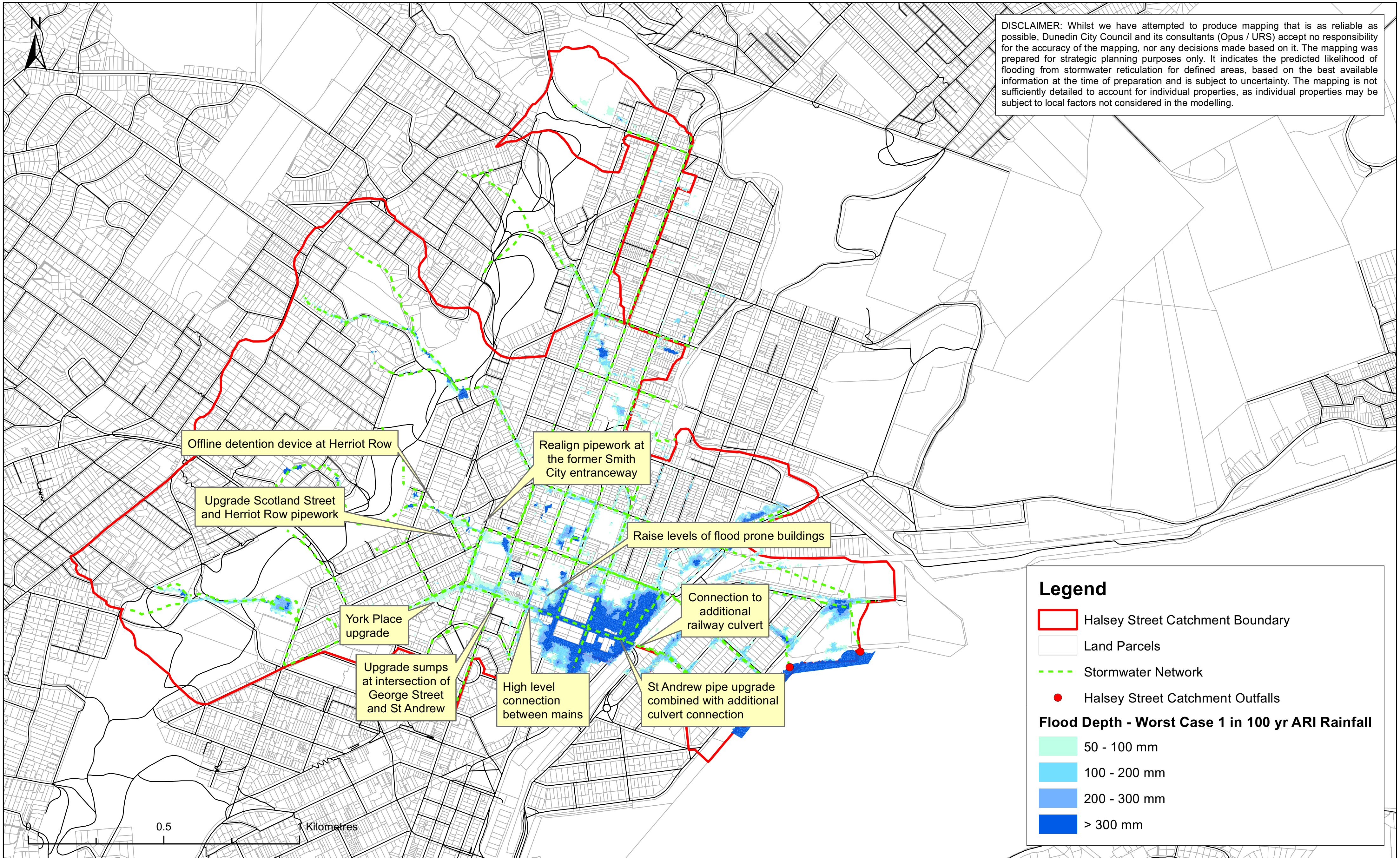
Include Additional or Improved Catchpits in any Capital Works

By ensuring any future capital works carried out on the stormwater network include either additional or improved catchpits, there would some increase hydraulic capacity in enabling surface flows into the piped network.

12.2.2 Blocking / Maintenance of Intake Structures – Manage Actively

Blocking of intake structures has been identified as an issue in the Halsey Street catchment. A number of intake structures have been identified as prone to blockage and in some cases this is known to exacerbate flooding issues within the catchment or present a risk to flooding of properties.

Screens on private property are infrequently inspected by DCC staff unless a known flooding issue results from screen blockage. Modelling indicates that there may be other intake structures in the catchment that would benefit from review. At minimum it would be advisable to have an inventory of the intake structures and their condition.



DUNEDIN CITY COUNCIL / OPUS / URS	Dunedin 3 Waters Strategy	**HALSEY STREET INTEGRATED CATCHMENT MANAGEMENT PLAN** **Figure 12-1** **Stormwater Quantity Management Options**	**DISCIPLINE** **Stormwater**	Drawn: JMH; Status: Final; Checked: HES; Scale: 1:12,500; Plot Date: Sep 2011; Approved: HES; Job. No: 42173227; Map No: Figure 12-1; Revision: -; Date: Sep 2011

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The following approach has been recommended for this issue:

- Undertake an inspection of all open channel sections, to record status of intake structures;
- Ensure damaged screens are replaced or repaired (in conjunction with watercourse approaches outlined in Section 11.2)
- Identify areas in catchment where more regular cleaning and maintenance could reduce flooding risk.
- Clarify ownership of stormwater assets.
- Work with property owners to ensure intakes and screens are properly maintained.

Actions to be considered in order to reduce the risk of flooding (locally and at key locations), will be site dependent. It is proposed that further investigation, in the form of stream inspections and asset inventories, would be the first step in this process. Following this, the criticality of each location would be assessed, and an appropriate management approach designed.

Regarding the London Street/Heriot Row intake structure, the management options developed to mitigate nuisance flooding effects will address the poor design of this structure. However, regular maintenance would still be required.

12.2.3 Flood Hazard (Current and Future) – Manage Actively

During a current 1 in 100 yr ARI rainfall event, with MHWS tide, flooding is predicted to cover approximately 3.6 % of the catchment. The majority of the flood extent is concentrated within on the flat land of the lower catchment within the central city. Due to the low capacity of the network, and the tidal influence on the piped network flooding of properties and roads during this event is unavoidable. Flood hazard during a current 1 in 100 yr ARI rainfall event also results from high velocity flows on the hill sections of the upper catchment.

During the extreme future scenario consisting of a 1 in 100 yr ARI rainfall event combined with a 2060 tide (including climate change impacts) and a 1 in 20 yr ARI storm surge, flooding is predicted to cover approximately 8.4 % of the catchment, with the lower catchment and central city the most affected by the flood extents. Due to the low capacity of the network, and the effect of high tides and storm surge, flooding of properties and roads during an event this large is unavoidable, and much of the flooding is predicted to be due entirely to tide levels inundating the low lying catchment.

Small benefits may be gained, during current and future (extreme) events, from other options seeking to alleviate more regular flooding, or improve network capacity. The catchment specific targets and approaches identified for this issue are as follows:

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

In terms of ensuring that development does not further exacerbate flooding, management of the effects of new development would be as per the requirements of DCC's Code of Subdivision and Development (refer to Section 12.2.2 for a discussion on this regarding levels of service).

Two options are presented for this issue, they are not presented as alternative however, both would be required to fully address the issue. One option addresses the current situation, the other the future extreme scenario.

Develop Emergency Response Plan

The 1 in 100 yr ARI rainfall event has been examined for emergency planning purposes and 'active management' in this context is likely to involve appropriate contingency planning only. The extent of the flooding, effect of the tide and lack of critical structures in the catchment means that the approach to flood hazard in this catchment is via an Emergency Response Plan. Consequently, only one option alternative for current flood hazard management is presented.

The areas predicted to have the most significant flood hazard is the lower catchment within the central city. It is predicted that several transport routes into and out of this area will be significantly affected during an extreme flooding situation, including State Highways 1 and 8. An Emergency Response Plan could be prepared to ensure that evacuation from flooded areas was possible during a large storm event. This could also include the identification of vulnerable premises and key industrial premises, and provide a specific evacuation plan for these.

It is anticipated that an Emergency Response Plan would be prepared for all harbour front catchments predicted to be significantly affected by the current 1 in 100 yr ARI rainfall event. The response for the Halsey Street catchment would form part of the Plan.

Develop Climate Change Adaptation Plan

Flood hazard in this catchment is predicted to intensify in the future due to climate change impacts; therefore a single option is presented reflecting this driver.

In order to develop a better understanding of the likely effects and magnitude of climate change, there needs to be an ongoing re-visitation of new information regarding climate change predictions, and the implications of these for the Halsey Street catchment. The hydraulic model developed for this study would be a key tool in assessing the impacts of a range of further climate change scenarios. A climate change adaptation plan for the whole of Dunedin City would incorporate findings in terms of a plan for low-lying catchments such as the lower Halsey Street. This plan may affect the options chosen in terms of on-going provision of level of service of the network. Damage assessment of critical and vulnerable sites (such as the State Highway and electricity substations) would form part of this work.

12.2.4 Network Maintenance – Manage Passively

Flooding extents and durations in the Halsey Street catchment could potentially be exacerbated should critical catchpits and inlet screens not be adequately cleaned.

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

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

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

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

- London Street – Intake screen
- City Road – Intake screen
- Logan Street – Intake screen

12.2.5 Low Level of Service – Manage Passively

The current level of service in some parts of the catchment is below DCC's target for new infrastructure, as a result of both tidal influence and inadequate network capacity. However, the majority of the network (84 %) of the network has the ability to accept rainfall from a 1 in 10 yr ARI event during MHWS tide conditions. In those areas where the network capacity is less, some adverse effects are predicted to occur; management options for these effects are addressed under the 'nuisance flooding' issue. The results of the ROS indicates that residents/building owners are not dissatisfied with the current level of service provided. This, combined with the fact that the dominant result of the low level of service is nuisance flooding, sets the management of this issue as passive.

The catchment specific approach for this issue includes the following:

- Maintain or improve existing level of service in network – ensure no increase in the number of manholes predicted to overflow in a 1 in 10 yr ARI rainfall event.
- Design new pipes with capacity to convey a 1 in 10 year storm event.
- Undertake pipe renewals programme from 2012.
- Ensure new development does not increase potential habitable floor flooding in events up to a 1 in 50 yr ARI rainfall event.
- Use customer complaints and ROS to gauge satisfaction with the stormwater system performance.

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 outlines the design criteria required by DCC for new stormwater work. Compliance with this document ensures that the approach to design new pipes to convey a 1 in 10 yr ARI rainfall event is met, and that secondary protection is provided up to a 1 in 100 yr ARI rainfall event.

As development occurs, or pipe renewals are undertaken, the level of service of parts of the network will gradually improve. Under DCC's pipe renewals programme, 66 % of the pipes in the catchment are due for renewal within the planning period of this document, based on the age of installation. The pipe renewal 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.

Due to the tidal influence on parts of the Halsey Street catchment stormwater network (the lower catchment), the levels of service may not improve significantly via just local upgrades as part of the pipe renewal process in certain locations. However, options investigated to resolve flooding, in conjunction with the renewals process, are likely to result in the improvements in system performance.

In the interim the ROS can be used to gauge satisfaction with the stormwater system performance. The ROS provides a city-wide impression of satisfaction with the stormwater system, and is used to measure progress against a target of 60 % satisfaction. The Halsey Street catchment is most aligned with the Dunedin City group surveyed. In 2010 45 % of residents in the Dunedin City area were either very satisfied or satisfied with the stormwater collection service, with 22 % being either dissatisfied or very dissatisfied. This is lower than the DCC target for satisfaction. However, since the survey began in 2003, city-wide satisfaction with the stormwater collection service has been above 60 % in every year except 2004/2005 (Research First 2010).

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

12.2.6 Deep Flooding – Manage Passively

A total of 20 land parcels in the Halsey Street catchment are predicted experience flood depths of greater than 300 mm during the current 1 in 10 yr ARI rainfall event combined with a MHWS tide, this rises to 26 when future land use scenarios and climate change are applied to the model. During a 1 in 50 yr ARI rainfall event, 32 and 56 land parcels are predicted to experience deep flooding under current and future scenarios respectively. However, a large proportion of the predicted deep flooding is within the Town Belt, away from buildings or is as a result of anomalies in the topographical data giving rise to uncertainty as to the extent of risk to building interiors.

The risk of habitable floor flooding, predicted by the model, is verified in some cases by flood complaints records. The main locations that deep flooding is predicted, posing a risk to habitable floor flooding during this event, are as follows:

- Former Smith City site (84 Filleul Street).
- George Street retail area.
- Harrow Street / St Andrew Street / Anzac Avenue intersection.
- London Street / Heriot Row intake structure.

The deep flooding predicted is predominantly due to the low capacity of the network and the tidal influence on the system in the lower catchment. Overland flows from the upper catchment contribute to the flood depths and extent on the flatter land in the central city.

The catchment specific targets and approaches identified for this issue are as follows:

- Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event.
- Ensure no increase in the number of properties predicted to flood during a 1 in 50 yr ARI rainfall event.
- Reduce number of properties predicted to flood during a current 1 in 10 yr ARI rainfall event.
- Ensure new development does not increase potential habitable floor flooding in events up to a 1 in 50 yr ARI rainfall event.
- Enhance understanding of effects of deep flooding, particularly on private property.

DCC's target with respect to potential habitable floor flooding is to ensure that the current risk is minimised during high frequency events, and is not increased in the future as development occurs and climate change is taken into account. Management of the effects of new development, therefore, would be as per the requirements of DCC's Code of Subdivision and Development (refer Section 12.2.2 to a discussion on this regarding levels of service).

In order to fully understand the risk of habitable floor / useful space 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 in nature is often useful in terms of identifying vulnerable premises.

A damage assessment would involve a topographical survey of building floor levels, and a report on the use of the premises by the occupant, and value of stock and/or fittings that would potentially be damaged by a flood event of a certain depth. An assessment would need to be undertaken with every change of use of the premises and potentially could be a requirement of the property owner.

Several options have been developed to alleviate the risk of nuisance and deep flooding during events of 1 in 10 yr ARI these are presented under the nuisance flooding issue. These options have been developed to alleviate both nuisance flooding and deep flooding and would therefore result in a reduced risk to properties during lower frequency (1 in 50 yr ARI) events.

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

The annual stormwater quality monitoring results from the Halsey Street catchment are variable and do not indicate high levels of many contaminants (with the exception of microbial contamination which is discussed further below). However, a single time-proportional sample was taken in 2009 indicating elevated levels of suspended solids, copper and zinc. Whilst the sediment monitoring results indicate elevated levels of certain contaminants, it cannot be concluded that this is a result of stormwater quality discharged from this catchment.

In general, the stormwater and harbour environment monitoring regime to date has been insufficiently robust to enable the identification of any relationship between stormwater quality and harbour environment health.

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

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

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

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

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

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

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

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

- Develop and implement a robust monitoring framework by 2012.

The approach and targets recommended include a staged approach that seeks to redesign the current monitoring framework to ensure that it will provide more comprehensive and defendable information on current stormwater discharge quality and the effects thereof. Following this, stormwater management approaches will be reviewed and adjusted where necessary to reflect DCC's strategic objectives. Depending on the extent of the monitoring programme developed, monitoring may be prioritised. Based on the time-proportional results obtained for this catchment, it is likely that this catchment would be prioritised for further monitoring.

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

Design a Framework for Stormwater Quality and Harbour Environment Monitoring

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

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

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

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

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

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

12.2.8 Potential Wastewater Contamination – Manage Actively

High levels of microbial contaminants have been observed in the stormwater monitoring result from the Halsey Street catchment throughout the monitoring years (2007 to 2010), measured at the upper levels or higher, than is typical for urban stormwater. The results could indicate wastewater contamination within the stormwater network. However, there are no known issues with the wastewater network in this catchment.

In order to enable DCC to maintain or improve stormwater quality, and implement appropriate management options to remediate any potential threat from microbial contamination a high confidence in monitoring data and identification of potential contaminant source/s is required, which can be gained through further investigation into this issue.

The catchment specific approaches recommended for this issue in the Halsey Street catchment are strongly related to those associated with the 'Ongoing Stormwater Discharge' issue, and are as follows:

- Improve data relating to levels microbial contamination and potential sources of microbial contamination within the catchment by 2012.
- Revise management approaches and ongoing monitoring protocols by 2014.

The approach to stormwater quality management in this catchment, relating to this issue will be revised following determination of the significance of this issue and identification of potential sources of contamination. This will be implemented by updating the ICMP and the continuous monitoring and improving of SMART targets.

12.2.9 Ongoing Stormwater Discharge – Manage Passively

The annual monitoring data at present indicates that the levels of many contaminants in stormwater from the Halsey Street stormwater are not significantly high (with the exception of microbial levels which are addressed in a separate issue). Whilst a single time-proportional sample taken in 2009 showed elevated levels of suspended solids, copper and zinc in the stormwater (at levels close to or above those typical for urban stormwater), a single sample is insufficient to provide evidence for 'contaminants of concern' within the stormwater and does not give an indication of trends in stormwater quality over time. Therefore based on the best available information at this time, the prioritisation of this issue has resulted in a 'passive management' approach. Furthermore, the development and implementation of a robust stormwater quality monitoring framework, as outlined in Section 12.2.8 will mitigate the uncertainty in the stormwater quality data from this catchment.

Options for management of this issue are detailed below. They take into account the mixed land use of this catchment (residential, commercial and industrial). It is recommended that all options are applied.

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

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

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

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

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

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

13 Three Waters Integration

13.1 General

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

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

13.1.1 Raw Water and Water Supply

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

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

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

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

13.1.2 Wastewater

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

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

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

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

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

To date there have been no specific issues identified with the wastewater network within the Halsey Street catchment, aside from sea water intrusion into the network, which has resulted in a number of pipe rehabilitations in the lower catchment.

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. Weighting for each of the criteria has been assigned by DCC.

Table 14-1: Option Assessment Criteria and Scoring System

QBL	Option Assessment Criteria	-10	-5	0	5	10
Environmental (10)	Removal of known wastewater cross connections	Does not remove cross connection.	Reduces likelihood of cross connection occurring.	Assists in finding unknown cross connections.	Removes cross connection for design events (emergency overflow still exists).	Removes cross connection under all events.
	Contaminant reduction	None.	5 - 25 %	25 - 40 %	50 - 75 %	75 - 100 %
	Use of source control / LID	No treatment or control.	End of pipe treatment (catchment or sub-catchment based).	Site based in-line treatment / collection of contaminant.	LID with water reuse up to design event.	Source control - avoid generation of contaminant of concern.
	I&I reduction	No I&I reduction possible.	-	-	Minor I&I reduction possible without exacerbating stormwater flooding.	Major I&I reduction possible without exacerbating stormwater flooding.
	Construction effects	Major discharge of contaminants into environment during construction.	Minor discharge of contaminants into environment during construction.	-	All contaminants generated contained on site and disposed of appropriately.	No effects on environment - no contaminants generated during construction.
	Replication of current flow patterns	No volumetric control.	Minimal attenuation.	Replicates or reduces current flow patterns up to 1 in 2 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	Option Assessment Criteria	-10	-5	0	5	10
Social (10)	Interest / support of community / social interest groups	Major opposition from community / special interests groups.	Some opposition from community / special interests groups.	-	Some support from community / special interests groups.	Major support from community / special interests groups.
Cultural (10)	Fit with Māori cultural values	Contradicts key cultural values.	Unlikely to fit with values and preferred approaches.	Not specifically identified as preferred approach, but likely to fit.	Fits with preferred approach recommended by local iwi.	Involves iwi in development and design of option.
Implementation Risk (20)	Risk of operational failure	Likely operational failure. Unproven technology.	New technology. Extensive training required.	Moderately complicated new technology.	Minor modifications to technology already used. Simple new technology.	Proven technology, already utilised throughout city.
Economic (10)	Estimated Capital Cost - order of magnitude (note does not allow for internal costs)	$ 10m+	$ 1 - $ 10m	$ 500k - $ 1m	< $ 500k	Free
	Risk of cost escalation due to construction unknowns	High - escalation likely as no alternatives and insufficient information.	Moderate risk. Low number of alternatives available.	-	Can be managed via alternatives.	Low risk. Well known issue and design criteria.
	Risk of land availability	Unlikely to secure land.	Long process for negotiation, or high cost of land expected.	Moderate process / costs anticipated.	Unutilised land likely easy to secure.	Land already owned by DCC.
	Risk of protracted consent process with authorities	Consent unlikely.	High risk of long process.	Medium consent process anticipated.	Short consent process anticipated.	No consent necessary.

QBL	Option Assessment Criteria	-10	-5	0	5	10
Effectiveness (Risk Reduction) (30)	Risk reduction	Extreme risk reduced to very high; Very High reduced to high.	Extreme risk reduced to High.	Extreme or Very High risk reduced to Moderate; High risk reduced to Moderate or low.	Extreme or Very High risk reduced to Moderate; High risk reduced to Low or negligible.	Extreme or Very High risk reduced to Low or negligible.
	Deep flooding 1 in 50 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 Options Comparison

Multiple options were not developed for all issues identified as requiring 'active management', as often the assessment of a number of issues resulted in only a single management option being identified, or the need for further study.

Where multiple options are available, these options have been screened further using the hydraulic model and a qualitative assessment, to determine technical feasibility and the likelihood of meeting the targets set for this catchment. The outcomes of this preliminary evaluation are presented in Section 14.3.

Only one 'manage actively' issue has prompted an options evaluation: this is to manage 'Nuisance Flooding'. Options developed have been designed to alleviate the effects predicted during a 1 in 10 yr ARI rainfall, including high velocity overland flows, nuisance flooding (50 – 300 mm) and deep flooding (> 300 mm). However, they have also been evaluated with regards to the potential to alleviate deep flooding during higher frequency events up to a 1 in 50 yr ARI rainfall event.

Areas of predicted nuisance flooding are located throughout the catchment, with the most significant in the following areas:

1. London Street;
2. York Place;
3. Filleul Street; and
4. St Andrew Street;

Preliminary evaluation of the options combined engineering judgement with hydraulic modelling of a number of options to assess the likely effectiveness of those options for reducing flooding. The 2-dimensional component of the InfoWorks model was used to calculate 'flood volume' leaving the pipe network, or the depth of overland flow during the 1 in 10 yr ARI rainfall event. The options developed and outcomes of the preliminary evaluation are described below.

14.2.1 Preliminary Options Evaluation

The following details the options and outcomes of the preliminary evaluation. Where options have been found to be 'deal breakers' they have not been taken forward for QBL evaluation.

From the preliminary evaluation a short list of options has been identified comprising those options which are deemed to be technically feasible and likely to meet the objectives and targets set for this catchment.

Option H1 - York Place Upgrade - Shortlist

There are two pipe networks at the lower end of York Place between Haddon Place and Filleul Street. One of the pipelines (600 mm diameter) is the transition between the York Place gravity and sealed pressure system, taking the flows from the higher part of the catchment, while the second pipeline (225 mm to 400 mm diameter) serves the local part of York Place into St Andrew Street.

The model predicts that there will be surcharging manholes on both pipelines which will result in overland flow down onto Filleul Street then into St Andrew Street where it ponds significantly.

Two pipe upgrade options were modelled to ascertain what would be required to prevent the manhole surcharge. The requirements are:

- Upgrade approximately 30 m of 600 mm pipe to 900 mm diameter; and
- Upgrade approximately 250 m of 225 mm and 375 mm diameter pipe to 450 mm and 900 mm diameter respectively.

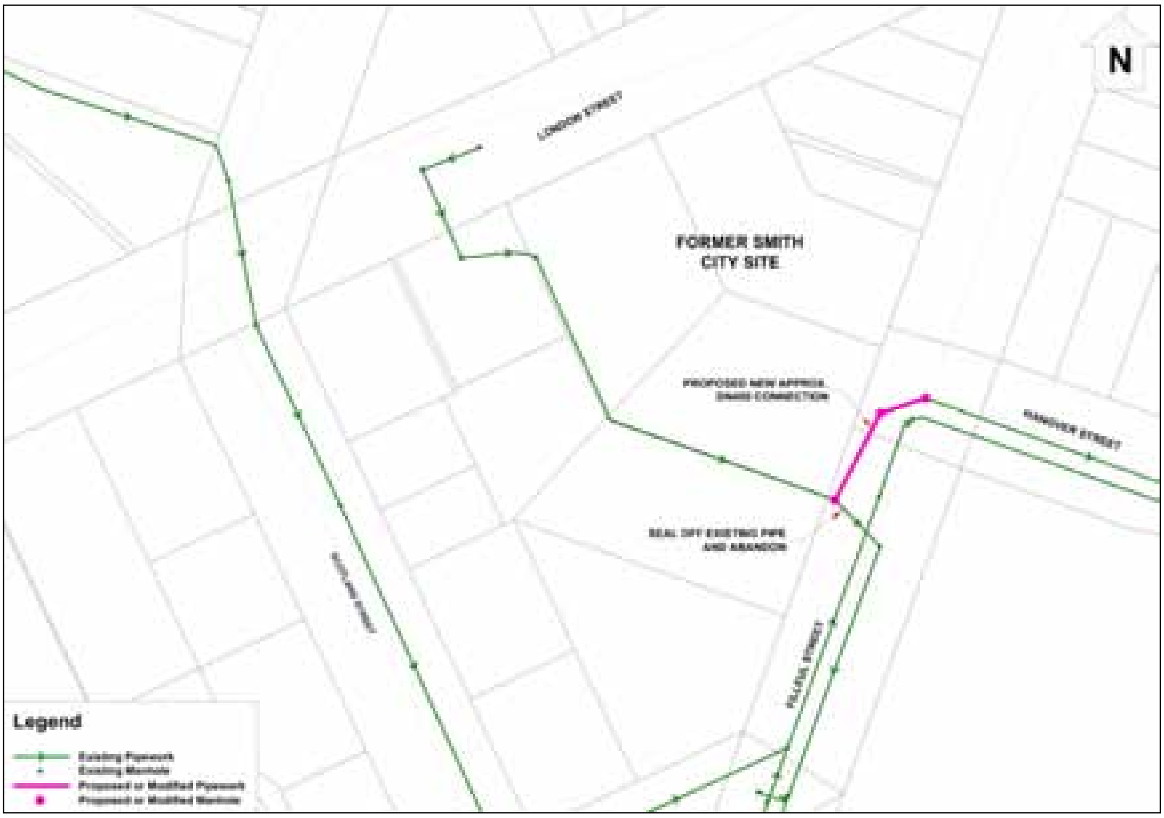


Figure 14-1: Option H1 - York Place Upgrade

This results in an improvement in the 1 in 10 year future growth scenario in both the individual and combined run scenario with both a reduction in flooded manholes and a reduction in flood extent. Individually both options provide some reduction in predicted downstream flooding, but the maximum benefit would be provided by carrying out both upgrades, possibly as a staged project.

Option H2 - Upgrade Scotland Street and London Street/Heriot Row Intake - Shortlist

There is an identified restriction with the current screen and intake structure at London Street, and capacity issues in the 600 mm diameter pipeline down Scotland Street. It is therefore proposed to upgrade the intake screens to improve inlet conditions and upgrade approximately 280 m of pipeline in Scotland Street to approximately 900 mm diameter. This will minimise overland flow volumes along London Street, hence reduce the flood risk to the former Smith City site (84 Filleul Street), and also the overland flows into Filleul Street, St Andrew Street and George Street.

This option will reduce the overland flooding risk from the inlet screen blocking, and from the surcharging manhole at the London Street / Heriot Row / Scotland Street intersection. Therefore this option will be carried through to the QBL assessment.

Option H3 - Realign Pipe Work at Former Smith City Entranceway - Shortlist

The option involves laying approximately 27 m of 450 mm diameter pipe and one new manhole to connect the pipeline through the former Smith City site into the Hanover Street sub-catchment rather than the Filleul Street sub-catchment.

This option was modelled and was found to reduce the number of flooded nodes and slightly reduce the flood extents in the future 1 in 10 yr ARI event. Therefore this option will be carried through to the QBL assessment.

Figure 14-2: Option H3 - Realign Pipe Work at Former Smith City Entranceway

Option H4 - Upgrade Catchpits at Intersection of St Andrew and George Street – Deal Breaker

A model run was carried out to assess the effect of using “super-pit” type catchpits with increased inlet capacity and larger leads, in areas where spare capacity was available in the stormwater network.

As catchpits have not generally been included in the hydraulic model, a baseline run was carried out to establish the flood extents with standard catchpits at the St Andrew Street / George Street intersection. Once this was done, the improved catchpit arrangement was modelled.

This option did not result in an improvement in the modelled network performance over the baseline catchpit model, increasing the number of surcharged manholes by one. Therefore this option has been identified as a deal breaker.

Option H5 - High Level Connection St Andrew and George Street – Deal Breaker

The model indicates that in the 1 in 10 yr ARI rainfall event, there is spare pipeline capacity albeit at different points within the catchment. This option was modelled to investigate the potential for utilising any available capacity in the city centre catchment network by creating a high level connection between the pipelines at the St Andrew and George Street intersection.

However, when a cross-connection was modelled, the net effect was to shift flooding from one point to another. Given the difficulty in defining the volume / extent of flooding at various locations, the differences in discrete locations due to the "shifting" of flooding cannot be realistically reported. Therefore this option has been identified as a deal breaker.

Option H6 - St Andrew Street Pipe Upgrade – Deal Breaker

As the main causes of the 'nuisance flooding' issue are influenced by capacity problems around the St Andrew area, it was considered appropriate to check the benefits of upgrading the St Andrew Street pipeline to the outfall.

This was modelled as firstly a 1350 mm diameter and then a 1500 mm diameter pipeline (it is currently 900 mm by 1200 mm egg shaped pipe) between George Street and the outfall. There was a benefit to the current 1 in 10 yr ARI event with a reduction in 10 manhole overflows and an 18 % reduction in flood extent.

However, when the 1 in 10 yr ARI future growth scenario was applied, there was an increase in flood extent and one extra flooded node upstream due to the elevated hydraulic grade line from the larger pipe intercepting a low lying area. Therefore, although this option works for the current 1 in 10 yr ARI rainfall event, it fails to satisfy the future growth scenario, and is therefore a deal breaker.

Option H7 - Connection to Additional Railway Culvert – Deal Breaker

The potential of connecting the St Andrew Street pipeline to a parallel 900 mm diameter culvert was modelled by providing a weir connection to see if there was the ability to use any spare capacity in the additional culvert and downstream pipework.

The model results show a worsening in the number of flooded manholes making this a deal breaker. However, the DCC GIS data does not contain the actual upstream node invert level, so the level of confidence with the results is reduced.

Option H8 - St Andrew Street Pipe Upgrade Combined with Additional Railway Culvert Connection - Shortlist

In addition to the modelled options of H6 and H7, a model of the combined options was carried out. Despite individual options being deal breakers, the net effect of both options is favourable, with the benefits of both options being synergistic for both the current and the future planning scenarios. It is also consistent with pipe upgrades expected to be necessary as part of the renewals process.

Option H9 - Off-line Detention Device Upstream London Street/Heriot Row intake – Deal Breaker

Although not modelled, a balance check on the inflow into the top of the London Street / Heriot Row intake compared to the flow rate at the Scotland / Filleul Streets intersection indicates that for a 1 in 50 yr ARI rainfall event a minimum of approximately 1500 m^3 of storage would be required upstream of the intake. Given the steep topography behind the intake it is unlikely that a structure could be physically located to provide the required detention.

Option H10 - Raise Levels of Flood Prone Buildings – Deal Breaker

Given the majority of the buildings along the flood prone areas, notably St Andrew Street and George Streets, are in a pedestrian area and likely to be constructed with concrete slab floors with no visible basements, it is considered that this option is not practically viable.

From the preliminary evaluation a short list of options has been identified comprising those options which are deemed to be technically feasible and likely to meet the objectives and targets set for this catchment.

14.2.2 Options Shortlist Evaluation

Following the preliminary evaluation, a number of 'shortlisted' options have been selected QBL analysis undertaken for direct comparison (for example to compare solutions for the specific issue) to enable a preferred / recommended option to be chosen.

The results of this comparison are presented in Table 14-2. Comparison of recommendations for this catchment alongside other catchments will be undertaken as part of the 3 Waters Strategic Plan.

It should be noted that even though the options proposed relate to capital works in slightly different areas, all would contribute to reducing flooding in the St Andrew Street area. Also, catchment wide benefits (in terms of flood reduction) have been used to compare options on a best for catchment basis.

Also, based on the 1 in 10 yr ARI future growth scenario modelling, the different options provide improvements in different areas of the quantitative assessment. For example:

- The best option for reducing the flood extent is option H2, and
- The best option for reducing the number of flooding manholes is option H1.

These results need to be considered in conjunction with the QBL assessment.

As mentioned above, as each option indicates improvements in different areas of the quantitative assessment, a pragmatic approach to the option selection must be used with this catchment given the pipe work interconnectivity and influence of one part of the network on another.

Table 14-2: Shortlist Option Comparison

QBL Assessment Criteria	Category Weighting	Sub-weighting	Option H1 York Place Upgrade	Option H2 Scotland Street / London Street Upgrade	Option H3 Realign Pipework Former Smith City	Option H8 St Andrew Street Upgrade / Railway Culvert Connection
Removal of known wastewater cross connections	10	N/A	N/A	N/A	N/A	N/A
Contaminant reduction		1.67	-10	-10	-10	-10
Use of source control / LID		1.67	-10	-10	-10	-10
I&I reduction		1.67	5	5	5	5
Construction effects		1.67	5	5	5	5
Replication of current flow patterns		1.67	-10	-10	-10	-10
Option flexibility		1.67	0	5	0	10
Interest / support of community / social interest groups	10	10	-5	5	10	10
Fit with Māori cultural values	10	10	0	0	0	0
Risk of operational failure	20	20	10	10	10	10
Estimated capital cost - order of magnitude (note does not allow for internal costs)	10	2.5	0	0	5	-5
Risk of cost escalation due to construction unknowns		2.5	-5	-5	-5	-5
Risk of land availability		2.5	10	0	10	0
Risk of protracted consent process with authorities		2.5	10	0	10	0
Risk reduction	30	7.5	5	5	5	5
Deep flooding 1 in 50 yr future-current		7.5	10	10	10	10
Manholes overflowing 1 in 10 yr - future-current		7.5	10	10	10	10
Improvement in level of service		7.5	10	10	5	10
Weighted Total Score:			**417**	**475**	**542**	**521**

15 Option Selection

15.1 Approaches for Active Management

The issues that have been prioritised in the Halsey Street catchment as requiring 'active management' are identified below:

1. Nuisance Flooding;
2. Blocking / Maintenance of Intake Structures;
3. Deep Flooding;
4. Flood Hazard – Current and Future (1 in 100 yr ARI);and
5. High Variability of Stormwater Quality Results.

A number of different options were considered relating to the 'nuisance flooding' issue, these options would also mitigate some of the effects of other issues identified for 'active management'. However, the majority of the management options for 'issues requiring 'active management' did not have any feasible alternatives and therefore all options presented have been recommended.

In order to manage nuisance flooding, two catchment-wide management options are presented for this issue, they are not presented as alternatives, but rather to be considered to assist with both the renewals programme and further design and development of capital works within the catchment to maximise the potential to alleviate flooding issues.

- Improve quality of stormwater network data.
- Include additional or improved catchpits in any capital works.

In addition to the catchment-wide management options, a comparison of infrastructure options for stormwater quantity management in the Halsey Street catchment for the 'nuisance flooding' issue ranks the alternative approaches for active management of stormwater as follows:

1. H3 - Realign Pipe Work at the Former Smith City Entranceway;
2. H8 - St Andrew Pipe Upgrade Combined with Additional Railway Culvert Connection;
3. H2 - Upgrade Scotland Street and Heriot Row Intake; and
4. H1 - York Place Upgrade.

All of the options carried forward into the QBL Assessment phase will provide a benefit to differing degrees across the catchment, in particular the central city area bounded by Hanover Street / St Andrew Street / George Street / Castle Street.

Due to the interconnected nature of the different pipe work and the flat topography of the lower catchment there is a "shifting" of the nuisance flooding between sub-catchments when water is added into pipelines that have spare capacity. This simply results in transference of the problem rather than providing a solution.

Therefore, several of the options in the ranking above could be carried out and provide a similar benefit to the level of service in the catchment. Of the options, H8 is the solution that provides the best overall result in terms of improving flooding for the future 1 in 10 year growth scenario, but at a much higher capital cost in comparison with other solutions which is reflected in the overall QBL score.

Also, there is likely to be a benefit to combining some options. For example, the former Smith City site connection option (H3) and the St Andrew Street upgrade (H8). These could be considered as a staged approach solution over several years of funding.

It is therefore recommended that once the data from the current CCTV inspections programme, level survey and GIS confirmation inspections have been collected, that a feasibility study is carried out. This would:

- Allow the existing model to be expanded and the network performance to be assessed with greater confidence,

- Provide a renewals / upgrade programme based on age and condition, and

- Provide a more a robust long-term solution for managing current and future nuisance flooding risk.

By focussing on further detailed investigation rather than simply considering the ranking of one proposed capital works option over another, DCC would be able to prepare an “action plan” of works for subsequent budgetary periods possibly providing further funds for a larger renewal / upgrade project.

For other issues that have been prioritised as requiring ‘active management’, a comparison of alternative options was not undertaken, as they either involved non-infrastructure options or did not have any feasible alternatives. The following options are recommended in order to manage those issues:

- Compile an inventory of stormwater structures, including details of asset condition and ownership, and identify sensitive locations requiring more frequent cleaning and maintenance.

- Review the education / advice to property owners responsible for watercourses to ensure adequate information and assistance is provided.

- Development of a Climate Change Adaptation Plan (city-wide).

- Development of an Emergency Response Plan for the Halsey Street catchment.

- Redesign and implement the city-wide framework for stormwater quality and harbour environment monitoring, prioritising Halsey Street catchment within the monitoring framework.

- Investigate microbial levels within stormwater from the catchment and identify potential sources of contamination by 2012.

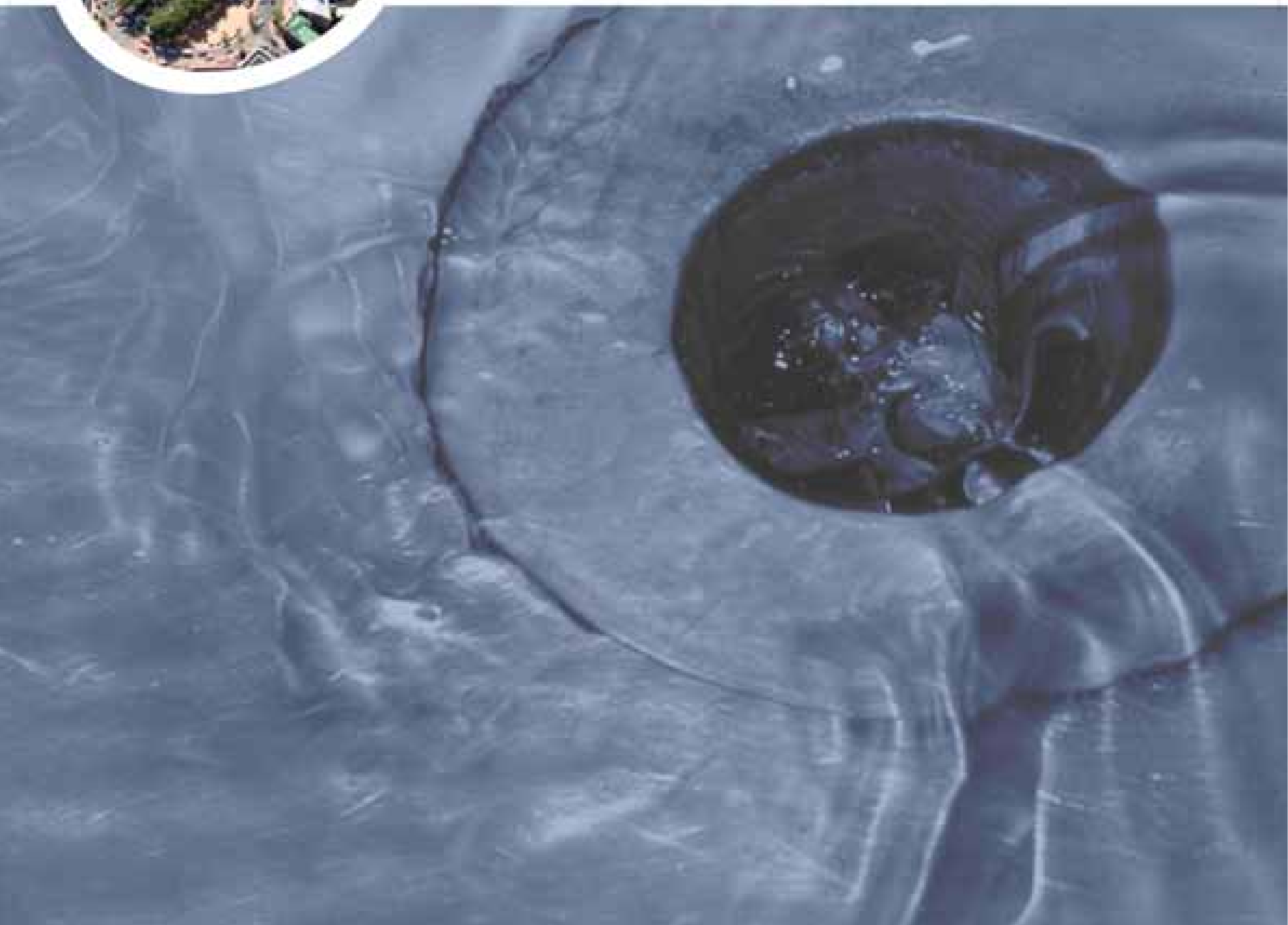
Improved data confidence will allow the prioritisation of stormwater management recommendations based on the significance of stormwater quality issues. This would occur city-wide and form part of the 3 Waters Strategic Plan.

15.2 Approaches for Passive Management

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

- Ensure planned renewals are designed to accommodate a 1 in 10 yr ARI rainfall event, and incorporate allowances for climate change effects;
- Undertake a review of schedules and methods used across the city to maintain stormwater structures (catchpits and inlets).
- Incorporate intake structures at London Street / Heriot Row, City Road and Logan Street into a priority list for more regular catchment inspection and cleaning.
- Utilise stormwater complaints information and ROS to continuously gauge customer satisfaction with the stormwater service.
- Identify and undertake floor level survey and damage assessment of properties potentially affected by habitable floor flooding / flooding of useful space during events up to 1 in 50 yr ARI rainfall event (including those areas in the catchment where habitable floors or useful space may be affected at flood depths of less than 300 mm).
- An amendment to the business processes used to manage subdivision and development to direct stormwater treatment based on catchment specific requirements.

Part 6
Way Forward



16 Recommendations

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

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

Table 16-1: Further Study Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
200	Undertake further stormwater monitoring to investigate the extent of potential wastewater contamination and likely sources within the catchment.	$ 20 k	6 - 8 months
160	Redesign the city-wide framework for stormwater quality and harbour environment monitoring.	$ 20 k	3 - 6 months
120	Improve quality of stormwater network data through (level survey, GIS confirmation, CCTV).	$ 0	Ongoing
120	Undertake feasibility study to enable preparation of an action plan of stormwater capital works in the catchment.	$ 100 – $ 150 k	tba
40	Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service.	$ 0	Ongoing
30	Identify and undertake floor level survey and damage assessment of properties potentially affected by deep flooding up to a 1 in 50 yr ARI event. (Include properties in George Street commercial area).	$ 20 k	3 - 6 months

Table 16-2: Planning and Education Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
120	Review the education / advice provided to property owners responsible for watercourses to ensure adequate information and assistance is provided.	$ 0	3 - 6 months
70	Develop a city-wide climate change adaptation plan, including ongoing monitoring of climate change predictions, incorporating damage assessment of the vulnerable infrastructure.	$ 0	6 - 12 months
70	Develop an emergency response plan for the catchment to ensure evacuation from flooded areas is possible during a large storm event.	$ 0	6 - 12 months
40	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	$ 0	2 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
120	Ensure damaged screens and / or intake structures on open channels and watercourses are replaced or repaired.	tba	Ongoing
50	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
50	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	$ 20 k	2 months

Table 16-4: Capital Works Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
120	Include additional or improved catchpits in all stormwater capital works.	tba	Ongoing

17 Implementation, Monitoring and Continuous Improvement of the ICMP

17.1 Implementation

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

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

17.2 Monitoring and Continuous Improvement

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

Recommendations presented in Section 16 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 recommended works appropriately.

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

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

2. Due to changes in climate change predictions; and

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

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