DUNEDIN CITY COUNCIL

Stormwater Integrated Catchment Management Plan – June 2017

Metropolitan Dunedin coastal marine areas

For consent series RM11.313

Executive Summary

This Integrated Catchment Management Plan (ICMP) describes the ten stormwater catchments that make up the greater metropolitan Dunedin area. It documents known operational issues in each catchment, potential effects on the harbour receiving environment, and the tools and practices available for the management of stormwater.

The aim of stormwater management is to maintain a level of service and improve environmental outcomes, at an affordable cost. The main issues in stormwater management are property flooding and the quality of stormwater discharge into the receiving environment.

Dunedin's stormwater network, first installed in the 1870's, has grown in response to the ongoing development of the city. Increasing hard surfaced areas and associated rates of runoff, rainfall intensities and durations, groundwater levels, harbour tide levels and ocean tide levels all influence the performance of the network. Flooding is not a new issue, with many notable city flooding events historically recorded. Contaminants associated with a modern urban lifestyle and pre-modern industrial practices are entrained by stormwater and make their way into waterways and the harbour. Changes in community expectations and environmental legislation put more emphasis on improving the quality of our stormwater discharges.

Hydraulic models have been developed to assess performance of the stormwater network under different development, rainfall and tidal scenarios. The model provides an indication of areas of the network most likely to experience flooding issues, and assists the DCC to prioritise capital works to address those problems. The ongoing refinement of the hydraulic models, first developed in 2009-2011, will improve current understanding of network performance.

The hydraulic models, along with historic observations, are used to identify areas where further improvements in network capacity are needed. The level of service for the existing network is to avoid flooding depths of >300 mm for a 1 in 10 year annual return interval (ARI) event, while new developments are designed to service of 1 in 50 year ARI. Most of the stormwater catchments will experience some flooding of private properties during certain rainfall events, with more properties affected as the size of the ARI increases. The table below summarises the results of hydraulic modelling using 2010 scenarios in terms of how many properties (all or part thereof) were predicted to be affected in different ARI events, and the percentage of the overall catchment that represents.

The catchments with the greatest number of potentially affected properties are Orari Street, Shore Street, Halsey Street and South Dunedin. These catchments have characteristics that include natural watercourses (flow paths, including the Leith) and are on flat, low-lying areas of land beneath the hill suburbs adjacent to the harbour. A great deal of knowledge has been gained from the 2015 floods that significantly affected the South Dunedin area. This knowledge has been incorporated into further ongoing study and the outcomes will be incorporated in future versions of this ICMP.

Catchment	Number of land parcels at risk of flooding to a depth ≥ 300mm			Flood extent (% of catchment area)		
	1 in 10 year ARI	1 in 50 year ARI	1 in 100 year ARI	1 in 10 year ARI	1 in 50 year ARI	1 in 100 year ARI
Halsey Street	20	32	64	1	3	4
Kitchener Street	2	16	21	1	3	4
Mason Street	7	24	29	1	3	4
Orari Street	50	85	98	1	2	3
Port Chalmers	4	9	9	<1	2	3
Portsmouth Drive	3	6	6	3	6	8
Ravensbourne	0	0	0	0	<1	<1
Shore Street	21	40	43	1	2	2
South Dunedin	8	31	40	4	6	8
St Clair	2	5	5	<1	<1	<1

Land zoned for development in the District Plan generally requires new connections to the stormwater network to be provided as a right, although where development requires consent, conditions may be imposed requiring stormwater retention. The second generation District Plan, currently in preparation, proposes new limitations on hard surface coverage from new developments to alleviate increased rates of runoff and hence volume, and incorporation of water sensitive urban design practices are increasingly being promoted by the DCC.

Maintenance of the network ensures levels of service are maintained and improved where necessary. Renewal of pipework is ongoing across the city, and known issues help prioritisation of work.

The main receiving environments for stormwater discharge are Otago harbour, from Port Chalmers to the upper harbour basin and Anderson's Bay Inlet, and the coast at St Clair. The DCC holds 10 resource consents for discharge (RM11.313.01-10), requiring the quality of stormwater, and upper harbour sediments and water to be monitored. Where monitoring indicates issues of concern, the ICMP will be updated to ensure those issues are identified and addressed.

Stormwater integrated catchment management plan – Metropolitan Dunedin coastal marine areas

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1 Background

1.1 Introduction

The Dunedin City Council (DCC) is responsible for management of the public stormwater network, which services around 107,000 properties over an area of about 47 km^2. Stormwater is collected across greater Dunedin and discharged into freshwater or the coastal environment. Infrastructure includes gutters, mud tanks, pipes, manholes, pump stations, detention ponds, stormwater reserves and outlet structures.

Stormwater networks facilitate the efficient and effective delivery of runoff from properties and roads to natural drainage systems (streams and rivers) or to the sea. This integrated catchment management plan (ICMP) supports management of the DCC's stormwater network.

1.2 Stormwater management objectives

The DCC's objectives for stormwater management are given in the *Three Waters Strategic Direction Statement 2010-2060*:

- **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:** Maintain 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:** Meet strategic objectives while limiting cost increases to current affordability levels where practical.

Performance measures for stormwater infrastructure management are set by the Department of Internal Affairs and are reported through the DCC Long Term Plan[1].

1.3 ICMP purpose

To facilitate the achievement of the DCC's stormwater management objectives, this ICMP provides a summary of all relevant information for stormwater management in one document[2], including:

- Statutory requirements that must be met;

[1] Long Term Plan http://www.dunedin.govt.nz/your-council/long-term-plan-2015-2016

[2] As it relates to discharges to the coastal environment

- Regulatory tools available to manage the stormwater network;
- A description of the stormwater catchments and the networks that service them;
- A description of the coastal environment to which stormwater is discharged, and its values;
- The monitoring required to facilitate determination of any adverse effects on the coastal environment; and
- Identification of water quantity (flooding) and water quality issues, and further work required to address those issues.

This ICMP is intended to evolve over time, being updated as knowledge of the network is developed, existing issues are addressed, and new issues and solutions arise.

The DCC hold 10 resource consents that provide for the discharge of stormwater to the coastal marine area (RM11.313 series, discussed further in section 2.2.1). To ensure any adverse effects of stormwater discharge to the environment continue to be managed over the 35 year term of consent, the consent requires the ICMPs are maintained and implemented.

1.4 Three waters strategy project & original ICMPs

ICMP development was part of the 'Three Waters Strategy Project', which commenced in 2007 with the objective to improve knowledge of DCC water, wastewater and stormwater assets, and identify needs, priorities and indicative costs for improving performance, prioritisation and delivery over the next 50 years. The *3 Waters Strategic Direction Statement 2010-2060* was a key outcome of this project, as were hydrological/hydraulic models to assess performance of the networks.

To help achieve the stormwater objectives identified in the *3 Waters Strategic Direction Statement 2010-2060,* and to facilitate planning and management, eleven stormwater ICMP were created.

These original ICMPs were published in 2009-2011. For each stormwater catchment, issues and solutions were identified then prioritised. They contain large amounts of background information, technical data and a proposal for environmental monitoring to support the then pending consent application to Otago Regional Council (ORC) to provide for the discharge of stormwater. The original ICMPs are available from the DCC on request.

This ICMP is 'second generation'. It combines 10 of the 11 original ICMPs[3] and contains updated stormwater management information as necessary. While the background information and data contained within the original ICMPs remains relevant and useful for certain applications, these documents contain more detail than is required for the day to day management. On this basis this ICMP provides a summary of this background information only.

The final phase of the Three Waters Strategy Project is the implementation of capital and operational works to realise the level of service improvements envisaged.

[3] All catchments that discharge to the coastal marine area are incorporated in this ICMP. The Mosgiel ICMP remains a separate document.

2 Statutory and planning framework

Public management of stormwater occurs within a wider legal and regulatory framework. The Local Government Act 2002 addresses infrastructure management, while the Resource Management Act 1991 addresses environmental effects of stormwater discharge and urban development.

2.1 The Local Government Act 2002

Meeting the current and future needs of communities for good quality (efficient, effective and appropriate) local infrastructure is a core function of local government. The DCC has an obligation to maintain its stormwater services, and to assess those services from time to time for the purpose of determining from a public health perspective: any community health risks, service quality, current and future demand, and actual and potential consequences of discharge.

Since 2014, performance measures for stormwater infrastructure have been set by the Department of Internal Affairs (DIA). These relate to flooding events, compliance with discharge consents, response times and complaints.

To protect its infrastructure and control discharges to it, bylaws may be made. The DCC Trade Waste Bylaw (2008) regulates the discharge of Trade Waste to the public sewerage system. 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 Bylaw Schedule 1E. Schedule 1E contains a number of acceptance standards, including limitations on the quality of the stormwater. A stand-alone Stormwater Bylaw is currently under consideration.

2.2 The Resource Management Act 1991

The relevant Resource Management Act 1991 (RMA) planning documents regulating stormwater discharge to the environment are:

a) The New Zealand Coastal Policy Statement (NZCPS);

b) The Otago Regional Policy Statement (RPS);

c) The Regional Plan: Coast for Otago (Coastal Plan); and

d) The Regional Plan: Water for Otago (Water Plan).

2.2.1 Coastal environments

Stormwater discharges from Dunedin City into Otago Harbour and the Pacific Ocean are largely controlled by the NZCPS, the coastal chapter of the RPS and the Coastal Plan. The NZCPS and the RPS provide policy guidance and must be "given effect to" by Otago's Regional Plans.

Rule 10.5.3.1 states the discharge of stormwater into the coastal marine area is a ***permitted*** activity provided:

(a) The discharge does not include stormwater from any industrial or trade premise, or any human sewage; and
(b) The discharge is into a well flushed area; and
(c) The contaminant or water discharged, after reasonable mixing, does not give rise to all or any of the following effects:
  (i) The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials; or
  (ii) Any conspicuous change in the colour or visual clarity; or
  (iii) Any emission of objectionable odour; or
  (iv) Any significant adverse effects on aquatic life.

As many of Dunedin's stormwater catchments contain industrial or trade premises, the discharge of stormwater is a ***controlled*** activity and resource consent is required.

The DCC hold a series of consents to discharge stormwater to the coastal marine area (RM11.313.01-RM11.313.10). Each of the 10 consents has identical conditions (with the exception of the St Clair catchment where an additional condition relating to flow measurement is included). A formatted copy of one of these consents is attached as Appendix A and copies of all the original consent documents can be found on the DCC website[4]. The consents broadly require the following:

- No conspicuous effects after reasonable mixing (condition 1);
- No human sewage lateral connections to the stormwater network (condition 2, appendix 1 to the consent);
- No trade waste in the stormwater network (condition 3(a)-(c));
- Investigation of a stormwater bylaw (condition 3(d));
- Notification to harbour users of any public health risk (condition 4);
- Stormwater management using an ICMP (condition 5);
- Establishment of a stakeholder group (condition 6);
- Stormwater quality monitoring (condition 7, appendix 2 to the consent);
- Environmental monitoring of the harbour: water quality, sediment, biological (conditions 7, 10, appendix 2 to the consent);
- No erosion or scour at outfalls (condition 12);
- An emergency spills protocol (condition 13);
- Annual reporting to the ORC (condition 11); and
- Installation of a flow recording device (St Clair catchment only, condition 14).

[4] http://www.dunedin.govt.nz/services/stormwater/stormwater-monitoring

The DCC manages stormwater to ensure these consent conditions are met, and report to the ORC as required. The ORC annually audits the DCC performance against the consent conditions.

2.2.2 Freshwater environments

While this ICMP focuses on the DCC stormwater discharge to the coastal environment, the rules for stormwater discharge to freshwater environments are included here for information. Water Plan Rules 12.B.1.8 and 12.B.1.9 permit the discharge of stormwater as follows:

Rule 12.B.1.8 states the discharge of stormwater from a reticulated stormwater system to water is a ***permitted*** activity, providing:

(a) Where the system is lawfully installed, or extended, after 28 February 1998:
- *(i) The discharge is not to any Regionally Significant Wetland; and*
- *(ii) Provision is made for the interception and removal of any contaminant which would give rise to the effects identified in Condition (d) of this rule; and*

(b) The discharge does not contain any human sewage; and

(c) The discharge does not cause flooding of any other person's property, erosion, land instability, sedimentation or property damage; and

(d) The stormwater discharged, after reasonable mixing, does not give rise to all or any of the following effects in the receiving water:
- *(i) The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials; or*
- *(ii) Any conspicuous change in the colour or visual clarity; or*
- *(iii) Any emission of objectionable odour; or*
- *(iv) The rendering of fresh water unsuitable for consumption by farm animals; or*
- *(v) Any significant adverse effects on aquatic life.*

Rule 12.B.1.9 states the discharge of stormwater from any road not connected to a reticulated stormwater system to water, or onto or into land, is a ***permitted*** activity, providing:

(a) The discharge does not cause flooding of any other person's property, erosion, land instability, sedimentation or property damage; and

(b) Where the road is subject to works, provision is made for the interception of any contaminant to avoid, after reasonable mixing, the following effects in the receiving water:
- *(i) The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials; or*
- *(ii) Any conspicuous change in the colour or visual clarity; or*
- *(iii) Any emission of objectionable odour; or*
- *(iv) The rendering of fresh water unsuitable for consumption by farm animals; or*
- *(v) Any significant adverse effects on aquatic life.*

The DCC stormwater discharges to freshwater meet the conditions of these rules so no consents are required.

2.2.3 The Dunedin City District Plan

The Dunedin City District Plan addresses potential adverse effects on water quality and stormwater generation through control of land use and subdivision. It also allows the effects of development on existing infrastructure to be considered, and for installation standards specified in the *Dunedin Code of Subdivision and Development (2010)* to be met before any new stormwater infrastructure will be taken over by the DCC.

The DCC has notified its second generation District Plan ("2GP"). The 2GP proposes performance standards in residential areas to limit the amount of building site coverage and impermeable surface allowed, for the purpose of minimising stormwater runoff (Rule 15.6.11). Submissions have been received on the 2GP, and the hearing process is currently underway.

2.2.4 Kāi Tahu ki Otago Natural Resource Management Plan

The Kāi Tahu ki Otago Natural Resource Management Plan is a non-statutory document that provides guidance to Kāi Tahu's resource management issues, including management guidelines and objectives relating to freshwater fisheries and coastal resources. The management plan identifies that Kāi 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 coastal marine area.

3 The coastal marine area receiving environment

3.1 Otago Harbour

Dunedin's stormwater discharges to the coast at Otago Harbour and to Second Beach, St Clair. Otago Harbour is a large, semi-enclosed embayment that is an extension of the sea rather than a true estuary. Although the entire harbour is completely inundated at high tide, extensive areas of sand and mud flats are exposed at low tide. Drainage is via numerous channels, including the Victoria Channel and main channel from Port Chalmers to Taiaroa Head.

The harbour is sheltered from ocean swells and the major source of disturbance comes from winds, especially from the north-east and south-west. As such, it is best described as a generally low energy environment, but moderately well flushed.

The harbour is effectively divided into upper and lower basins by the Portobello Peninsula and what are generally termed the "Halfway Islands", near Port Chalmers.

Figure 1:Otago Harbour and the Halfway Islands

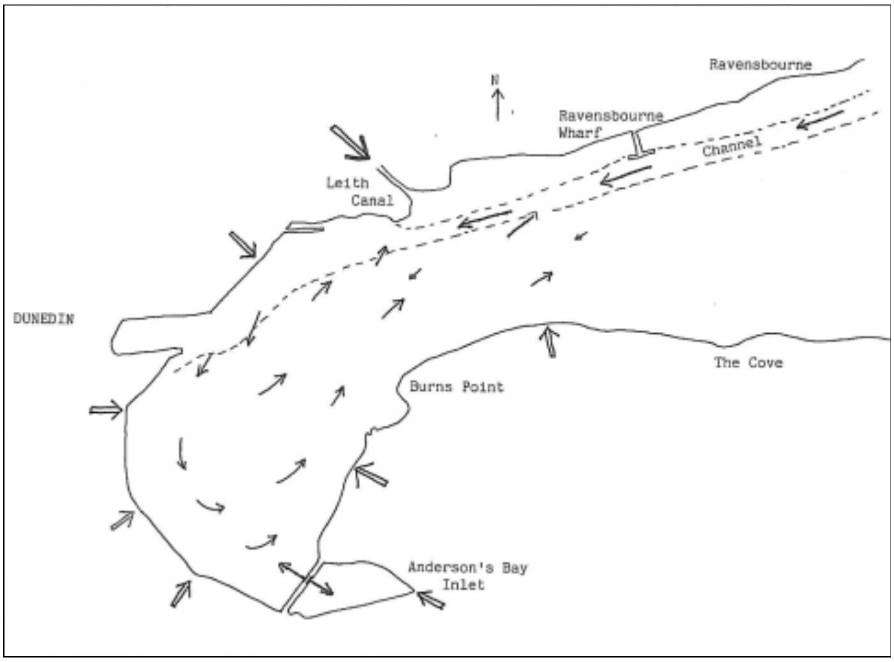
3.1.1 Upper Otago Harbour basin and Andersons Bay inlet

The greatest volume of stormwater discharges to the upper harbour area. The upper harbour basin is a highly modified environment as a result of reclamation, road works and dredging activities. These modifications have resulted in changes to the natural currents, flushing, and movement of sediments in the harbour. Andersons Bay inlet is separated from the upper Harbour Basin by a causeway that was completed in 1872. Dredging of the inlet occurred as early as 1890, and there is a large area of reclaimed land adjacent to the inlet now known as Bayfield Park. In 2009 a 'Bird Island' was constructed in the inlet.

Figure 2: Andersons Bay inlet

A study of the upper harbour was undertaken by Smith and Croot (1993). Water circulation was found to be dominated by the tide and inputs of heavy rainfall. Flushing times are likely to vary and be greatly reduced during rainfall events, due to the effect of rainfall on dilution and displacement. A later study by Grove and Probert (1999) estimated harbour flushing times range from 4 to 15 days.

Smith and Croot also found low flushing levels within Anderson's Bay inlet due to the relatively long residence time of water in the inlet and low current velocities. They estimate that 2-5 days (4-10 tidal cycles) are necessary for 99% flushing.



(from Smith and Croot, 1993). Single arrows indicate tidal flows, double arrows indicate freshwater inputs

Figure 3: Circulation of water in the Upper Otago harbour basin

The upper harbour basin bed has been generally classified as muddy sands/sandy muds, with varying proportions of fine gravels (Ryder Consulting Ltd, 2005a).

A number of natural freshwater inputs have an effect on the upper harbour, in particular the Water of Leith, which discharges water from a 9,416 ha catchment to the north-west of the city.

3.1.2 Port Chalmers and Sawyers Bay

The majority of studies carried out in the Otago Harbour have concentrated on the upper Harbour Basin area, and as such information relating to the harbour environment in the vicinity of the Port Chalmers outfalls is limited.

The Port Chalmers George Street outfall discharges into deep water within the port. Sediments in this location are generally composed of fine muds (Probert, 1990a). The Watson Park outfalls discharge stormwater to Sawyers Bay; the substrate in this location comprises muds, fine and coarse sand and small gravels (Ryder Consulting Ltd, 2010a).

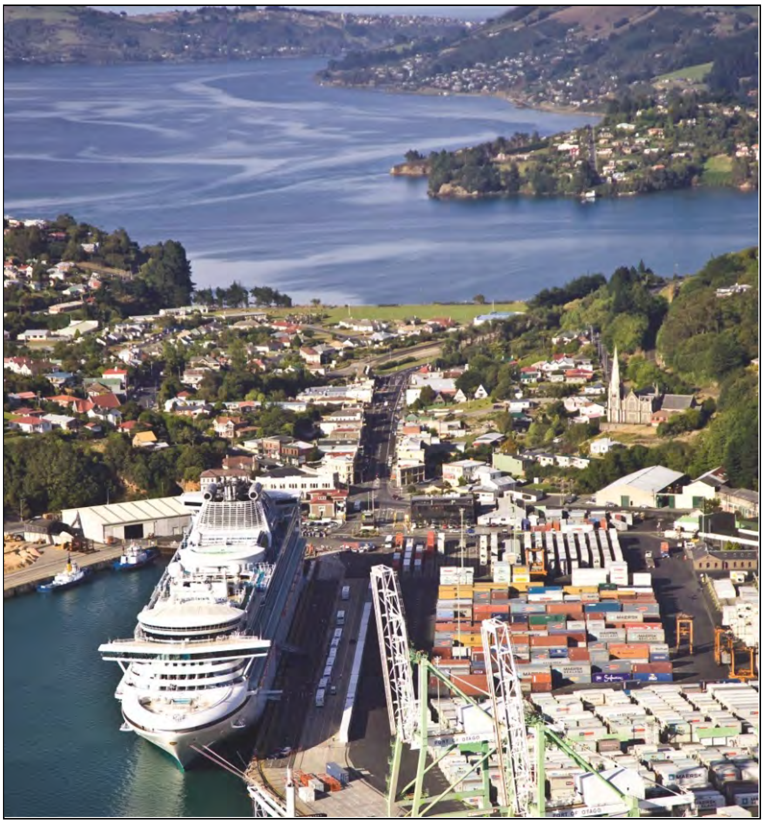


Figure 4: Port Chalmers and Sawyers Bay

3.2 St Clair and Second Beach

St Clair and Second beaches are located to the south-west of Dunedin, and are exposed to swells from the south. St Clair beach is an open and exposed fine sand beach with a landward boarder of artificially laid boulders abutting a concrete seawall. Second beach lies around a small headland immediately to the south-west of St Clair, and is rocky and boulder strewn. Both beaches are high energy environments.

Figure 5: St Clair Beach

3.3 Recreational and cultural significance

Greater metropolitan Dunedin is built around the harbour and beaches, which have important recreational and cultural value to local residents and visitors alike. 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 and there are yacht and rowing clubs in Port Chalmers. Port Chalmers is also an important location for tourism with many cruise ships berthing in the port each year and a number of tourism companies operating in the area.

The Otago Harbour Reserves Management Plan (DCC, 2006) states that Andersons Bay inlet is used by schools, disabled groups and other people learning how to row, canoe and kayak. Water going from the harbour to the inlet is excellent for teaching whitewater kayaking. A rock bird roost was constructed in the inlet in 2009 to provide a safe bird roost and bird viewing opportunity.

The coastline around St Clair is an important area for tourism and recreation, and the area is listed in the Otago Regional Council, Coast Plan: as a Coastal Recreation Area. The renowned surf beaches are amongst the most popular in Dunedin. There are a number of hotels, restaurants and tourism operators in the area that benefit from the coastal location.

The Cultural Impact Assessment undertaken by Kāi Tahu ki Otago Ltd (2005) describes the strong relationship that Kāi Tahu ki Otago have with the coastal environment. Evidence of Māori use of the Otago Harbour extends back to Māori earliest tribal history when the harbour was a valued food resource and used for transport. The report states that the increasing degradation of the harbour environment has affected Māori in many ways and its place as a mahika kai has been dramatically altered.

4 Network management and maintenance

The DCC stormwater network includes gutters, mud tanks, pipes, manholes, pump stations, detention ponds, stormwater reserves, inlet and outlet structures and some watercourses. The network is mapped in detail and can be viewed at www.dunedin.govt.nz/council-online/webmaps/waterservices.

4.1 Network management

The DCC manages its network a number of ways. Of particular relevance is the actions it undertakes in managing private and new connections to the stormwater network, and how it manages watercourses.

4.1.1 Private connections

Private connections to the stormwater network may be made where public infrastructure is available, and where District Plan zoning anticipates such servicing. Where public infrastructure is not available stormwater may be disposed of to watercourse or to ground (subject to the discharge conditions of the Otago Regional Plan: Water).

The construction of private stormwater drainage is subject to the Building Act (2004). Stormwater drainage must meet the performance standards specified in clause E1 of the Building Code, including avoiding damage and nuisance to other property and using gravity flow where possible.

Most residential connections are made to the kerb and channel (gutter), where flows are directed into mud tanks and then into the piped network. For connections directly into the piped network (e.g. larger commercial connections or subdivisions), an application for a saddle connection must be made to the DCC.

Water quantity

Where an activity (e.g. residential or commercial development) is anticipated by the District Plan, a stormwater connection is generally allowed as of right. Where a consent is required and network capacity is an issue, the DCC has reserved its right to specify when and how stormwater discharge to the network is made. Network capacity is also a matter considered for any rezoning request the DCC receives.

Water quality

The quality of private discharge into the stormwater system is currently regulated by the Trade Waste Bylaw (2008):

SCHEDULE 1E: STORMWATER DISCHARGE ACCEPTANCE STANDARDS
To enable compliance with these Bylaws; stormwater discharges in Council's reticulated stormwater system from connected premises shall: 1) Be Approved; 2) Not contain any hazardous substances; 3) Not contain substances that are toxic to the aquatic ecosystem (as measured relative to the ANZECC Guidelines for Fresh and Marine quality, 2001); 4) Not cause any conspicuous colour changes in the receiving water; 5) Not cause the production of any conspicuous oil, grease films, scums or floatable materials; 6) Not contain any wastes (including but not limited to waste water or condensates) from a trade or industrial process; 7) Not be discharged from a timber preservation site, timber treatment site, or a site where chemically treated timber is stored; 8) Not have wastes from trade or industrial processes that should be discharged to a trade waste system, or suitable alternative subject to a Resource Consent. 9) Any water used during the repair, maintenance and/or construction of water mains, or the flushing or testing of water mains shall be de-chlorinated and screened as required prior to the discharge into the stormwater system. The water used will need to be de-chlorinated such that there is no detectable free or residual chlorine. If the water used during work as described above is discharged directly into adjacent water courses a consent will need to be obtained from the Otago Regional Council as per section 12.11 in the Regional Plan: Water (dated January 2004) and section 10.5 of the Regional Plan: Coast (dated September 2001).

4.1.2 Water sensitive urban design

Water sensitive urban design (WSUD) is an approach to water management that addresses both water quality and water quantity. WSUD draws upon processes of natural water systems and adapts these to suit urban environments, integrating buildings, infrastructure and landscapes with stormwater networks that allow the passage of runoff while avoiding nuisance flooding and consequential damage to public and private property where possible.

The overarching objectives of WSUD are:

- Protection or enhancement of the environmental, social and economic values of downstream environments.
- Reduction in the frequency, duration and volume of stormwater runoff, mitigating the risks of nuisance flooding and moderate post-development flows to watercourse.
- Reduction in the demand on potable water supply (through reuse of stormwater).
- Improvement in the amenity of the urban environment.

The DCC intends to actively develop and promote WSUD practices within the urban environment, both in terms of new development and retro-fitting, where possible.

4.1.3 New infrastructure

New public stormwater infrastructure is frequently vested to the DCC by private developers. The *Dunedin Code of Subdivision and Development* prescribes the minimum requirements that must be met before the DCC takes ownership.

4.1.4 Watercourses

A watercourse is literally the course water takes across land. It is generally defined as an open channel through which water flows or collects (be it natural, modified or artificial), either continually or intermittently, or has the potential to do so, and includes river beds, stream beds, gullies, natural depressions, ditches, and drainage channels. A watercourse also includes any culvert or pipe that replaces a natural open channel.

Smaller watercourses are usually owned by the property owner through which the watercourse passes, from the point of entry to the exit point of the property boundary. The property owner is responsible for ensuring that:

- There are no obstructions or impediments in the watercourse which may inhibit the flow of water; and
- Any grates or outlets within their property are kept clear of debris at all times.

The DCC regularly encounters issues arising from poorly-maintained, privately-owned watercourses that no longer safely pass flows due to vegetation growth, siltation or other blockages. The watercourses are usually ephemeral or small. The issues are either with the channel itself, or associated in-stream structures.

Ensuring watercourse issues are promptly, efficiently and consistently addressed is not always straightforward due to the requirements of different legislation, notably the Land Drainage Act 1908, and the Resource Management Act 1991, and the roles of the DCC and the Otago Regional Council. DCC are currently undertaking a stormwater rationalisation study in order to provide clear and pragmatic guidelines to the public and staff alike. The guidelines will address issues relating to watercourses and the pipework networks and interaction between the private and public systems.

The DCC also has responsibility for some watercourses within the city as a property owner.

4.2 Network maintenance

4.2.1 Street cleaning

Gutters direct stormwater runoff from the road into the stormwater network, and many private properties discharge their stormwater to the kerb and channel. To clear litter, sediment and other debris from the gutter, and to improve aesthetics, most urban areas are swept by DCC contractors every 6 to 8 weeks. Shopping precincts and higher use areas are swept more frequently. Most carriageway sweeping is carried out by sweeper trucks, although the central business district and other areas unable to be reached by truck, is cleared by hand crews.

4.2.2 Mud tanks and other intakes

Mud tanks are important for trapping litter, sediment and other debris washed into the stormwater system. Contaminants such as heavy metals bind to sediments, so their removal from stormwater flow is important to improve stormwater quality at outfalls. Failure to remove debris from the mud tanks can also lead to blockages and flooding. Poor mud tank maintenance can also result in siltation and hence capacity reduction of the pipe network. During autumn months, some mud tanks or inlet screens become blocked with vegetation regardless of how well maintained they are.

There are around 8000 mud tanks in the stormwater network. The DCC Transportation Operations unit contracts out urban roading network maintenance, including mud tank maintenance, on a five-yearly basis. This contract (contract number 6369) requires:

- At any time at least 95% of mud tanks shall have available 90% of their grate waterway area clear of debris.
- For at least 95% of mud tanks the outlet invert shall be no less than 150 mm above the surface level of accumulated debris and sediment.
- At least 95% of all other stormwater structures shall have 90% of the waterway area clear of debris/detritus.
- Mud tanks identified as "critical" are to have the grates cleaned three times a month, and within 24 hours upon request.
- All urban catchpit[5] grates on sealed roads are to be cleared at least three times a year, and those on unsealed roads are to be cleared at least twice a year, with additional clearing during periods of high leaf drop or the build-up of detritus or litter.
- All rural catchpit grates are to be kept clear of detritus or litter.
- All non-critical, non-priority mud tank grates shall otherwise be cleared within one week of request.

Following the 2015 flood, and prior to new contract 6369 being finalised, mud tanks in the South Dunedin area were cleaned by City Care Ltd.

4.2.3 Pipelines

The DCC currently contracts the maintenance of its stormwater network to City Care Ltd. The contract has a term of 8 years and expires in 2022. The contract includes 24/7 response to flooding, blocked pipes and network safety issues, programmed and reactive cleaning, root cutting, reactive and planned CCTV, minor pipeline renewal and other minor capital work.

[5] A catchpit refers to a grate that goes directly into a culvert, that does not have an associated tank

Where siltation occurs the pipes are programmed for flushing. A major pipe cleaning programme was undertaken in 11/12 and 12/13 at a cost of $350k. Siltation is assessed as part of the ongoing city wide closed circuit television (CCTV) programme.

4.2.4 Pump stations

The stormwater network has a number of pump stations. These are maintained on a regular basis by DCC staff as part of operations and maintenance scheduling. External contractors are used for work that requires specialist skills on an irregular or infrequent basis (e.g. maintenance of specialist equipment) or that is outside the core function of service provision (e.g. pest control or tree removal).

The most significant pump station in terms of volume pumped and potential impact in the event of failure is Portobello Road. This pump station clears the very low gradient pipelines on the low-lying flats of South Dunedin. During the significant flooding of June 2015, blockage of the upstream screens resulted in reduced efficiency of the pump station, so new screens were designed and installed in 2016. The Portobello Road Pump station is also discussed in Section 0.

4.2.5 Salt water / saline groundwater intrusion

The intrusion of saltwater into pipelines is a major concern due to its corrosive effects. Some outfalls are below the high tide mark, so saltwater intrusion into the pipes due to tides is a regular occurrence. Ingress of saltwater also reduces the carrying capacity of the network. In low lying areas around the harbour and South Dunedin saline groundwater intrusion into the network may occur but the extent is unknown. Catchment specific comments are as follows:

- **Mason Street:** Pipes to the east of the railway lines have been rehabilitated to reduce saline intrusion.

- **Shore Street:** Stormwater flow monitoring indicates some tidal influence from the outlet, and also baseflows (dry weather flow), however it is unclear if baseflows are due to saline intrusion or freshwater sources.

- **St Clair:** The majority of the stormwater system is laid well above sea level although tidal influence is present at the Bell Chamber outfall.

Outfalls below the high tide mark either had flap gates recently installed, or will have flap gates installed over the 2016/17 year. Older pipes of earthenware and concrete, more susceptible to saline corrosion, continue to be replaced with modern materials (PVC or PE).

4.3 Renewals

There are a number of competing demands when considering network renewals. The *Three Waters Strategic Direction Statement 2010-2060* and issues identified in this ICMP are used to assist in prioritising work. Prioritisation of the proposed renewals programme is considered during the Annual Plan / Long Term Plan Process.

Renewal of assets is planned to:

- Reduce service interruptions;
- Smooth peaks in expenditure; and
- Enable the coordination of works both within and between DCC departments.

The drivers for replacement could include:

- Poor asset condition;
- Maintenance of existing levels of service; or
- High operational costs.

Renewal expenditure forecasts are made using a combination of:

- Remaining theoretical asset life/age;
- Replacement cost information;
- Verbal reports from maintenance/operations staff;
- Asset fault and customer complaint history; and
- Condition assessment.

5 Stormwater catchment and drainage network descriptions

A description of each of the 10 stormwater catchments included under the RM11.313 consent series is provided in this section of the ICMP. The boundaries of each catchment and associated catchment outfalls are shown in Figure 6.

Section 5.1 provides descriptive comments applicable to all catchments and section 5.2 outlines the development of the hydrological and hydraulic model used to assess capacity issues across all of the catchments. A description of the topography, geology, land use, the stormwater drainage network and capacity or flooding issues relating to each of the catchments is provided in the sections 5.4 to 5.12. Further catchment detail can be found in the original ICMP documents.

5.1 General catchment information

5.1.1 Groundwater

The majority of the stormwater catchments have limited information available relating to groundwater levels and groundwater quality. An exception to this is the South Dunedin catchment where further details are provided in Section 0. In areas near the coast groundwater is likely to be shallow, limited to the coastal flats and tidally influenced. In some areas groundwater levels are being lowered by drainage infrastructure. The Kitchener Street catchment is slightly different, in that the western half of the catchment may contain a fractured rock groundwater system.

5.1.2 Surface water

A brief description of streams within each catchment is included in sections 5.4.1 through 5.13.1. The natural values of significant streams are detailed in *Dunedin Three Waters Strategy Stream Assessments,* Ryder Consulting Limited (2010). It is recognised that freshwater environments hold particularly high values for Kāi Tahu.

5.1.3 Imperviousness

The amount of impervious surface (imperviousness) in a catchment is a major influence on the quantity of runoff generated and the contaminants carried (water quality). Imperviousness is the amount of any building and surface cover, such as concrete or asphalting. Imperviousness change over time is critical for determining the potential future effects of urban development. Imperviousness calculations used in the hydraulic models for the 3 Waters Strategy Project are for the most part based on the amount of site coverage allowed for by the District Plan. A summary of land uses in each catchment provides an indication of the extent of impervious surfaces.

5.1.4 Operational issues

The operational issues in each catchment are predominantly related to flooding, as set out in relation to each catchment below. Other issues relate to the overtopping of intake screens, and the blockage of stormwater culverts or the maintenance of mud tanks in some catchments.

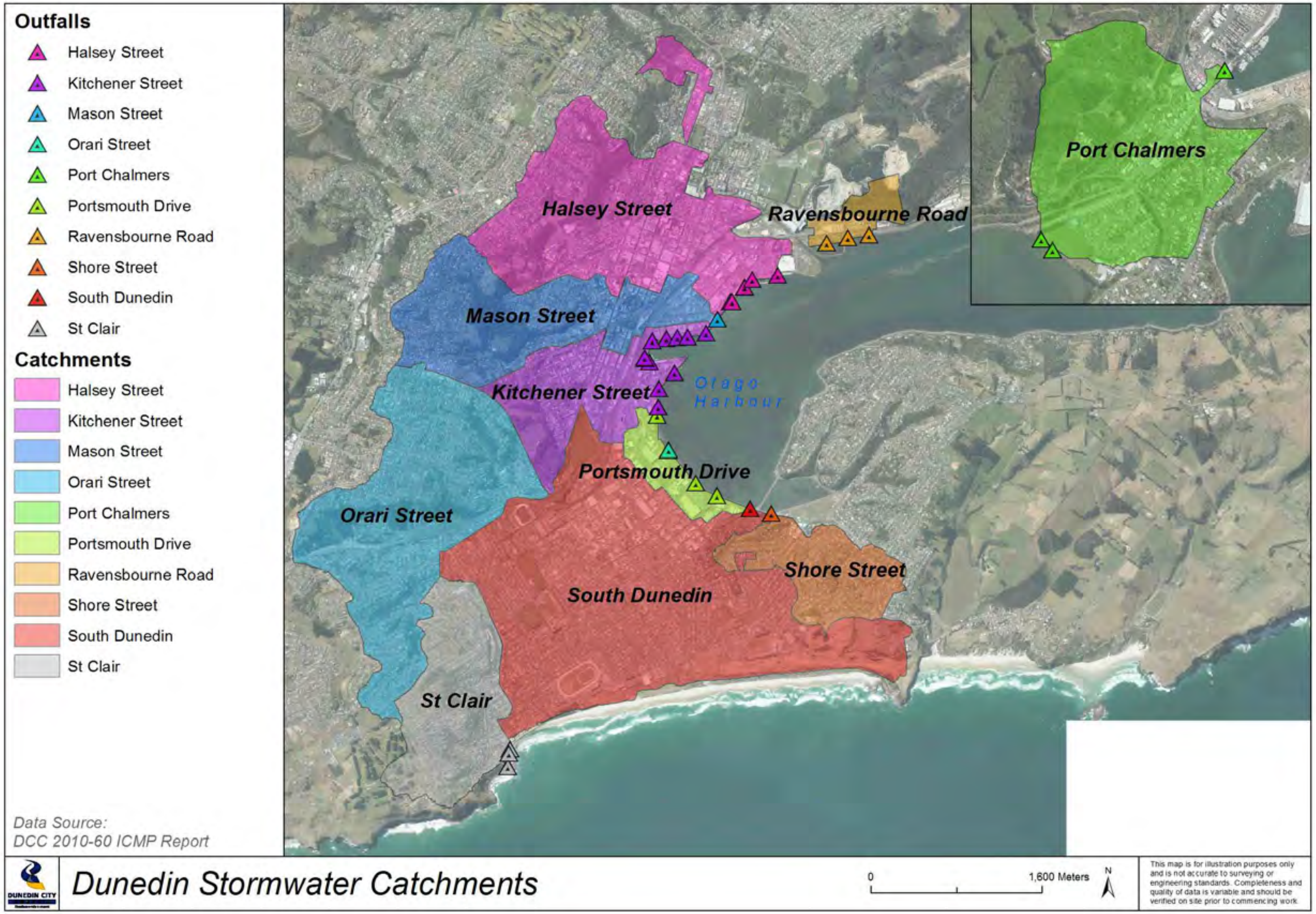


Figure 6: Stormwater management catchment boundaries and associated outfalls to the coastal marine area

5.2 Hydrological and hydraulic model development

A summary of the development of the models used to assess the stormwater network and the methods used to assess flood issues are outlined in the following sections and the results for each catchment are outlined in sections 5.4 to 5.12.

5.2.1 Modelling

The 3 Waters Strategy included a specific project to create hydraulic models for the stormwater network. Once validated, the models were used to predict flood extents for a number of different scenarios of rainfall, tide, urban growth (imperviousness changes) and climate change. Outputs from the model are not absolute, but provide useful information for the purposes of indicating areas with a potential to flood, and allowing the comparative effects of different rainfall events and climate change scenarios to be assessed. The effects of stimulated rainfall events with an average recurrence interval (ARI) of 1, 2, 10, 50 and 100 years were assessed. The models assist the DCC to prioritise capital works.

Detailed results are reported in the original ICMPs published in 2009-2011. Summaries from those reports are provided for each catchment in sections 4.3 to 4.11. The summaries include assessments based upon rainfall events that trigger significant effects pertinent to its catchment. The 10 catchment stormwater models are in the process of being updated into new software (Innovyze ICM) and the modelling outputs are being reviewed and updated as required. Updated outputs and flood maps will be available in due course and will be reported in future iterations of this ICMP.

The validation process involved comparing predicted hydraulic outputs against; available flood maps, observed catchment issues, anecdotal evidence and operational information.

5.2.2 Network capacity

The capacity of the piped network in each catchment was assessed and is summarised in Table 1.

Table 1: pipe network capacity

Catchment	Pipe network capacity (% by number of pipes not surcharging)		
	1 in 2 year ARI	1 in 5 year ARI	1 in 10 year ARI
Halsey Street	73	58	43
Kitchener Street	46	36	34
Mason Street	71	44	35
Orari Street	59	43	30
Port Chalmers	61	33	20
Portsmouth Drive	0	0	0
Ravensbourne	78	44	12
Shore Street	33	19	13
South Dunedin	88	86	86
St Clair	89	62	47

5.2.3 Flood assessment

Flooding is assessed in relation to the potential to cause nuisance, and the potential to cause habitable floor level flooding. Further work on flooding is being completed following the significant flood event of June 2015 and this section of the ICMP will be updated once complete.

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.

Habitable floor flooding

The DCC are particularly concerned where predicted flood depths have the potential to reach the habitable floor level of a dwelling. Habitable floor flooding is the flooding of 'useful floor space' being that floor space of a dwelling or premises inside the outer wall, excluding cellars and non-habitable basements.

It is recognised that flooding at various depths can affect the habitability of a property e.g. that the flooding of foundations can render a property uninhabitable. However, for modelling purposes a depth of at least 300 mm was selected to represent potential habitable floor flooding risk. Properties were defined as 'at risk' of habitable floor flooding where the boundary is intersected by a flood depth of equal to or greater than 300 mm. As the exact location of buildings and corresponding floor levels are not part of the model, 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 year (ARI) rainfall event. For existing stormwater systems, analysis of a variety of rainfall events was modelled in order to assess the risk of flooding. A summary of predicted flooding issues for all catchments is provided in Table 2.

Table 2: Predicted flooding issues (2010 model)

Catchment	Number of land parcels* at risk of flooding to a depth ≥ 300mm			Flood extent (% of catchment area)		
	1 in 10 year ARI	1 in 50 year ARI	1 in 100 year ARI	1 in 10 year ARI	1 in 50 year ARI	1 in 100 year ARI
Halsey Street	20	32	64	1	3	4
Kitchener Street	2	16	21	1	3	4
Mason Street	7	24	29	1	3	4
Orari Street	50	85	98	1	2	3
Port Chalmers	4	9	9	<1	2	3
Portsmouth Drive	3	6	6	3	6	8
Ravensbourne	0	0	0	0	<1	<1
Shore Street	21	40	43	1	2	2
South Dunedin	8	31	40	4	6	8
St Clair	2	5	5	<1	<1	<1

*On all or part of a parcel, or against a building void in the 2-D surface

5.2.4 Flood hazard rating

There are a number of factors contributing to flooding hazard including network capacity (i.e. pipe size), pipe gradient and tidal influence (some outfalls discharge below the high tide water level and tidal influence can cause upstream pipes to surcharge). In addition, blockage of mud tanks and other intake structures significantly reduces efficiency and during significant rainfall events may contribute to catchment flooding. High groundwater levels can also reduce natural ground infiltration and hence exacerbate the effect of a rainfall event.

A predicted flood hazard rating has been calculated for the current and future (extreme) planning scenario during a 1 in 100 year ARI rainfall event. A flood hazard rating is a factor of velocity and depth calculated from 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 is given in Table 3 below.

Table 3: Flood hazard rating summary

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.

5.3 Previous significant flood events

Dunedin's piped stormwater network dates back to the 1870's, and reports of significant flooding date back to about the same time. Those areas most significantly affected by flooding are near waterways such as the Water of Leith and Lindsay Creek, and in the low lying areas of South Dunedin.

The DCC archives hold information relating to numerous flood events where roads and private property were affected. The earliest reliable DCC data records an event in 1914, with at least one notable event every subsequent decade (and up to five events per decade). The Otago Regional Council (ORC) reports major events associated with the Water of Leith as far back as 1868.

In the Water of Leith, the Otago Harbour Board constructed a concrete channel from Forth Street to the harbour in 1913 -14. Immediately after the 1929 flood the concrete channel was extended, and protection works were also carried out in Lindsay Creek. Further work was undertaken in the 1950s and 1960s. The ORC is now responsible for the Leith-Lindsay Flood Protection Scheme and in 2010 commenced works to upgrade the scheme to cope with a 1 in 100 ARI flood.

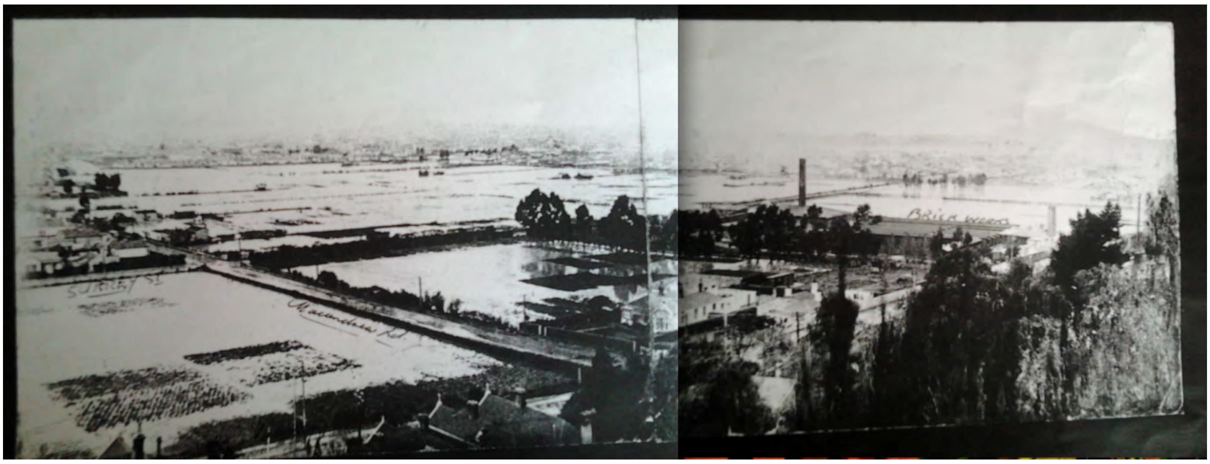
In the mid-19th century, the area that is now South Dunedin comprised salt marshes, wetlands and lagoons. As demand for land increased the area was filled in, including with sand from the St Kilda dunes which had previously provided some protection from storms surges at the coast. In general, land filling was just above the height of the local water table at that time.

Figure 7: Flooding in Musselburgh, 1917

Figure 8: Flooding in Queens Drive, St Kilda, 1923

Figure 9: Flooding in Castle St, University area, 1923

Figure 10: Flooding in South Dunedin – MacAndrew Rd/Surrey St, 1927



5.4 Halsey Street

5.4.1 Catchment location, topography and geology

The Halsey Street stormwater catchment, shown in Figure 10, is approximately 390 ha. The catchment includes a large part of the central commercial and industrial area, north and east of the Octagon, as well as the residential suburbs of Roslyn and Māori Hill. The Town Belt runs through the catchment in the west.

The catchment has low lying relatively flat areas in the east, with topography increasing to approximately 165 m above mean sea level to the west. The flat area adjacent to the harbour is reclaimed land. The deposits include unconsolidated and unsorted 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. The upper western hills were created by lava flows. Around the waters of the Leith there are natural alluvial deposits.

A series of small gullies run through the Town Belt. These are a mix of piped, open concrete channels or natural channels. Below the Town Belt the streams are generally piped through to the harbour. The three more significant streams in the catchment are characterised as shallow (between 2 and 40 cm deep) and relatively narrow (less than 1.2 m wide).

5.4.2 Land use

The catchment is predominantly residential (78%) with around 10% industrial land use. A range of other zoning makes up the balance.

Residential development commenced on the city side of the Town Belt in the late 19th century. The harbourside area is used for industrial and port purposes, and has both the railway and main transport route to Port Chalmers running through it. The University of Otago south campus is also located within this catchment.

Cultural and heritage sites

The Halsey Street catchment contains a number of Townscape and Heritage 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 houses are clustered in the Royal Terrace/Pitt Street/Heriot Row Heritage Precinct. The catchment also includes the Cadbury factory, Dunedin Central Fire Station and Otago Museum.

Contaminated land

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 recorded as 'managed' although the Wickcliffe Street Shell Depot is recorded as 'contaminated'.

Future land use and imperviousness

The Halsey Street catchment has some opportunity for in-fill housing within the residential zones, and re-development within the industrial zones.

Imperviousness varies, with the Town Belt being highly pervious, and the harbourside almost entirely impervious. Overall imperviousness is estimated at approximately 60%, and there is expected to be little change between now and 2060.

5.4.3 Stormwater drainage network

Key features of the Halsey Street network are gully intakes within the Town Belt; six tidally influenced harbour outfalls; a tidal weir in Bauchop Street; and sealed manholes. The diameter of the pipes within the network varies significantly, with the majority of the pipes being 600 mm diameter or less. Table 4 summarises pipe shapes and sizes in the catchment.

Table 4: Pipe shapes and sizes in the Halsey Street catchment

Pipe shape	Pipe size (mm)	Total length (m)
Round	100-375 diameter	3095
	>375 to 1800 diameter	8346
Oval	600 x 900	7304
	700 x 1050	301
	900 x 1200	902
Arch	675 x 1350	61
	900 x 1200	16
	900 x 1800	80
	other sizes	24
Box culvert	600 x 900	225
	1300 x 1300	433
	1500 x 500	236
	1800 x 1320	427
	1800 x 1800	121
	1800 x 1950	723

Several of the mains running through the lower areas of the catchment have sealed manholes resulting in the stormwater pipes along York Place, Filleul Street, Frederick and Hanover Street to the harbour operating under pressure. This enables the system to become pressurised during periods of high flow, increasing flow capacity. A parallel gravity system provides local drainage in this area. Overland flow from adjacent catchments (for example an area on Maori Hill) also contributes stormwater to the Halsey Street catchment network during large events.

The ability of the reticulated network to intercept 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 downstream flooding.

In 2015 a new tidal ingression flap gate was installed on the Fryatt Street outfall. This is not currently included in the hydraulic model because the flap gate remains open in a 1 in 10 year ARI event, although it will be included in future. In 2015 the stormwater pipe running through 80 Anzac Avenue was relocated to allow for a new development.

5.4.4 Network age

The majority of the network in the central commercial area of Dunedin is likely to be original, with close to 30 % of the network installed prior to 1900. Some of this pipework has been upgraded or supplemented with new infrastructure during the 1980 and 1990s, which may assist in providing capacity and reliability.

Based on a theoretical life of 100 years, 66 % of the pipe network will be subject to inspection, which will improve remaining life forecasts or initiate renewal by 2060. Table 5 summarises the age of pipes in the catchment.

Table 5: Pipe ages in the Halsey Street catchment

Installation date	Approximate age	Number of pipelines	Length of pipe (m)	% of pipe length
1900 or before	> 110 years	219	8475	27
1901 to 1920	90-110 years	57	2035	6
1921 to 1940	70-90 years	178	9103	29
1941 to 1960	50-70 years	38	1283	4
1961 to 1980	30-50 years	81	2402	8
1981 to 2000	10-30 years	287	7620	24
2001 to 2009	< 10 years	28	857	3

5.4.5 Network capacity

The stormwater model estimates the following:

- 98% of the network can accept a 1 in 2 year annual recurrence interval (ARI) rainfall event;
- 84% of the network can accept a 1 in 10 year ARI rainfall event; and
- 64% of the network can accept a 1 in 100 year ARI rainfall event.

There are some restrictions in the upper part of the Halsey Street catchment due to insufficient network capacity but the majority of the restrictions are predicted to occur on the flat land in the lower catchment. Tidal influence extends up the network to approximately Filleul Street/ York Place causing surcharging of pipes upstream.

5.4.6 Flooding issues

A number of historic flood complaints have been recorded and confirmed through anecdotal evidence by DCC operational staff. In the lower part of the Halsey Street catchment near the wharf on Fryatt Street the flood hazard rating was predicted as 'extreme' due to tide levels and storm surge. Areas within the catchment predicted to have a flood hazard rating of 'significant' are the Central Activity Zone, particularly in the vicinity of St Andrew Street, London Street, Pitt Street and Rattray Street in the Town Belt. It was predicted that during these 'significant' flood events several sections of road would become impassable and the high velocity flows in several locations would pose a risk to the public.

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. Areas of predicted nuisance flooding were London Street/Heriot Row intake structure, York Place and St Andrews Street/George Street. The predicted causes of this flooding are inadequate capacity in the local network, a hydraulic bottleneck upstream of York Place and tidal influences in the lower catchment. The areas most affected by nuisance flooding in the Halsey Street catchment include busy parts of the city with vehicular and pedestrian traffic. Other areas identified that may experience nuisance flooding in small events are Bute Street/ Duchess Avenue, City Road Intake Structure/ Queens Drive, Claremont Street, Anzac Avenue/ Parry Street, Frederick Street, and Akaroa Street.

Habitable floor level flooding was predicted to impact 2 land parcels during the modelled 1 in 5 year ARI event and increases to approximately 56 properties during the modelled 1 in 50 year rainfall event which included climate change projections. The locations predicted to experience deep flooding were:

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

The areas where the model has predicted potential flooding issues in a 1 in 10 year ARI event and a 1 in 100 year ARI event (worst case scenario) are shown in Figure 11 and Figure 13. Predicted habitable floor flooding in a 1 in 50 year event is shown on Figure 12.

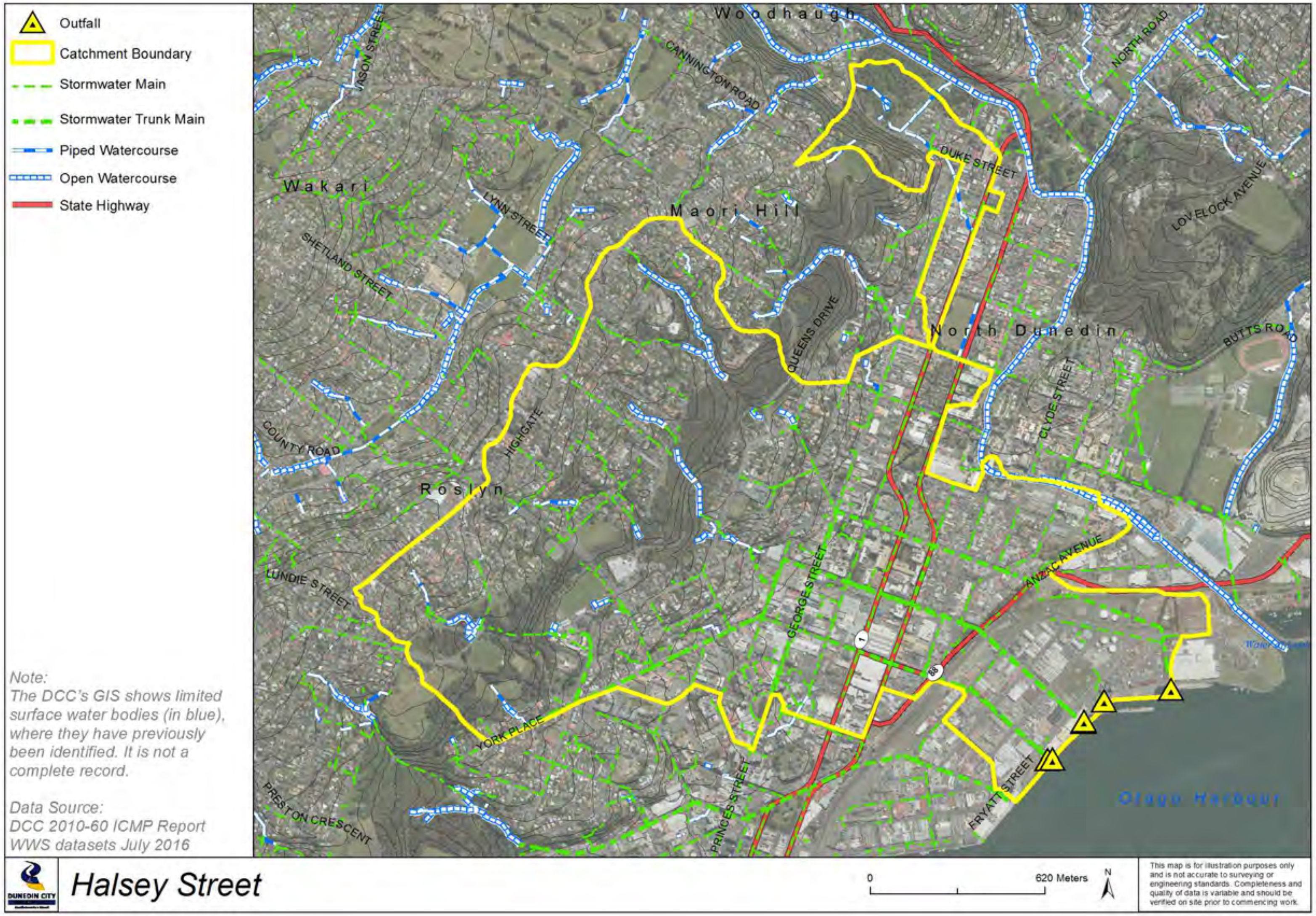


Figure 10: Halsey Street catchment

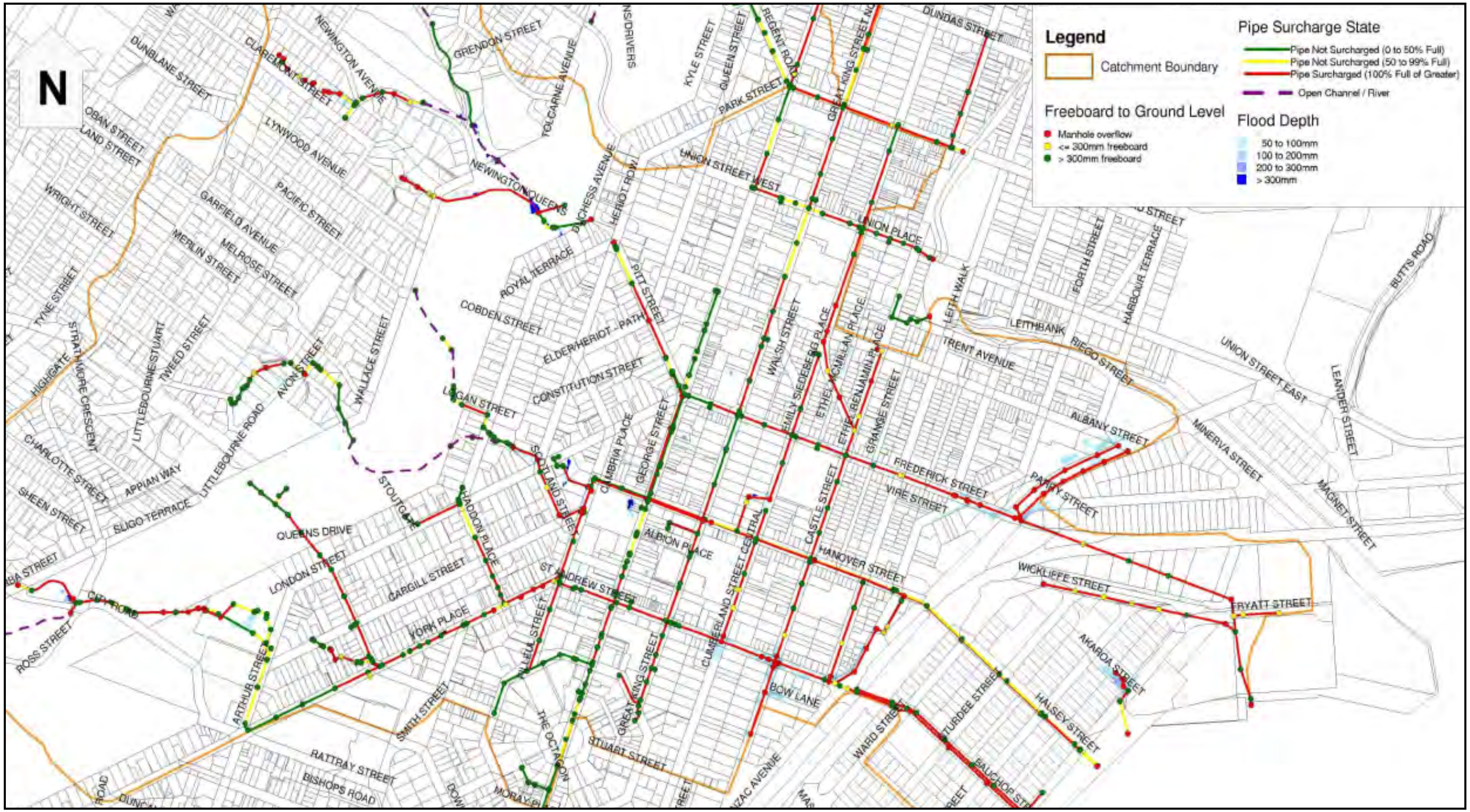


Figure 11: Halsey Street catchment predicted flood hazard during 1 in 10 year ARI rainfall event (2010)

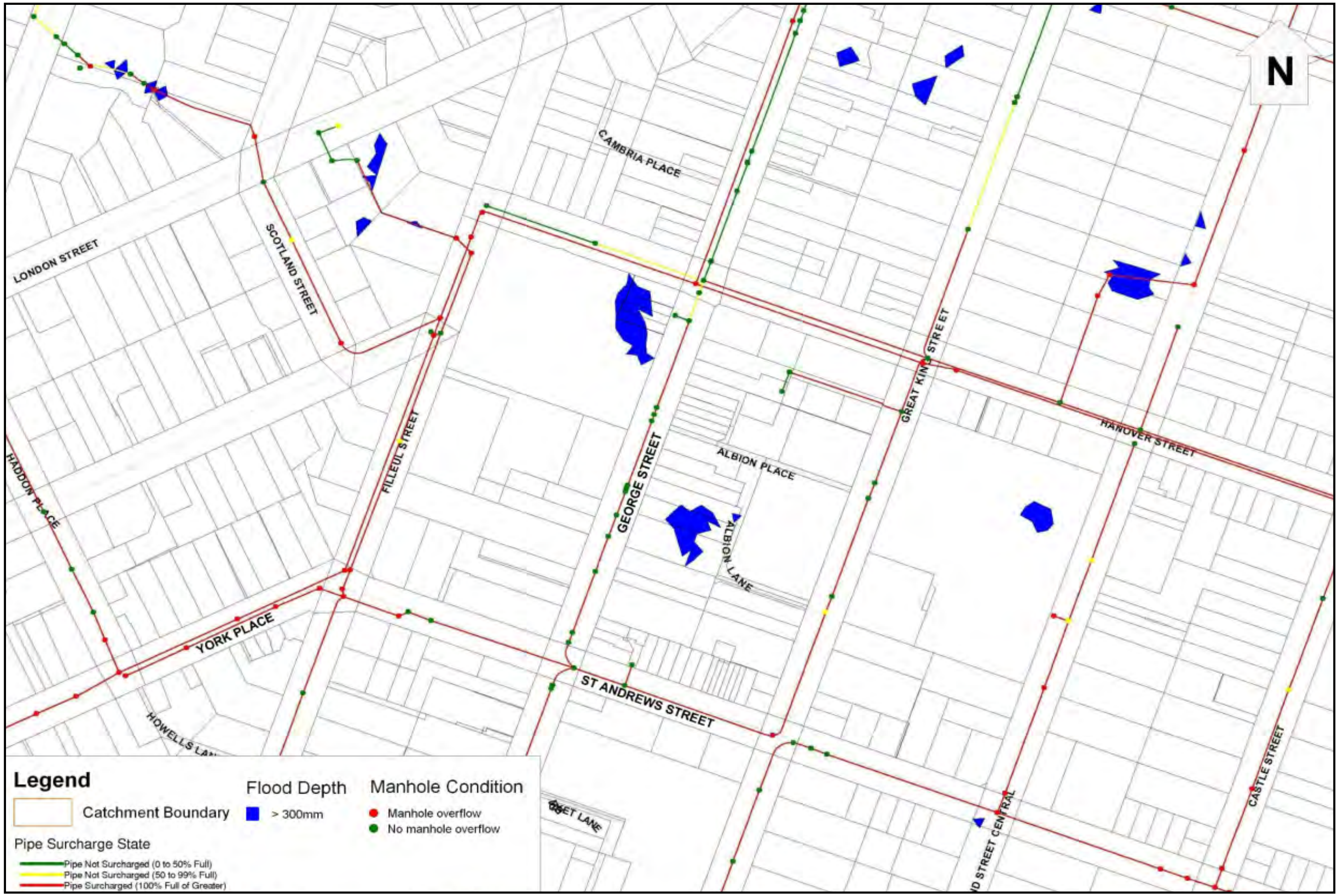


Figure 12: Halsey Street catchment potential habitable floor flooding during 1 in 50 year ARI rainfall event

Figure 13: Halsey Street catchment predicted extreme flood hazard during 1 in 100 year ARI rainfall event (2060)

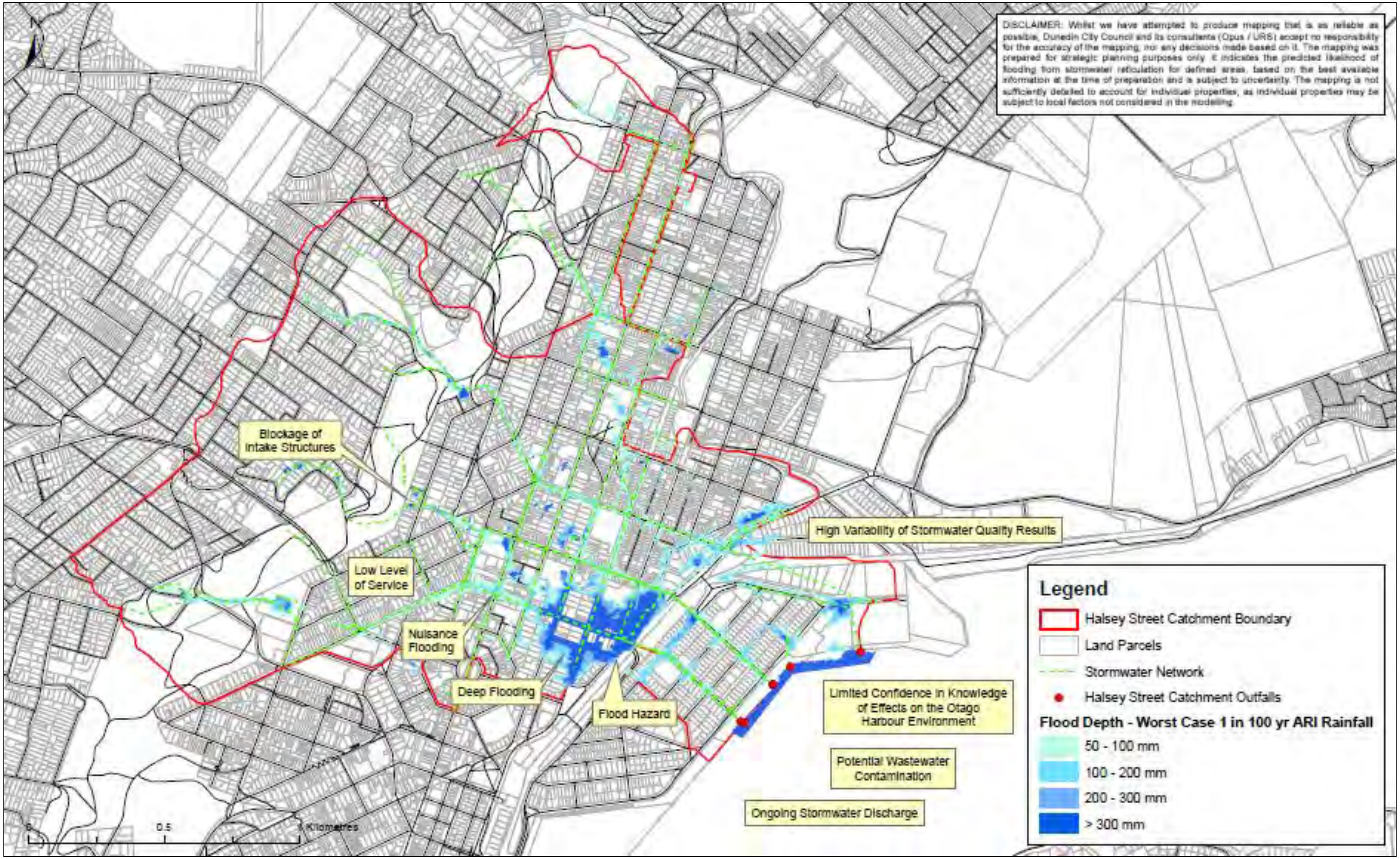


Figure 14: Summary of Halsey Street catchment issues

5.5 Kitchener Street

5.5.1 Catchment location, topography and geology

The Kitchener Street catchment, shown in Figure 15, lies adjacent to the Otago Harbour and covers approximately 137 ha. It includes approximately 10-15% of the relatively flat Dunedin harbourside and commercial areas and includes the residential area bound by High Street and Maitland Street.

The catchment lies between sea level and 120 m above mean sea level, with approximately 50% of the catchment no more than 20 m above sea level. The harbourside area is reclaimed, including with Bell Hill cuttings and harbour dredgings, the upper catchment is formed from lava flows.

There is a short section of open channel, approximately 60 m in length, which runs from the bottom of the Town Belt down the north side of 73 Maitland Street. This stream was considered unsuitable for assessment by Ryder Consulting Ltd in 2010.

5.5.2 Land use

The harbourside area is used for industrial and port purposes, and has both the railway (laid in the mid-1870s) and main transport route to Port Chalmers running through it. Nearly half of the catchment is zoned residential, including a significant area of Residential 4 in the centre of the catchment, and a large portion of the Town Belt. The catchment contains sections of the High Street, Vogel Street, and Queens Gardens Heritage Precincts and the South Princes Street and Crawford Street Townscape Precincts.

Contaminated land

Various and unknown types of fill used during land reclamation may have been contaminated. Historical Port and industrial activities in this area may also have resulted in contamination.

There are three closed landfill sites in the catchment: the Unity landfill off Eglinton Road, Montecillo landfill off Steep Street, and the Wharf Street landfill.

Future land use and imperviousness

While there are a small number of vacant or large land parcels which can potentially be developed or subdivided in the future due to zoning, it is not anticipated that the currently occupied sites will experience significant change in imperviousness over the next 50 years. Overall catchment imperviousness is estimated at 65%, ranging from almost completely impervious in the industrial areas, to the highly pervious Town Belt.

5.5.3 Stormwater drainage network

One main branch drains more than 80% of the catchment, with ten small independent sub-networks draining the remaining area, predominantly surrounding the wharf. The network is entirely piped, except for a short (approximately 60 m) section of open channel from the Town Belt through to the piped network on Maitland Street.

Significant features of the Kitchener Street stormwater network are as follows:

- A high point in the road (372 Princes Street) separates the topographical catchments of Mason Street and Kitchener Street; however the corresponding stormwater pipe is open along its length, creating a direct link between the two catchments' networks.

- Two bifurcations on Hope Street, splitting stormwater flows between the Kitchener catchment and the adjacent Mason Street catchment. These result in a small area of the Kitchener Street catchment draining into the Mason Street catchment.

- Cumberland Street has two large chambers separated by a flap valve.

Pipe shapes and sizes within the catchment are summarised in Table 6.

Table 6: Pipe shapes and sizes in the Kitchener Street catchment

Pipe shape	Pipe size (mm)	Total length (m)
Round	100-375 diameter	2870
	>375 to 1500 diameter	1399
Oval	600 x 900	2419
	900 x 1200	235
	1200 x 1650	427
Arch	600 x 1800	23
Box culverts	1650 x 1200	11

A new tidal ingress flap gate was installed in 2016 on one of the Kitchener Street outfalls. This is not currently included in the hydraulic model because the flap gate remains open in a 1 in 10 year ARI event, although it will be included in future.

5.5.4 Network age

A significant proportion of catchment pipework was original infrastructure laid in the late 1800s to early 1900s. Based on a theoretical life of 100 years, 68 % of the pipe network will be subject to inspection, which will improve remaining life forecasts or initiate renewal by 2060.

Table 7 summarises the age of pipes in the catchment.

Table 7: Pipe ages in the Kitchener Street catchment

Installation date	Approximate age	Number of pipelines	Length of pipe (m)	% of pipe length
1900 or before	> 110 years	59	2490	25
1901 to 1920	90-110 years	48	1880	18
1921 to 1940	70-90 years	39	1781	17
1941 to 1960	50-70 years	18	808	8
1961 to 1980	30-50 years	94	2433	24
1981 to 2000	10-30 years	26	869	8

Installation date	Approximate age	Number of pipelines	Length of pipe (m)	% of pipe length
2001 to 2009	< 10 years	0	0	0

5.5.5 Network capacity

The stormwater model estimates the following:

- 89% of the network can accept a 1 in 2 year ARI rainfall event;
- 70% of the network can accept a 1 in 5 year ARI rainfall event; and
- 57% of the network can accept a 1 in 10 year ARI rainfall event.

The majority of the predicted flooding in the catchment occurs in the flatter industrial, commercial and port zones in the eastern half of the catchment, whereas most of network in the hilly residential zone has capacity beyond the 1 in 10 year ARI event.

An industrial block adjacent to The Oval, at the southern end of Princes Street, was identified as one of the most flood-prone areas in the catchment and it is predicted that overflows at this location cross over into the South Dunedin catchment during large events, potentially contributing to surface flooding issues identified in and around The Oval. This connectivity will be addressed in future modelling.

5.5.6 Flooding issues

Parts of the Kitchener Street catchment were classified as having a 'moderate' to 'significant' flood hazard rating in the 1 in 100 year ARI event. The most significant is an area of approximately four hectares surrounding the wharf (between Kitchener and Birch Streets). Areas at the edge of the harbour classified as 'extreme' risk due to tidal storm surge. Areas of 'moderate' flood hazard risk include small regions of road, carpark and hardstand in the industrial, commercial and port zones within the catchment.

Nuisance flooding was predicted in three main areas; South Road/Princes Street in the vicinity of The Oval, the central commercial/industrial area and the wharf area. The predicted causes of nuisance flooding in the catchment were that there is a large upstream catchment, insufficient pipe capacity and tidal influence.

Habitable floor level flooding was predicted on 2 land parcels during a 1 in 10 year ARI event, with the number of land parcels predicted to be affected rising to 21 in the extreme planning scenario. Although most of the areas predicted to experience flooding deeper than 300 mm are used for commercial or industrial purposes and aerial photos at the time of modelling indicated it is unlikely the flooding would enter habitable floors.

The areas where the model has predicted potential flooding issues in a 1 in 10 year ARI event and a 1 in 100 year ARI event (worst case scenario) are shown in Figure 16 and Figure 18. Predicted habitable floor flooding in a 1 in 50 year event is shown on Figure 17.

Figure 15: Kitchener Street catchment

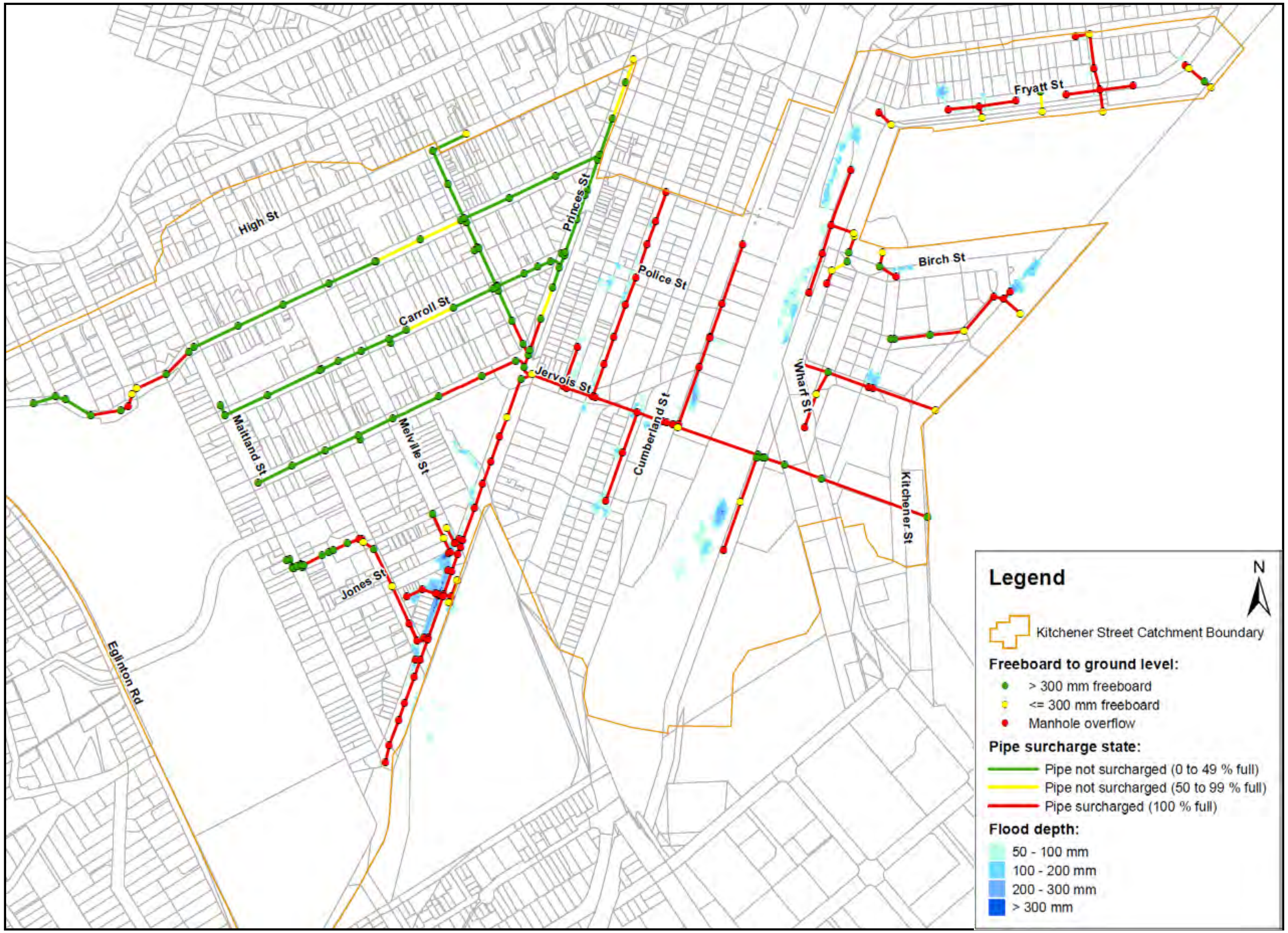


Figure 16: Kitchener Street catchment predicted flood hazard during 1 in 10 year ARI rainfall event (2010)

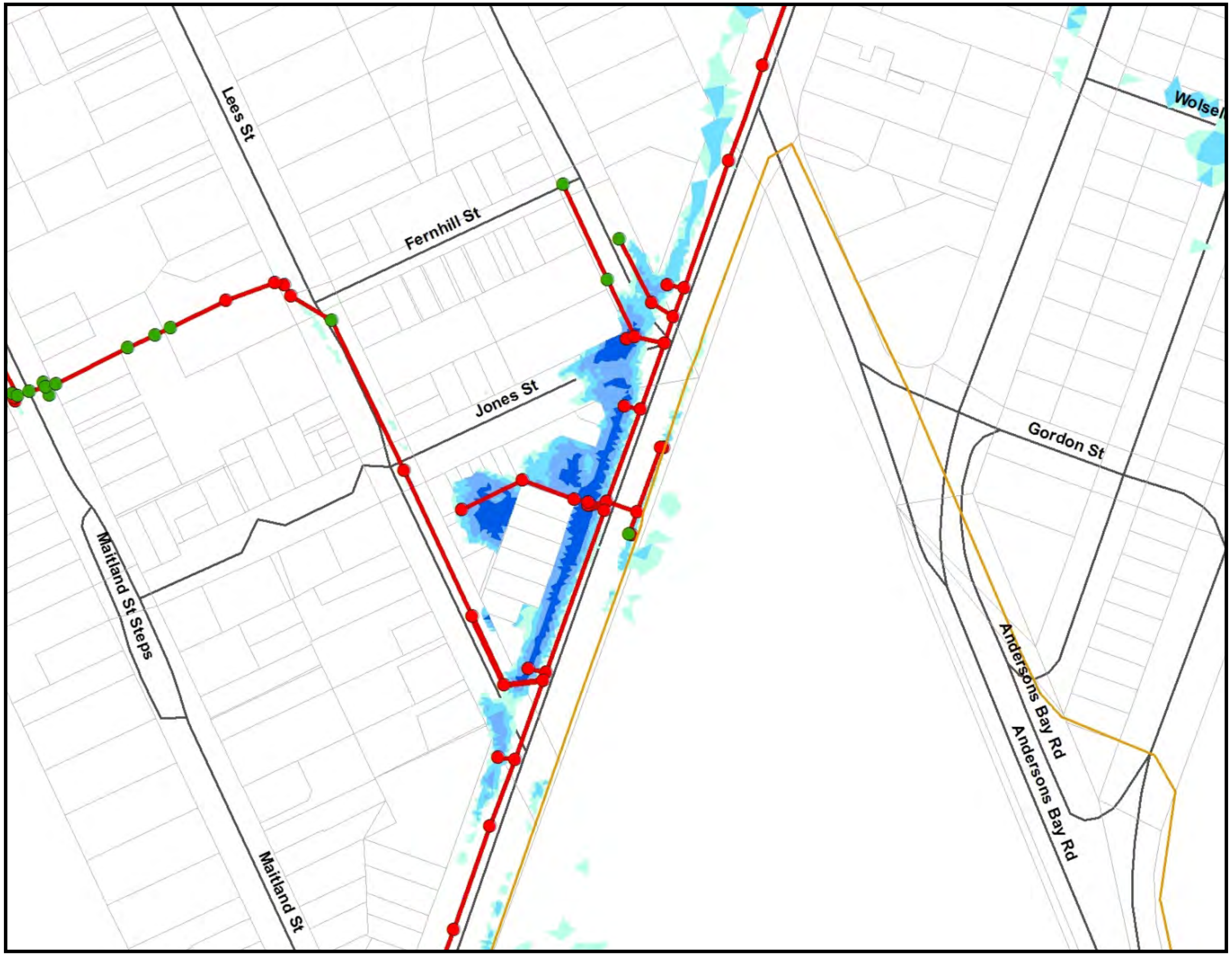


Figure 17: Kitchener Street catchment potential habitable floor flooding during 1 in 50 year ARI rainfall event

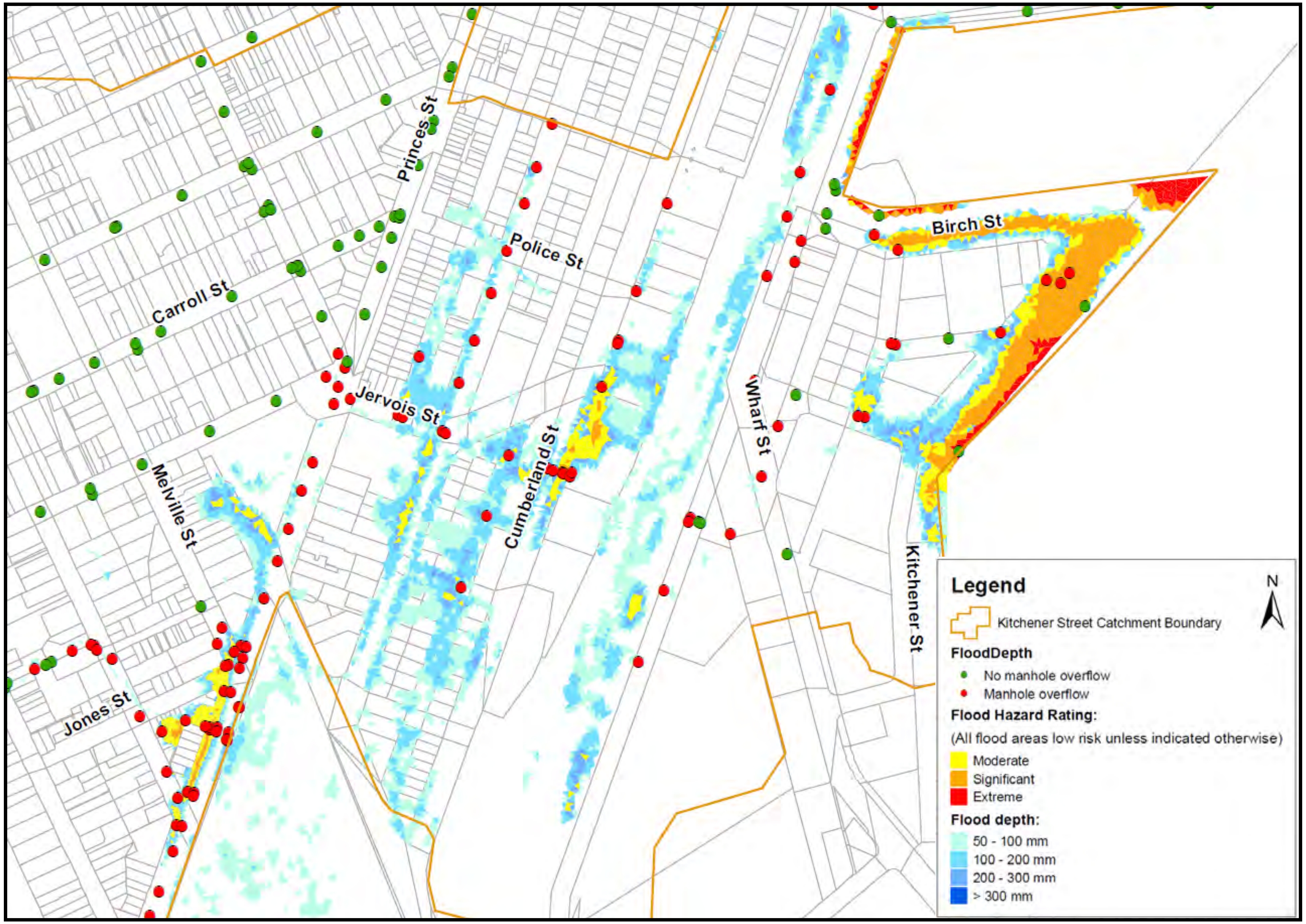


Figure 18: Kitchener Street catchment predicted flood hazard during 1 in 100 year ARI rainfall event and 1 in 20 year tide level (2060)

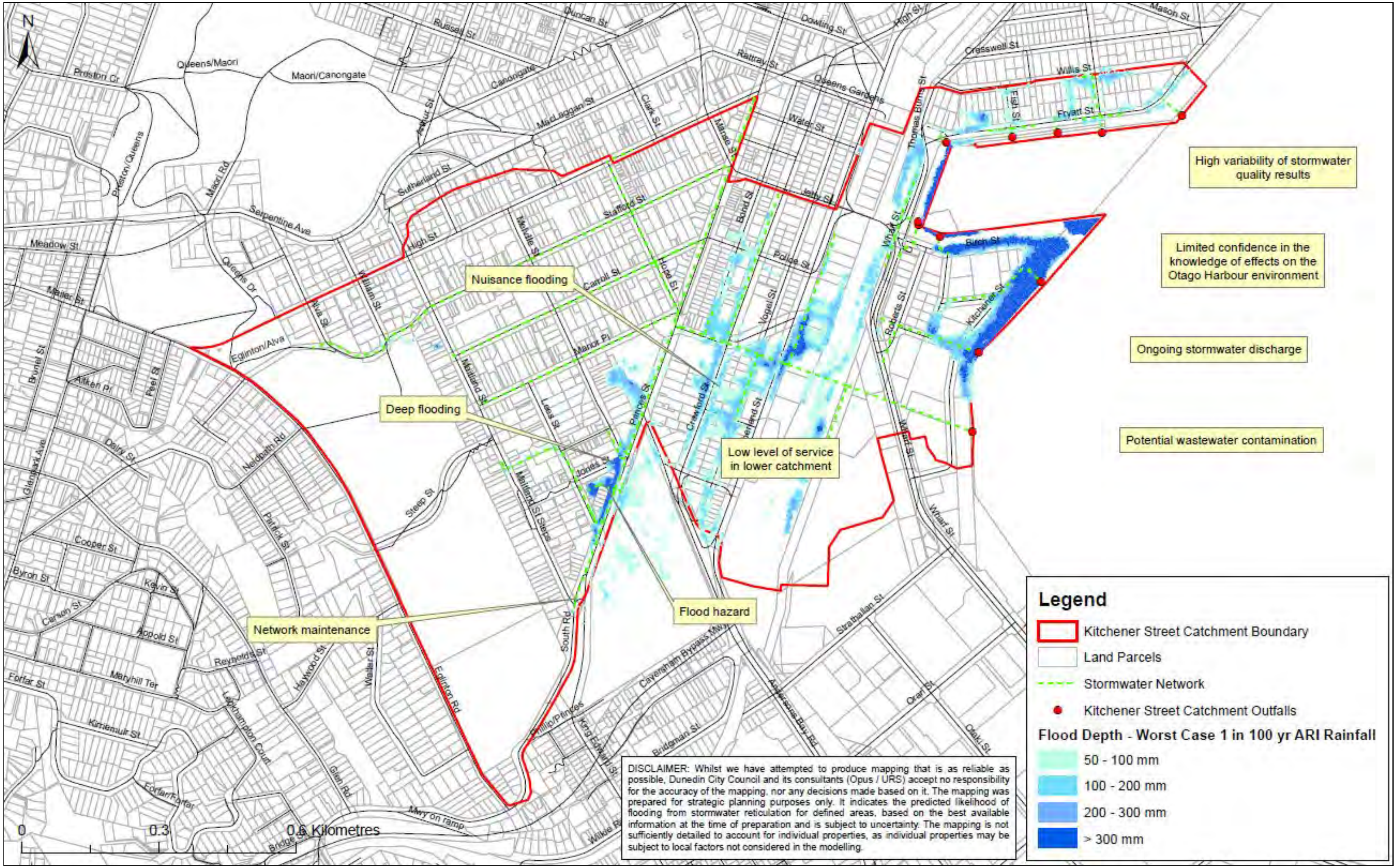


Figure 19: Summary of Kitchener Street catchment issues

5.6 Mason Street

5.6.1 Catchment location, topography and geology

The Mason Street catchment, shown in Figure 20, is approximately 210 ha and incorporates southern Roslyn and Belleknowes down to the harbourside. The head of the catchment is approximately 210 m above mean sea level, and is very steep with gradients of up to 17%. The hills are formed from lava flows which flatten out east of Broadway Avenue, where the volcanic deposits give way to sedimentary deposits. The flat area east of Crawford Street is reclaimed, likely with unconsolidated and unsorted material from a variety of sources. The steep terrain directs surface water into two gullies at Jubilee Park, which combine to a single gully that follows the general direction of Serpentine Avenue. The two streams have been modified over time and incorporated into the stormwater network.

5.6.2 Land use

The catchment is predominantly residential (72%), including the suburbs of Roslyn and Belleknowes and the Town Belt.

The flat area east of Lower High Street and Princes Streets in the lower part of the catchment is reclaimed (~13%) and used for commercial activities. The Octagon was created when swampland was drained. There are many heritage structures and precincts (High Street, North Princes Street/Moray Place/Exchange Townscape Heritage Precincts, Queens Garden Heritage Precinct). The area adjacent to the coast is still used for industrial and port purposes. Immediately adjacent to the industrial area is the Central Activity Area, and together with the large scale retail located on the southern margin of the CBD forms around 15% of the land use.

Contaminated land

The land adjacent to the harbour was reclaimed with various and unknown types of fill which may contain contaminants. There is also a small reclamation site on Dowling Street which is currently used as a car park.

Future land use and imperviousness

The catchment is not expected to undergo any significant change in land use over the next 50 years, based on predicted growth demands and the District Plan.

Overall imperviousness is estimated to be 58%, ranging from more than 95% impervious in the commercial and industrial areas, to the greenfields of the Town Belt. By 2060 there is anticipated to be an increase in imperviousness in the large scale retail and high density residential zones.

5.6.3 Stormwater drainage network

The network drains to a single, tidally influenced, harbour outfall adjacent to Fryatt Street. In some of the steeper, bush covered areas of the catchment, flows are collected via natural gullies intercepted by the piped stormwater network. Pipe sizes within the catchment are summarised in Table 8.

Table 8: Pipe shapes and sizes in the Mason Street catchment

Pipe shape	Pipe size (mm)	Total length (m)
Round	150 – 2175 diameter	3313
Oval	600 x 900	1688
Arch	600 x 1725	21.5
	750 x 1650	3.5
	1350 x 1350	607
	1800 x 1800	791
	2100 x 2100	39
	2100 x 2550	11
Box culverts	600 x 300	132
	600 x 825	191
	1350 x 1350	67
	1500 x 2150	21

Key network features are:

- Culvert intake screens on Māori Road, Canongate and Queens Drive and Serpentine Avenue intersection collect a large portion of stormwater from part of the upper catchment and convey it into the reticulated network.
- Bifurcations occur at intersection of High and Hope Streets as well as Stafford and Hope Streets.

5.6.4 Network age

The oldest stormwater pipes in the network were installed in 1867, and the outfall to the harbour is over 100 years old. With a theoretical life of 100 years, approximately 18 % of the network is currently overdue for renewal, with a further 18 % requiring renewal within the next ten years. The remaining 64 % of the network will be eligible for renewal within the timeframe of this ICMP (by 2060). Table 9 summarises the age of pipes in the catchment.

Table 9: Pipe ages in the Mason Street catchment

Installation date	Approximate age	Number of pipelines	Length of pipe (m)	% of pipe length
1900 or before	> 110 years	84	3141	18
1901 to 1920	90-110 years	73	3059	18
1921 to 1940	70-90 years	134	5641	33
1941 to 1960	50-70 years	11	428	2
1961 to 1980	30-50 years	56	1702	10
1981 to 2000	10-30 years	122	2959	17
2001 to 2009	< 10 years	14	323	2

5.6.5 Network capacity

The stormwater model estimated the following:

- 96% of the network can accept a 1 in 2 year ARI rainfall event;
- 82% of the network can accept a 1 in 10 year ARI rainfall event; and
- 70% of the network can accept a 1 in 100 year ARI rainfall event.

There are hydraulic pinch points in the upper catchment that create overland flow in smaller rainfall events, and levels of service are restricted in the lower catchment during the 1 in 5 year ARI event due to tidal influence.

5.6.6 Flooding issues

In parts of the Mason Street catchment the flood hazard rating was predicted to be 'extreme' during the future 1 in 100 year ARI event, although the locations are limited to intake screens along parts of Canongate and Serpentine Avenue, and areas of the Town Belt to the west of the catchment.

Areas of significant flood hazard risk identified by the model included Serpentine Avenue, Rattray Street, and Queens Gardens/High Street areas due to flow velocities, depth and extent of predicted flooding. It was predicated that during the extreme planning event flooding will cause significant disruption to sections of roads (including State Highway 1) which may be of significant depth and therefore be a risk to the public.

Nuisance flooding was predicted within the catchment at a number of locations; including the following areas:

- Serpentine Avenue;
- Maclaggan Street / Clark Street / Rattray Street;
- Bond Street / Water Street / Crawford Street;
- Queens Gardens / High Street; and

- Cresswell Street.

Habitable floor level flooding was predicted to affect 2 land parcels during the 1 in 2 year ARI event and increases to 24-40 land parcels at risk of flood depths over 300 mm during the future 1 in 50 year ARI event with projected climate change. The areas mostly affected by this flooding are Queens Drive/Serpentine Avenue, Rattray Street, Bond Street/Water Street Intersection and the High Street/Queens Gardens area.

The areas where the model has predicted potential flooding issues in a 1 in 10 year ARI event and a 1 in 100 year ARI event (worst case scenario) are shown in Figure 22 and Figure 24. Predicted habitable floor flooding in a 1 in 2 year event is shown on Figure 21 and 1 in 50 year event is shown on Figure 23.

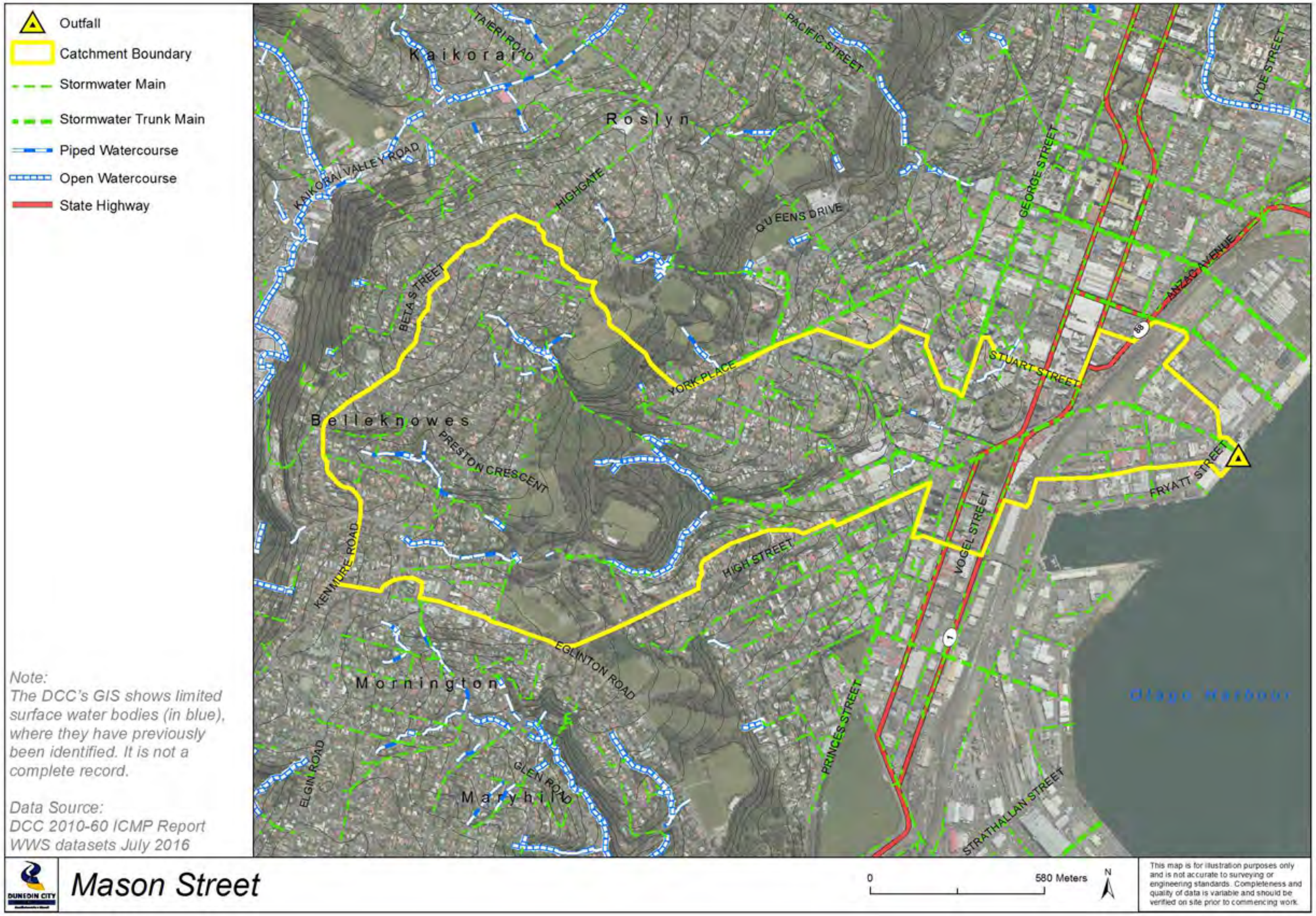


Figure 20: Mason Street catchment

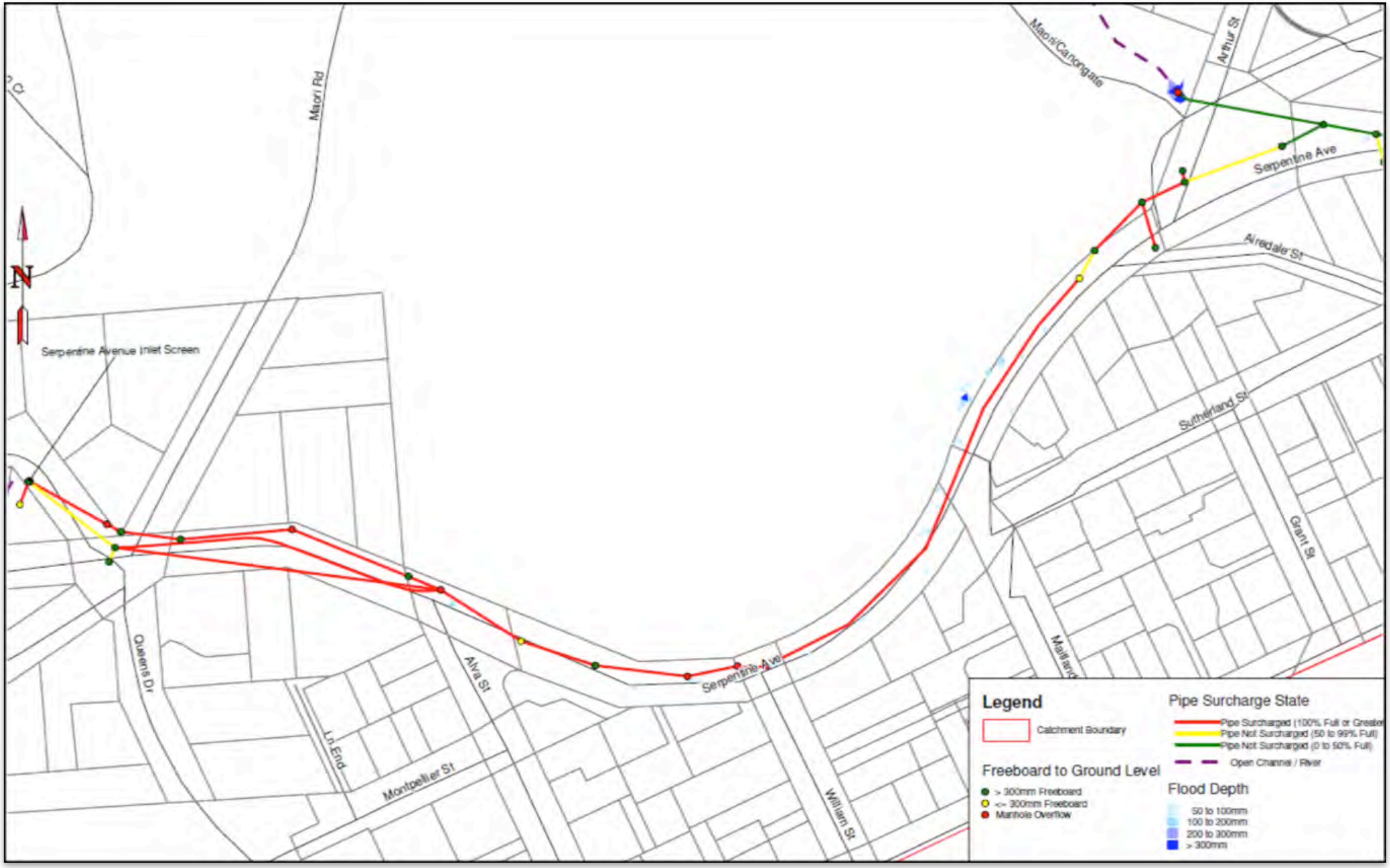


Figure 21: Mason Street catchment potential habitable flooding 1 in 2 year ARI rainfall event

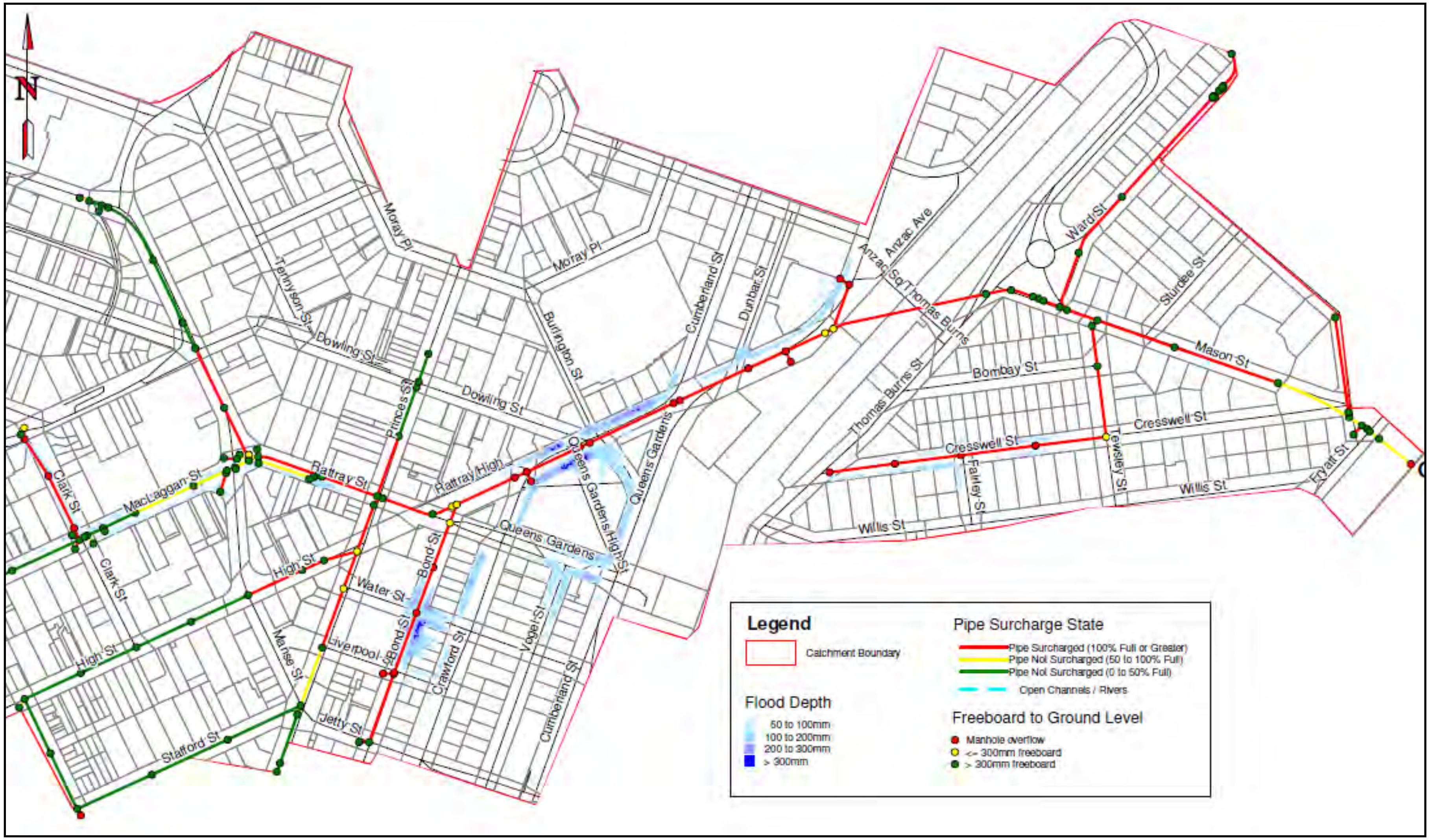


Figure 22: Mason Street catchment predicted flood hazard during 1 in 10 year ARI rainfall event (2010)

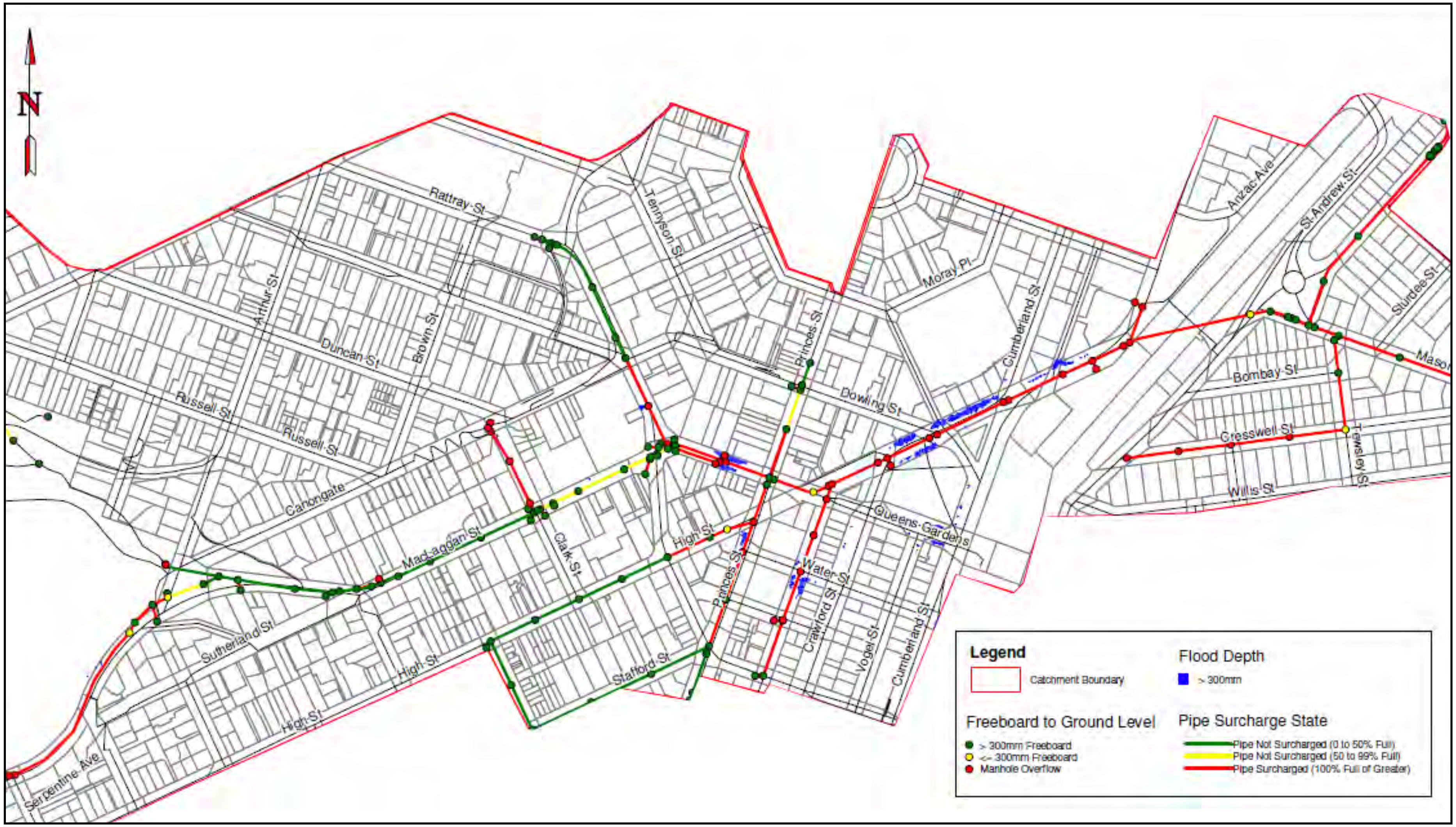


Figure 23: Mason Street catchment potential habitable flood flooding during 1 in 50 year ARI rainfall event

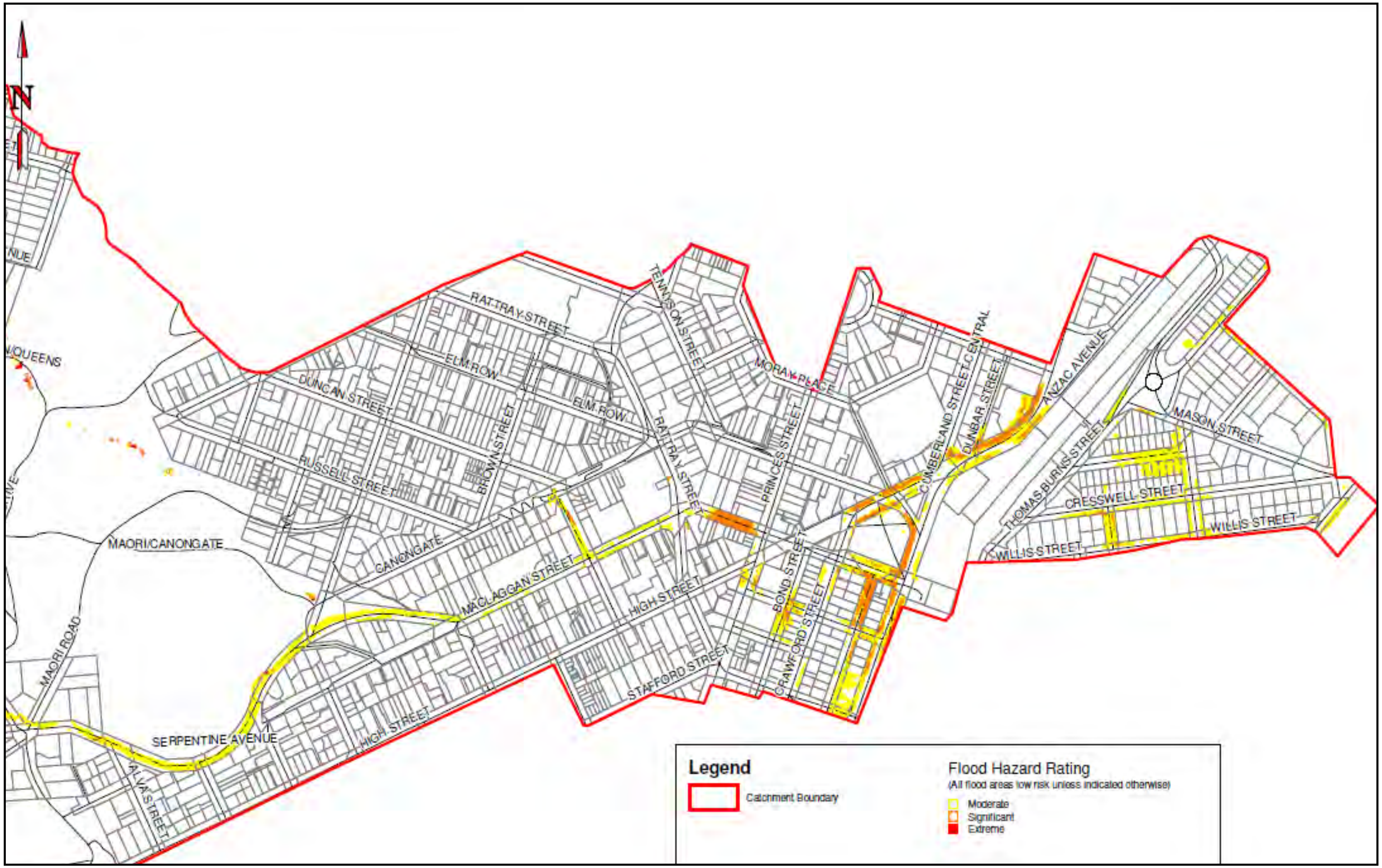


Figure 24: Mason Street catchment predicted flood hazard during 1 in 100 year ARI rainfall event (2060)

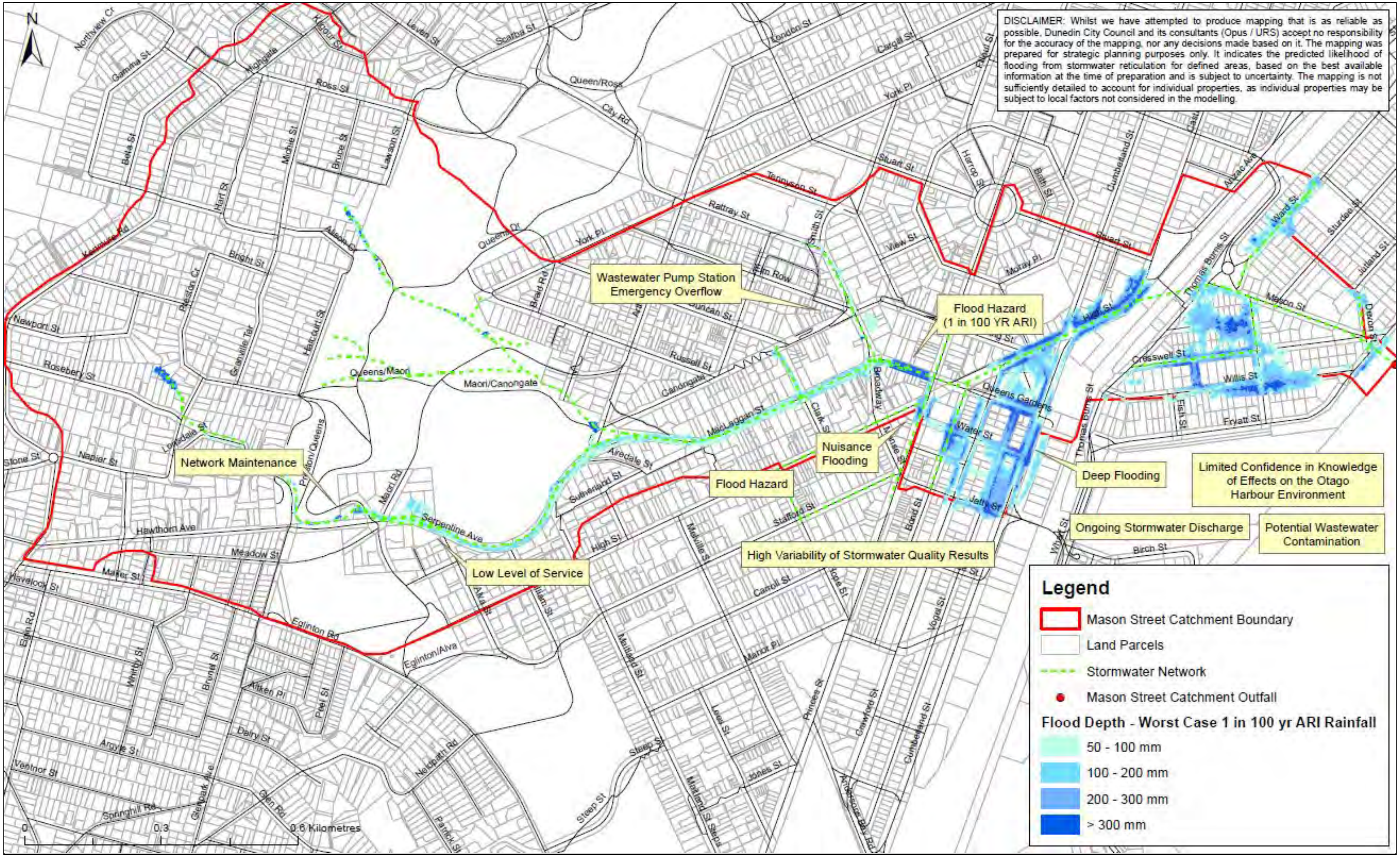


Figure 25: Summary of Mason Street catchment issues

5.7 Orari Street

5.7.1 Catchment location, topography and geology

The Orari Street catchment, shown in Figure 26, is approximately 344 ha. The catchment lies on a ring of hills that surround Dunedin (Mornington, Maryhill, Caversham, Balaclava and Corstorphine, and small parts of Kenmure and Kensington).

The hills are formed from lava flows. Along the Caversham Bypass Motorway there is an area of marine sediments which consist of calcareous sandstone, sandy limestone and tuff. This material is softer than the basalt, and the old Caversham railway tunnel was built through it. Near the centre of the catchment in the east, is a small area of alluvial fan deposits which consist of poorly consolidated and sorted, slightly weathered, fine to bouldery sandstone or gravel, sand and mud.

There are a large number of open and piped watercourses within the catchment. The steep terrain directs surface water into three main gullies at Caversham Valley Road, Corstorphine Road and Glen Road. The topography becomes flatter towards the southeast. Unlike the majority of the other stormwater catchments discharging to the Otago Harbour, the Orari Street catchment does not include a large flat area adjacent to the harbour. Stormwater is conveyed through the flat South Dunedin and Portsmouth Drive catchments via a 3 km long, large, sealed stormwater main.

5.7.2 Land use

The Orari Street catchment is a mix of high and medium density residential land (97%). There are small Local Activity zones to the north (Havelock Street) and east (South Road area). Heritage structures (such as Mornington Presbyterian Church and a former post office) are scattered throughout the Orari Street catchment, however there are no archaeological sites or heritage precincts recorded in the District Plan.

There is some anecdotal evidence citing the hilltop area known as Lookout Point, in the suburb of Caversham, as a burial place (Opus, 2010).

Contaminated land

There is a small area of reclaimed land on the harbour front in the eastern-most section of the catchment, and a service station site between the motorway and South Road are identified as contaminated. The service station site is recorded as 'managed'.

Future land use and imperviousness

The catchment is not expected to undergo any significant change over the next 50 years based on the growth predictions and the District Plan.

Most of the catchment is zoned residential (98%), so overall current imperviousness is estimated to be approximately 39%. While there are a number of vacant lots that can potentially be developed, it is not anticipated that the currently occupied sites will experience significant change in imperviousness into the future.

5.7.3 Stormwater drainage network

There are three major network branches, which in turn are made up of an intricate network of smaller sub-branches comprising a number of piped and open watercourses. These branches come together in a large pipeline, approximately at the junction of the South Road and Glen Road, and continue along the alignment of the Caversham Bypass Motorway before running adjacent to Orari Street and discharging to the Otago Harbour via a single outfall. Significant network features are as follows:

- The Orari Street outfall is a tidally influenced and fitted with a flap valve. Three new tidal ingress flap gates were installed in 2016.

- There is a 1 m high sediment wall in the main stormwater pipe approximately 200 m upstream of the outfall.

- To provide clearance beneath Andersons Bay Road, the Orari pipeline splits into two, and then four smaller pipes to cross beneath the road. These four pipes then merge back into a single pipe of the same shape and dimensions as the upstream pipe.

- 'The Glen intake', near the intersection of Glen Road and South Road is a concrete basin structure, approximately 12 m wide, with a 2 m high weir and debris screen. The weir contains two 150 mm diameter low flow pipes, and an adjustable weir section. Immediately downstream of the intake structure is a 1500 mm square box culvert.

- An intake structure on private property at 91 Glen Road experiences regular blocking and associated flooding. This issue is being addressed in 2017.

Most pipes in the catchment are relatively small, and the majority of the pipes in the catchment have a diameter of between 150 mm and 300 mm. Table 10 summarises pipe shapes and sizes in the catchment.

Table 10: Pipe shapes and sizes in the Orari Street catchment

Pipe shape	Pipe size (mm)	Total length (m)
Round	100-375 diameter	11176
	>375 to 1800 diameter	2676
Arch	600 x 900	764
	1200 x 1200	42
Box culverts	800 x 800	78
	900 x 600	1019
	1000 x 1000	3558
	1125 x 850	24
	1500 x 1500	45
	1575 x 1575	383
	1800 x 1800	495
	2700 x 2700	1639
	Other sizes	1226

Pipe shape	Pipe size (mm)	Total length (m)
	100-375 diameter	11176
	>375 to 1800 diameter	2676

5.7.4 Network age

The majority of pipework in the catchment was laid in the mid-1900s, with pipework in Corstorphine installed in the 1940s and 1960s, most likely as part of the state housing scheme. Based on a theoretical life of 100 years, 82 % of the pipe network will be subject to inspection, which will improve remaining life forecasts or initiate renewal by 2060. Table 11 summarises the age of pipes in the catchment.

Table 11: Pipe ages in the Orari Street catchment

Installation date	Approximate age	Number of pipelines	Length of pipe (m)	% of pipe length
1900 or before	> 110 years	0	0	0
1901 to 1920	90-110 years	67	3537	17
1921 to 1940	70-90 years	214	8031	39
1941 to 1960	50-70 years	137	5242	26
1961 to 1980	30-50 years	44	1156	6
1981 to 2000	10-30 years	82	1968	10
2001 to 2009	< 10 years	19	404	2

5.7.5 Network capacity

The stormwater model estimates 70% of the network can accommodate flows from a 1 in 10 year ARI rainfall event.

Many of the small diameter pipes in the upper reaches of the network can only convey small rainfall events, e.g. a 1 in 2 year ARI rainfall event. This can result in manhole overflow, and overland flow down the steep upper catchment. A hydraulic bottleneck on Barnes Drive, north of the motorway, also results in capacity issues.

5.7.6 Flooding issues

A number of areas in the Orari Street catchment were identified as having 'significant' or 'extreme' flood hazard ratings due to the depth or velocity of flood water estimated.

Nuisance flooding was predicted and confirmed in three main areas; South Road beneath the motorway over-bridge (at The Glen), in the South Road commercial area, and on the northern part of the Caversham bypass motorway. Additional areas of the catchment may experience nuisance flooding as predicted by the model but not confirmed, including; areas of the Glen Valley, north and west of the Caversham Motorway, and South of South Road.

Habitable floor level flooding was predicted in similar areas, including South Road/The Glen, South Road commercial area, and Glenpark Avenue/Mitchell Avenue. Ten properties are predicted to experience flood depths on at least part of the land parcel during a 1 in 10 year ARI event, increasing to 99 during the predicted 1 in 50 year ARI event including the impacts of climate change and land use change experienced by 2060.

The emergency planning modelling identifies the Glen Valley and the properties / streets to the southeast of the catchment such as Corstorphine Road, South Road and Playfair Street, as being the most at risk of deep and / or fast surface flooding.

The areas where the model has predicted potential flooding issues in a 1 in 10 year ARI event is shown in Figure 27, and a 1 in 100 year ARI event (worst case scenario) are shown in Figure 29 and Figure 30. Predicted habitable floor flooding in 1 in 50 year event is shown on in Figure 28.

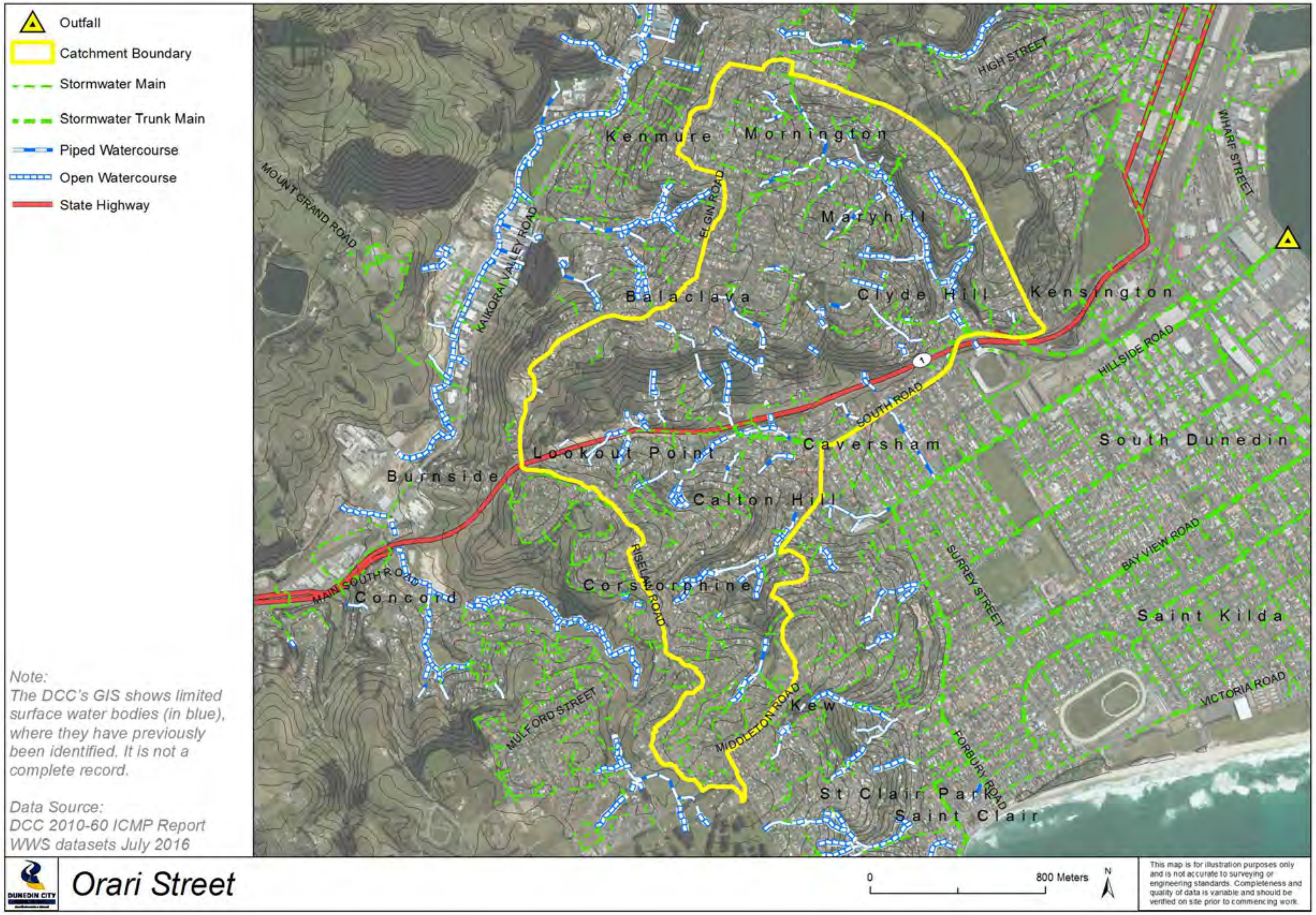


Figure 26: Orari Street catchment

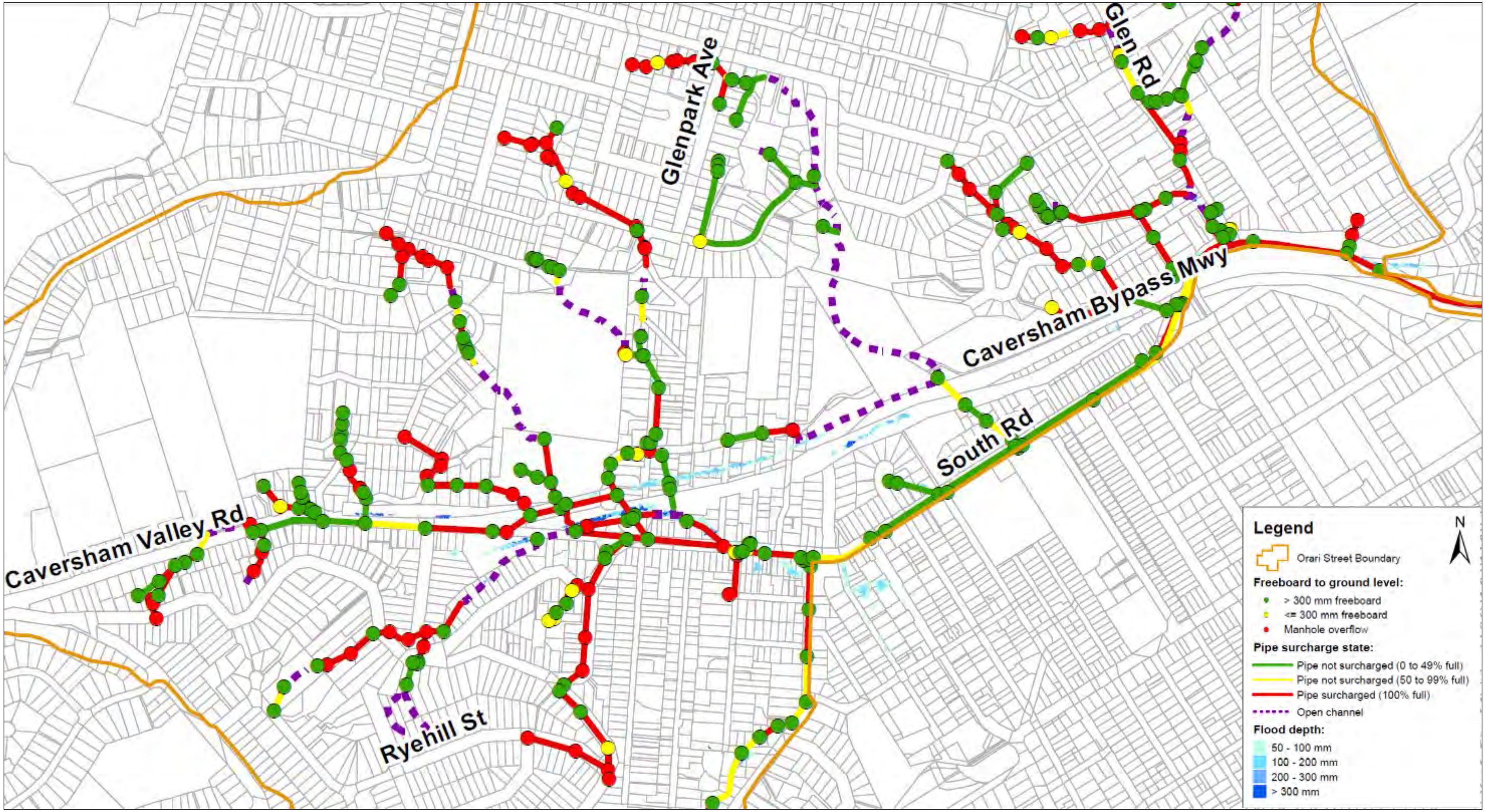


Figure 27: Orari St catchment predicted flood hazard during 1 in 10 year ARI rainfall event (2010)

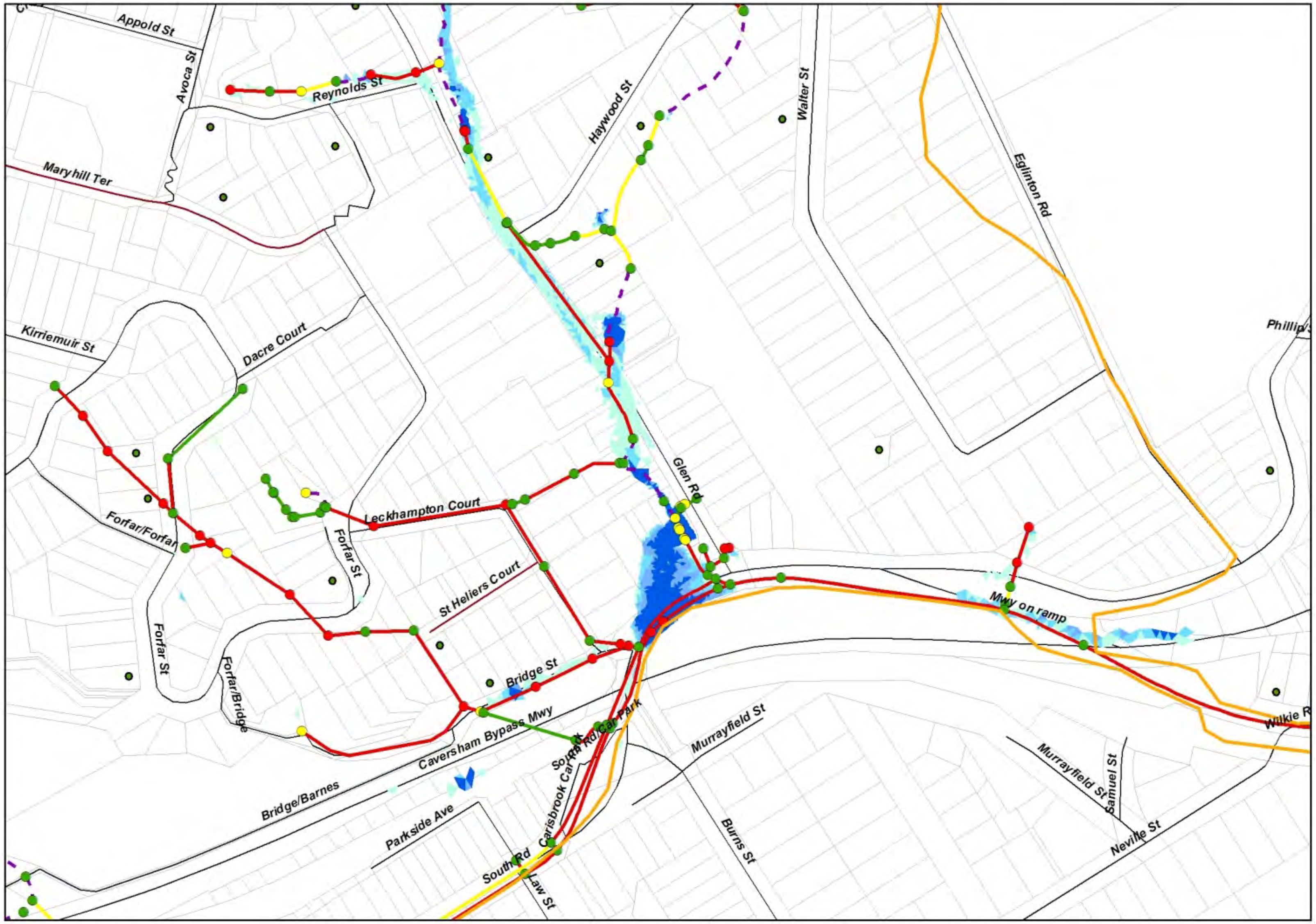


Figure 28: Orari St catchment potential habitable flood flooding during 1 in 50 year ARI rainfall event

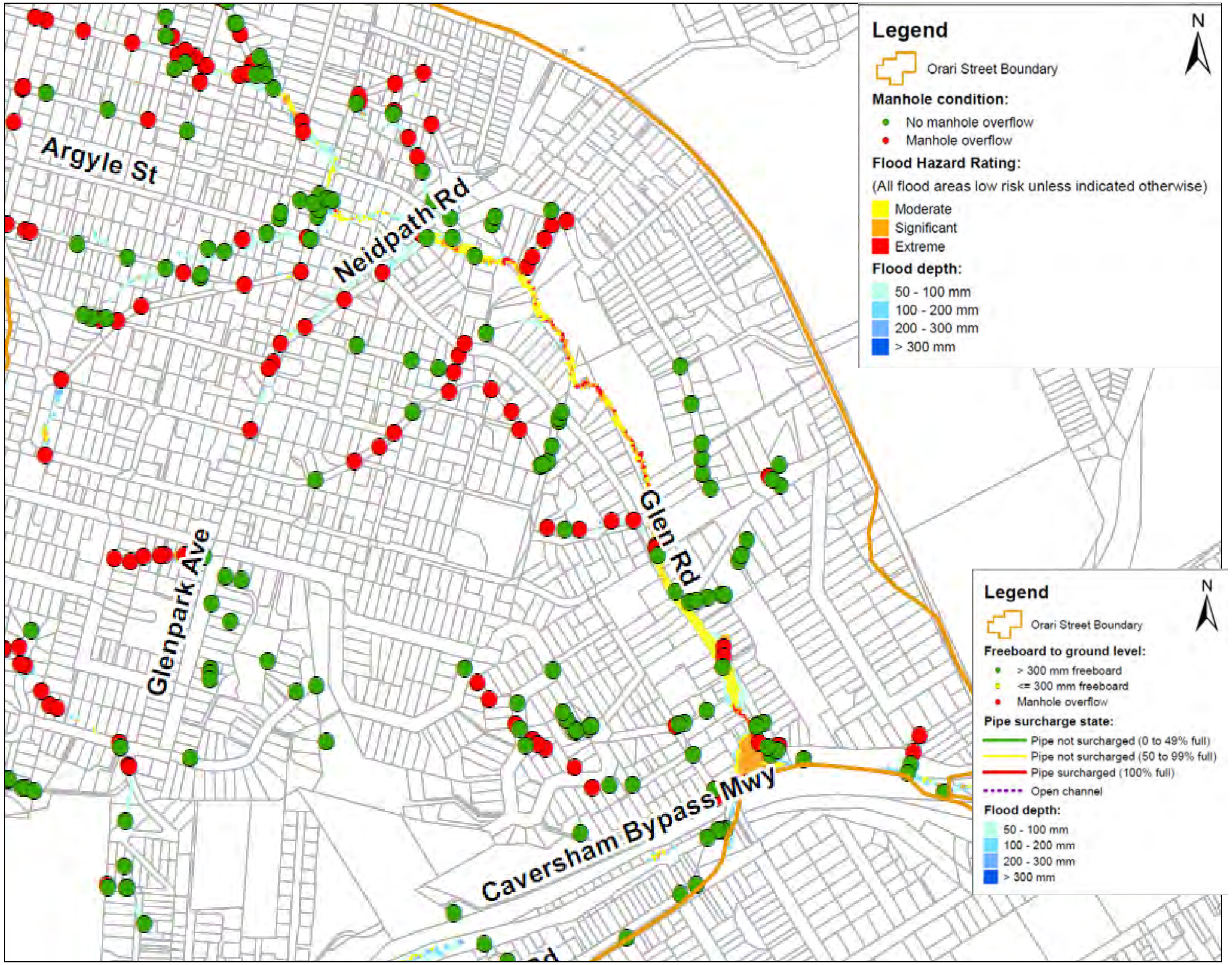


Figure 29: Orari St catchment (Glen Valley) predicted flood hazard during 1 in 100 year ARI rainfall event (2010)

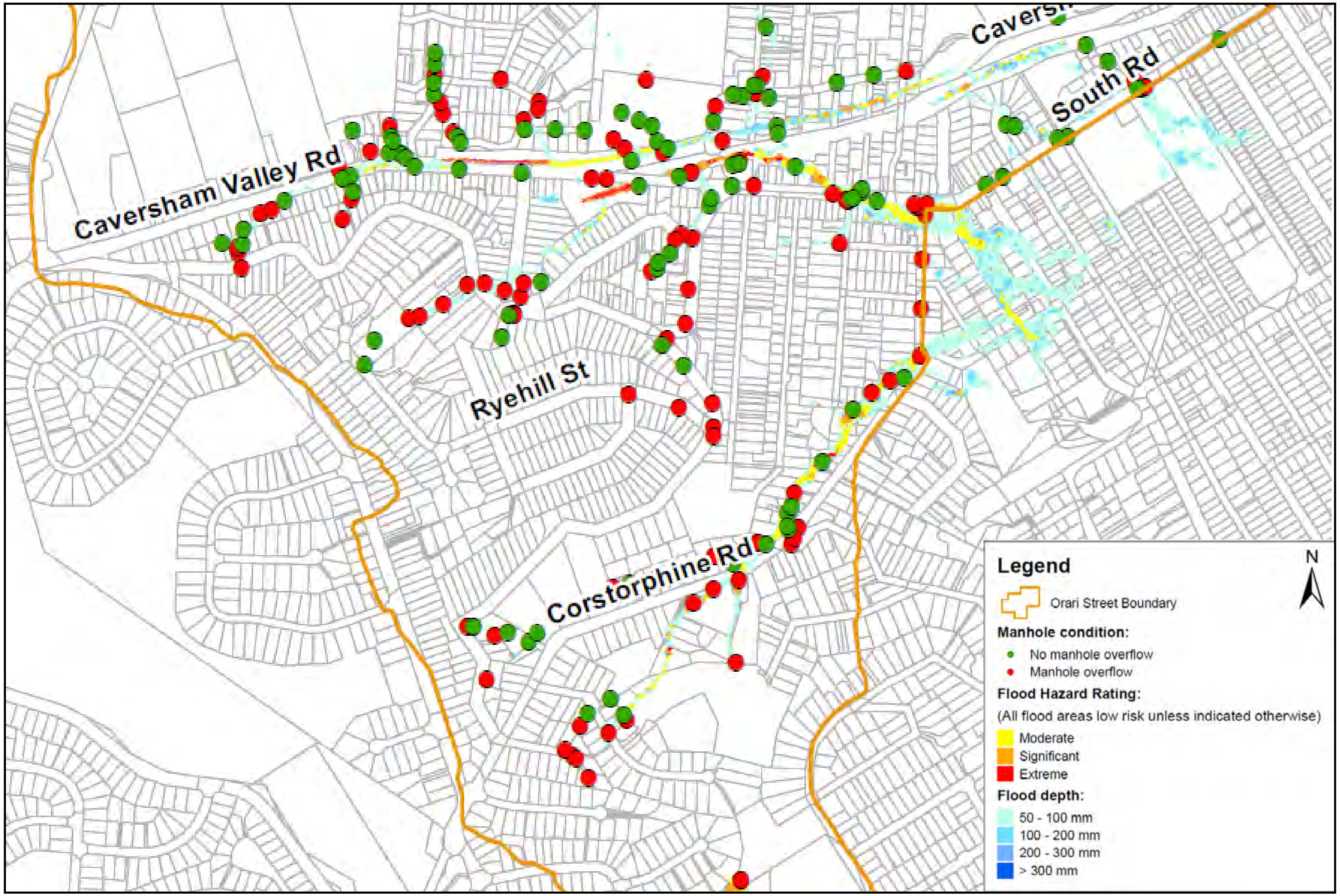


Figure 30: Orari St catchment (Caversham/Corstorphine) predicted flood hazard during 1 in 100 year ARI rainfall event (2010)

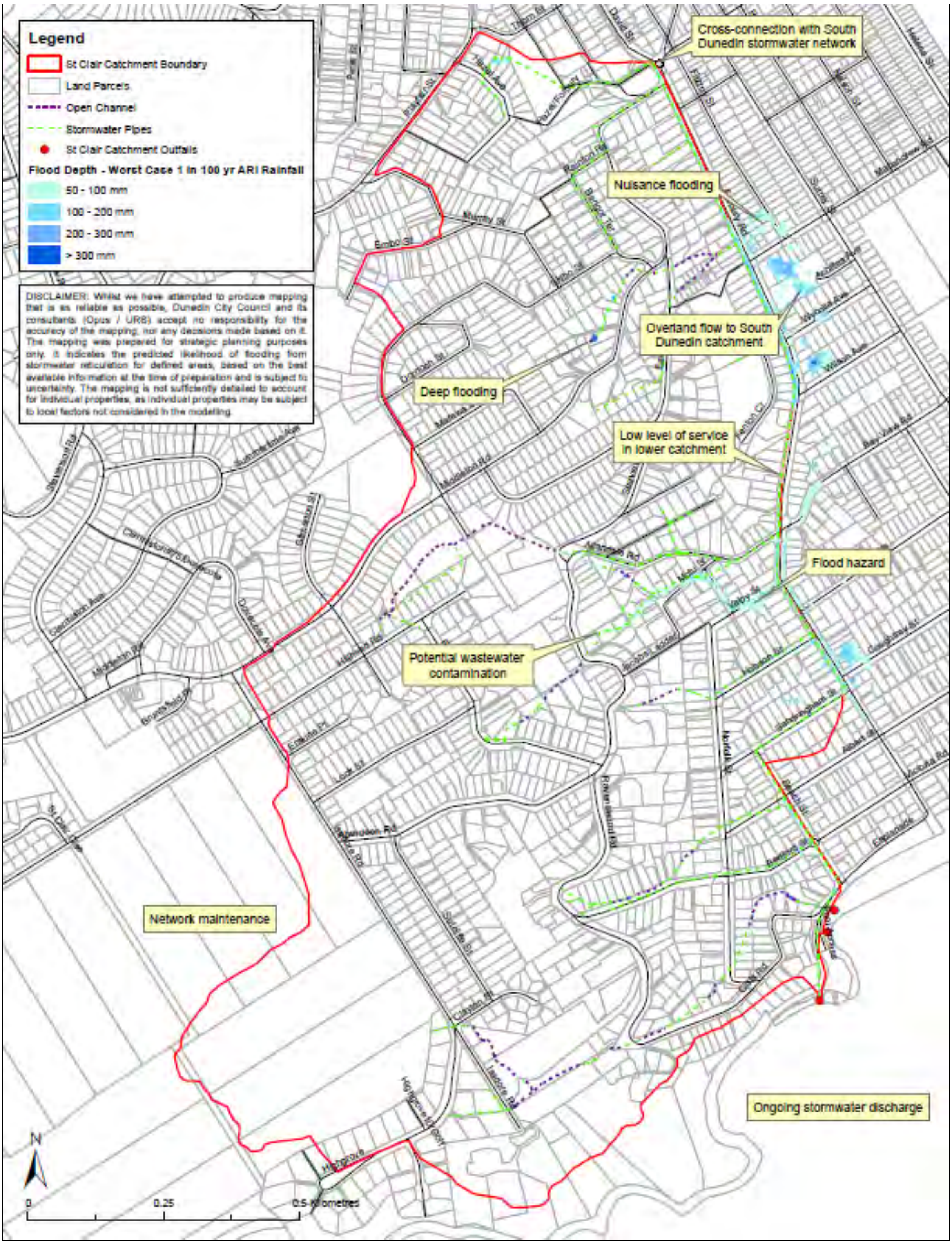


Figure 31: Summary of Orari Street catchment issues

5.8 Port Chalmers

5.8.1 Catchment location, topography and geology

The Port Chalmers catchment, shown in Figure 32, is approximately 58 ha, and comprises moderately steep harbour-side catchment, and essentially flat port land.

The catchment's predominant geology is trachyte and basaltic breccia, and drainage is dependent on the extent of fractures in the rock. The Otago Harbour Board reclaimed part of the port area with dredged material, however, the extent of other types of fill, such as domestic and industrial waste, is unknown. Drainage capabilities of this material will be variable.

5.8.2 Land use

Port Chalmers is the main port of Dunedin City. Land use in the catchment is a mix of residential, rural, retail and industrial. The Port Chalmers Heritage Precinct runs the length of George Street from Beach Street to Wickliffe Terrace. There are a number of heritage structures within the catchment.

Resource consents within the catchment

Otago Regional Council has granted Port Otago Limited consent to discharge stormwater from their industrial premises via 18 outfalls extending the length of their site. Whilst the Port Otago site is outside the Port Chalmers catchment, their stormwater is discharged into the Upper Harbour to the north of Port Chalmers, sharing a common receiving environment with the DCC stormwater discharges.

Contaminated land

The land in the north east and south west of the catchment has been reclaimed in conjunction with port and harbour activities. Various unknown types of fill containing contaminants may have been used during land reclamation. There are also two former gasworks sites - one on George Street which operated from 1871-1889 and a second that operated from 1889-1950 located adjacent to the Dunedin-Port Chalmers Road.

Future land use and imperviousness

Approximately 65% of the Port Chalmers catchment area is zoned rural and largely undeveloped. This is unlikely to significantly change in the foreseeable future apart from minor residential and rural development.

Overall the catchment is estimated at 18% imperviousness. With allowances for increases within the residential and rural zones, the future imperviousness of the catchment has been estimated to be approximately 28%.

5.8.3 Stormwater drainage network

Three outfalls discharge below the high tide level to Otago Harbour. Two outfalls at Watson Park discharge stormwater from a predominantly residential / commercial portion of the catchment draining to Sawyers Bay. The third, the George Street outfall, discharges stormwater from the industrial / commercial portion of the catchment into deep water within the lower harbour at the port.

The original combined stormwater and wastewater sewer system in Port Chalmers was separated some time ago, with part of the original system being dedicated to wastewater, and part of it to stormwater. It is estimated that 83% of the current stormwater system originally formed part of the combined network. Approximately half of the pipes in the catchment are fairly small with diameters between 150 mm and 225 mm. Table 12 summarises pipe shapes and sizes in the catchment.

Table 12: Pipe shapes and sizes in the Port Chalmers catchment

Pipe shape	Pipe size (mm)	Total length (m)
Round	100-375 diameter	1787
	>375 to 1250 diameter	1011
Arch	600 x 600	187
	600 x 900	334
Box culvert	500 x 400	71
	900 x 900	49

5.8.4 Network age

The majority of pipework in the catchment is estimated at between 90 and 110 years. However, data reliability in this catchment is considered to be low.

Based on a theoretical life of 100 years, 83 % of the pipe network will be subject to inspection, which will improve remaining life forecasts or initiate renewal by 2060. Using this process, it is possible that a significant portion of the catchment will be found to be in reasonable condition upon inspection (i.e. younger than suggested by the data). Therefore, it is unlikely that the portion of the network requiring upgrade within the next 50 years will be as high as 83 %. Table 13 summarises the age of pipes in the catchment.

Table 13: Pipe ages in the Port Chalmers catchment

Installation date	Approximate age	Number of pipelines	Length of pipe (m)	% of pipe length
1900 or before	> 110 years	88	3421	83
1901 to 1920	90-110 years	0	0	0
1921 to 1940	70-90 years	0	0	0
1941 to 1960	50-70 years	0	0	0
1961 to 1980	30-50 years	15	308	7
1981 to 2000	10-30 years	15	233	6
2001 to 2009	< 10 years	5	176	4

5.8.5 Network capacity

The stormwater model estimated the following:

- 95% of the network can accept a 1 in 2 year ARI rainfall event;
- 67% of the network can accept a 1 in 10 year ARI rainfall event; and
- 48% of the network can accept a 1 in 100 year ARI rainfall event.

There are some restrictions in the network to the west of the catchment as pipes are predicted to be flowing full during the 1 in 2 year ARI rainfall event. The catchment is not significantly influenced by tides but flooding in some conditions could be affected by tidal conditions.

5.8.6 Flooding issues

The flood hazard rating for the Port Chalmers catchment was predicted as 'moderate' to 'significant'. With the main locations potentially impacted by flooding being the George/Wickliffe Street intersection, George Street and Beach Street. Flooding may also occur to the west of the catchment at Albertson Avenue. Much of the deep flooding was predicted to be located in roads resulting in some disruption to traffic.

Nuisance flooding was predicted in various locations throughout the Port Chalmers catchment due to hydraulic restrictions caused by limited pipe capacity, insufficient network capacity and tidal influence on the network. The areas affected were identified as:

- Albertson Avenue (west);
- Albertson Avenue (east) / Wickliffe Terrace;
- George Street / Wickliffe Terrace;
- George Street / Beach Street; and
- Mary Street.

Habitable floor level flooding is predicted to occur on 4 land parcels within the catchment during the 1 in 10 year ARI event and increases to approximately 12 properties during the future 1 in 50 year ARI rainfall event. Deep flooding on Beach Street during this larger event may pose a risk to building interiors but across the catchment the majority of flooding is expected to be away from buildings.

The areas where the model has predicted potential flooding issues in a 1 in 10 year ARI event and a 1 in 100 year ARI event (worst case scenario) are shown in Figure 33 and Figure 35. Predicted habitable floor flooding in a 1 in 50 year event is shown on Figure 34.

Figure 32: Port Chalmers catchment

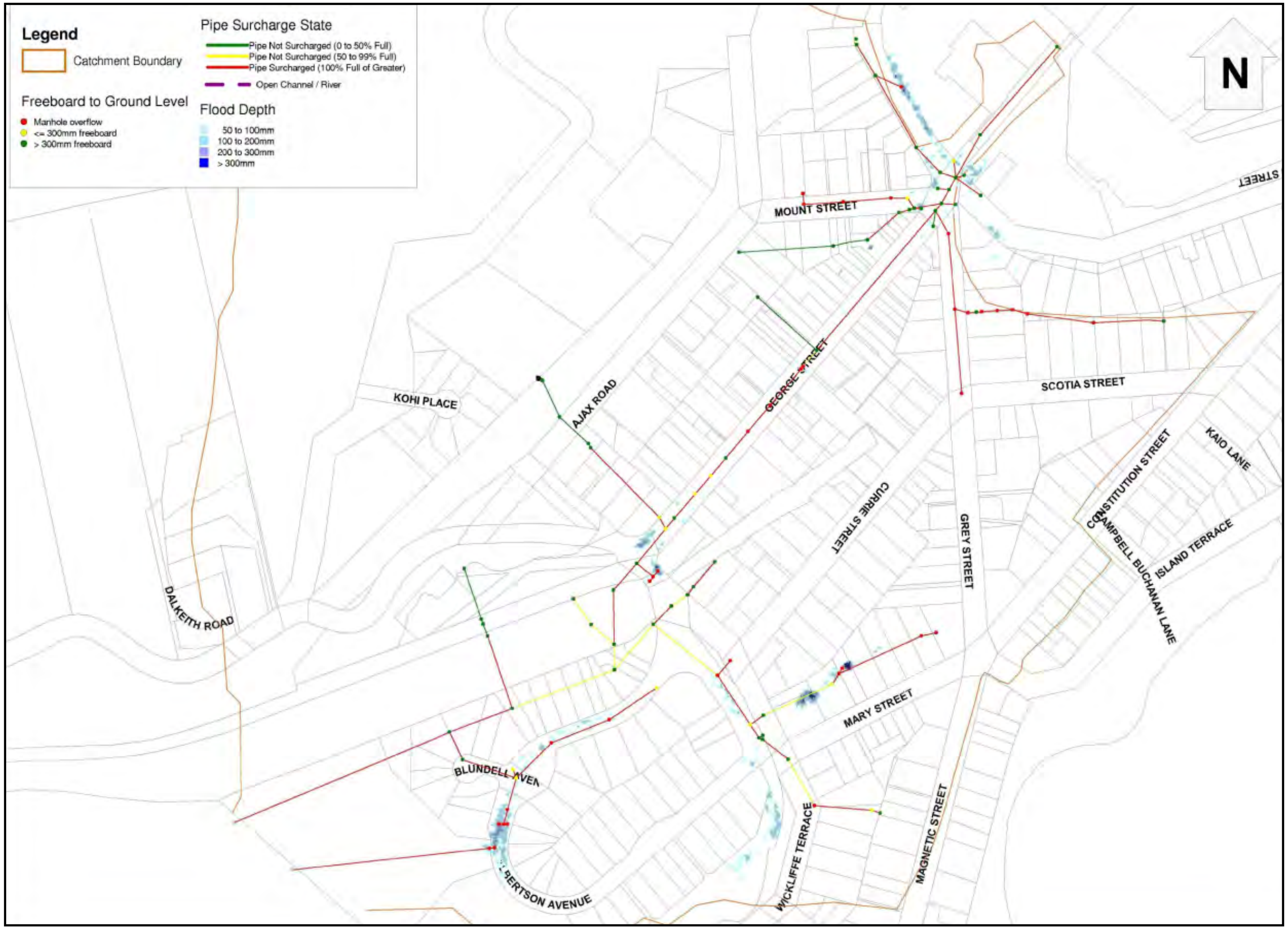


Figure 33: Port Chalmers catchment predicted flood hazard during 1 in 10 year ARI rainfall event (2010)

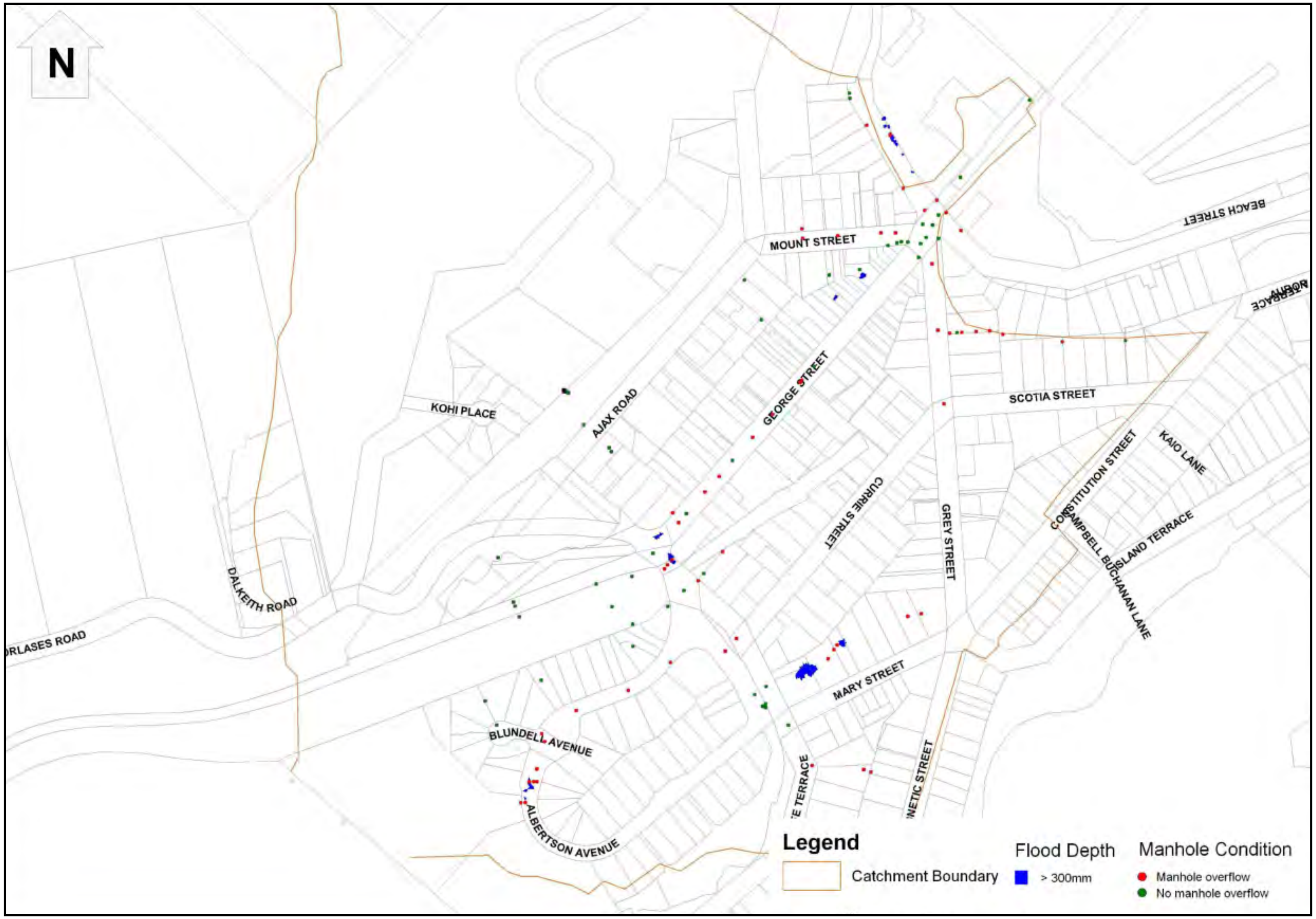


Figure 34: Port Chalmers catchment potential habitable flooding during 1 in 50 year ARI rainfall event

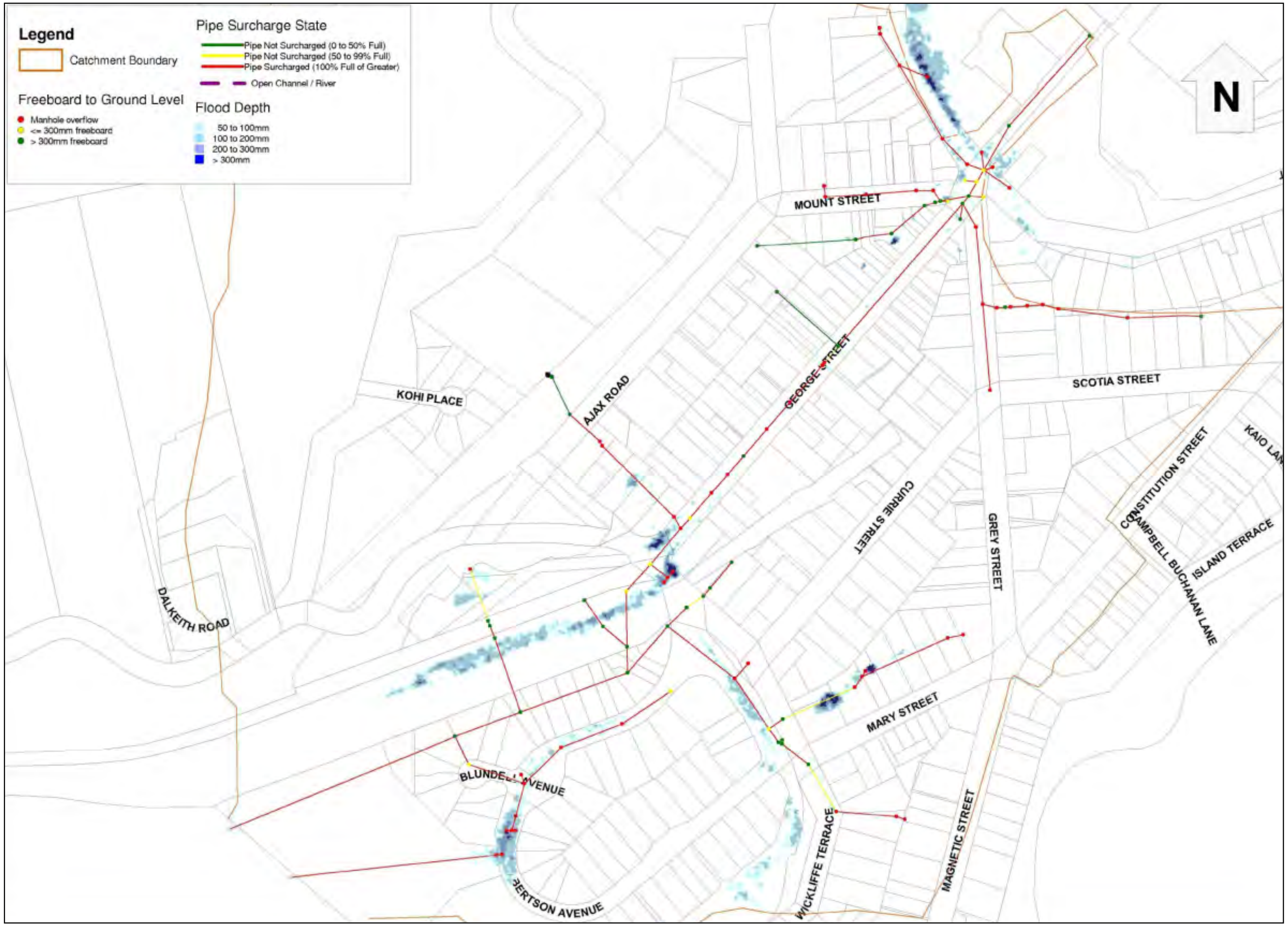


Figure 35: Port Chalmers catchment predicted flood hazard during 1 in 100 year ARI rainfall event (2060)

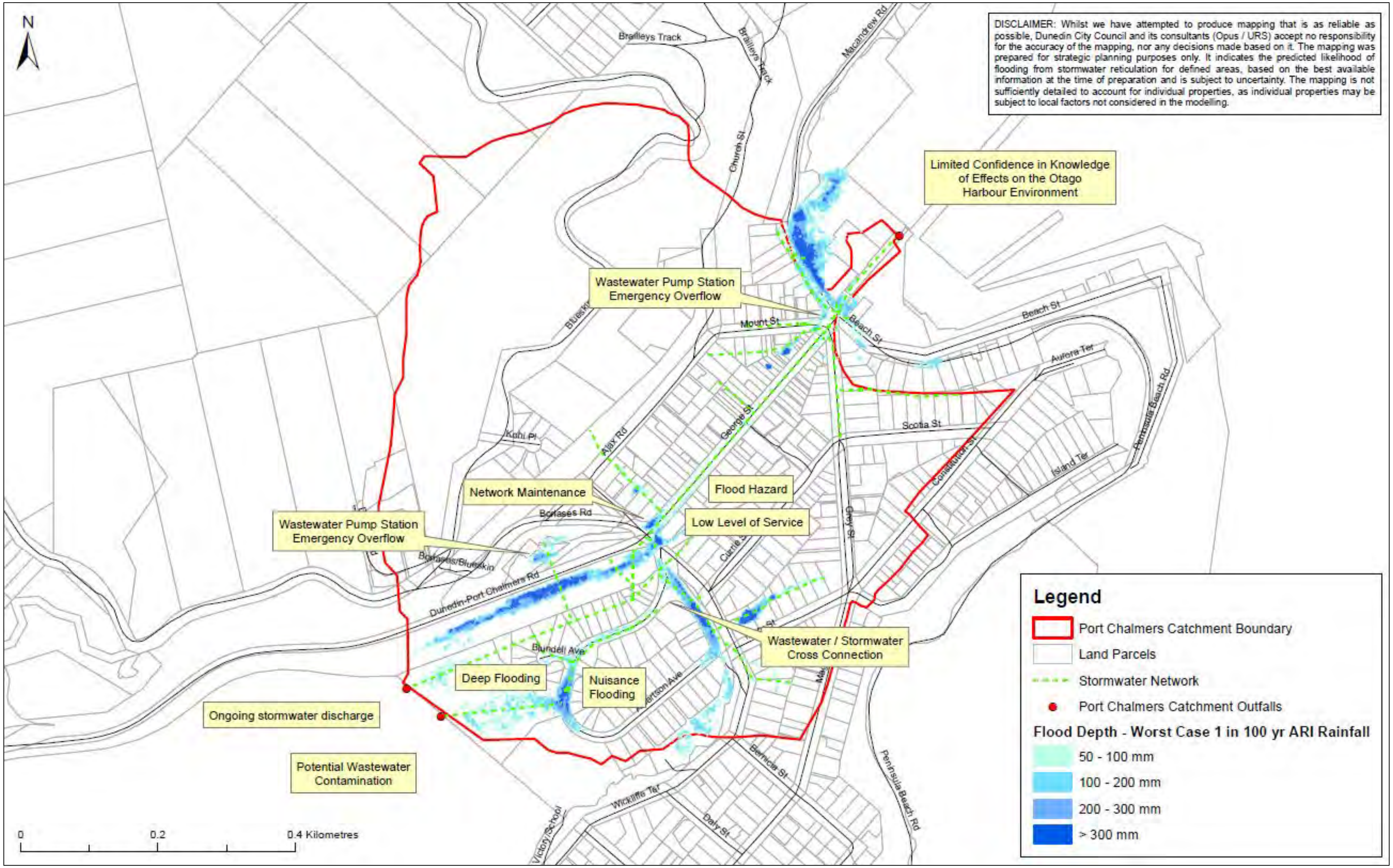


Figure 36: Summary of Port Chalmers catchment issues

5.9 Portsmouth Drive

5.9.1 Location, topography and geology

The Portsmouth Drive catchment, shown in Figure 37, is approximately 40 ha of flat, low-lying reclaimed land between South Dunedin and the harbour.

A causeway was constructed around the head of the harbour in 1912, and the area behind the causeway (known as 'the Southern Endowment') was filled with dredged harbour tailings between the 1940s and the 1970s. The extent of other types of fill, such as domestic and industrial waste, is unknown. Drainage capabilities of this material will be variable.

The Portsmouth Drive stormwater network is entirely piped, with no open drains or watercourses in the catchment.

5.9.2 Land use

The area is entirely zoned industrial, and since reclamation has been used for light industry, retail and storage. There is no record of any significant archaeological or heritage sites within the Portsmouth Drive catchment.

Contaminated land

The entire Portsmouth Drive catchment is within an area of reclaimed land adjacent to the harbour. Various types of fill may have been used during land reclamation, so the fill material may contain contaminants. Information available on contaminated land sites may be incomplete, and the extent of remediation is unknown in some instances.

Future land use

The Portsmouth Drive catchment is considered fully developed, however there is the opportunity for re-development within the industrial zone; sites currently used for light industry could be converted to large retail sites, and vice versa.

Imperviousness

As the catchment is zoned industrial, maximum future and current imperviousness is assumed to be 100%.

5.9.3 Stormwater drainage network

Four independent branches discharge to Otago Harbour below the high tide level. The pipes vary between 300 mm and 600 mm diameter, laid at low gradients due to the flatness of the catchment. Table 14 summarises pipe shapes and sizes in the catchment.

Table 14: Pipe shapes and sizes in the Portsmouth Drive catchment

Pipe shape	Pipe size (mm)	Total length (m)
Round	300-375 diameter	420
	>375 to 600 diameter	716

5.9.4 Network age

The northern most outfall is between 50 and 70 years old , while the remaining three outfalls are less than 50 years old. With a theoretical life of 100 years, the renewals programme for the network in Portsmouth Drive would begin in 2040. Via this programme, 43 % of the pipe network would be renewed by 2060. Table 15 summarises the age of pipes in the catchment.

Table 15: Pipe ages in the Portsmouth Drive catchment

Installation date	Approximate age	Number of pipelines	Length of pipe (m)	% of pipe length
1900 or before	> 110 years	0	0	0
1901 to 1920	90-110 years	0	0	0
1921 to 1940	70-90 years	0	0	0
1941 to 1960	50-70 years	15	947	43
1961 to 1980	30-50 years	28	1215	55
1981 to 2000	10-30 years	1	44	2
2001 to 2009	< 10 years	0	0	0

5.9.5 Network capacity

The stormwater model estimates the following:

- 65% of the network can accept a 1 in 2 year ARI rainfall event;
- 35% of the network can accept a 1 in 10 year ARI rainfall event; and
- 22% of the network can accept a 1 in 100 year ARI rainfall event.

The network analysis and flood mapping undertaken for the current land use showed that the predicted level of service provided by the majority of the stormwater network in the Portsmouth Drive catchment is approximately a 1 in 2 year ARI rainfall event. Parts of the network, however, have greater capacity during high frequency events. During a current 1 in 2 year ARI rainfall event combined with a Mean High Water Springs tide condition, model results show that all pipes in the network are flowing full.

5.9.6 Flooding issues

The maximum flood hazard rating for the Portsmouth Drive catchment during a current 1 in 100 year ARI rainfall event was classified as 'significant', with the locations of this rating being Otaki Street, Midland Street and Teviot Street.

In the future rainfall event scenario the maximum flood hazard rating is 'extreme' around the Canongate intake screen, with further areas of 'significant' flood hazard rating on Serpentine Avenue, Clark Street / Maclaggan Street, and Cresswell Street.

Nuisance flooding was predicted in the following areas of the catchment:

- Teviot Street- covering the width of the road with depths above 300 mm in some areas which may cause minor traffic disruptions.

- Midland Street- covering the width of the road but with depths less than 200 mm which are unlikely to render the road completely impassable.

- Orari Street and Otaki Street- predominantly along the kerb and not predicted to extend across the width of the road.

Habitable floor level flooding was predicted to affect 5 land parcels in the 1 in 10 year ARI event and increase to approximately 12 properties during the future 1 in 50 year ARI event. The majority of flooding was expected to be away from buildings but deep flooding predicted on Beach Street may pose risks to building interiors.

The areas where the model has predicted potential flooding issues in a 1 in 10 year ARI event, and a 1 in 100 year ARI event (worst case scenario) are shown in Figure 38 and Figure 40. Predicted habitable floor flooding in a 1 in 50 year event is shown on Figure 39.

Figure 37: Portsmouth Drive catchment

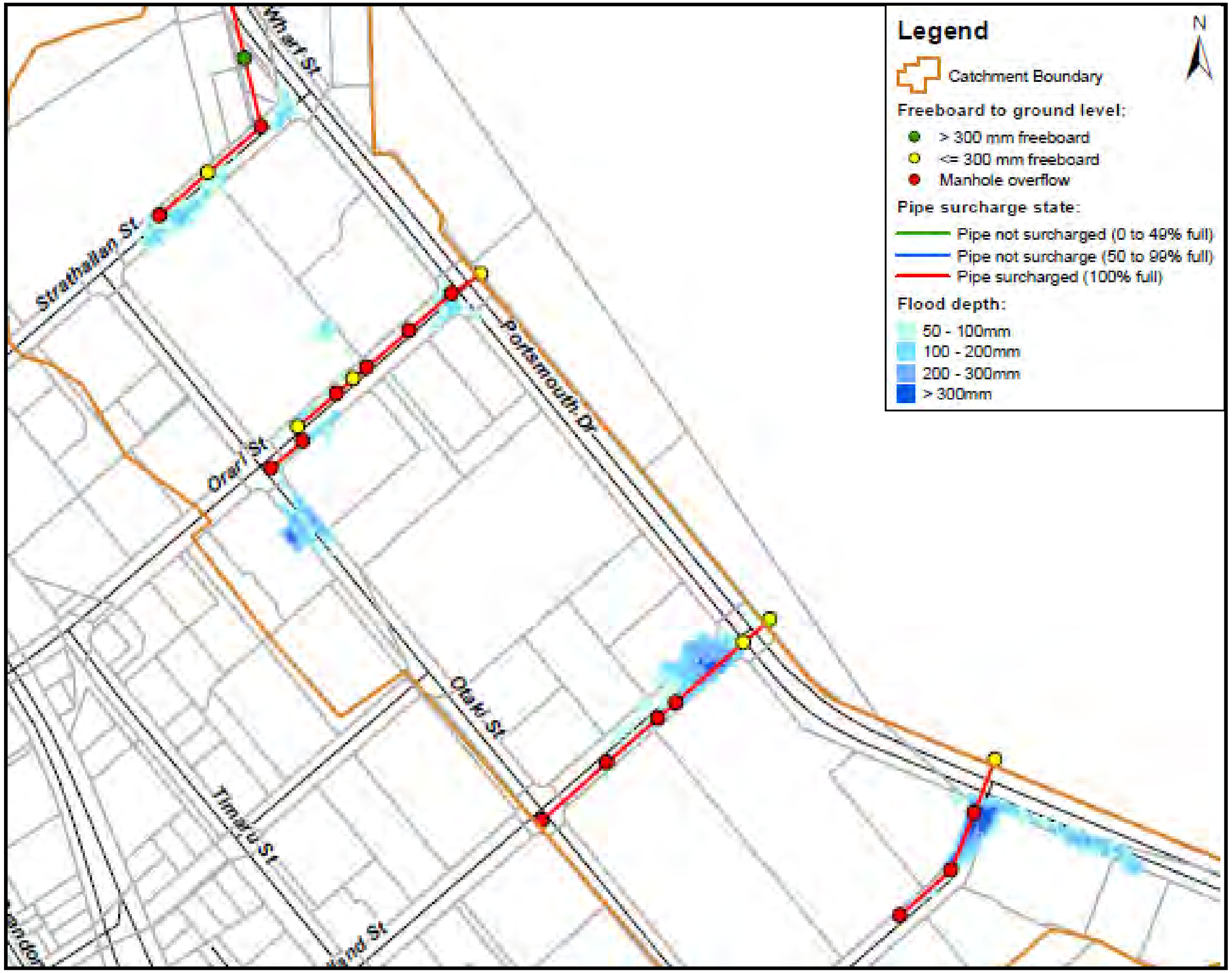


Figure 38: Portsmouth Drive catchment predicted flood hazard during 1 in 10 year ARI rainfall event (2010)

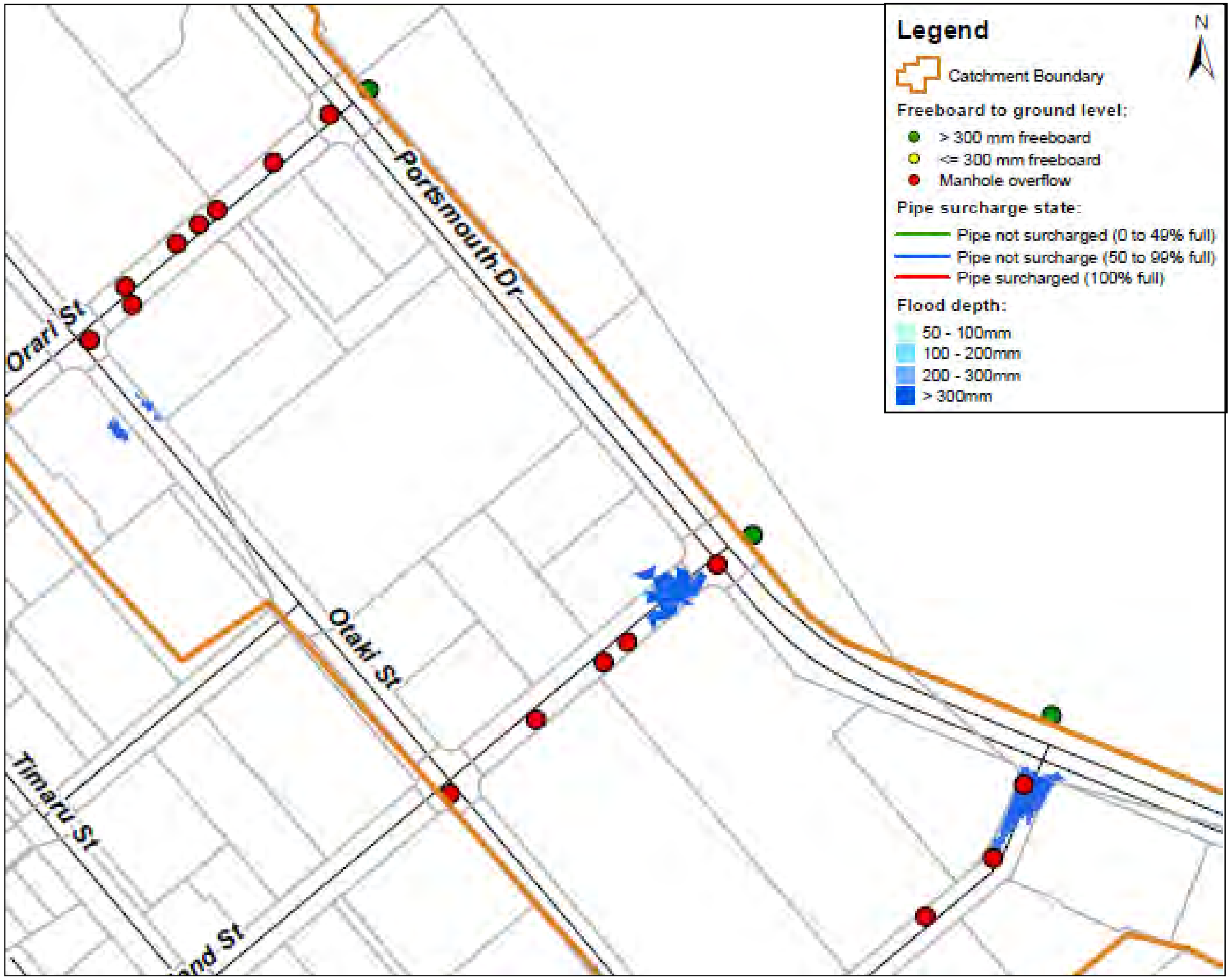


Figure 39: Portsmouth Drive catchment potential habitable floor flooding during 1 in 50 year ARI rainfall event

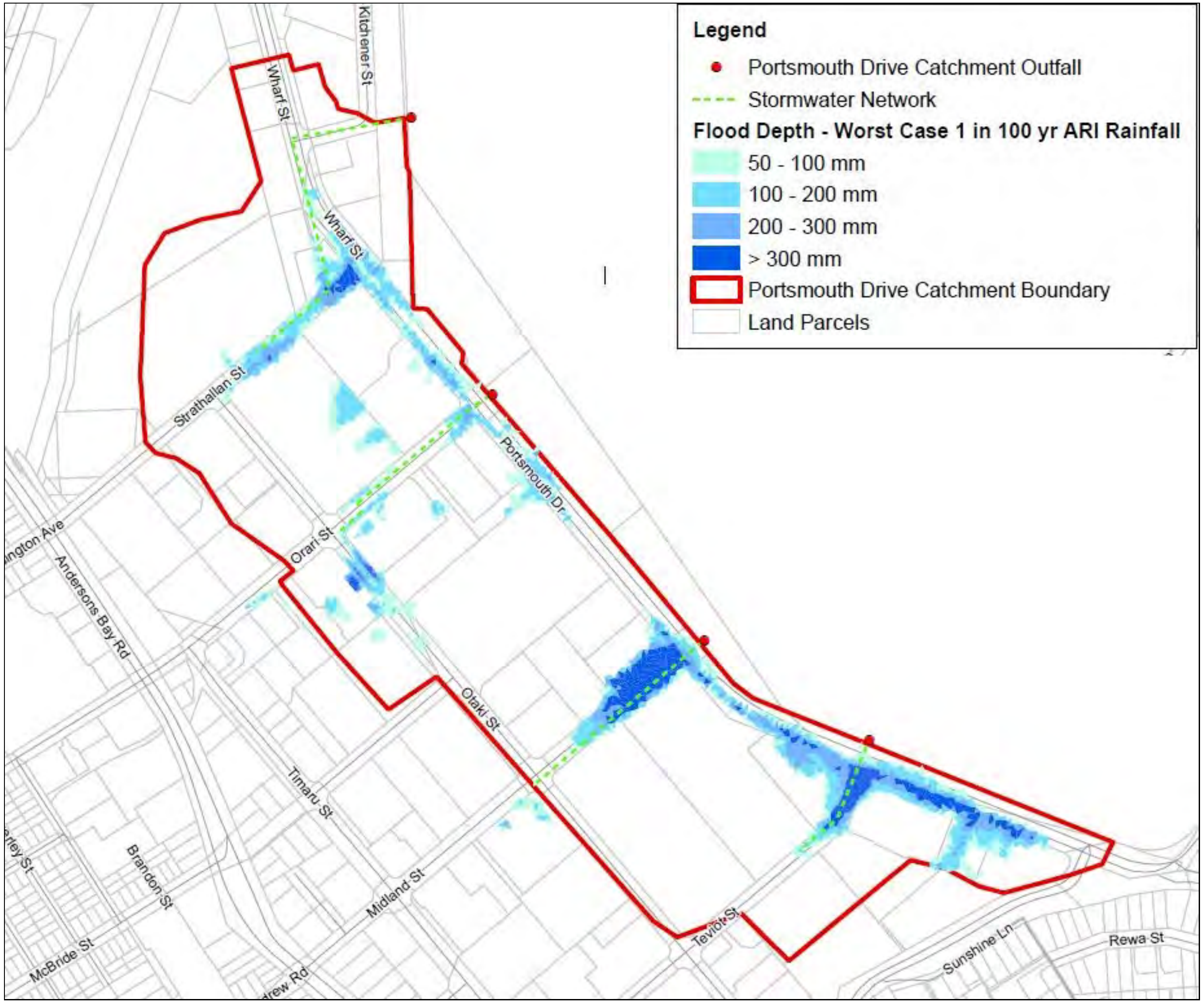


Figure 40: Portsmouth Drive catchment predicted flood hazard during 1 in 100 year ARI rainfall event (2010)

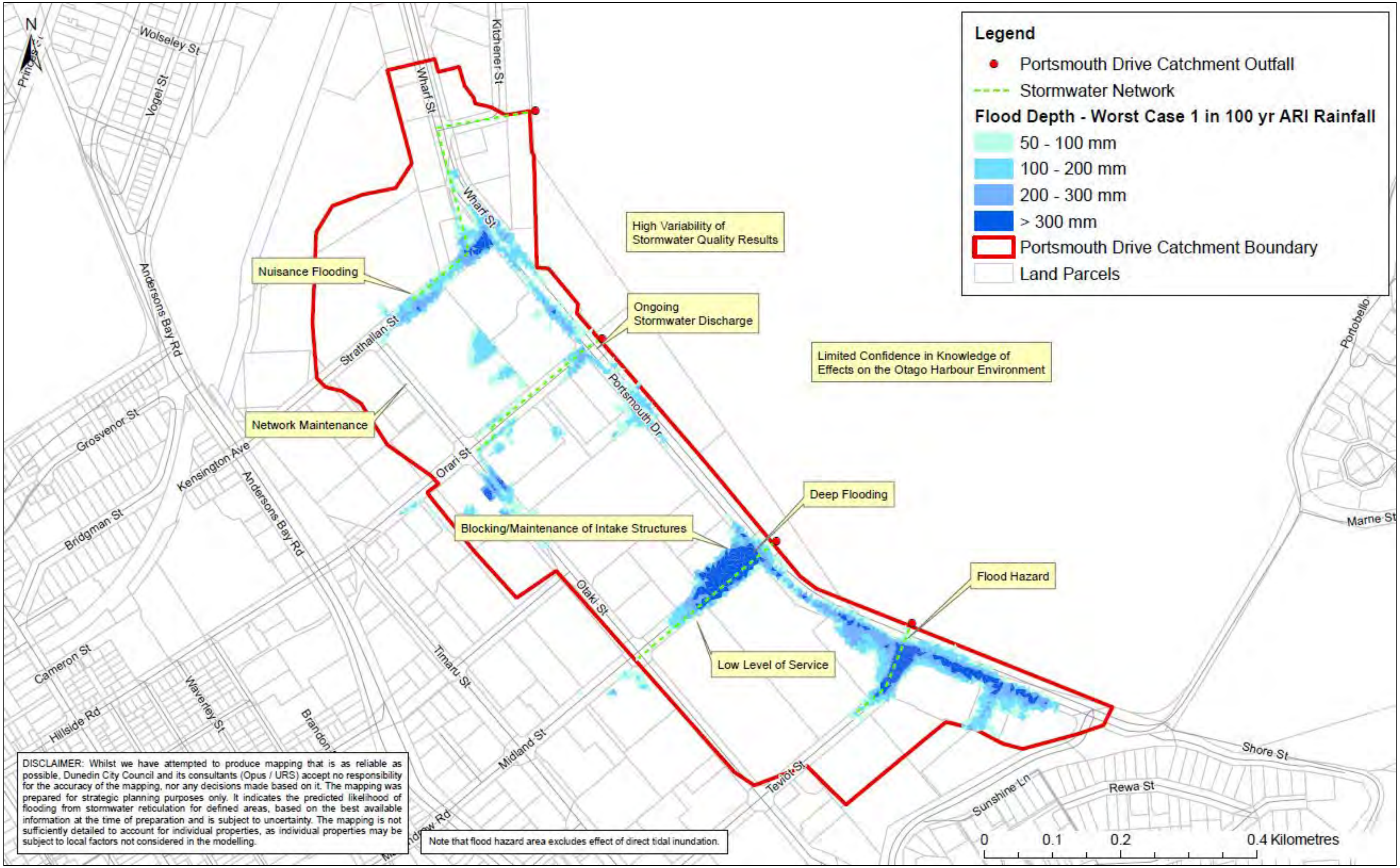


Figure 41: Summary of Portsmouth Drive catchment issues

5.10 Ravensbourne

5.10.1 Catchment location, topography and geology

The Ravensbourne catchment, shown in Figure 42, is relatively small at approximately 25 ha. Land use consists primarily of industrial lots on flat, harbourside land below steep bush covered hillside adjacent to a quarry. There are some small areas of road, including State Highway 8. The excavation of a quarry has reduced the area of steep hillside draining to Ravensbourne Road, thus significantly modifying the upper catchment drainage area, and likely contributing to changes in the original flow regime. The majority of the adjacent quarry drains outside the catchment.

South of Ravensbourne Road the coastal margins of the catchment are flat, low-lying reclaimed areas. Natural ground comprises gravels, sands, marine silts and clays, with fill most likely from industrial and domestic waste, and material from the adjacent quarry operation. Drainage capabilities will be variable. The surrounding hills are basalt, which is reflected in the topography by the lack of surface features that are generally formed by runoff erosion.

The only natural stream is a small, likely ephemeral gully draining the hillside to the north. Flow is intercepted at Ravensbourne Road and diverted via pipework and an open channel to an outfall discharging to the Otago harbour. Any runoff from the rest of the hill is captured by the roadside drainage network.

5.10.2 Land use

Land use has changed little over time, being approximately 40% industrial, with no residential housing. The remainder of the catchment is rural. The hills are covered in bush and scrub, with an area of plantation forest. The coastal flat area comprises reclaimed land.

The petroleum tank farm on Ravensbourne Road was the first major industrial activity to occur in the catchment post 1950s. Other industrial activities include storage of wood and wood products, wool scouring and tanning processes (1980s). Between the 1970's and 1990's there was an increase in covered buildings in the catchment and a reduction in the open storage of wood products.

There are no records of significant archaeological or heritage sites within the Ravensbourne catchment.

The Otago Boat Harbour Recreation Reserve is located on Magnet Street and is well used.

Resource consents within the catchment

Otago Regional Council have consented a number of discharges to the Coastal Marine Area from a series of outfalls from the Ravensdown Fertiliser Co-operative, which occupies a site adjacent to this catchment to the east. The discharges include cooling water, process water, washdown water, stormwater and scrubber liquid from the fertiliser works. These discharges share the same receiving environment as the DCC stormwater discharges.

Contaminated land

There is a contaminated site within the Stadium boundary (formerly 77 Parry Street). This site was in use as a saw mill and timber storage area (1948 until 1980), then for tanning and wool scouring until at least 1993. The land adjacent to the harbour was reclaimed with various and unknown types of fill, which may contain contaminants.

Future land use and imperviousness

The flat industrial area that forms around 40% of the catchment is mostly impervious, with the exception of the reserve area adjacent to the shoreline, and the rural area. Land use, and therefore imperviousness, is not expected to change significantly over the next 50 years.

5.10.3 Stormwater drainage network

The flat industrial area is drained via two piped networks which discharge to the harbour on Magnet Street. Runoff from the hillside is collected via a natural gulley which is intercepted at Ravensbourne Road and diverted via pipework and an open channel to the harbour. The gully is suspected to be ephemeral in nature, given the small catchment area.

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

The network comprises relatively small pipes laid at flat gradients. All of the pipes in the catchment have diameters of between 225 mm and 450 mm. Table 16 summarises pipe shapes and sizes in the catchment.

Table 16: Pipe shapes and sizes in the Ravensbourne catchment

Pipe shape	Pipe size (mm)	Total length (m)
Round	150-375 diameter	662
	>375 to 450 diameter	85

5.10.4 Network age

The entire network was installed between 1941 and 1960. With a theoretical life of 100 years, the renewals programme in the catchment would begin in 2040. Via this programme, 100 % of the pipe network would be renewed by 2060 (i.e. within the planning horizon of this ICMP).

5.10.5 Network capacity

The stormwater model estimates the following:

- 100% of the network can accept a 1 in 2 year ARI rainfall event; and
- 75% of the network can accept a 1 in 10 year ARI rainfall event.

The network analysis and flood mapping undertaken for the current land use shows that the predicted level of service provided by the stormwater network in the Ravensbourne catchment is between a 1 in 2 and a 1 in 5 year ARI event. During larger events some manholes are predicted to overflow causing localised flooding.

5.10.6 Flooding issues

Flooding in the Ravensbourne catchment is predicted to be limited as flood depths are expected to remain shallow and confined to road corridors. The flood hazard rating was classified as 'low' and there is little risk of habitable floor level flooding as the flood depths are not predicted to be greater than 300 mm.

Nuisance flooding may occur at the eastern and western ends of Parry Street but is predicted to remain within the road and at depths that would not cause traffic disruptions.

The areas where the model has predicted potential flooding issues in a 1 in 10 year ARI event and a 1 in 100 year ARI event (worst case scenario) are shown in Figure 43 and Figure 44.

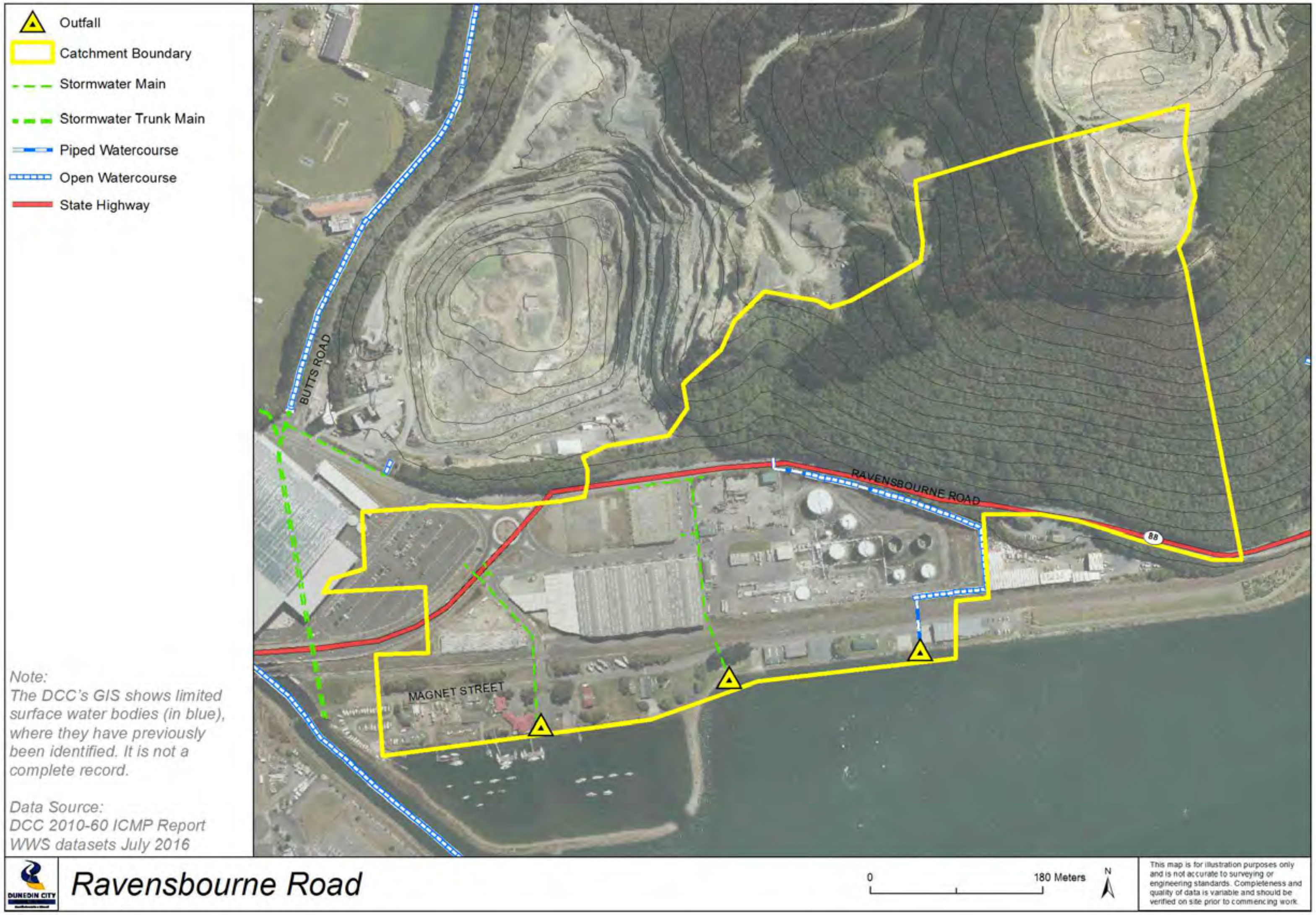


Figure 42: Ravensbourne catchment

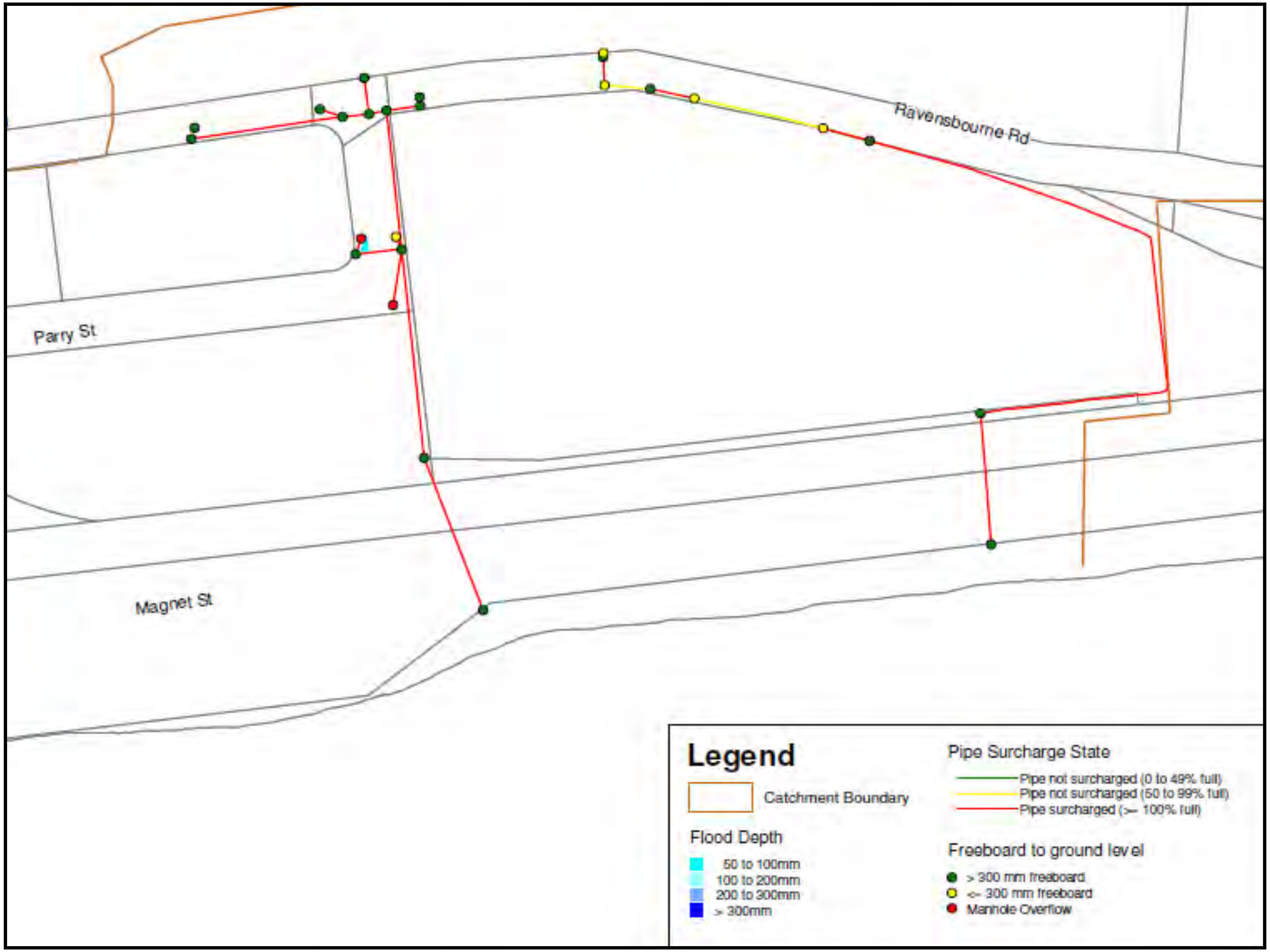


Figure 43: Ravensbourne catchment predicted flood hazard during 1 in 10 year ARI rainfall event (2010)

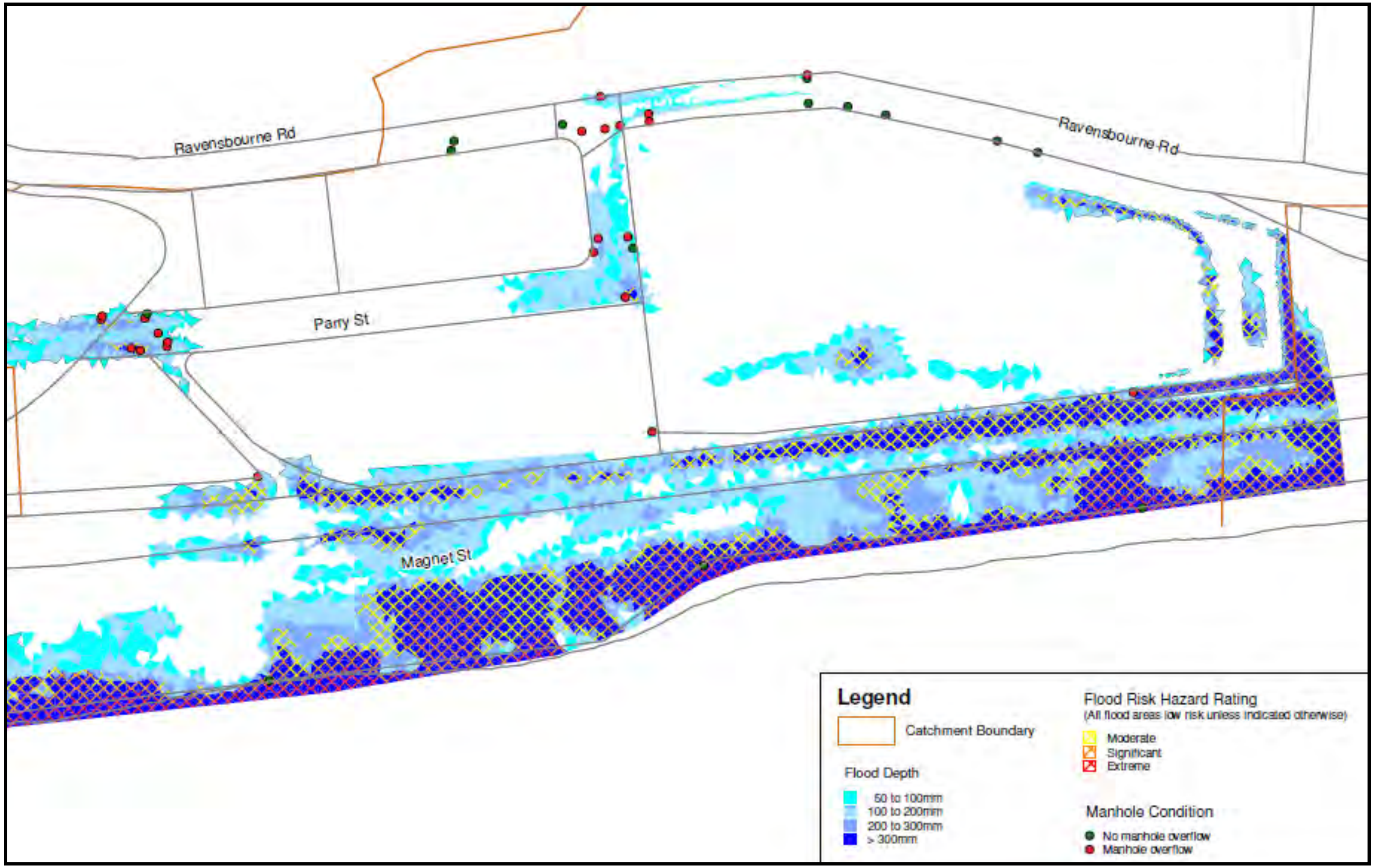


Figure 44: Ravensbourne catchment predicted flood hazard during 1 in 100 year ARI rainfall event (2060)

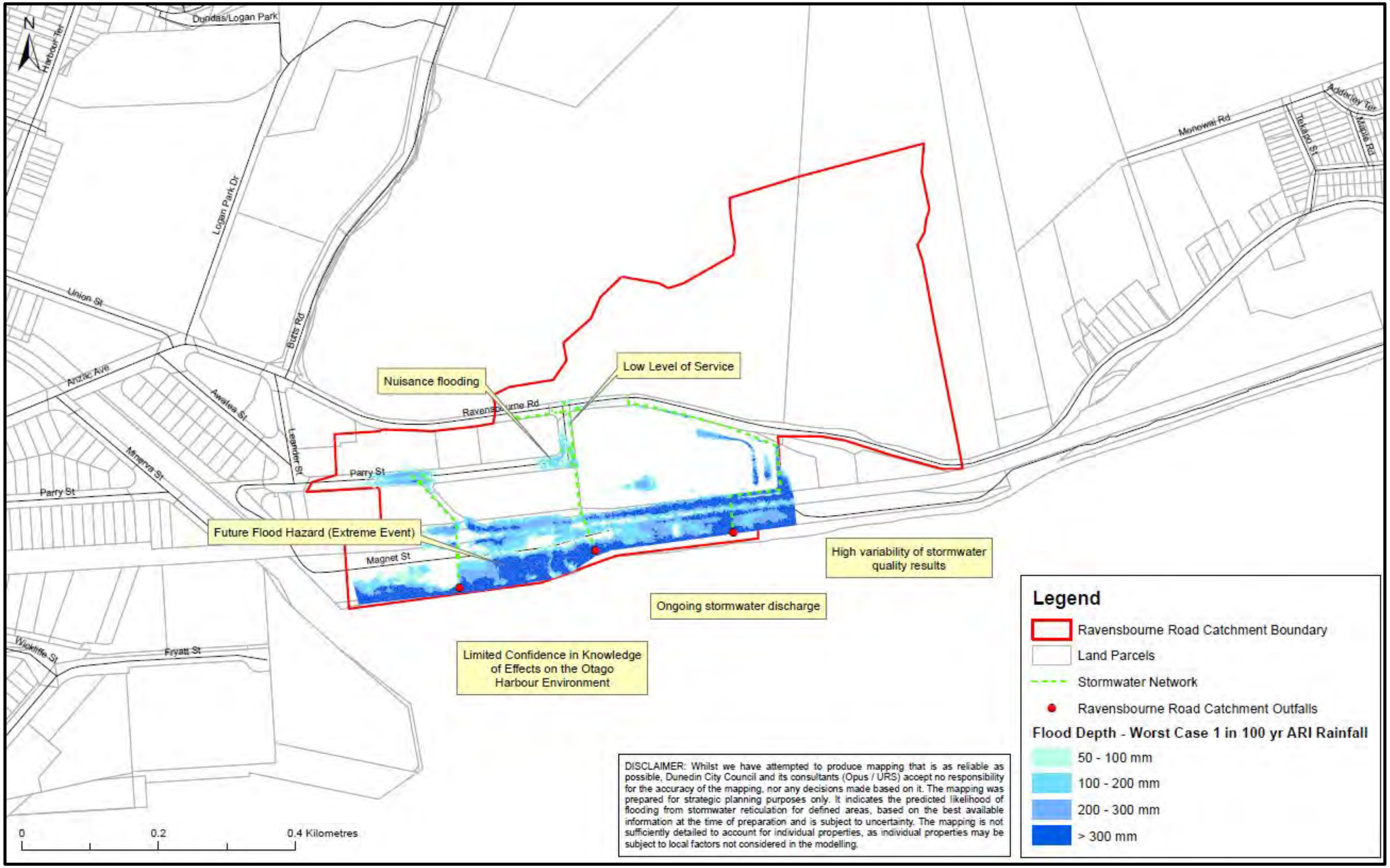


Figure 45: Summary of Ravensbourne catchment issues

5.11 Shore Street

5.11.1 Catchment location, topography and geology

The Shore Street catchment, shown in Figure 46, covers an area of approximately 100 ha, extending from the suburb of Andersons Bay towards South Dunedin and includes parts of Tainui and Musselburgh.

The catchment is characterised by steep gullies at the head of the catchment in the east, and Musselburgh Rise in the west. Approximately 70% of the catchment is located on hillside. The topography flattens towards the harbour. There is a large area of reclaimed land adjacent to the Andersons Bay inlet, some of which is included in the Shore Street catchment.

Infiltration capacity of the volcanic hills will be dependent on the extent of fracturing present. The steep terrain at the head and sides of the catchment directs surface water into one main gully which is found above and surrounding Chisholm Place. The gully then divides into two, one heading in the direction of the harbour to the north and the second towards St Kilda Beach in the south.

In the vicinity of Rawhiti Street is an area of marine terrace deposits which consist of weathered sand and gravel with a cap of loess. To the south of this area are alluvial deposits consisting of gravel, sand and peat. These deposits would be expected to have good drainage capabilities; however this would be influenced by groundwater levels in the area. Close to the harbour is an area of reclaimed seabed, formed from unconsolidated and unsorted material from a variety of sources with variable drainage capabilities.

One stream located in the Shore Street catchment was assessed by Ryder Consulting Limited (2010).

5.11.2 Land use

It is likely that a Māori pa was located on or near Musselburgh Rise as it would have provided a strategic position over the harbour and Otago Peninsula. In the late 19th century a railway and ferry service connected the area with central Dunedin, however, neither of the transport links survived. The inlet incorporates land that was reclaimed in the 1950s to provide grounds for the Bayfield High School. The Shore Street catchment is currently primarily zoned for residential purposes (mainly Residential 1). Less than 1% of the catchment is used for commercial purposes.

The Shore Street catchment does not contain any heritage precincts or heritage structures.

Contaminated land

The northern side of Shore Street, on the edge of the Andersons Bay inlet, has been identified as a contaminated site. A significant area of land has been reclaimed adjacent to the Andersons Bay inlet, and reclaimed land has been used as the site of Bayfield High School on Shore Street - the materials used in the reclamation during the 1950s are unknown, but it are likely to have included domestic waste and other potentially contaminated fills. There is another site on Minto Street (which is possibly landfill, rather than reclamation), and there is also a small landfill site located on Gresham Street.

Future land use and imperviousness

The Shore Street catchment is not expected to undergo significant changes to the existing land use over the next 50 years based on the current understanding of the growth demands on the city and the existing District Plan provisions. Overall imperviousness for the catchment is estimated to be 39%. The maximum future imperviousness has been calculated to increase by 2060.

5.11.3 Stormwater drainage network

There are two main branches based on historic stream gullies. One runs along Tainui Road, picking up flow from the Musselburgh Rise area, with the second following Bayfield Road draining the balance of the catchment. These branches meet at Shore Street, continuing 200 m towards the Shore Street harbour outfall into the Andersons Bay inlet. The inlet then discharges into the harbour beneath a bridge across the causeway.

The network is predominantly piped, but includes several lengths of open channel in the upper reaches of the Tainui Road branch, and also several private drainage discharges to roads. The longest drainage path is approximately 1.42 km. There is one natural stream in the Shore Street catchment, which receives discharges directly from the stormwater network as well as direct runoff from surrounding land.

There are a number of smaller pipes in the catchment and a significant length of large 900 mm diameter pipe. There is a tidal ingression flap gate at the outfall. Table 17 summarises pipe shapes and sizes in the catchment.

Table 17: Pipe shapes and sizes in the Shore Street catchment

Pipe shape	Pipe size (mm)	Total length (m)
Round	100-375 diameter	1826
	>375 to 1800 diameter	2858
Box culvert	900 x 500	68
	1000 x 1000	232
	800 x 800	162
	Other sizes	252

5.11.4 Shore Street catchment network age

The majority of pipework in the catchment was laid in the early to mid-1900s. Based on a theoretical life of 100 years, 66 % of the pipe network will be subject to inspection, which will improve remaining life forecasts or initiate renewal by 2060. Table 18 summarises the age of pipes in the catchment.

Table 18: Pipe ages in the Shore Street catchment

Installation date	Approximate age	Number of pipelines	Length of pipe (m)	% of pipe length
1900 or before	> 110 years	0	0	0
1901 to 1920	90-110 years	26	993	21
1921 to 1940	70-90 years	28	1397	30
1941 to 1960	50-70 years	13	695	15
1961 to 1980	30-50 years	22	526	11
1981 to 2000	10-30 years	26	793	17
2001 to 2009	< 10 years	15	240	5

5.11.5 Network capacity

The stormwater model estimates the following:

- 93% of the network can accept a 1 in 10 year ARI rainfall event;
- 84.5% of the network can accept a 1 in 5 year ARI rainfall event; and
- 76% of the network can accept a 1 in 10 year ARI rainfall event.

Overall, the current level of service of the stormwater network in the Shore Street catchment is variable. The hydraulic capacity of the pipe network in Shore Street catchment is related not only to the pipe sizes and grades, but also to the tidal influence originating from the Andersons Bay outfall.

5.11.6 Flooding issues

Areas of the Shore Street catchment have a 'significant' flood hazard rating, however these are very localised and the remainder of the catchment has low flood risk. The areas of significant hazard predicted were Lochend Street and Cavell Street, Bayfield Road/Musselburgh Rise on the flat and Gresham Street/Norman Street, Tahuna Road and Bayfield Road along the watercourse channels.

Nuisance flooding was predicted in two main areas at Lochend Street and Tainui Road during small recurrence interval rainfall events. The predicted cause of this flooding is inadequate capacity and tidal influence on the network.

Habitable floor level flooding was predicted to affect 2 properties during the 1 in 5 year ARI rainfall event and up to 43 land parcels during the 1 in 50 year ARI future rainfall event which included mean climate change and the maximum land use increase. The areas predicted to experience deep flooding which may put buildings at risk were:

- Lochend Street / Musselburgh Rise;
- Bayfield Road; and
- Norman Street / Gresham Street.

The areas where the model has predicted potential flooding issues in a 1 in 10 year ARI event, and a 1 in 100 year ARI event (worst case scenario) are shown in Figure 48 and Figure 50. Predicted habitable floor flooding in a 1 in 5 year event is shown on Figure 47, and a 1 in 50 year event is shown on Figure 49.

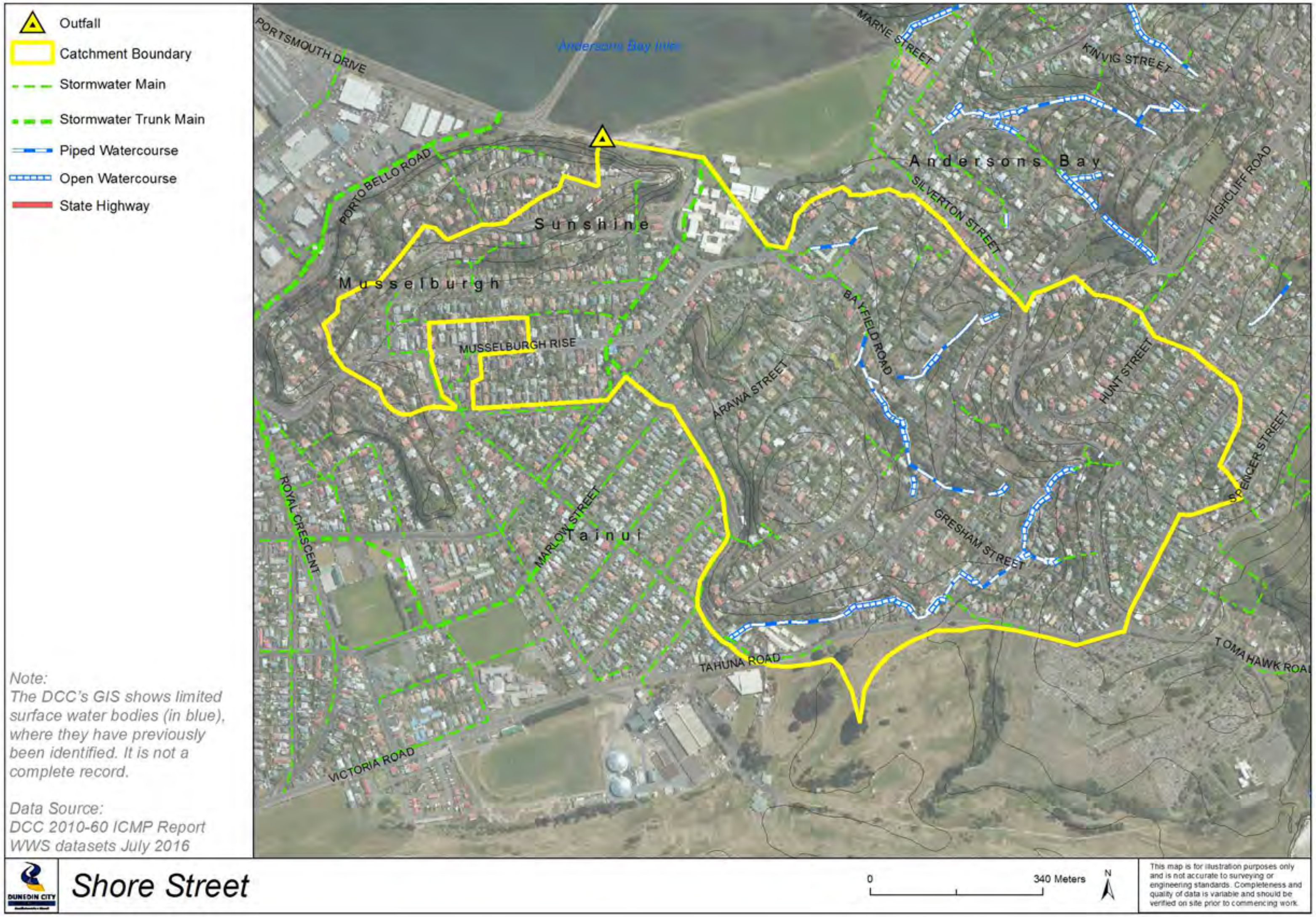


Figure 46: Shore Street catchment

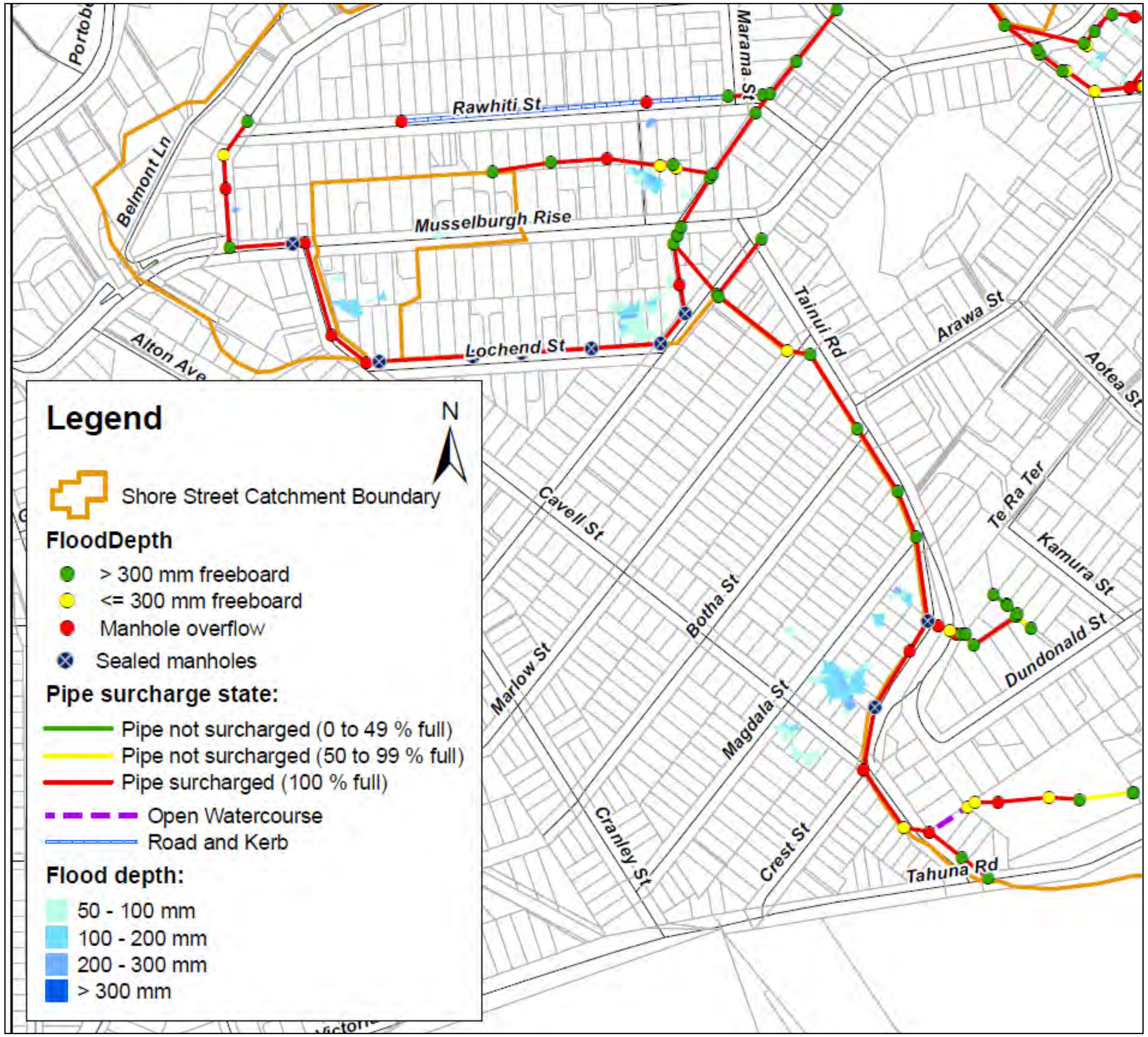


Figure 47: Shore Street (and South Dunedin) catchment potential habitable floor flooding during 1 in 5 year ARI rainfall event

Figure 48: Shore Street catchment predicted flood hazard during 1 in 10 year ARI rainfall event and 1 in 20 year tide level (2010)

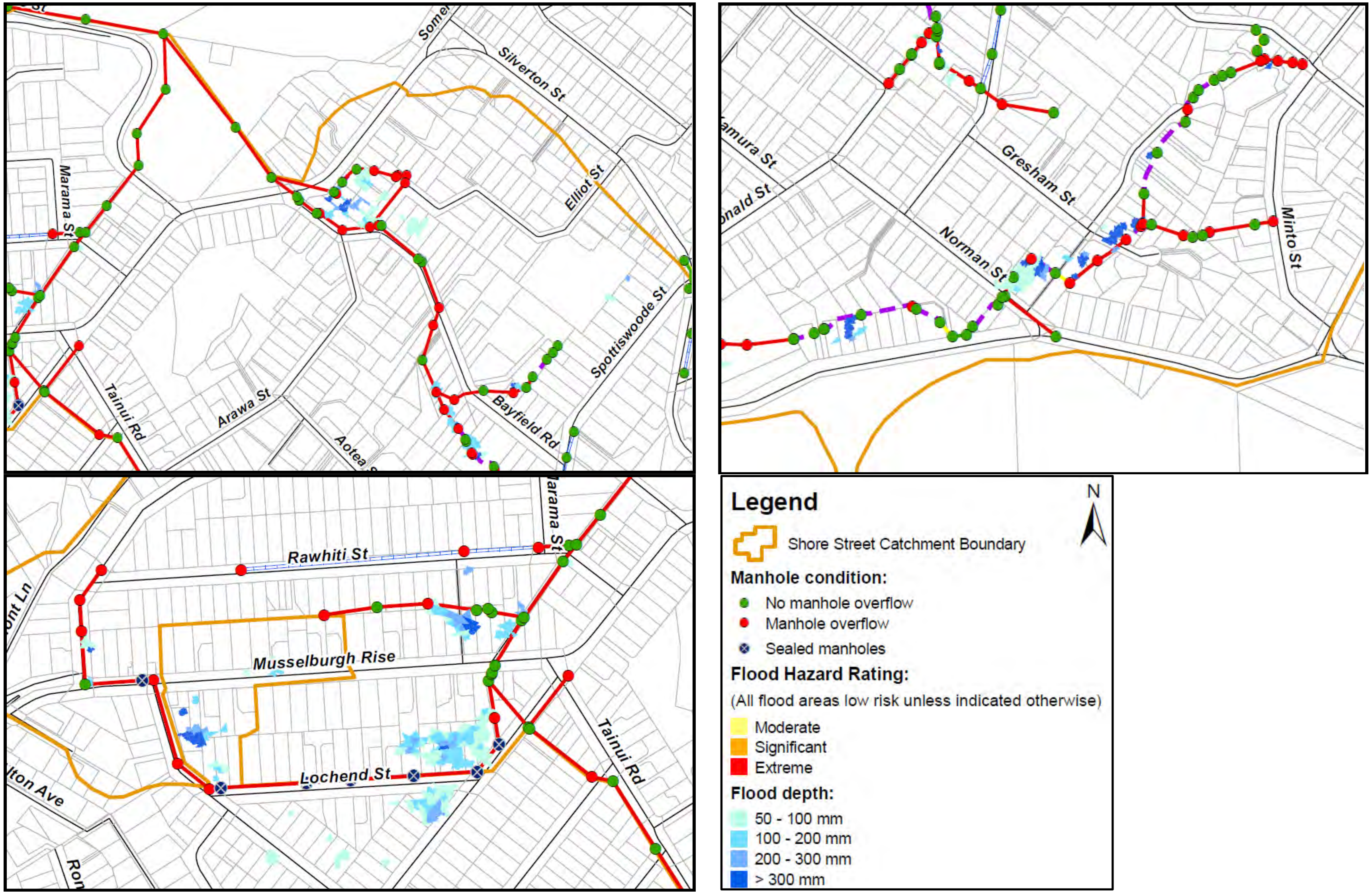


Figure 49: Shore Street catchment potential habitable floor flooding during 1 in 50 year ARI rainfall event

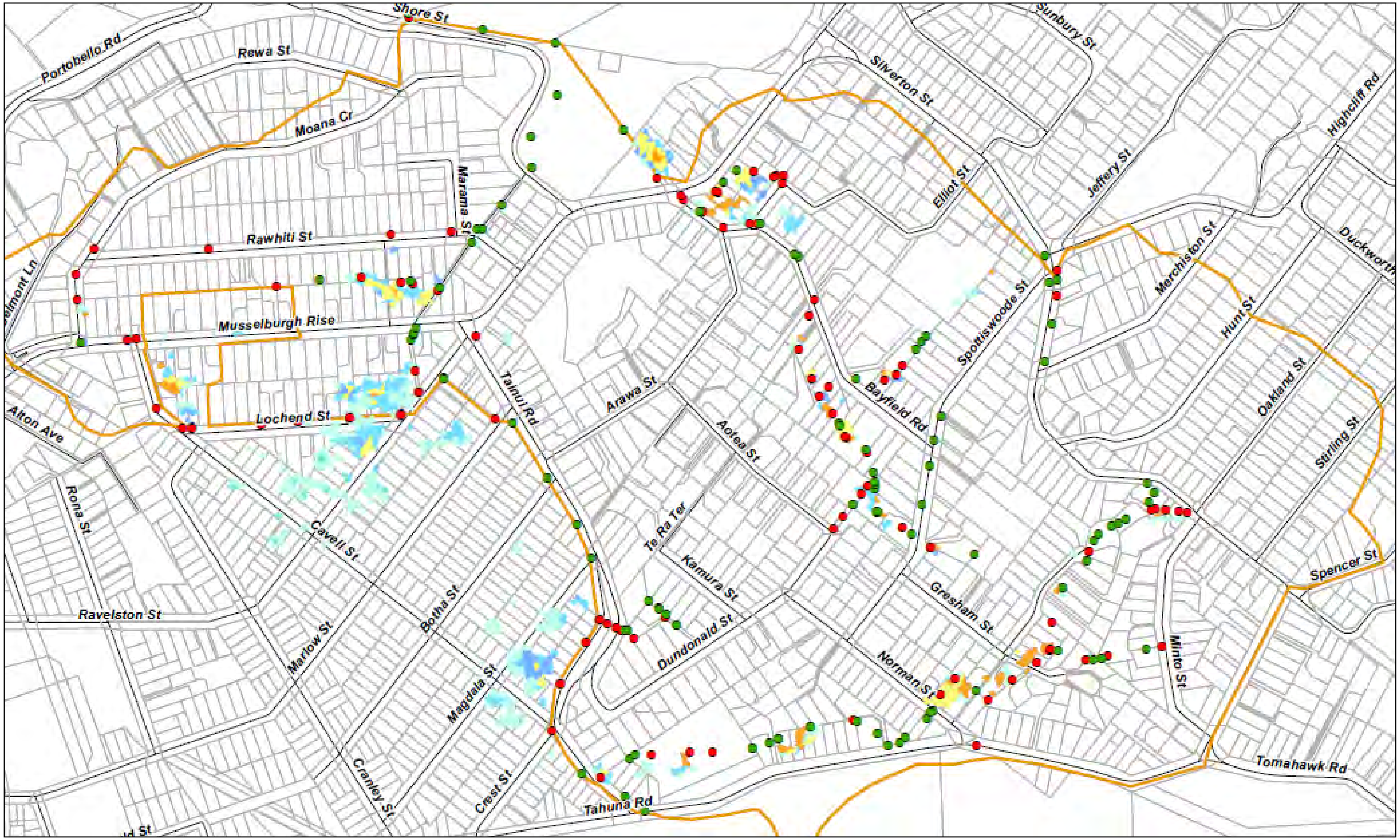


Figure 50: Shore Street catchment predicted flood hazard during 1 in 100 year ARI rainfall event and 1 in 20 year tide level (2060)

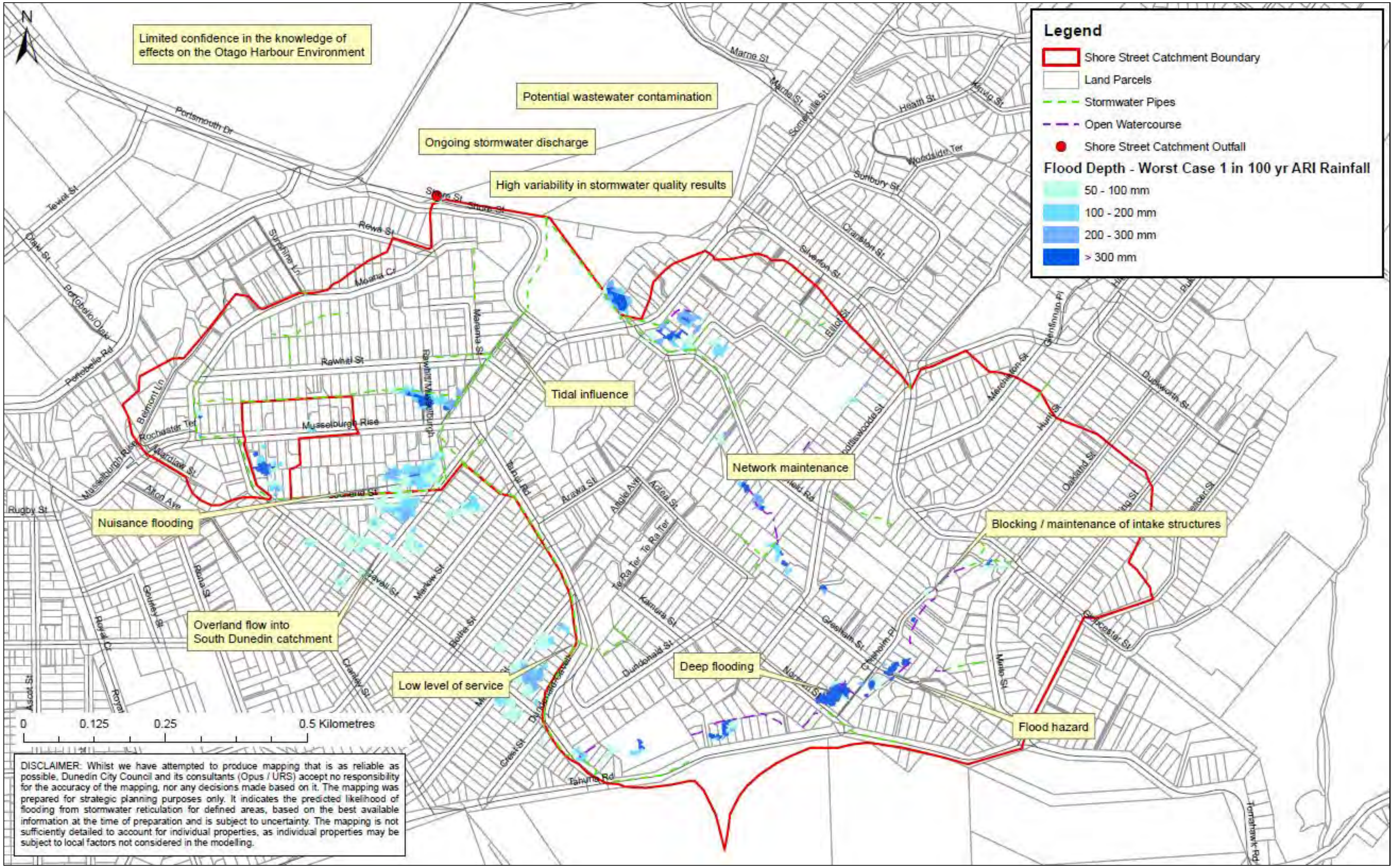


Figure 51: Summary of Shore Street catchment issues

5.12 South Dunedin

5.12.1 Catchment location, topography and geology

The South Dunedin catchment, shown on Figure 531[6], lies adjacent to the upper Otago Harbour and covers an area of approximately 570 ha. The catchment is generally flat and includes most of the South Dunedin suburb.

The catchment lies between 0 and 140 m above mean sea level, with approximately 72% of the catchment no more than 20 m above sea level. This area has an average slope of only 0.008%, providing the potential for flooding due to slow moving surface water. The catchment is bounded by shallow sand dunes to the south, the harbour to the north and with hills to the west and east.

The majority of the catchment consists of well sorted gravel and sand. Reclaimed land to the west of Portsmouth Drive was developed by the Otago Harbour Board, predominantly using dredge tailings between the 1940s and 1978.

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

5.12.2 Groundwater

The ORC has investigated groundwater in this aquifer using three monitoring bores (ORC, 2012). Groundwater is shallow (around 0.3 – 0.7 m below ground level), and tidally influenced. There are also drawdown effects due to the drainage of groundwater where it enters the stormwater and wastewater networks by inflow and infiltration. High and tidally influenced groundwater can limit natural drainage opportunities.

Groundwater quality monitoring has been undertaken by the DCC in the vicinity of the former gasworks site. Gasworks contaminants (heavy metals and polyaromatic hydrocarbons) are elevated. Water quality samples from monitoring wells located closer to the harbour (down gradient of the gasworks) exhibit significantly lower levels of contamination than the gasworks wells. Groundwater is not used for any purpose.

5.12.3 Land use

Land use in the catchment is predominantly residential, with some large scale commercial / retail zoning around Hillside and King Edward Street, and an area of industrial land use adjacent to the harbour. Cargill's corner is considered the city's second most important retail district and historically borders a significant industrial area. Several clusters of heritage structures exist in the northern half of the South Dunedin catchment, as well as a townscape / heritage precinct along King Edward Street that encompasses a number of heritage facades. The location of these sites is relevant when planning stormwater

[6] The catchment boundary has been determined for stormwater management purposes based on the area served by the pipe network and discharged to the Otago Harbour via the Portobello Road Stormwater Pump Station. There is a small area in the northeast of the catchment where overland flow travels into South Dunedin from the adjacent St Clair catchment during large storm events. During small rain events the St Clair stormwater reticulation conveys this stormwater to the St Clair outfall.

management options, which may include devices requiring land acquisition, or capital works involving open trenching.

The area is host to the only gasworks museum in the southern hemisphere, (Category 1 historic building), as well as St Patrick's Basilica and the St Edward Picture Theatre (Category II historic buildings).

Contaminated land

Contaminated sites include the former gasworks and areas of reclaimed land adjacent to the harbour. Various types of fill may have been used during land reclamation, so the material of the fill is likely to be varied and unknown, and may contain contaminants.

Future land use and imperviousness

Overall, catchment imperviousness is calculated at 60%. Land use in the catchment is not expected to change significantly in the future.

5.12.4 Stormwater drainage network

The stormwater network is comprised of shallow pipes and box culverts laid at gentle gradients. The total network is approximately 63 km long. There are no streams or open channels, other than roadside kerbs, in the catchment. Table 19 summarises catchment pipe shapes and sizes.

Table 19: Pipe shapes and sizes in the South Dunedin catchment

Pipe shape	Pipe size (mm)	Total length (m)
Round	100-375 diameter	39016
	375-1500 diameter	18735
Box culvert	1050 x 1200	618
	1200 x 900	818
	1200 x 1350	454
	1275 x 1500	164
	1450 x 900	217
	1494 x 1310	111
	1500 x 1275	605
	1626 x 1242	448
	1800 x 2025	582
	1875 x 1220	254
	2025 x 2100	86
	2100 x 1275	361
	2400 x 2575	12

All stormwater from the catchment discharges into the harbour via the Portobello stormwater pump station. The pump station is equipped with seven pumps ranging in capacity from 0.2 m^3/s to 1.5 m^3/s. A second stormwater pump station at Musselburgh pumps stormwater from a low-lying area in Tainui to the Portobello pump station. It has been operational for over 50 years.

5.12.5 Network age

Based on a theoretical life of 100 years, 55% of the pipe network will be subject to inspection, which will improve remaining life forecasts or initiate renewal by 2060. Table 20 summarises the age of pipes in the catchment.

Table 20: Pipe ages in the South Dunedin catchment

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

5.12.6 Network capacity

The stormwater model estimates the following:

- 82% of the network can accept a 1 in 2 year ARI rainfall event;
- 70% of the network can accept a 1 in 5 year ARI rainfall event; and
- 56% of the network can accept a 1 in 10 year ARI rainfall event.

The network analysis and flood mapping undertaken for the 1 in 10 year ARI rainfall event with current land use showed that approximately 56% of the network in the South Dunedin catchment can accept a 1 in 10 year ARI rainfall event without overflowing. However, results also show that almost the entire system (98%) is fully surcharged during this event.

5.12.7 Flooding issues

The South Dunedin catchment has been the subject of a number of flooding incidents both historically and in recent years (see section 5.3). The June 2015 flood event has resulted in further modelling work being undertaken in the South Dunedin catchment. As analysis and reporting is ongoing, the results will be reported in future updates of the ICMP. Previous modelling carried out for the catchment is summarised below.

The model predicted widespread but generally shallow flooding in the South Dunedin Catchment. During the future extreme planning scenario with a 1 in 100 year ARI rainfall event, only two areas were predicted to have a ‘significant’ flood hazard rating. These areas are the Burns, Law and Baker Street area, and the areas downstream of the Portobello Road Pump Station. Other areas in the catchment where flooding has been predicted were classified as having ‘moderate’ flood risk.

Nuisance flooding was predicted in the following areas of the South Dunedin Catchment:

- Hillside Road North- Josephine Street, Eastbourne Street, Baker Street, Law Street, Neville Street and Burns Street;
- Hillside Road South- Glasgow Street, Reid Street and King Edward Street;
- Ascot Street/ Royal Crescent- Ravelston Street and Normanby Street;
- Tainui- Magdala Street and Botha Street;
- Bay View Road; and
- Hargest Crescent.

The areas within the South Dunedin catchment predicted to experience deep flooding, and therefore potentially resulting in habitable floor level flooding were:

- Properties in the block between Law Street and Baker Street, and on Burns Street near Hillside Road are predicted to be subject to deep flooding.
- Neville Street – this area is serviced by an undersized pipe network.
- Cavell Street – Deep flooding is predicted to potentially affect a small number of properties at the north end of Cavell Street.

Linkages between the stormwater and wastewater networks are also suspected to contribute to flooding issues.

- Wet-weather flooding of both the wastewater and stormwater networks in Surrey Street. Residents have noted a high level of stormwater overland flow from Forbury to Fitzroy Road down to Sussex Street which then ponds. Annual flooding has been recorded to occur at 93 Surrey Street due to runoff from Surrey Street and the adjacent Mobil station on Hillside Road.

The number of properties predicted to be affected by habitable floor level flooding was 1 property during the 1 in 5 year ARI event and up to 31 properties during a 1 in 50 year ARI rainfall event. A number of these properties were only predicted to experience flooding on part of the land parcel.

The areas where the model has predicted potential flooding issues in a 1 in 10 year ARI event are shown in Figure 54 through to Figure 57. The areas of predicted potential flooding issues in a 1 in 100 year ARI event (worst case scenario) are shown in Figure 60. Predicted habitable floor flooding in a 1 in 50 year event is shown on Figure 58 and Figure 59.

5.12.8 Operational issues

Other network specific issues identified for South Dunedin are:

High level stormwater overflows

There is a 'high level overflow', which operates to transfer flows between South Dunedin and the adjacent St Clair catchment (from the Forbury Road stormwater interceptor) during heavy flows. It is not known how often this high level overflow operates the DCC are investigating how a flow recording device may be installed.

To reflect the interconnection between these catchments, in 2016 parts of the St Clair and South Dunedin catchment model have been combined for analysis.

Portobello pump station

The South Dunedin catchment relies on a large pump station stormwater discharge. The pump station pumping rate is determined by a combination of the level in the pump wet-well and the measured flow entering the pump station. The seven pumps at the pump station are of varying sizes and so this control philosophy is required to match the incoming flow to the discharge flow and prevent the pump wet-well from being pumped dry, which would damage the pumps. Improved control philosophy of the pumping station is currently under review in order to maximise efficiency. An investigation to establish reduced operational risk from external influence; for example power failure is also being undertaken.

A new screen that has the facility to be cleaned safely and reliably during high intensity storm events was installed in 2016.

Wastewater overflow

The carrying capacity of Dunedin's aging wastewater network is sometimes exceeded during rainfall, as fresh water enters the wastewater network through inflow and infiltration. To avoid uncontrolled (surcharge) overflow causing habitable floor flooding, or discharge into private gardens or on the road, constructed overflow points were historically installed. These constructed overflows divert excess wastewater into natural water bodies, either directly, or via the stormwater network. There are six such constructed overflows operating in the Dunedin wastewater network, all of which are monitored.

A constructed overflow is located near the intersection of Surrey Street with Hillside Road in South Dunedin. The overflow enters the stormwater network, travelling down Hillside Road, along Timaru Street and into Portobello Road before passing through the Portobello Road pumping station and discharging to the upper Otago Harbour through the associated stormwater outfall.

This constructed overflow has the largest upstream catchment affecting it, and it is linked with the Kaikorai Valley and Kaikorai Common constructed overflows upstream (which discharge into the Kaikorai Stream). Figure 52 plots the incidence and volume of recorded overflows. The upstream Kaikorai overflows alleviate the frequency and volume of overflows at Surrey Street.

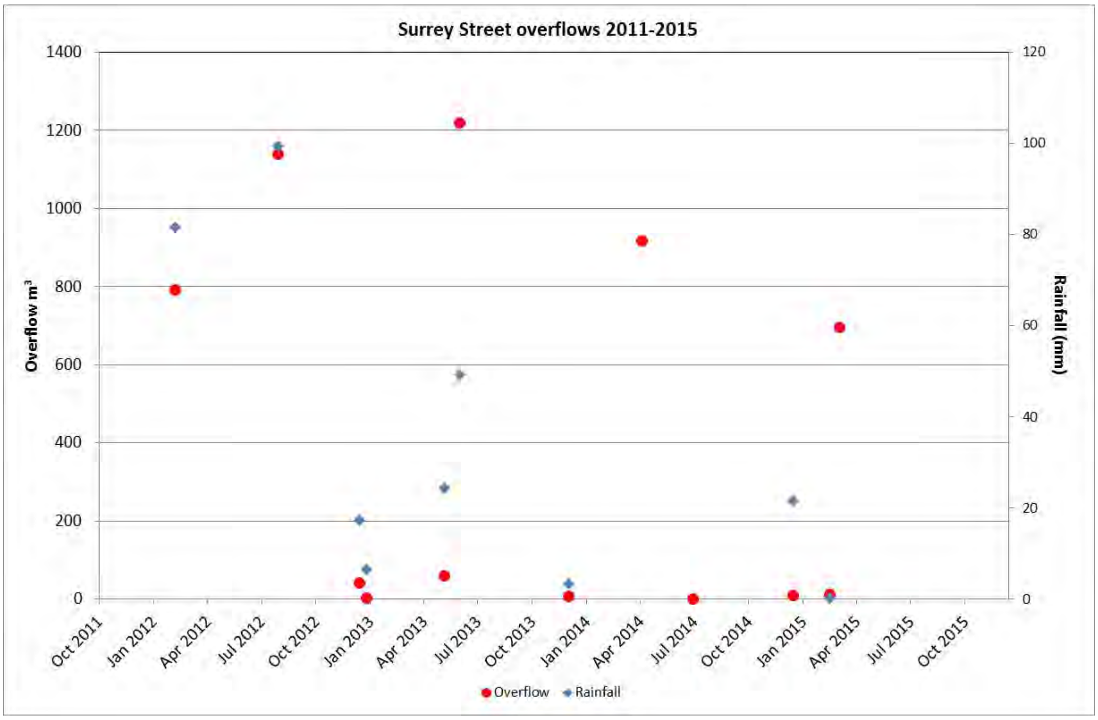


Figure 52: Plot of Surrey Street overflows 2011-2015

When the Surrey Street overflow is triggered it is usually accompanied by surface flooding due to the stormwater network being overwhelmed, and as such poses a significant public health risk. During the 3rd June 2015 flood event the monitor disabled so the period and volume of discharge is unknown. In the period of monitoring the overflow is triggered on average 3 times a year. The average discharge volume is 408 m^3, with a maximum recorded discharge of 1220 m^3.

Consent applications to provide for the discharge of wastewater into water are expected to be lodged in late 2016. The ORC has confirmed that consent RM11.313.09 provides for the wastewater periodically entering the stormwater network to discharge at the Portobello Road outfall.

The DCC has committed to resolving wastewater overflows through its strategic framework and financial planning. The preferred long-term approach is to remove infiltration from the wastewater network, avoiding pipe capacity becoming exceeded. There is a long-term capital programme underway to upgrade and replace pipes in poor condition and with insufficient capacity over the next 30 years. Renewals are currently focused in the upstream Kaikorai catchment, with work scheduled until about 2020. As renewals are completed, the effect on overflows will be gauged, and the works programme revised accordingly.

These upstream works in Kaikorai Valley will have an impact on the Surrey Street overflow, but given the significant size of the catchment upstream of Surrey Street, it may be some time before the overflow is resolved completely.

There is potential for wastewater overflows within both the Kaikorai area and South Dunedin to be mitigated through diversion of some wastewater from Tahuna WWTP to the Green Island WWTP. Such a diversion may require significant investment in both piped and plant infrastructure, would be a long-term approach if hydraulic modelling indicates significant gains could be made.

Figure 53: South Dunedin catchment

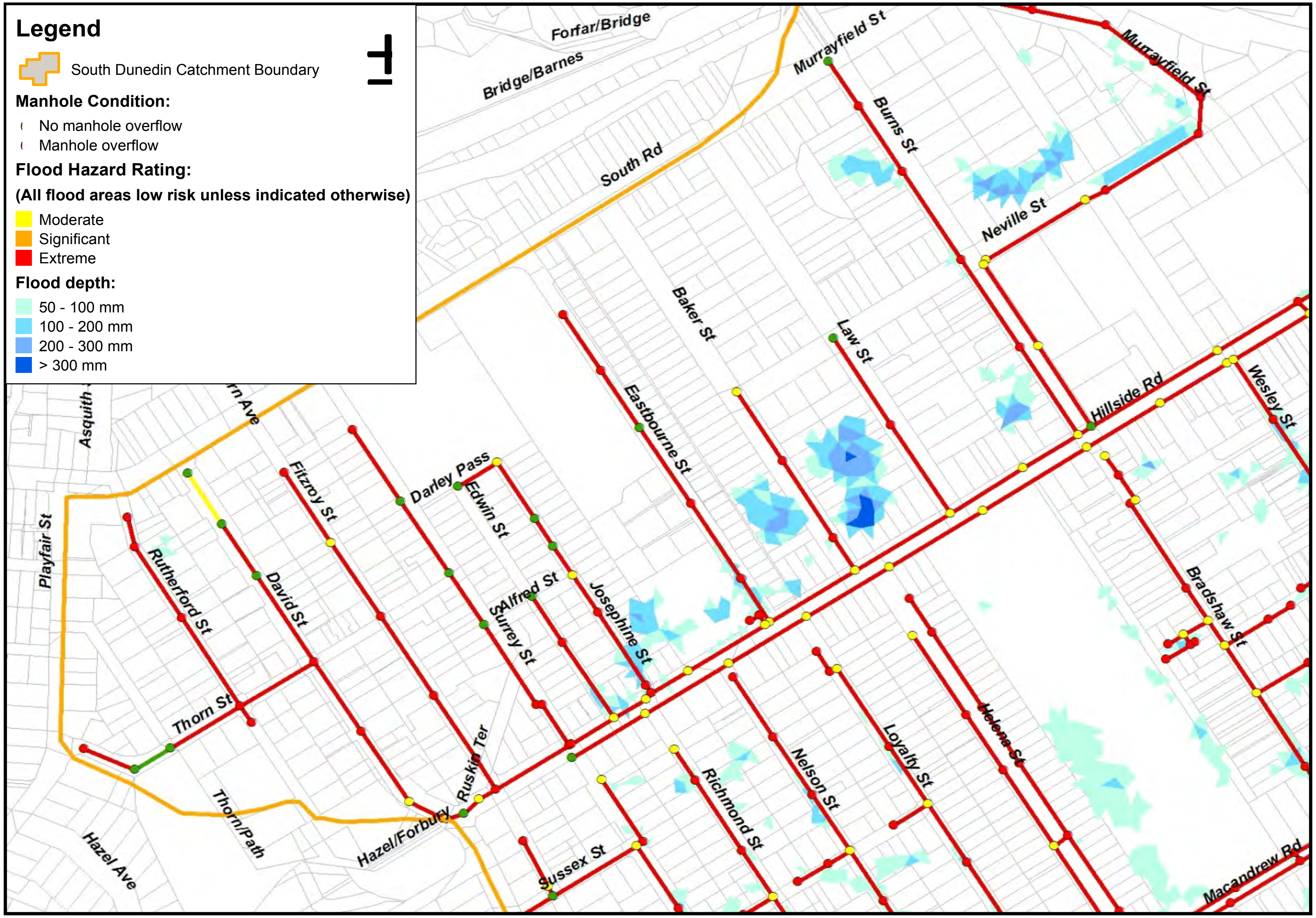


Figure 54: South Dunedin catchment (Hillside Road North area) predicted flood hazard during 1 in 10 year ARI rainfall event

Figure 55: South Dunedin catchment (Hillside Road South area) predicted flood hazard during 1 in 10 year ARI rainfall event

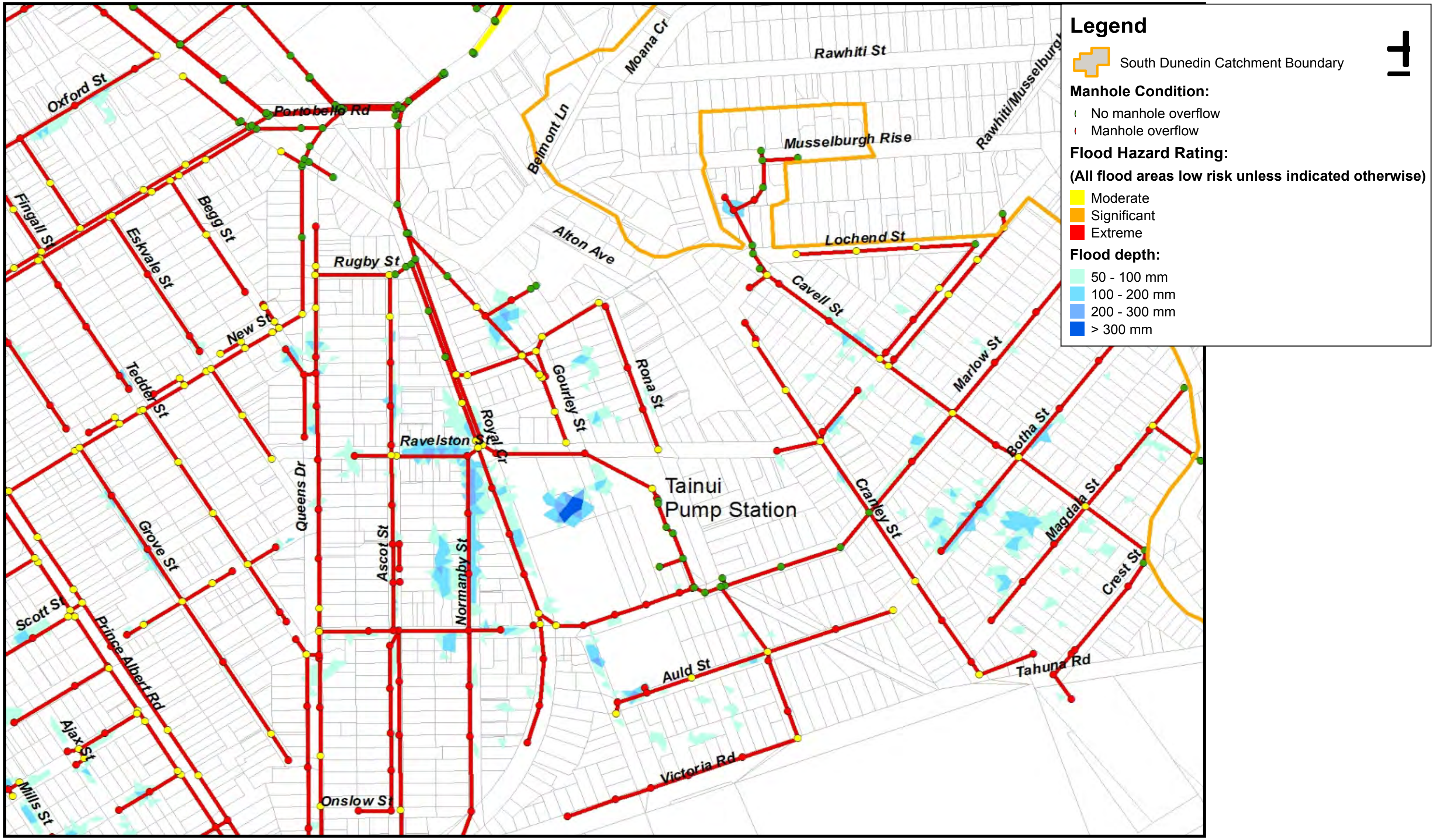


Figure 56: South Dunedin catchment (Tainui area) predicted flood hazard during 1 in 10 year ARI rainfall event

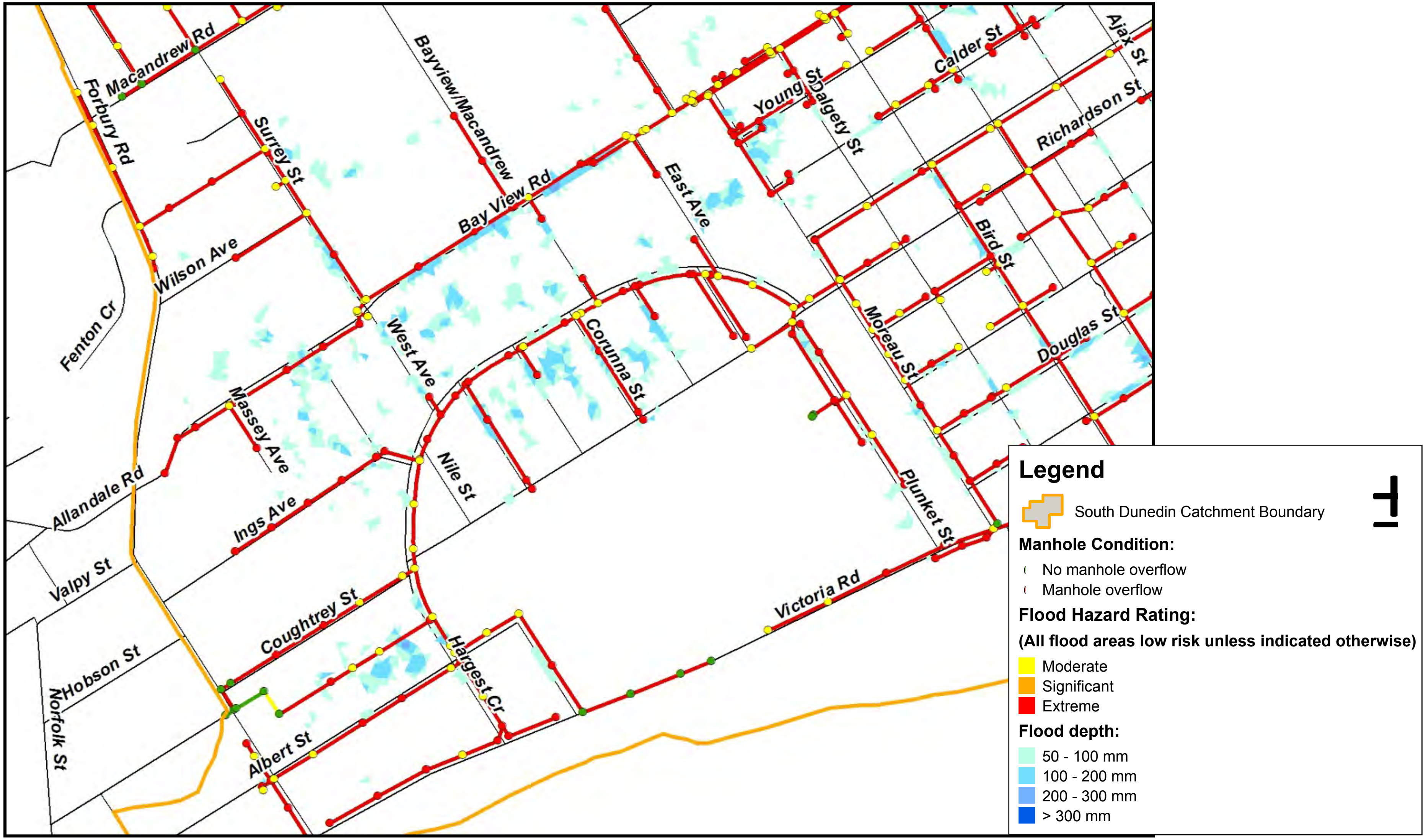


Figure 57: South Dunedin catchment (Bay View Road area) predicted flood hazard during 1 in 10 year ARI rainfall event

Figure 58: South Dunedin catchment (Hillside Road area) potential habitable floor flooding during 1 in 50 year ARI rainfall event

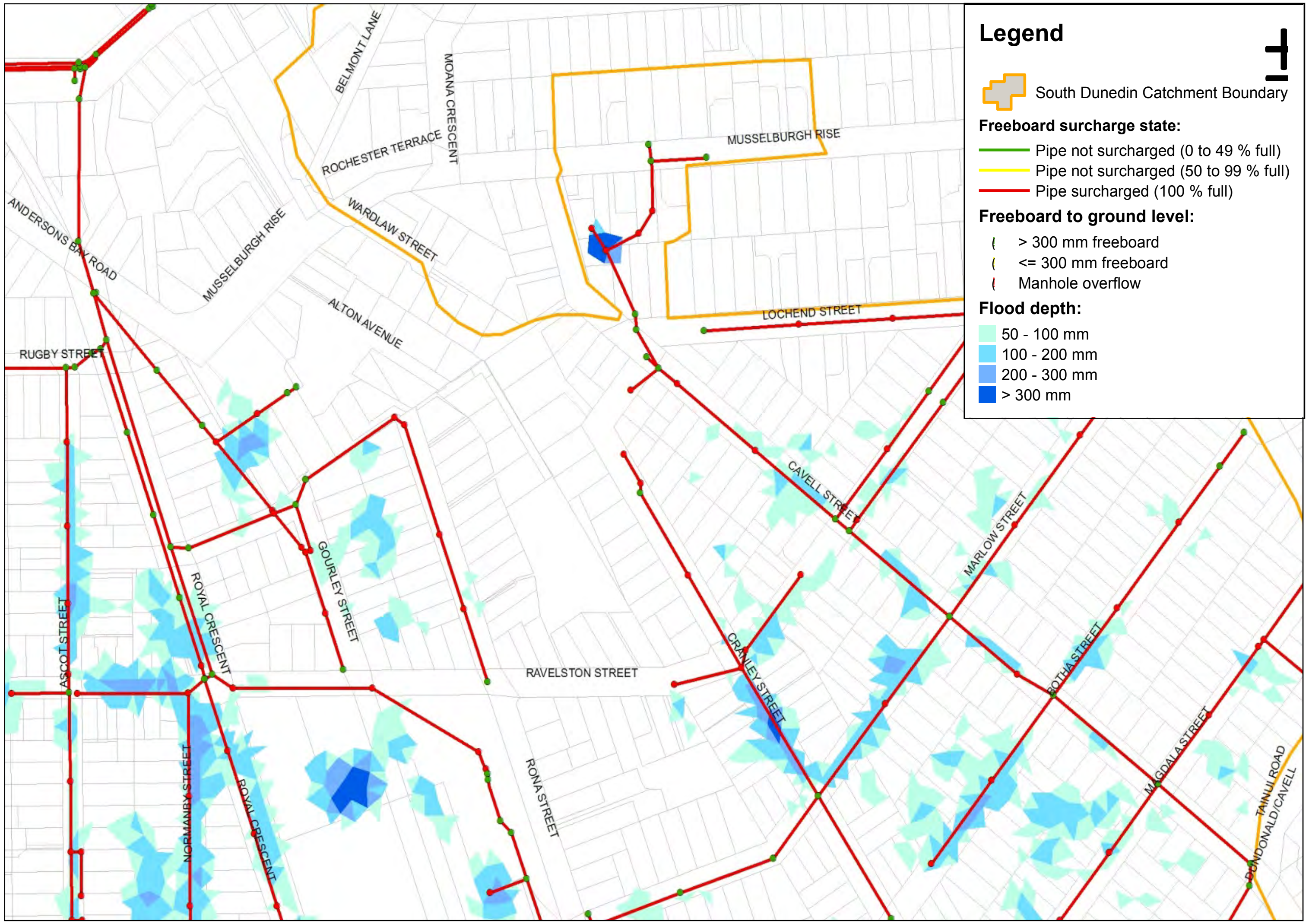


Figure 59: South Dunedin catchment (Tainui area) potential habitable floor flooding during 1 in 50 year ARI rainfall event

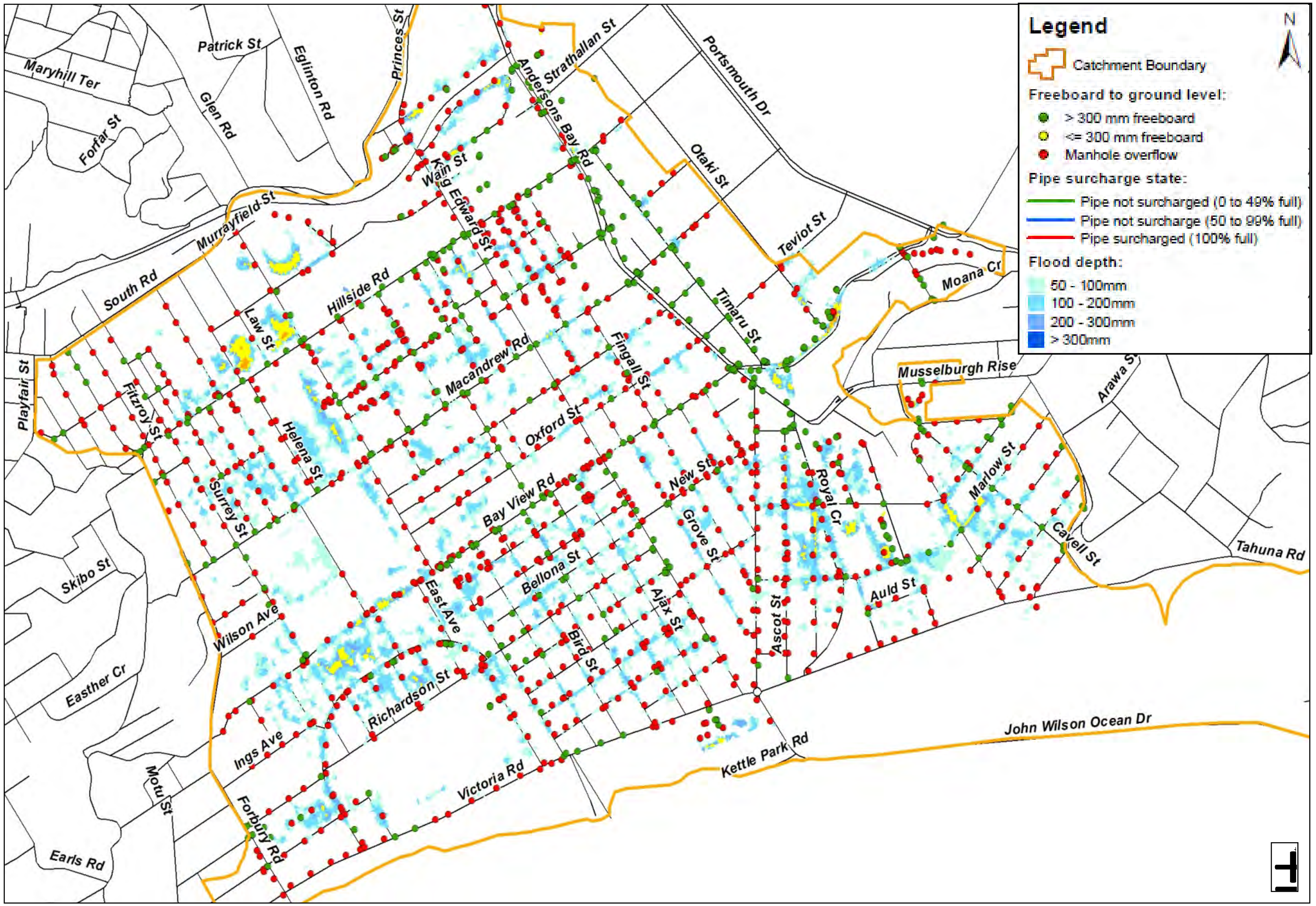


Figure 60: South Dunedin catchment predicted flood hazard during 1 in 100 year ARI rainfall event and 1 in 20 year tide level (2060)

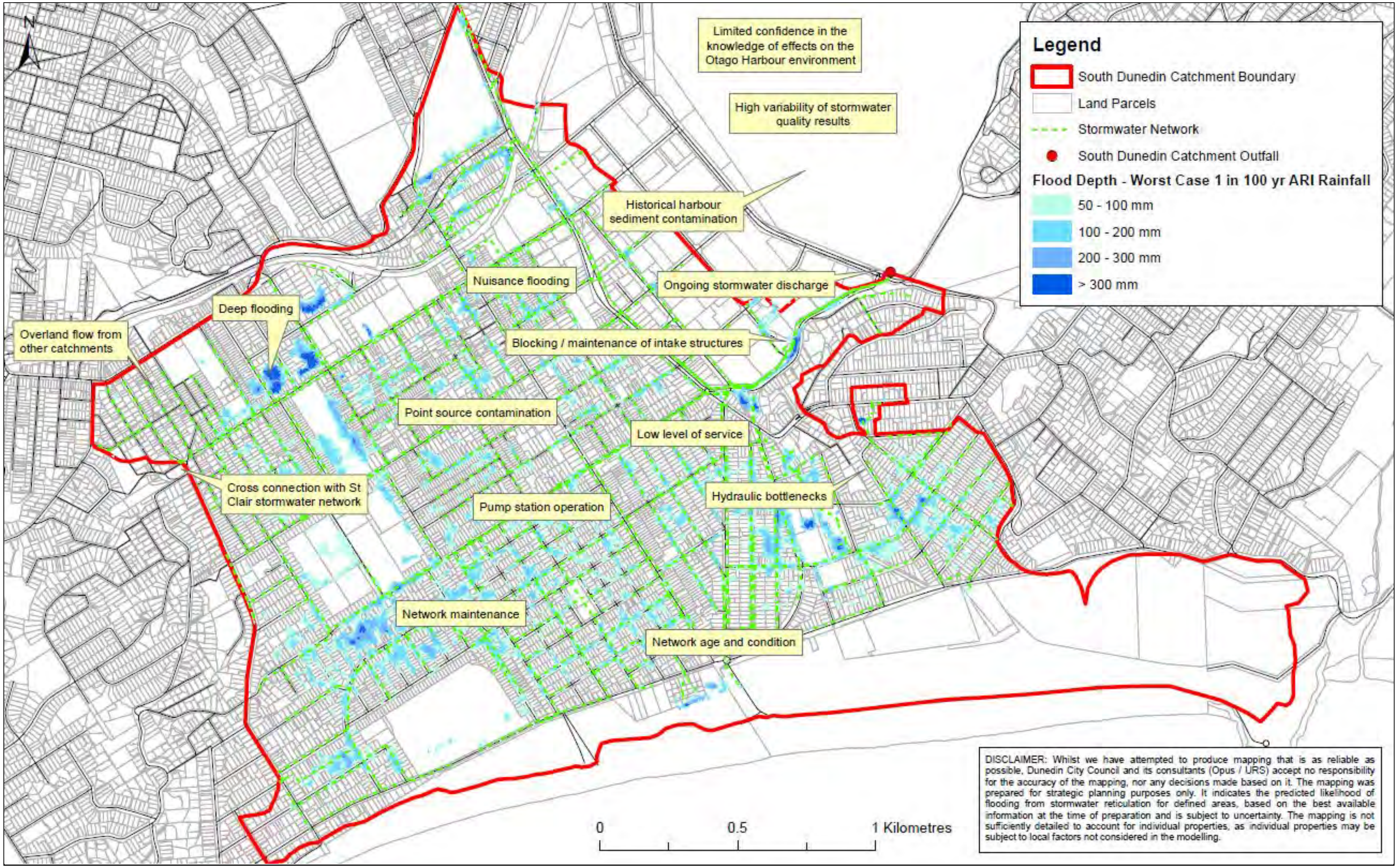


Figure 61: Summary of South Dunedin catchment issues

5.13 St Clair

5.13.1 Catchment location, topography and geology

The St Clair catchment, shown in Figure 62, covers an area of approximately 164 ha between Caversham, to the north at South Road and Forbury Road and to the south between Cargill Castle and St Clair Beach. The catchment is characterised by steep gullies along the head of the catchment in the west. The topography flattens to the east. The head of the catchment has an elevation of approximately 154 m above mean sea level.

The hills are formed by lava flows, with small areas to the north and east of the catchment, along Forbury Road have sand and gravel alluvial deposits.

The steep terrain at the head of the catchment directs surface water into three main gullies at Cliffs Rd, Bedford St and, Motu St and to several smaller gullies in the north. The gullies head towards the low lying areas of South Dunedin and St Kilda in the east.

5.13.2 Land use

Current land use

From the early 1900s, St Clair became predominantly residential (over 90%), and remains that way today with the exception of the St Clair Golf Course, located in the south west of the catchment, and a Local Activity Zone at the Esplanade.

Heritage structures in the catchment include Lisburn House, Middleton Lodge and Caversham Church. There was a Māori settlement in the area close to the St Clair Esplanade in pre-European times, and artefacts have been discovered close to the western end of the Esplanade and occasionally uncovered in the dunes which lie to the east.

Contaminated land

Available information shows three identified areas of brownfield/reclamation sites in the catchment. These are located off Ravenswood Road, Bedford Street, and Middleton Road.

Future land use and imperviousness

The St Clair catchment is not expected to undergo any significant change over the next 50 years based on predicted growth and the District Plan. The St Clair catchment is estimated to have an overall imperviousness of approximately 43%.

5.13.3 Stormwater drainage network

In some of the steeper bush covered areas, mostly located in the upper reaches of the catchment, flows are collected via natural open drains, which in turn are intercepted by the piped network which is predominantly less than 250 mm in diameter.

Table 21: Pipe shapes and sizes in the St Clair catchment

Pipe shape	Pipe size (mm)	Total length (m)
Round	100-375 diameter	3209
	>375 to 1050 diameter	1523
Box culvert	900 x 700	429
	900 x 800	170
	1050 x 825	1441
	1000 x 1000	598
	1000 x 2000	123
	1300 x 1000	141
	1300 x 1500	109
	other sizes	820

The piped network has ten branches running west to east, and a large 'interceptor' pipeline running north to south. Nine out of the ten branches discharge into a large box culvert (1050 x 925 mm) along Forbury Road. This main stormwater line ultimately discharges to Second Beach via the bell chamber outfall and to St Clair Beach via a bifurcation (St Clair Beach South Outfall) located approximately 120 m upstream of the bell chamber outfall. The bell chamber outfall consists of a large conical concrete structure containing six orifices of varying dimensions distributed around the chamber, two of which include debris screens. This outfall is vulnerable to strong wave action and it has been designed to resist wave action and minimise rock intrusion.

The St Clair Beach north outfall collects surface water from the southernmost branch of the network and part of the golf course (primarily an open watercourse with several piped sections) and discharges independently into St Clair Beach via a culvert beneath the junction of Second Beach Road and Cliffs Road. This outfall is not one of the consented outfalls because it is a watercourse and the discharge is permitted under the Regional Plan: Water.

The Forbury Corner bypass manhole near the intersection of Forbury and Hillside Roads provides a high level overflow to and from the South Dunedin stormwater network. Overland flows can pass from the St Clair catchment to the South Dunedin catchment. Following the June 2015 rainfall event the St Clair and South Dunedin stormwater models have been combined for further analysis.

5.13.4 St Clair catchment network age

The majority of the pipework in the catchment was laid in the early to mid-1900s. Based on a theoretical life of 100 years, 83 % of the pipe network will be subject to inspection, which will improve remaining life forecasts or initiate renewal by 2060. Table 21 summarises pipe shapes and sizes in the catchment.

Table 22: Pipe ages in the St Clair catchment

Installation date	Approximate age	Number of pipelines	Length of pipe (m)	% of pipe length
1900 or before	> 110 years	0	0	0
1901 to 1920	90-110 years	49	2185	20
1921 to 1940	70-90 years	73	3434	32
1941 to 1960	50-70 years	94	3528	32
1961 to 1980	30-50 years	45	1042	10
1981 to 2000	10-30 years	22	640	6
2001 to 2009	< 10 years	2	59	1

5.13.5 Network capacity

The stormwater model estimates the following:

- 90% of the network can accept a 1 in 10 year ARI rainfall event; and
- 34 % of the network can accept a 1 in 100 year ARI rainfall event.

The main interceptor pipe along Forbury Road, which dictates the capacity of the overall network, appeared to provide a lower level of service. Manhole overflows from just upstream of Macandrew Road down to Wilson Avenue accumulate in the north-bound lanes of the street and stormwater is predicted to cross over the road into the South Dunedin catchment for rainfall events in excess of a 1 in 5 year ARI.

5.13.6 Flooding issues

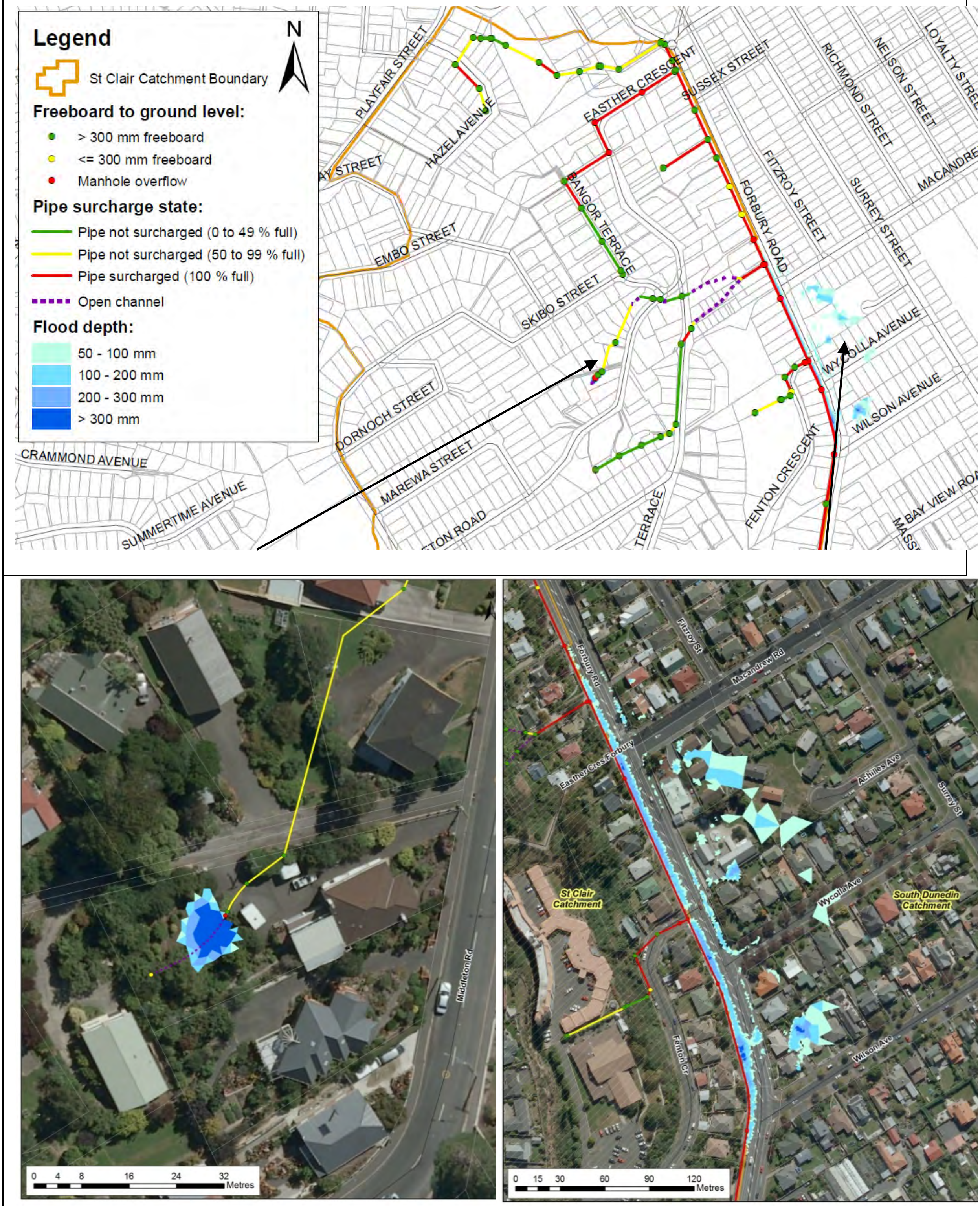
The flood hazard rating for parts of the St Clair catchment was 'moderate' to 'significant' due to the depth and velocity of flood waters. These ratings are only in pockets of the catchment at Middleton Road and small parts of Forbury Road.

Nuisance flooding in the St Clair catchment was expected to be minimal but was predicted in at Forbury Road from approximately 80m north of Macandrew Road to Wilson Avenue and at 30 Middleton Road.

Habitable floor level flooding was predicted to impact 2 properties during the 1 in 10 year ARI event and increased to seven properties during the future 1 in 50 year ARI event scenario. However the flooding was expected to be located away from buildings and unlikely that floodwaters will enter habitable floors. It is noted that the majority of the affected properties are located in the South Dunedin catchment.

The areas where the model has predicted potential flooding issues in a 1 in 10 year ARI event, and a 1 in 100 year ARI event (worst case scenario) are shown in Figure 63 and Figure 65. Predicted habitable floor flooding in a 1 in 50 year event is shown on Figure 64.

Figure 62: St Clair catchment



Predicted flooding at the inlet screen at 30 Middleton Road	Predicted flooding along Forbury Road, overflowing into the South Dunedin catchment

Figure 63: St Clair catchment predicted flood hazard during 1 in 10 year ARI rainfall event (2010)

Figure 64: St Clair catchment potential habitable floor flooding during 1 in 50 year ARI rainfall event

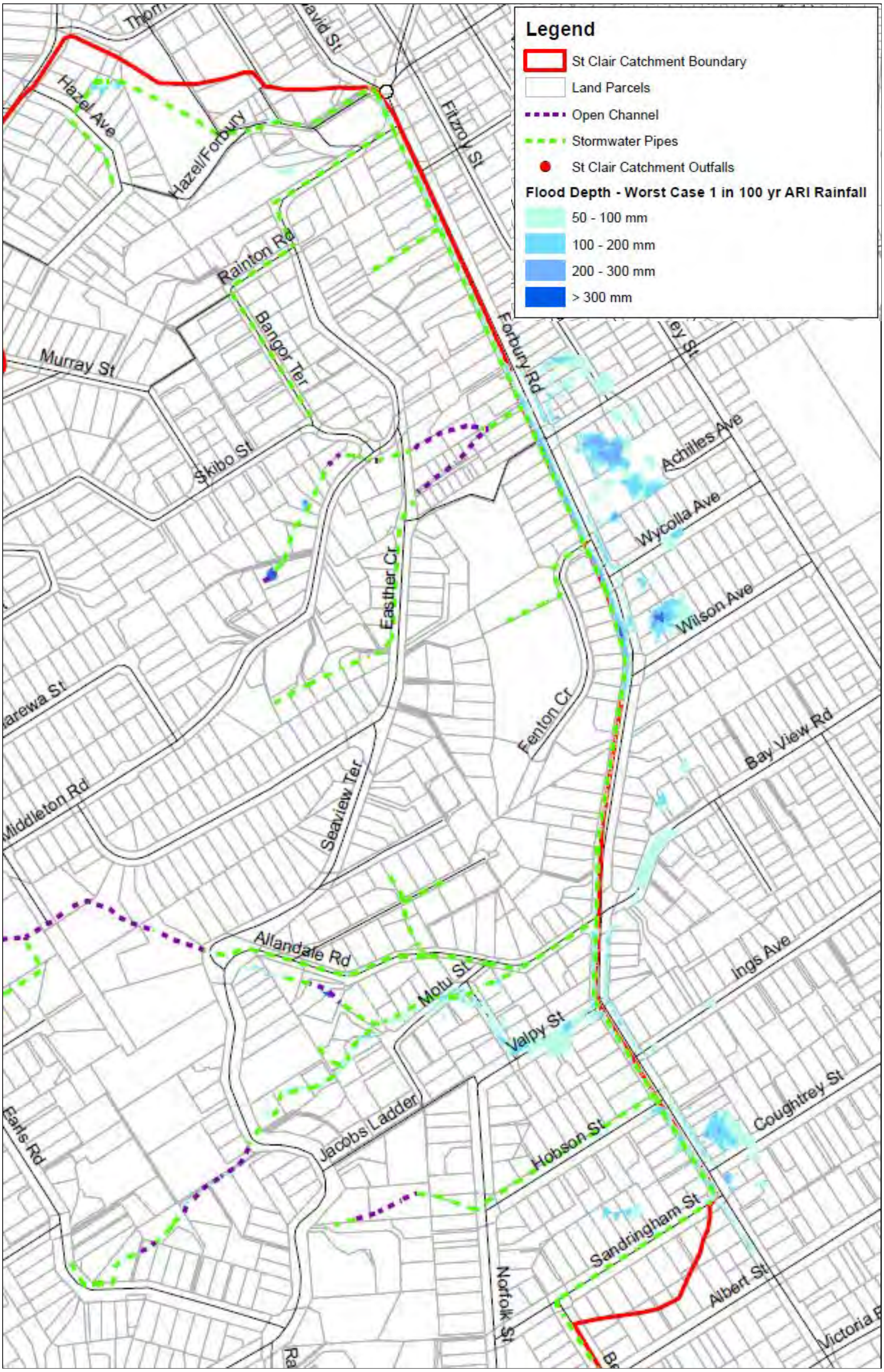


Figure 65: St Clair catchment predicted flood hazard during 1 in 100 year ARI rainfall event (2060)

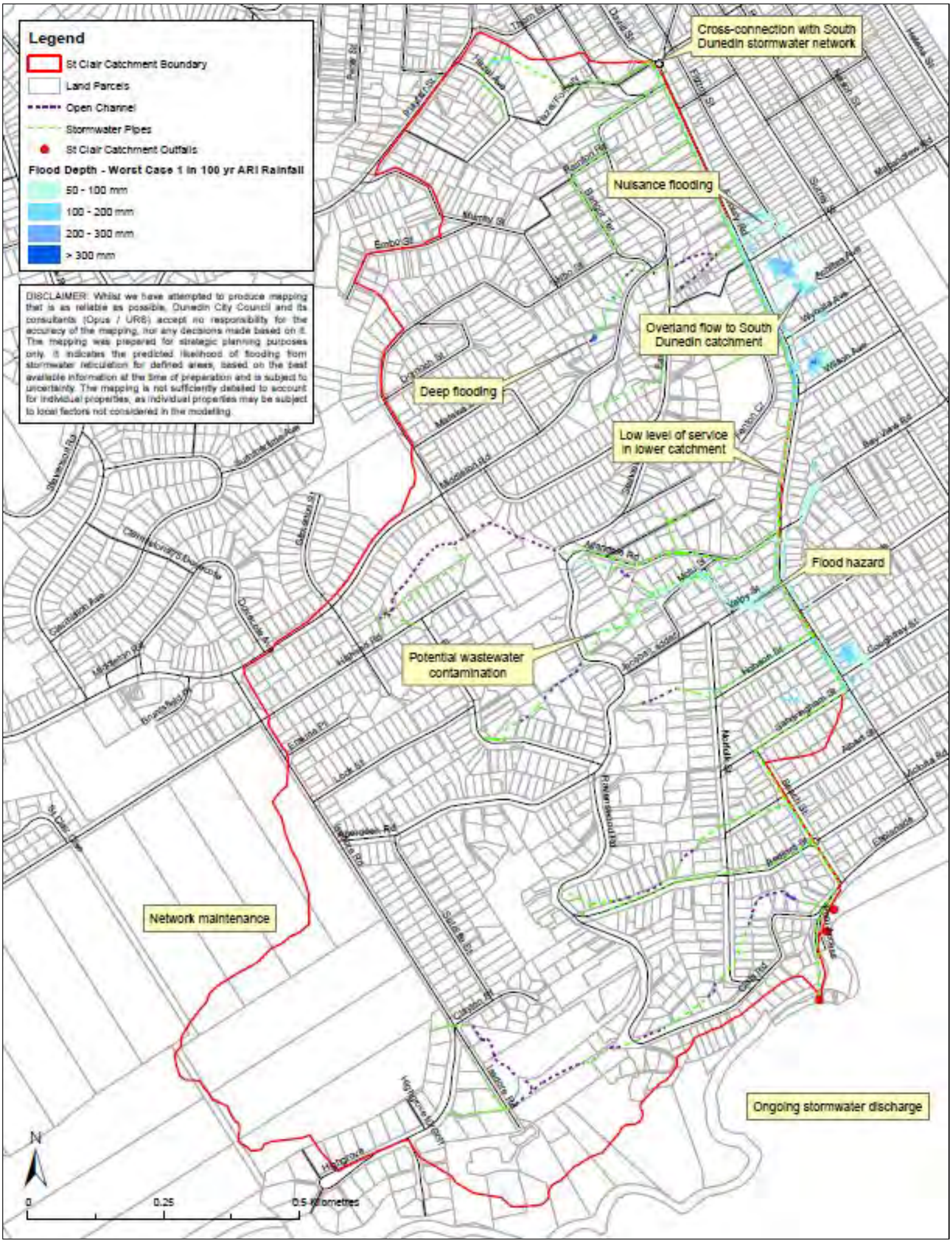


Figure 66: Summary of St Clair catchment issues

6 Stormwater quality

6.1 Contaminants

Urban stormwater contains a wide range of contaminants, ranging from suspended sediments and micro-organisms to metals and petroleum compounds, amongst others. The sources of contaminants are also wide ranging in urban environments with anthropogenic activities significantly contributing to runoff quality (Table 23).

Considerable variability of contaminants in stormwater occurs 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 (which bind to sediment). 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.

Table 23: Typical sources of urban 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.
Polycyclic aromatic hydrocarbons (PAHs)	Vehicle / engine oil; vehicle exhaust emissions; erosion of road surfaces; pesticides; gasworks by-product.
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.

6.2 Stormwater sampling

Stormwater sampling continues to be undertaken in Dunedin. This is to both monitor the type and range of contaminants within the stormwater and to assist in managing adverse environmental effects.

6.2.1 Grab sampling

'Grab' samples are those manually collected from an outfall at any time during a storm event. Annual water quality grab sampling has been carried out at most key outfalls since 2007. From 2014 (under the RM11.313 consent series) annual grab sampling has been carried out at 10 outfalls – one outfall in each catchment. Collection occurs within 1 hour of the commencement of a >2.5 mm rain event, that follows a dry period of at least 72 hours, to ensure the 'first flush' is captured.

The results of grab sampling have been variable, and are reported in detail in annual monitoring reports prepared by Ryder Consulting Ltd (2007-present). These are available on request and online at www.dunedin.govt.nz/services/stormwater/stormwater-monitoring.

6.2.2 Time-proportional sampling

Time proportional sampling involves installation of an automated sampler in the pipeline near the outfall, which is triggered by pre-determined weather conditions and collects a sample every 10 minutes for 2 hours. This sampling provides a contaminant profile across a rainfall event.

From 2014 (under the RM11.313 consent series) the automated sampler must be used to sample 3 storm events a year.

The results of time-proportional sampling are reported in detail in annual monitoring reports prepared by Ryder Consulting Ltd (2014-present). These are available on request and online at www.dunedin.govt.nz/services/stormwater/stormwater-monitoring.

6.3 Specific contaminant concerns

6.3.1 South Dunedin catchment PAH contamination

Road runoff is usually the principal source of polyaromatic hydrocarbons (PAHs) in urban runoff, and the extent of the contamination depends on the road use intensity (i.e. the rate of vehicles per day). However, PAH in South Dunedin stormwater (and sediment below the outfall) is elevated compared to other catchments. Concentrations of (PAHs) in South Dunedin stormwater (and sediment below the outfall) are unusually elevated. The gasworks site formally located in the catchment may be contributing PAHs to stormwater, by ingress of contaminated groundwater into the stormwater network through ageing pipes.

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

There are potentially other sources of 'spike' PAH release such as coal tar (used in road construction) and domestic fires. Monitoring by Ryder Consulting Limited (2009) indicates that the dominant PAH types found in South Dunedin stormwater in 2008 (anthracene and biphenyl-d10) are components of coal tar whereas domestic fires are more likely to release benzo[a]pyrene, a constituent not present during winter monitoring events (2008 and 2009).

Stormwater sampling within the network is currently being undertaken (2016) to identify any significant source(s) of PAH, so its ingress into the network may be addressed.

6.3.2 Effects of overflows from the wastewater system

As discussed in Section 0, a wastewater overflow into stormwater occurs near the intersection of Surrey Street with Hillside Road in South Dunedin. When the Surrey Street overflow is triggered it is usually accompanied by surface flooding due to the stormwater network being overwhelmed. During the period that monitoring has been undertaken; the overflow is triggered on average 3 times a year.

The inflow and infiltration that trigger wastewater overflows also cause significant dilution. For reference, wastewater pipes are typically designed to be able to convey six times the dry weather flow, thus at the point of discharge overflows are at most 17% wastewater with the remainder being rainwater or groundwater. Domestic wastewater is typically 25% toilet waste, with the remainder being 'grey water' from household appliances, sinks and showers. Typically overflows are therefore at most 4% toilet waste. The trade waste discharges upstream of the overflows have been reviewed. All have similar characteristics to 'domestic' wastewater.

Overflows may increase bacteria and pathogens (measured using *E coli* in freshwater, and Enterococci in marine water), biological oxygen demand (BOD_5), suspended solids and nutrients.

The Surrey Street overflow has not been sampled as there is no access point for sampling that would provide a meaningful measure. Sampling of overflows has occurred elsewhere across the city and generally showed impacted water quality both upstream and downstream of the overflows during rainfall events.

6.3.3 Human sewage lateral cross-connections

Connection of private sewers to the stormwater network, instead of the wastewater system, can occur.

To facilitate discovery of these cross-connections, dry weather monitoring is undertaken. In dry conditions each outfall is inspected, and where there is a discharge a sample is collected and analysed for *E.coli* and fluorescent whitening agents (FWA).

E.coli is an indicator of faecal contamination from, humans or animals. FWAs are used in laundry detergents and are a useful test to assist in establishing whether the E.coli source is of human origin. It is therefore expected that where human wastewater is present in the stormwater, elevated levels of microbial contamination will correspond with elevated levels of FWAs. However, the measure is not infallible as there are naturally occurring FWAs, usually associated with clayey soils and some vegetation.

Where consistently high *E.coli* and FWA are found, an investigation into the source of the issue commences. However results to date have been variable and inconclusive. Alternative means to detect accidental cross-connections are being considered.

Ravensbourne catchment (Magnet Street outfall) investigation

An investigation at the Magnet Street outfall (SWX02623) was initiated in 2014 because of three outfall monitoring rounds returning both high *E.coli* and FWA results. The investigation included:

- Testing all private wastewater laterals from properties in the catchment;
- Additional stormwater sampling at the outfall;
- Site visits to businesses in the catchment to check on site stormwater disposal practices;
- Site visits to ensure stormwater interceptor drains were operating correctly.

This thorough investigation did not reveal any evidence of cross-connections from the wastewater network into the stormwater network.

Given on numerous occasions there was high FWA levels but low *E.coli*, and the outfall has occasionally been blocked by algae and debris, the FWAs could be due to a natural source. Such a result could also be due to an activity such as the washing of cars or boats into the stormwater network. On this basis the DCC is satisfied the high *E.coli* and FWA levels are the result of natural sources and not human sewage. As such, the investigation is considered complete and dry weather sampling at that outfall has ceased.

Halsey Street catchment (Wickcliffe Street outfall) investigation

The Wickcliffe Street outfall in the Halsey Street catchment is also under investigation (2016) to determine the source of elevated *E.coli* and FWA results.

7 Environmental effects

Contaminants entrained in stormwater have potential to cause adverse environmental effects on the receiving water environment, including on water quality, aquatic ecosystems, human health, and on recreational and cultural values.

Contaminants entering the marine environment potentially pose a risk to human health, through recreational contact, and the health of marine organisms, primarily through the accumulation of the contaminants in marine sediments. High levels of contaminants within the sediments may result in adverse impacts on marine flora and fauna which come into contact with those sediments.

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 may indicate effects. However, significant amounts of data are required to link the presence or absence of indicator species with contamination. Harbour ecology is likely to be affected by a number of factors apart from stormwater, including other discharges, freshwater input to the harbour and historic sediment contamination (annual deposition rates are thought to be low).

Discharge of stormwater and associated contaminants has the potential to significantly impact Kāi Tahu values and beliefs. These adverse impacts are associated with effects on the spiritual value of water, mahika kai, aquatic biota and water quality. The traditional resource management methods of Kāi Tahu require coordinated and holistic management of the interrelated elements of a catchment, from the air to the water, the land and the coast. It is accepted by Kāi Tahu that removal of all contaminants from stormwater is not possible (KTKO, 2005), but reduction in contaminants should be achieved through measures such as reducing the area of impervious land; using grass swales to filter stormwater; installing sediment/grease traps; requiring Industrial and Commercial Management Plans; ensuring no industrial or human sewage is discharged to the stormwater network; and implementation of best management practices to reduce contaminant levels as appropriate. The ICMP approach to stormwater management encompasses much of what is desired by Kāi Tahu.

Environmental monitoring is undertaken in accordance with the conditions of the RM11.313 consents to determine the effects of the DCC stormwater discharges (refer to appendix 1 of the consent). Monitoring includes:

- Stormwater quality at the outfalls;
- Harbour water quality;
- Sediment quality; and
- Biological flora and fauna.

The results of environmental monitoring are reported in detail in annual monitoring reports prepared by Ryder Consulting Ltd (2007-present), and are not repeated here. These are available on request and online at www.dunedin.govt.nz/services/stormwater/stormwater-monitoring.

7.1 Environmental guidelines

The *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas*, 2003, Ministry for the Environment and Ministry of Health, set the following levels for *enterococci* in the marine environment:

- Surveillance “green” mode – no single sample greater than 140 *enterococci*/100 ml.
- Alert “amber” mode – single sample greater than 140 *enterococci*/100 ml.
- Action “red” mode – two consecutive samples greater than 280 *enterococci*/100 ml.

Compliance with the guidelines generally indicates water is suitable for recreation. While the guidelines state *“These guidelines are not intended to be used as the basis for establishing conditions for discharge consents, although they may be used as a component for decision making”*, they provide a useful means of comparison.

The *Australian and New Zealand guidelines for fresh and marine water quality, 2000, by* the Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) and the Australian and New Zealand Environment and Conservation Council (ANZECC), and commonly known as the “ANZECC guidelines” provide some guidance on contaminant levels in marine water and sediments. ANZECC trigger levels are conservative levels at which further investigation may be necessary, rather than pass/fail criteria. ANZECC recommends trigger levels be tailored to local conditions.

The RM11.313 consents prescribe trigger levels for both harbour water and sediment, based on the MfE/MoH and ANZECC guidelines. As more information on contaminant concentrations is obtained, the trigger levels may require refinement.

7.2 Water quality

7.2.1 Otago Harbour

Marine water quality is highly variable both spatially and temporally, and sampling results only provide a ‘snapshot’ of water quality. Many factors influence the water quality, including dilution and dispersion, freshwater inputs, rainfall events and tidal currents. There is little historic upper harbour water quality data available.

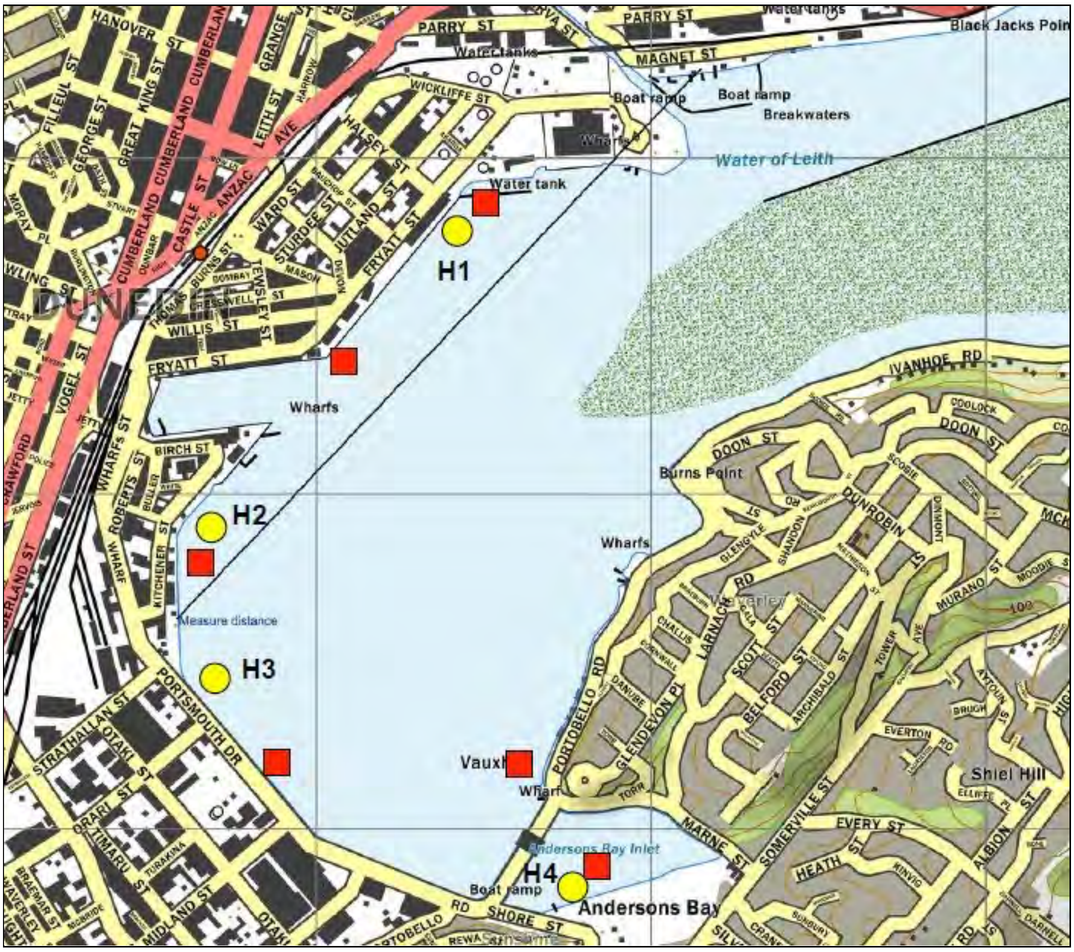
Under the RM11.313 consents (i.e. from 2014), monitoring of harbour water quality is carried out annually at six locations in the upper harbour basin (refer Figure 67)[7]. Samples are collected during two rainfall events and two dry periods, on a mid flood tide and mid ebb tide. The samples are analysed for heavy metals (total cadmium, copper, lead and zinc) and *enterococci*.

Contaminants present in seawater in an outgoing tide in wet weather may indicate stormwater contamination, while contaminants present in seawater on an incoming tide may indicate other sources further up the harbour (such as the Leith, runoff or permitted

[7] RM11.313 series Appendix 2B(a)-(d)

stormwater discharges). Dry weather sampling allows comparison of harbour water quality when it is not influenced by stormwater.

Exceedance of any trigger value requires resampling, and confirmation of an exceedance due to stormwater discharges requires an investigation into the cause of the exceedance. Where attributable to stormwater, management options will be assessed and incorporated as necessary into the ICMP.



Red squares= harbour water quality sites, yellow circles=sediment sites. From Ryder Consulting Ltd (2014)

Figure 67: Upper harbour basin seawater and sediment sampling sites

7.2.2 St Clair

Both St Clair beach and Second beach are high-energy environments; stormwater contaminants discharged at these locations will be quickly diluted and dispersed. While there has been some evidence of increased microbial levels at Second Beach in the past, the commissioning of the extended outfall from the Tahuna Wastewater Treatment Plant and tertiary treatment has led to a decrease in bacterial levels to below maximum acceptable levels for recreational contact at both St Clair and Second Beach. There is no requirement of the RM11.313 consents to monitor seawater quality in the vicinity of the St Clair catchment outfalls.

7.2.3 Port Chalmers

Little monitoring has been carried out in the Port Chalmers catchment receiving environment to date, nor is it a requirement of consent RM11.313. Harbour water quality is of sufficiently high quality for Southern Clams Ltd to have embarked on the resource consent to commercially grow and harvest shellfish within the harbour.

7.3 Sediment quality

7.3.1 Otago Harbour

Sediments entrained in stormwater fall out of suspension in the harbour environment, and some soluble contaminants can become bound to sediment.

The stormwater catchments and associated outfalls 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. Further, the influence of other urban stormwater discharges, and discharges from a variety of other activities, both current and historical[8], are also expected to be evident in harbour sediments.

Historical, particularly industrial, activities in Dunedin have contaminated some areas of the marine environment (Baird 1997, Stewart and Ryder 2004 cited in Stewart, 2013). Historic sediment sampling at various depths in the upper basin shows heavy metal and polycyclic aromatic hydrocarbons (PAHs) are above recommended guidelines at some sites (Stewart & Ryder 2004, Stewart 2005, cited in Stewart, 2013). Sediments in the vicinity of Portobello Road outfall also showed PAH and other organocarbon contamination most probably from the Dunedin Gasworks site (Ryder Consulting Limited, 2005b cited in Stewart, 2013).

Annual sampling of sediments from the top 20 mm of substrate has been carried out since 2007. Levels of contaminants are highly variable and fluctuate between years.

Under the RM11.313 consents monitoring of upper harbour surficial sediments is carried out annually at four locations in the upper harbour basin (refer Figure 67)[9]. Despite being collected from the surface, samples may contain a number of years' worth of sediment deposition, and there is a chance that any contamination measured in those samples may be historic. Each sample should not therefore be considered as indicative of the contamination deposited in any given year.

As with harbour water quality, exceedance of a consent trigger value requires resampling, and confirmation of an exceedance due to stormwater discharges requires an investigation into the cause of the exceedance. Where attributable to stormwater, management options will be assessed and incorporated as necessary into the ICMP.

[8] A range of historic data is also available for contaminant levels within the harbour sediments. However, this data is viewed with caution as sampling may have used different protocols and sediments may have been collected from different substrate depths and by different methods.

[9] RM11.313 series Appendix 2C(a)-(f)

7.3.2 St Clair

St Clair Beach is a high energy environment, and the opportunity for sediments to be deposited and contaminants to accumulate is limited due to the constant re-working of the substrate by the tides.

Sediment samples taken in 2010 at the St Clair Beach outfall showed low contaminant levels well below ANZECC (2000) low trigger values. Enterococci and faecal coliform levels in the sediments were at very low levels (<2 MPN/g).

The substrate at Second Beach was unsuitable for sampling during the 2010 study due to its coarse rocky substrate.

Whilst it is possible that the low contaminant levels in the sediments reflect the high energy environment and lack of sediment deposition and contaminant accumulation, it is also likely, based on the stormwater quality results, that the stormwater discharges are not significantly contributing to the contaminant levels in the sediments.

It is noted that sampling of sediments in the St Clair catchment is not required as part of consent RM11.313.10.

7.3.3 Port Chalmers

At Port Chalmers the harbour receives stormwater from residential / commercial land uses and parts of the railway. Sawyers Bay was historically the location of a significant tannery operation, and until the late 1970's tannery effluent was discharged directly into Sawyers Bay. This is likely to have contributed to sediment contamination.

Sediments were collected from Sawyers Bay in 2010. Closer to the outfall lead and PAHs were found to be slightly above the ANZECC low trigger value, while further from the outfalls arsenic was found to be at the ANZECC low trigger value

The results of the annual stormwater monitoring (grab samples) and the single time-proportional data set do not indicate levels of contaminants which are cause for concern and levels of lead, arsenic and oil and grease are not elevated. There is little evidence to suggest that stormwater quality from the Watson Park outfall is of concern and so it is considered that the risk to sediment deterioration due to the stormwater discharge in this location is low.

7.4 Ecology

7.4.1 Upper Harbour

The upper harbour basin is a highly modified environment as a result of reclamation, road works and dredging activities (Smith, 2007) which have changed natural currents, flushing, and movement of sediments in the harbour (Stewart, 2013). Despite these changes, the upper harbour is considered to have reasonable ecological health compared to other enclosed New Zealand harbours (Stewart, 2013).

Invertebrate diversity and abundance decreases with increasing distance towards the head of the Harbour (Rainer 1981, Grove, 1995 cited in Stewart, 2013). The intertidal communities of the Otago Harbour are considered to be typical of the communities found in enclosed harbours and estuaries around southern New Zealand (Stewart, 2013). In general, benthic and infaunal communities near Portobello Road, Orari Street and Kitchener Street have reasonably low diversity as do a large proportion of the upper harbour basin (Stewart, 2013).

Annual monitoring of harbour ecology has been carried out since 2007. This consisted of sampling macroalgae, epifauna and infauna, shellfish and octopus (until 2013). Benthic and infaunal communities at the outfalls sampled generally had relatively low diversity, as does most of the upper harbour basin. Cockles tended to be small near the Portobello Road outfall, possibly because of historic PAH contamination. The results of various historical studies and the biological monitoring carried out for consent compliance indicates that, in general, a reasonably low diversity amongst the benthic and infaunal communities is likely to be symptomatic of much of the upper harbour basin. The overall conclusion of the monitoring is 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.

Under the RM11.313 consents, harbour ecology sampling of infauna, epifauna, macrofauna is carried out biannually at five locations, with cockles sampled at three locations, commencing in 2015[10].

7.4.2 St Clair

Ryder Consulting Ltd (2010) concludes that the ecological communities at St Clair Beach and Second Beach are typical of intertidal communities in high energy environments. Ryder Consulting Ltd (2010) found macroalgal cover was sparse with low diversity at both the St Clair Beach and Second Beach outfalls. Epifauna at both outfalls was restricted to hard substrate and found to be typical of intertidal animals in high energy environments, dominated by small barnacles, snails, limpets and chitons. Diversity and abundance did not change significantly with distance from the outfalls.

Biological monitoring at Second Beach has found low levels of contaminants in sampled mussel flesh. The concentration of heavy metals in mussel flesh has remained well below the New Zealand accepted food guidelines levels for shellfish flesh (ANZ Food Standards Code 2002; NZ Food Regulations 1984). There is little evidence of contamination of shellfish by stormwater at the Second Beach site. Furthermore, faecal coliform counts within the mussel flesh were found to be low across all years monitored. It is noted that biological monitoring is not required by the St Clair catchment consent RM11.313.10.

7.4.3 Port Chalmers

There is little data on the ecology of the Port Chalmers catchment. An environmental impact assessment was carried out as part of Port Otago's reclamation programme with the marine ecology in the area summarised as follows (Probert 1990a, 1990b):

[10] RM11.313 series Appendix 2D(a)-(f)

- Benthic communities in and around Port Chalmers are generally similar to those of mud bottoms throughout the Otago Harbour.

- The intertidal zone around Port Chalmers appears to contain organisms similar to other rocky shore communities within Otago Harbour, are more diverse than in the Upper Harbour Basin but less diverse than those further out in the harbour and on naturally occurring rocky shores.

The Ryder Consulting Ltd (2010) assessments were limited by the substrates in the vicinity of the outfalls. No assessment was carried out at the George Street outfall as it discharges into deep water. At the Watson Park outfalls, it was not possible to survey infauna as any suitable substrate was deemed to be too far away from the outfalls to be directly influenced by the stormwater discharges. Macroalgae was virtually absent and epifauna was moderately abundant but diversity was relatively low and dominated by barnacles.

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 Ryder Consulting Ltd (2010) study concluded that the outfalls for the Port Chalmers catchment are not in locations with a suitable environment to adequately assess the ecology, and that there is a lack of data available relating to the Port Chalmers catchment. It is therefore not possible to identify any clear trends in the state of the ecology in the receiving environment at Port Chalmers.

8 Further work required

8.1 Risk management

The original ICMP documents developed a decision-making framework in line with the New Zealand and Australian risk management framework (AS/NZS 4360), to enable the comparison of stormwater management issues and options. This resulted in a 'manage passively' or 'manage actively' categorisation. Active management indicates that the 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.

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.

While there were different outcomes from the prioritisation of issues between catchments, there have been a number of common catchment management approaches recommended across the catchments; in some instances, a number of catchments have the same issue, and the use of a common approach and target setting methodology allows for coordination of the recommended works programme.

It is noted that for water quality, the original ICMP risk assessment has been superseded by ongoing monitoring requirements and re-evaluations under resource consent series RM11.313.

8.2 Passive management

Issues that are at least in part managed passively in the majority of the catchments are low levels of service in parts of the network; targeted information collection; and continued assessment of current technical advice, standards and guidelines. Passive management measures to address these issues include:

8.2.1 Pipe upgrades

Much of the network is approaching the end of its theoretical useful life (100 years). The ongoing pipe renewals programme progressively improves the level of service provided up to current design standards.

8.2.2 Compliance with design standards for new stormwater infrastructure

Compliance with design standards provides certainty that flood risk is not unacceptably increasing, and stormwater discharge quality is not deteriorating as a result of new development. Vulnerable buildings (such as rest homes) subject to resource or building consent processes can be reviewed alongside flood risk information to ensure vulnerable structures are not placed in flood prone areas, or that appropriate measures are taken to avoid, remedy or mitigate those hazards.

8.2.3 Climate change

Ensuring that climate change considerations are taken into account when new infrastructure is designed also ensures that targets relating to future levels of service provision can be met.

8.2.4 Customer satisfaction

The DCC undertakes a Resident's Opinion Survey on an annual basis, enabling customer satisfaction for stormwater servicing to be measured. Collating and mapping customer complaints is also a way of measuring satisfaction, identifying issues, or confirming predictions from the hydraulic model.

8.2.5 Floor level survey and damage assessment

Prior to embarking on costly capital works to alleviate predicted habitable floor flooding, further information is required in order to provide certainty with respect to model predictions. Undertaking survey of identified flooding areas is an essential first step. In many instances, it may be discovered that predicted flooding is not likely to enter buildings. Conversely, areas where properties are found to be affected can be prioritised for urgent remedial works.

8.3 Active management

Maintenance of intake structures; nuisance flooding; deep flooding; flood hazard management; and hydraulic model confidence are matters that require active management. Active management measures to address those issues are outlined below.

8.3.1 Blocking / maintenance of intake structures

Blocked screens and intake structures divert stormwater overland or detain water in a ponding area. Maintenance has been improved through revising criteria for screen cleaning and intake inspection (including active response times), and clearly identifying roles and responsibilities of various parties in ensuring this work is undertaken.

The DCC is also considering the need to take a more active role in ensuring intake structures and screens on privately owned watercourses meet required standards, and are well maintained. Initially, inspections of catchment drainage channels should be undertaken to identify critical structures. Following this, options for structure improvement / optimisation can be considered along with options for managing and maintaining the watercourse.

8.3.2 Nuisance flooding

As noted in section 5.2.3, nuisance flooding constitutes predicted flood depths between 50 mm and 300 mm, or flooding in locations unlikely to cause habitable floor flooding or serious transport disruption. Nuisance flooding is caused by capacity restrictions in the network at potentially a number of locations during a 1 in 10 year ARI rainfall event, along with tidal influence on the network in the lower catchment.

The DCC's focus is on improving the existing level of service under current and future development and climate change scenarios. The objective for flooding identified in the *Three Waters Strategic Direction Statement 2010-2060* 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. This will be achieved over the long-term by ensuring that all new network components (for example, planned pipe renewals, or upgrades in specific locations) are designed to a 1 in 10 year 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.

8.3.3 Deep flooding

The Building Act requires that habitable floors (or 'useful floor space' in relation to non-residential properties) should not be at risk of flooding during a 1 in 50 year rainfall event. The DCC's objective for managing this flood hazard is avoiding habitable floor flooding under both current and future land use and climate change scenarios, for all events smaller than and including the 1 in 50 year ARI rainfall event. It is also desirable to avoid any increases in surface flooding of private properties.

The hydraulic models used to predict flood extents only provides information in terms of 'land parcels' or 'properties', and not buildings on those properties. In many cases, flooding may not actually enter buildings, on land parcels identified as potentially being subject to deep flooding during storm events with 1 in 50 year ARI rainfall and smaller. Therefore actual numbers of buildings at risk is likely to be less than the number of land parcels reported.

Individual property owners should undertake a damage assessment or survey to gauge the effects of deep flooding, prior to any detailed design for site development.

Network capacity issues 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.

8.3.4 Flood hazard – current and future (1in 100 year ARI)

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 approaches identified are:

- Ensure new development does not increase the number of properties predicted to flood due to the stormwater network in a 1 in 100 year ARI rainfall event.
- Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply) 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.
- Ensuring that development does not further exacerbate flooding, management of the effects of new development would be as per the requirements of the *Dunedin Code of Subdivision and Development*.
- Develop Emergency Response Plans.

- Develop a Climate Change Adaptation Plans.

8.3.5 Hydraulic model confidence

Hydraulic model calibration and verification will aid the DCC in measuring network performance with confidence. Increased confidence in model results can be achieved by; flow monitoring, rainfall event calibration, physical position and condition survey of the asset network and collection of further anecdotal evidence of flooding.

8.4 Action plan – water quantity issues

Specific tasks that the DCC may undertake to meet water quantity stormwater management objectives are outlined in Table 24. The tasks are categorised as 'further studies', 'planning and education', 'operation and maintenance', and 'capital works'. Further studies recommended will assist in improving certainty around catchment management targets, or where further information is required in order to develop options. Where no costs have been identified in the tables, it is intended that DCC staff will undertake the work.

The intention is that as individual tasks are completed, their influence on catchment objectives will be assessed, and further tasks that provide the greatest benefit toward objective achievement will be identified and prioritised.

Table 24: Actions to improve the stormwater quantity issues

Catchment	Task	Timeframe	Progress to date	Cost
Further study recommendations				
All	Improve stormwater network data through level surveys, GIS confirmation, CCTV.	Ongoing	Data being captured through Network Maintenance Contract, as part of investigations to network issues and renewals programmes.	-
All	Undertake feasibility study to enable preparation of an action plan of stormwater capital works in the catchment.	TBA	Yet to be programmed. Capital works currently targeted to addressing catchment issues that are already occurring.	$100 –$150k
All	Utilise stormwater complaints and Residents Opinion Survey information to continuously gauge customer satisfaction with the stormwater service.	Ongoing	Being monitored. More detailed analysis yet to commence.	-
All	Identify and undertake floor level surveys and damage assessment of properties potentially affected by deep flooding up to a 1 in 50 year ARI event.	3 - 6 months	Limited floor level surveys in areas where problems are already occurring have taken place. Used to inform capital works design.	$20k
All	Undertake comprehensive watercourse inspections.	3 - 6 months	Limited inspections being carried out reactively following customer complaints.	$50k
Halsey Street	Identify and undertake floor level survey and damage assessment of properties potentially affected by deep flooding up to a 1 in 50 year ARI event (include properties in George Street commercial area).	3 - 6 months	Yet to be programmed.	$20k
Orari Street	Increase hydraulic model confidence in The Glen, South Road commercial area and around the Caversham Bypass Motorway, via survey, data collection and / or flow monitoring and calibration.	12 months	Planned as part of wider hydraulic model improvements for combined South Dunedin / St Clair / Orari St model. Funding approval through 2018/19-2027/28 LTP process.	$50-100k
South Dunedin	Combine the South Dunedin, Shore Street, Orari Street and St Clair 1-D and 2-D stormwater models.	6 months	The South Dunedin, St Clair and Orari Street models have been combined in 2016 / 17.	$60k
Planning and education recommendations				
All	Review the education / advice provided to property owners responsible for watercourses to ensure adequate information and assistance is provided.	3-6 months	A watercourse information sheet has been developed (April 2014) and is available on-line	-

Catchment	Task	Timeframe	Progress to date	Cost
All	Develop a city-wide climate change adaptation plan, including ongoing monitoring of climate change predictions, incorporating damage assessment of the vulnerable infrastructure.	6-12 months	A Climate Change Predictions Policy has been developed. AECOM consultants are involved in developing details relating to climate change vulnerability and risk assessment. A DCC climate change adaptation group has also been established.	-
All	Develop an emergency response plan for the catchment to ensure evacuation from flooded areas is possible during a large storm event.	6-12 months	Yet to be programmed.	-
All	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	2 months	Completed in 2014/15.	-
All	Work with Otago Regional Council to develop a plan for education programmes in relation to best practice site management of industrial premises.	6-12 months	In progress.	$20k
Orari Street	Review flood hazard in the South Dunedin catchment, incorporating effects from the Orari Street catchment.	2 months	Completed in 2016/2017.	$10-20k
Shore Street	Review flood hazard in the South Dunedin catchment, incorporating effects from the Shore Street catchment.	2 months	Completed in 2016/2017.	$10-20k
St Clair	Review flood hazard in the South Dunedin catchment, incorporating effects from the St Clair catchment.	2 months	Completed in 2016/2017.	$10-20k
Operation and maintenance recommendations				
All	Ensure damaged screens and / or intake structures on open channels and watercourses are replaced or repaired.	Ongoing	Ongoing programme established.	TBA
All	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance.	3-6 months	DCC owned structures captured through Network Maintenance Contract. Condition data yet to be collected. Cleaning & maintenance of key locations managed as planned maintenance through Network Maintenance Contract.	$20k
All	Undertake a city-wide review of all current contracts for	2 months	Complete.	$20k

Catchment	Task	Timeframe	Progress to date	Cost
	maintenance of stormwater structures; documenting scope and standards.			
All	Ensure planned renewals are designed to accommodate a 1 in 10 year ARI rainfall event and incorporate allowances for climate change.	Annual	1 in 10 year design criteria is part of Dunedin Code of Subdivision & Development 2010. Allowances for climate change are currently adhoc. To be incorporated as part of review/update to Dunedin Code of Subdivision & Development 2010 which is currently in progress.	-
Mason Street	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance. Include the Queens Drive / Serpentine Avenue and Canongate intake screens.	2 months	DCC owned structures captured through Network Maintenance Contract. Condition data yet to be collected. Cleaning & maintenance of key locations managed as planned maintenance through Network Maintenance Contract.	$5k
Portsmouth Drive	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance. Include Teviot Street and Midland Street catchpits.	2 months	As above.	$5k
Ravensbourne Road	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance. Include Parry Street catchpits and the Ravensbourne Road stormwater intake structure.	2 months	As above.	$5k
Capital works recommendations				
All	Include additional or improved catchpits in all stormwater capital works.	Ongoing	Transportation Services allocated $300k per annum.	TBA
Orari Street	Undertake local pipe and catchpit upgrades in South Road / Leckhampton Court area.	6 months	Yet to be programmed. Work to be done in collaboration with DCC Transport.	$200k
Orari Street	Replace the screen at 91 Glen Road with a design less prone to blockage.	1 month	Works are programmed to commence in 2017.	$10k
Orari Street	Assess the feasibility of installing tide gates / flap valves on tidally influenced outfalls.	1 month	A capital project was completed for Orari Street in 2016.	$35k

Catchment	Task	Timeframe	Progress to date	Cost
Kitchener Street	Assess the feasibility of installing tide gates / flap valves on tidally influenced outfalls.	1 month	A capital project was completed for Kitchener Street in 2016.	$15k
Halsey Street	Assess the feasibility of installing tide gates / flap valves on tidally influenced outfalls.	1 month	A capital project was completed for Halsey Street in 2015.	$12
Portsmouth Drive	Assess the feasibility of installing tide gates / flap valves on tidally influenced outfalls (Teviot Street)	2 months	Yet to be programmed.	TBA
South Dunedin	Progressively develop and implement infrastructural upgrades to reduce critical location flooding in 1 in 10 year ARI through to 1 in 50 year ARI events.	TBA	Ongoing feasibility and concept option studies are in progress 2015 to 2018.	TBA
St Clair	Provide input into wastewater investigation and subsequent upgrade to reduce manhole overflows.	6 months	Yet to be programmed.	$20k

8.5 Action plan – water quality issues

Specific tasks that the DCC will undertake to meet water quality stormwater management objectives in the near future are outlined in an action plan[11]. The action plan targets resources at areas where they can deliver maximum benefit against the strategic objectives of the 3 Waters Strategy.

Recommended actions for addressing stormwater quality issues were outlined in the original ICMP. Also importantly the action plan includes actions generated as a result of the conditions of the RM11.313 consents and is central to avoiding, remedying and mitigating any adverse effects that may be associated with stormwater discharges.

Table 25 represents the consolidated action plan for the period 2016-2017 for which funding is provided in the Long Term Plan. Table 26 is a record of actions completed in previous years.

[11] Note that the action plan required by consent RM11.313 condition (5)(b) is now incorporated into section 8.3 of this ICMP

Table 25: Actions to improve the quality of stormwater discharges for 2016-2017 year

Action No	Catchment	Task	Timeframe	Progress to date	Cost
001	Port Chalmers and South Dunedin	Wastewater network overflow monitoring to stormwater network or receiving environment. Constructed overflows continue to be monitored for frequency and volume to inform plan for cessation.	Ongoing	Installation of monitors complete, monitoring ongoing. Ecological assessment of receiving environments completed in 2015. Resource consent for discharges granted by Otago Regional Council (RM11.313.09 and RM16.335.02)	$10k/year
002	St Clair	Investigate potential wastewater contamination to determine whether stormwater contamination is caused by wastewater overflow or other, then programme works to resolve.	Ongoing	Continues to be monitored a part of dry weather monitoring programme (Action 004). Consistently no flow and very low FWA's, indicating contamination is not caused by human sewage cross connections.	See action 004
003	All	Improved monitoring of mud tank maintenance contract to ensure that contractors are performing to required standards.	Ongoing	New Transportation maintenance contract commenced July 2016. New performance measures for mud tank maintenance introduced. Stormwater quality improvements to be determined through monitoring programme.	DCC Transport budget
004	All	Continue the stormwater quality and harbour environment monitoring as required by the RM11.313 suite of consents.	Ongoing	Monitoring is implemented as required by RM11.313 suite of consents. Results are reported annually to ORC and are available on www.dunedin.govt.nz/stormwater-monitoring.	$50k/year
005	Halsey Street	Investigate potential wastewater contamination of stormwater, and potential sources.	Ongoing	Continues to be monitored a part of dry weather monitoring (Action 004). Very low FWA's indicate contamination is not caused by human sewage cross connections.	See action 004
006	Mason Street	Investigate potential wastewater contamination of stormwater, and potential sources.	Ongoing	Dry weather sampling programme ongoing (Action 004).	See action 004
007	South Dunedin	Input to the development of the 2nd Generation District Plan (2GP) to clearly incorporate stormwater management objectives.	Ongoing	The 2GP has been notified, submissions received, and hearings are now in progress. The 2GP includes specific objectives, policies and rules relating to impermeable surfaces to reduce the	-

Action No	Catchment	Task	Timeframe	Progress to date	Cost
				amount of stormwater runoff, and specific performance standard to prevent potential sedimentation from earthworks.	
008	South Dunedin	Undertake further quality monitoring and pipe survey to identify source of point discharge PAH contaminants. Instigate sampling regime to locate source of PAH contamination and inform plan for cessation.	Targeted investigation commenced 2016	Annual grab outfall samples results show elevated and seemingly increasing PAHs. Autosampling has shown similar elevated results on one occasion, but lower results on two other occasions. Targeted investigation of stormwater around the former gasworks site has commenced. A sample plan has been formulated, and sampling is underway. CCTV of pipes is planned. Application has been made with the Otago Regional Council to access the Contaminated Sites Remediation Fund (CSRF) re 45 Hillside Road and the tar tank.	$20k
009	Portsmouth Drive	Position and effectiveness of drain inlets needs confirmation (Midland St and Portsmouth Drive intersection). Appraisal and subsequent upgrade to drain inlets in these locations to alleviate flooding and sediment input to Otago Harbour.	2016/17	Was planned for 2015/16, but not actioned. Will be added to the 2016/17 budget.	$10k
010	All	Update and simplify all ICMPs so they can be easily understood and updated in future.	2016/17	This is the “second generation” version of the ICMP.	-
011	All	Identification and targeting of contaminants of concern as a result of monitoring and analysis required by consent conditions. Contaminants of concern have specific targets developed and an investigation plan developed, as required.	Ongoing	Monitoring is implemented as required by RM11.313 suite of consents (see action 004). Dry weather monitoring programme seeks to determine any human sewage cross connections (see action 4). PAH investigation underway in South Dunedin catchment (see action 008).	-
012	All	Develop and implement an education programme to control discharges to the stormwater network. Best practice site management of industrial premises are implemented.	Ongoing	The education programme is ongoing and includes website maintenance, articles in FYI, responding to complaints and letters to residents next to sensitive stormwater areas (such as	Staff costs

Action No	Catchment	Task	Timeframe	Progress to date	Cost
				Tomahawk Lagoon). The senior education and compliance officer has become a Futureintech ambassador and is speaking to schools as part of the education programme. Industrial premises are managed under the Trade Waste programme.	
013	All	Dry weather flow investigation to identify sources of lateral human sewage cross-connection from the wastewater into the stormwater network are identified and removed.	Ongoing	Continues to be monitored a part of dry weather monitoring (Action 004). Outcomes have been variable, and not as successful as hoped. A full investigation of the Ravensbourne catchment, including site visits and CCTV, did not locate the source of contamination (see action 014). Alternative approaches to dry weather monitoring are under consideration.	$15K
014	Ravensbourne	Further dry weather flow highlighted this small catchment as having issues during dry weather monitoring. Investigate potential wastewater contamination of stormwater and potential sources.	Ongoing	Sources of lateral human sewage cross-connection from the wastewater into the stormwater network through further sampling, property checks and CCTV were inconclusive and no cross-connections were identified.	Action 004
015	All	Stormwater Bylaw	Ongoing	Background work regarding stormwater issues that would ultimately contribute to any stormwater bylaw is underway. A new position of Stormwater Planning Engineer has been created, with the position filled from 1 August 2016.	Staff costs
016	South Dunedin	Network renewals focussed on reducing inflow and infiltration into wastewater network.	Ongoing	Next two phases of renewals in Kaikorai Valley to commence mid 2016/17 and continue for approx. two years. Post-works flow monitoring to assess Kaikorai Valley renewals benefits will commence 2016/17. Pipe condition assessments for additional areas of	$6.8m (2015/16) Approximately $3m/year for 5 years

Action No	Catchment	Task	Timeframe	Progress to date	Cost
				Kaikorai Valley and also for North East Valley are planned for 2016/17. This will inform planned locations of future renewals work.	thereafter
017	All	Promote low impact design methods to improve stormwater quality and quantity	Ongoing	Consenting processes emphasise use of low impact design methods in sensitive areas (quantity and quality)	None

Table 26: Water quality projects completed in previous years

Catchment	Task	Comments
South Dunedin	Wastewater and stormwater pipe renewals to eliminate inflow and infiltration and minimise stormwater overflows.	Kaikorai Valley Phase 1 and Phase 2 completed.
Port Chalmers	Remove wastewater/stormwater cross connection.	Cap fitted on connection preventing overflow from wastewater to stormwater network.
All	Redesign and implement the city-wide framework for stormwater quality and harbour environment monitoring.	Undertaken as part of the consent application process, since superseded.
All	Incorporate stormwater management considerations into draft spatial plan.	DCC Spatial Plan complete.
All	Deliver erosion and sediment control course in Dunedin for DCC / ORC staff, consultants and contractors.	Completed.
All	Ensure that stormwater management objectives are effectively incorporated into revised catchpit maintenance contract.	Completed.
All	Develop Dunedin-specific erosion and sediment control guide.	Completed.
All	Review the education / advice provided to property owners responsible for watercourses to ensure adequate information and assistance is provided.	Advice leaflet developed and information attached to LIMs to enable better watercourse management across the board and improved ownership responsibility.

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Appendix A – Consent RM11.313.10[12]

COASTAL PERMIT

Pursuant to Section 105 of the Resource Management Act 1991, the Otago Regional Council grants consent to:

Name: Dunedin City Council

Address: 50 The Octagon, Dunedin

To discharge contaminants to the coastal marine area for the purpose of disposing of stormwater

For a term expiring 35 years from the commencement of this consent

Location of consent activity:

St Clair Catchment, St Clair Beach Dunedin, outfall location 1: approximately 80 metres south west of the intersection of Cliffs Road and Beach Street

St Clair Catchment, St Clair Beach Dunedin, outfall location 2: approximately 215 metres south west of the intersection of Cliffs Road and Beach Street

Legal description of consent location: Common Marine and Coastal Area, Pacific Ocean

GPS Reference:

Outfall location 1 NZTM 2000: 1405187 E 4912507 N

Outfall location 2 NZTM 2000: 1405180 E 4912376 N

Secondary overflow outfall: NZTM 2000: 1405525 E 4912555 N

Conditions

ALL DISCHARGES

1. The discharge of stormwater shall not after reasonable mixing;
   (a) cause a conspicuous change in the colour in the receiving environment; and
   (b) cause the production of any conspicuous oil, grease, films, scums or floatable material.

SEWAGE – DRY WEATHER MONITORING

2. (a) The consent holder shall investigate and determine the source of all human sewage entering through lateral connections to the stormwater network within the St Clair Beach catchment, known at the time this consent was granted, within two years of the granting of this consent. The investigation shall be undertaken in accordance with the sampling regime attached in Appendix 1 to this consent, from the outfalls at the following locations:

   Outfall location 1 NZTM 2000: 1405187 E 4912507 N

   Outfall location 2 NZTM 2000: 1405180 E 4912376 N

   (b) All samples shall be analysed for Escherichia Coli (*E Coli*) Units (No/100 millilitres) and shall be collected at the end of pipe or as near as practicable thereto prior to the discharge

[12] For ease of reading, subheadings (in blue) have been included here. A copy of the original ORC consents are available on request.

mixing with seawater.

(c) Dry weather is defined as a period of at least 72 hours with no more than 1 millimetre of measurable rainfall. If no dry weather conditions occur within a calendar month, no sample shall be taken for that month.

(d) If *E Coli* contamination greater than 550 units per 100 millilitres is identified, an investigation shall be initiated into the cause of the contamination within 7 days of the monitoring results being received.

(e) Should this investigation identify that enforcement and/or remedial action is required, this shall be undertaken as soon as is practicable.

(f) A record shall be kept of all confirmed human sewage contaminant sources. The record shall be provided to the consent authority within one month of being completed and annually thereafter as part of the annual reporting required by Condition 11. For annual monitoring, the annual median value, as recorded for each outfall, shall be clearly identified within the monitoring results.

(g) The consent holder shall give high priority to the removal of any further human sewage entering through lateral connections to the stormwater system identified within the relevant ICMP and action plan. All human sewage discharges to the stormwater system, as identified following the two year investigation period required by (a), shall be removed as soon as is practicable but within not more than 5 years of granting of this consent. Following the date of expiration of the two year investigation period, any further connections identified shall be removed within 3 months of their first discovery.

TRADE WASTE DISCHARGES

3. (a) From the third anniversary date of the consent being granted, the discharge of stormwater shall not contain waste from an industrial or trade process from a source known to the consent holder at the time this resource consent was granted.

(b) Where further trade waste contaminants are identified in stormwater or the environment after the date this resource consent was granted, the consent holder shall implement measures to have the contaminant source removed within 6 months of its first discovery.

(c) If any enforcement and/or remedial action is required, this shall be undertaken as soon as is practicable.

(d) Subject to the required statutory processes, the consent holder shall as soon as practicable implement its proposal to enact a "Stormwater Discharge Bylaw' to enable it to assume better control of inputs to its stormwater systems particularly from industrial and trade premises and from new development.

HEALTH RISKS

4. If the consent holder identifies any public health risk to recreational users of Otago Harbour caused by all or any of the stormwater discharges, the consent holder shall undertake suitable measures to advise the users that there is a risk to public health from recreating and or bathing within the vicinity of the relevant discharge outfall following rainfall. Such suitable measures shall include, but not be limited to, public notices of the risk in newspapers circulating within the environs, radio announcements and signage maintained until such time as the risk is eliminated.

ICMPS AND ACTION PLANS

5. The consent holder shall prepare and implement an Integrated Catchment Management Plan (ICMP) for the management of stormwater within the St Clair catchment.

(a) The ICMP shall be amended as may be required. The consent authority shall be provided with the latest version of the ICMP, within one month of adoption.

(b) The consent holder shall, at all times have in place and implement an Action Plan to implement management actions to achieve ICMP targets. The purpose of the Action Plan is to improve stormwater quality and address any adverse environmental effects.

The actions must include:

(i) The development and implementation of regulatory controls and or enforcement programmes to control discharges to the stormwater network.

(ii) The prioritisation of good management practice for the treatment of stormwater on any new development or complete site redevelopment within the catchment.

(iii) The adoption of best practice stormwater network maintenance; and

(iv) The development and implementation of an education program, within 1 year of the granting of this consent; and

(v) The identification and targeting of contaminants of concern as identified within monitoring and analysis required by condition 7. Specific targets are to be developed and included within the action plan. These targets shall be to reduce or eliminate problem contamination sources within 6 years of the granting of this consent. Should any investigation work identify a discharge source of a problem contaminant(s) to a specific property and or location, steps shall be taken to remove this contaminant source as soon as practicable.

(c) Details of the on-going implementation of the ICMP for each 12 month period, including an update on the progress towards achieving the relevant targets outlined in the ICMP and implementation of the Action Plan, shall be provided to the consent authority in accordance with the annual report required by condition 11.

STAKEHOLDER GROUP

6. (a) The consent holder shall facilitate the establishment of a Stormwater Stakeholder Group (SSG) within one year of the granting of this consent.

(b) The consent holder shall invite members of the SSG to a consultative meeting at least once annually.

(c) As a minimum, the following organisations shall be invited to nominate a representative on the SSG: the Department of Conservation, Otago Regional Council, Southern District Health Board, Port Otago, Te Runanga o Otakou, Save the Otago Peninsula Incorporated Society and any other relevant community/interest groups as deemed appropriate by the consent holder.

(d) The purpose of the meetings shall be to report on and discuss progress with the implementation of each ICMP and action plan, discuss any monitoring results, compliance with the conditions of this consent, and stormwater management options that have been implemented.

(e) Minutes of the annual meeting shall be provided as part of the annual reporting required in condition 11.

Performance Monitoring

ENVIRONMENTAL MONITORING

7. The following monitoring shall be undertaken as specified in Appendix 2 and as shown in the plan in Appendix 3 to this consent.

(a) Stormwater quality monitoring

(b) Harbour receiving water quality

(c) Harbour sediment monitoring

(d) Biological monitoring including cockles

LAB ACCREDITATION

8. All sampling techniques, including sample preservation and despatch to the analysing laboratory, employed in respect of the conditions of this consent shall be carried out by suitably trained and experienced persons in accordance with best practice and in accordance with the requirements of the analysing laboratory. All water and sediment analyses undertaken in connection with this consent shall be performed by an International Accreditation (IANZ) registered laboratory.

PROTOCOL FOR DECREASING MONITORING

9. (a) If sampling and subsequent analysis undertaken in accordance with 7 (b), or (c) show no exceedance of the trigger values for harbour water or sediment quality specified in Appendix 1 for a sequential three year period, the sampling frequency or number of sites specified in Appendix 2 may be reduced with the agreement of the ORC.

   (b) If sampling and subsequent analysis undertaken in accordance with Conditions7(d) show no change over three consecutive sampling rounds then the frequency of monitoring specified in Appendix 2 can be reduced with the agreement of the ORC.

PROTOCOL FOR TRIGGER LEVEL EXCEEDENCE

10. The protocol set out below is to be implemented should the harbour water quality or sediment quality trigger values identified in Appendix 2 be confirmed as exceeded utilising the method described in Sections B or C of Appendix 2. This stormwater management protocol is as follows:

    (a) An investigation will be undertaken by the consent holder as to the likely source of the contaminant(s) that caused the exceedance of the harbour water quality or sediment quality trigger values identified in Appendix 2. A report will be prepared by the consent holder within 3 months of the trigger(s) being exceeded, and provided to the Otago Regional Council outlining the likely source of the contaminants and describing the stormwater contamination issue.

    (b) If the report referred to in Condition (a) above concludes that contaminants present in the samples are attributable to the stormwater discharge authorised by this consent, then the consent holder shall implement clauses c) through d) of this protocol. If the report referred to in Condition (a) above concludes that contaminants identified in the samples are not attributable to the stormwater discharge authorised by this consent then no further action is required by the consent holder in relation to the identified exceedance of the trigger values outlined in Appendix 2.

    (c) The stormwater contamination issue identified in accordance with condition (a) above shall be given a priority rating and included within the relevant ICMP under the section titled 'Issues Prioritisation'.

    (d) The relevant ICMP will be revised to prioritise the stormwater issue and include stormwater management options relevant to the contaminant(s) present. Management option(s) will be implemented as prioritised and may include but not be limited to: the installation of stormwater treatment measures; planning and education initiatives; or operations and maintenance tasks.

ANNUAL REPORTING

11. The consent holder shall prepare and submit an annual report to the consent authority by 1 August each year. The consent holder may provide annual reporting information for each of the catchments as a single document provided any results, summaries, or detailed explanations are clearly identified for each catchment. The report shall include but not be limited to:

(a) The results of any environmental monitoring required by this consent;

(b) An assessment of the environmental monitoring results provided by an appropriately qualified and experienced person. This assessment shall include an analysis of any differences or trends from previous results;

(c) Progress on the development of any regulatory controls for stormwater;

(d) Details of any stormwater issues included within an ICMP or action plan that year including the relative priority ranking of that issue;

(e) Details of any stormwater management options implemented;

(f) The results of any monitoring undertaken to measure the performance of any stormwater management options implemented;

(g) Details of any enforcement action taken within the previous 12 months;

(h) An up to date copy of the record of human sewage contamination in stormwater as required in condition 2;

(i) Minutes of meetings held with the Stormwater Stakeholder Group.

NO EROSION OR SCOUR AT DISCHARGE POINT

12. The stormwater discharge shall be managed so that erosion and scour of the coastal marine area is minimised as far as is practicable.

EMERGENCY SPILLS PROTOCOL

13. The consent holder shall as soon as is practicable, advise the Consent authority and Te Runanga o Otakau of any incident(s) involving spillages or discharges of chemicals, fuels, hazardous substances or other contaminant sources into the stormwater network which may result in a significant adverse environmental effect within the receiving environment. The consent holder shall immediately upon confirmation of the incident(s) undertake an investigation into the cause. A written report shall be submitted to the Consent authority within 7 working days of the incident occurring, advising of the cause and any remedial steps taken to avoid any similar events in the future.

OVERFLOW MONITORING (ST CLAIR CATCHMENT ONLY)

14. The consent holder shall install a flow recording device at the outfall located at GPS reference NZTM 2000: E1405525, N4912555 which shall be set to record the frequency, time and volume of any stormwater discharged from this outfall. The results of this monitoring shall be forward to the consent authority as part of the annual monitoring condition 11.

REVIEW CLAUSE

15. The Consent authority may, in accordance with Sections 128 and 129 of the Resource Management Act 1991, serve notice on the consent holder of its intention to review the conditions of this consent within 3 months after the 5th anniversary of the commencement of this consent and within 3 months after each 5th anniversary thereafter, for the purpose of:

    (a) determining whether the conditions of this consent are adequate to deal with any adverse effect on the environment which may arise from the exercise of the consent and which it is appropriate to deal with at a later stage; or

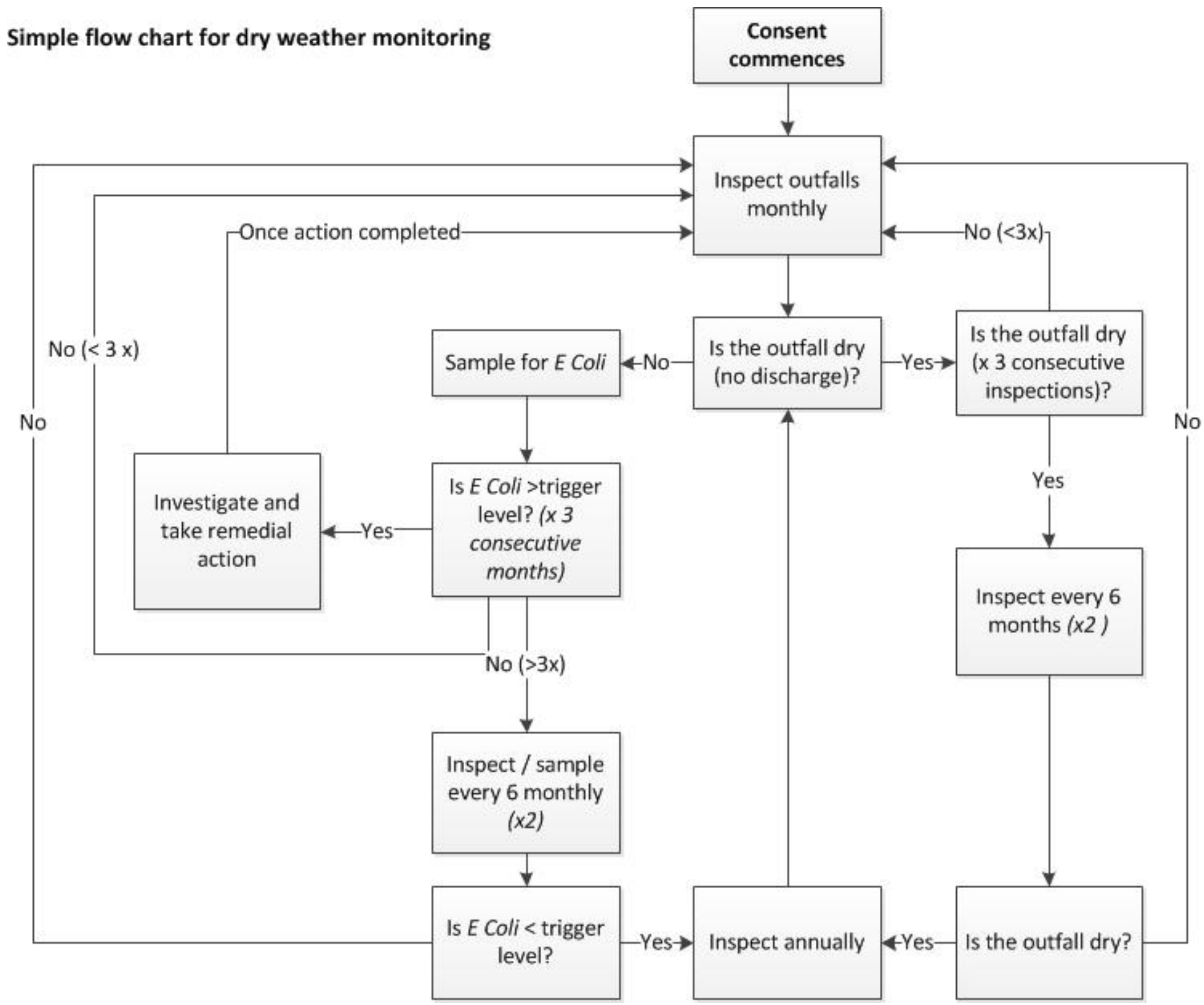
    (b) ensuring the ICMP, any regulatory controls and any monitoring are adequately being completed, implemented and providing the appropriate environmental outcomes anticipated; or

    (c) ensuring that the best practicable option to remove or reduce any adverse effect on the environment is adopted; this could include specific treatment options.

APPENDIX 1

To Discharge Permits RM11.313.01, RM11.313.02, RM11.313.03, RM11.313.04, RM11.313.05, RM11.313.06, RM11.313.07, RM11.313.08, RM11.313.09, RM11.313.10 (10 permits)

Dry weather monitoring sample regime



APPENDIX 2 To Discharge Permits RM11.313.01, RM11.313.02, RM11.313.03, RM11.313.04, RM11.313.05, RM11.313.06, RM11.313.07, RM11.313.08, RM11.313.09, RM11.313.10 (10 permits)

A Stormwater Quality

TIME/FLOW PROPORTIONAL SAMPLES

(a) The consent holder shall install an automated monitoring device to record stormwater discharge quality over a duration of one year, once every five years, at the following outfalls in turn, being one outfall in each of the ICMP catchments of South Dunedin, Halsey Street, Shore Street, Kitchener Street and Mason Street:

Coordinates provided in NZTM 2000 format

Catchment:	Easting	Northing	DCC application reference
South Dunedin	1407365 E	4914848 N	5
Halsey Street	1407391 E	4916854 N	16(a)
Shore Street	1407645 E	4914742 N	4
Kitchener Street	1406573 E	4915910 N	9(b)
Mason Street	1407124 E	4916579 N	15(a)

(i) The automated monitoring device shall be set to take time or flow proportional samples within the first 2 hours of the sampled storm event within the catchment prior to any mixing with seawater and:

1. The monitoring device shall be set to be triggered by connection to either a rain gauge or a flow/water level monitor. If flows are used as the trigger, flow monitoring or stormwater modelling shall be used to set the trigger corresponding to a rainfall intensity of 0.5mm per hour. A period of flow and rainfall monitoring is to be undertaken prior to setting this trigger value, to ensure that the trigger is set appropriately to capture a full storm hydrograph.

2. There must be at least 72 hours of dry weather before the monitoring device is activated.

(ii) The consent holder shall sample a minimum of 3 storm events over the 1 year sampling duration at each outfall commencing six months from the date of granting of this consent. Any further sampling of the catchment may be at the discretion of the consent holder.

GRAB SAMPLES

(b) Once per year the consent holder shall take a grab sample of stormwater from an outfall in each of the 10 catchments described in the 10 permits that are subject to this appendix.

(i) The grab samples in the non priority catchments, i.e. those that are not listed in (a) above shall be taken from the outfall in the non priority catchments with the highest flows during rainfall events or otherwise from an alternative outfall in agreement with the consent authority.

(ii) The grab samples in the priority catchments listed in (a) above shall not be required in the years when the automated monitoring device described in (a) above is operating in a catchment.

(iii) The grab sample shall be taken before the stormwater mixes with seawater, and shall be taken within the first 2 hours of a storm event, and following a period of 72 hours of no rainfall in the catchment.

ANALYTES

(c) All stormwater samples required under A(a) and (b) above shall be analysed for the following parameters:

(i) pH

(ii) suspended solids

(iii) Escherichia coli units

(iv) total copper

(v) total lead

(vi) total zinc

(vii) total arsenic

(viii) total nickel

(ix) total cadmium

(x) total chromium

(xi) polycyclic aromatic hydrocarbons

(xii) oil and grease

(d) the raw data results from each stormwater event shall be forwarded to the consent authority annually as part of the annual reporting required by condition 11.

B Harbour water quality monitoring

(a) Harbour water quality monitoring shall be undertaken annually to determine the effect the authorised stormwater discharge is having on water quality in the Otago Harbour and to determine whether the trigger values in Table B 1 are being exceeded.

(b) Harbour water quality sampling shall be undertaken at the six locations as identified within the plan attached in Appendix 3 during wet and dry weather.

(i) samples are to be taken on 4 occasions (two rounds (see below) annually
(ii) samples shall be taken no closer than 20 metres horizontal distance from the location of the confluence of the stormwater outlet and the waters edge if there are stormwater discharges occurring from the outfall at the time of sampling
(iii) samples must be taken 100-200mm below the surface of the water
(iv) first round sampling shall be three hours apart following high tide, and at mid ebb tide during a period when there has been no measurable rainfall for at least 72 hours prior to sampling.
(v) the second round sampling will occur at the same state of tides as the first round, no less than three hours after the commencement of a rain event that is likely to produce at last 2 mm of rainfall and that has had an antecedent dry period of at least 72 hours.

(c) If harbour water quality sampling identifies the following contaminants at a level exceeding the trigger values set out below in Table B 1, the level of contamination shall be confirmed by re-sampling and re-analysis.

(i) total cadmium
(ii) total copper
(iii) total lead
(iv) total zinc
(v) enterococci cfu/100ml (indicator organism)

Table B 1. Harbour Water Trigger Levels

Indicator	Unit	ANZECC 95%Marine Guideline value	2013 Trigger	Description
Total Arsenic	(g/m$^{3)}$		0.036	USEPA chronic trigger
Total Cadmium	(g/m$^{3)}$	0.00550	0.00550	ANZECC guideline
Total Chromium	(g/m$^{3)}$	0.00440	0.00440	ANZECC guideline
Total Copper	(g/m$^{3)}$	0.00130	0.00130	ANZECC guideline
Total Nickel	(g/m$^{3)}$	0.07000	0.07000	ANZECC guideline
Total Lead	(g/m$^{3)}$	0.00440	0.00440	ANZECC guideline
Total Zinc	(g/m$^{3)}$	0.01500	0.01500	ANZECC guideline
Enterococci	Cfu/100ml	-	140	MfE guideline (amber alert)

(d) If the harbour water quality is confirmed as exceeding the trigger values outlined in Table B 1, the protocol outlined in Condition 10 of the permits shall be implemented.

C Harbour sediment quality

(a) The consent holder shall undertake sediment quality sampling using sediment samples taken from the top 20 millimetres of the seabed. Samples shall be collected from the 4 locations as identified within the plan attached as Appendix 3. The sampling point shall be at or about 20 metres from the nearest stormwater outfall to each site marked on Appendix 3. Samples shall be collected between January and June, on an annual basis.

(b) The sediment properties and contaminants from each sample site are to be tested. At a minimum the consent holder shall for each of the sites collect and analyse one composite surface sediment sample made up of 5 sub-samples for:

(i) weak-acid extractable copper,
(ii) total lead,
(iii) total zinc,
(iv) total total arsenic,
(v) total cadmium,
(vi) total chromium,
(vii) total copper,
(viii) total mercury,
(ix) total nickel,
(x) polycyclic aromatic hydrocarbons (the 16 USEPA priority compounds, retene, 2,6- and 1,7-methylated phenanthrene, and hopanes),
(xi) total petroleum hydrocarbons, and
(xii) organochlorine pesticides.

(c) The sample results obtained are to be forwarded to the Consent Authority along with a comparison with any previous monitoring in accordance with the annual reporting required by condition 11 of the permits that apply to this appendix.

(d) Table C 1 sets out the trigger levels for harbour sediments. The trigger levels may be changed with the written agreement of the consent authority, as new monitoring results or other information comes to hand. If agreement cannot be reached on (a) new trigger level/s the consent holder has the option of applying to vary the conditions under s127 of the Act.

(e) If harbour sediment sampling identifies the following contaminants at a level exceeding the trigger values set out below in Table C 1, the level of contamination shall be confirmed by re-sampling and re-analysis. The effect of the trigger exceedance shall be assessed taking into account the results of biological monitoring that is nearest and/or most relevant to the sediment monitoring site.

Table C 1 Harbour Sediment Trigger Levels

Indicator	Unit	ANZECC Guideline		2013 Trigger	Reason for 2013 trigger	Amended Trigger Reason
		Low	High			
Total Arsenic	(mg/kg dry wt)	20	70	19	80^{th} percentile of samples collected to date	
Total Cadmium	(mg/kg dry wt)	1.5	10	1.7	80^{th} percentile of samples collected to date	
Total Chromium	(mg/kg dry wt)	80	370	80	ANZECC trigger most samples to date below ANZECC	
Total Copper	(mg/kg dry wt)	65	270	122	80^{th} percentile of samples collected to date	
Total Nickel	(mg/kg dry wt)	21	52	21	ANZECC trigger most samples to date below ANZECC	
Total Lead	(mg/kg dry wt)	50	220	209	80^{th} percentile of samples collected to date	
Total?Zinc	(mg/kg dry wt)	200	410	902	80^{th} percentile of samples collected to date	
Total PAH	(mg/kg dry wt)	4	45	183	80^{th} percentile of samples collected to date	
TPH	(mg/kg dry wt)			To be determined	To be determined	
Enterococci	Cfu/100 ml			108	80^{th} percentile of samples collected to date	

(f) If the harbour sediment contamination is confirmed as exceeding the trigger values outlined in Table C 1 and analysis of biological monitoring under (e) above supports that confirmation, the protocol outlined in Condition 10 of the permits shall be implemented.

D Biological Monitoring

EPIFAUNA, INFAUNA AND MACROFLORA

(a) The consent holder shall undertake biological sampling from the five locations identified on the plan attached as Appendix 3 to the permits. Samples shall be collected between the months of January and June at two yearly intervals. The monitoring shall include:

(b) Sampling is to be at 3 sites per location as follows: the waters edge at low tide; within 20 metres of the confluence of the stormwater outlet and the waters edge at low tide, and a minimum of 50 metres from the confluence of the stormwater outlet and the waters edge at low tide.

(c) From the top 200 millimetres at each site, three randomly spaced 5 square metre quadrats shall be sampled for epifauna, infauna and macroflora.

(d) Sampling and species identification for each site shall include:

   (i) For epifauna within each 5 square metre quadrat, the number of each species shall be recorded in five 0.1 square metre quadrats.

   (ii) For infauna a sediment core shall be taken in three 0.1 square metre quadrats and the number of each species shall be recorded.

   (iii) For macroflora, the percentage cover of each species shall be estimated in three 1.0 square metre quadrats.

COCKLES

(e) The consent holder shall undertake samples of the flesh of cockles (Austrovenus stutchburyi) at the 3 locations identified in Appendix 3 to the permits.

   (i) Sampling shall be carried out at two yearly intervals.

   (ii) Sampling from each location shall be at the waters edge at low tide and within 20 metres of the confluence of the stormwater outlet and the waters edge at low tide.

   (iii) Analysis shall be from a composite sample from each location of at least 200 grams of cockle flesh. The number and size of cockles used shall be recorded.

   (iv) If no cockles are present from in front of an outfall no sample to be taken at that location.

   (v) The cockle flesh samples shall be analysed for:

      1) total copper

      2) total lead

      3) total arsenic

      4) total cadmium

      5) total chromium

      6) polycyclic aromatic hydrocarbons

      7) Enterococcus Colony Forming Units (in No/100 millilitres)

   Dry weight sample results shall be recorded for each sample.

APPENDIX 3 To Discharge Permits RM11.313.01, RM11.313.02, RM11.313.03, RM11.313.04, RM11.313.05, RM11.313.06, RM11.313.07, RM11.313.08, RM11.313.09, RM11.313.10