BALANCING ACTS: STORMWATER MANAGEMENT AMID BREAKNECK GROWTH

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ABSTRACT

Queenstown Lakes District Council (QLDC) is home to some of New Zealand's most iconic waterbodies, including lakes Wānaka, Hāwea and Wakatipu, and the headwaters for the Clutha River / Mata-Au, the largest river in New Zealand (by volume and area). While the volumetric contribution of urban stormwater to these large waterbodies might be small, maintaining pristine water quality in these receiving environments is of national importance.

The key stormwater challenges that this small council faces include:

1. **A volatile legislative environment:** There is an uncertain legislative environment, with draft, notified and partially notified legislation from both central government and Otago Regional Council, resulting in difficulty allocating investment through the Long Term Plan.
2. **Pristine receiving environments with varying guidelines and targets:** QLDC currently manages several discrete stormwater network schemes which span across a large geographic area and discharge into several distinct receiving environments.
3. **High growth leading to ad-hoc development driven by developers:** QLDC is experiencing the highest population growth rates in the Country (Gui, 2023) resulting in rapid land use intensification, and rise in development resource consent applications. This has led to a wide variety of approaches to stormwater management, and an increase in stormwater infrastructure vested to Council for maintenance.
4. **Information Variability in each area:** A variety of levels of information available for each area has led to a variety of approaches to stormwater management.

With several diverse, rapidly changing catchments, QLDC needs an approach to stormwater management that gives effect to Te Mana o Te Wai through balancing the importance of water, community development, and economic prosperity. In 2023, Beca was engaged by QLDC to create a wholistic catchment management plan (CMP) for the wider Wānaka area including Hāwea, Luggate, Wānaka, outer Wānaka, and Cardrona, building on earlier work by others and flood modelling completed by DHI.

This paper specifically reviews the challenges in developing a consistent CMP for Wānaka, Hāwea, and Cardrona. These three systems were selected as case studies to highlight the variation across the district in the stormwater systems, the receiving environments, and in the quality and quantity of the existing data.

For example, Wānaka is a town adjacent to Lake Wānaka, with recent flood modelling and ongoing water quality monitoring. It is an example of a more urban catchment discharging to a pristine lake with good asset information. Conversely, Cardrona is a mostly rural catchment, with limited stormwater quantity and quality data, discharging to a seasonally influenced river. Hāwea is in the middle, it is a rural township discharging into a dam controlled lake, with older (2009) quantity modelling and some water quality information available.

In order to develop a CMP that provides district wide consistency in stormwater management and can be used for all types of development, Beca and DHI are implementing the following:

- Defining a common context for all areas that can act as a base for all areas.
- a bottom up prioritization framework that can be tailored to the level of information available.
- utilizing the Urban Stormwater Management Principles to provide a foundation for nature based solution generation.

The paper will explore the challenges Queenstown Lakes District Council faces in the development of a CMP. It will also explore the interaction of the CMP with a wider stormwater strategy and how the CMP information can be kept live to respond to changes in legislation, Council priorities, and stakeholder input.

KEYWORDS

Catchment Management, Fit For Future, Enabling Investment

1 INTRODUCTION

The Queenstown Lakes District Council (QLDC) is responsible for the management of public stormwater throughout the district. Council's stormwater system includes a number of discrete, unconnected networks which vary from urban areas to small settlements and rural areas. In 2023, Beca was engaged by QLDC to create a holistic CMP for the wider Wānaka area including Hāwea, Luggate, Wānaka, outer Wānaka, and Cardrona, building on earlier work by others and flood modelling completed by DHI. This paper focuses on the challenges encountered in Wānaka, Hāwea, and Cardrona (Figure 1).

Figure 1: Overview of CMP Locations

1.1 OBJECTIVES

CMP's act as a master plan and set of tools for managing stormwater on a catchment scale. The key stormwater challenges that this small council faces include:

1. **A volatile legislative environment:** There is an uncertain legislative environment, with draft, notified and partially notified legislation from both central government and Otago Regional Council, resulting in difficulty allocating investment through the Long Term Plan.
2. **Pristine receiving environments with varying guidelines and targets:** QLDC currently manages several discrete stormwater network schemes which span a large geographic area and discharge into several highly valued receiving environments.
3. **High growth leading to ad-hoc development driven by developers:** QLDC is experiencing the highest population growth rates in the Country (Gui, 2023) resulting in rapid land use intensification, and rise in development resource consent applications. This has led to a wide variety of approaches to stormwater management, and an increase in stormwater infrastructure vested to Council for maintenance.
4. **Varying Levels of information available per area:** Understanding of stormwater quantity and quality issues varies. variety of levels of information are available for each area has led to different approaches to stormwater management.

Wānaka, Hāwea, and Cardrona were selected as case studies for this paper to highlight the variation across the district in the stormwater systems, the receiving environments, and in the understanding of stormwater issues.

1.2 CATCHMENT DESCRIPTIONS

The three townships discussed in this paper are very different. A summary of the key catchment characteristics for each of the three locations is outlined in Table 1 below.

Table 1: Sub Catchments Characteristics Summary

Characteristic	Wānaka	Hāwea	Cardrona
Topography	Mixture of floodplains on the shore of Lake Wānaka, and steep mountain ranges which surround the areas. The catchment is generally gently sloping towards the lake with a number of steep hills to the east (Mount Iron) and the south-west (Mount Alpha) of the Township.	Most of Hāwea slopes gently towards the lake. While, on the far east and far west of the township, the catchment is draining towards the south.	Mountainous and hilly topography that feeds to well defined river valleys. The southern portion of the catchment area slopes towards the Cardrona River.
Geology and Soils	Typically sand loams and smaller sections of gravelly sand, as well as isolated pockets of other soil types. The Wānaka Township sits within the wider Wānaka Basin, formed by glacial erosion in the last ice age more than 15,000 years ago.	Located on a terminal moraine which slopes towards the lake. GNS Maps (GNS, n.d.) describes the area as Older Quaternary with the area nearest the lake being well drained. This indicates the soil consists of gravels, silts, sand, conglomerates and shelly limestones (S-Map, n.d.). Moving further from the lake, the soils are less pervious and have a greater silt content.	More than 80% of the Cardona catchment consists of basement shist, and the remaining consists of glacial or alluvial deposits either side of the valley. The flanks of the Cardrona Valley and floor of the Wanaka-Cardrona Flats are in-filled by tertiary lake sediments.
Land Use and Cover	Mix of medium density residential, lower density residential, and some general industrial and services.	Largely lower density suburban residential.	Mainly rural with several discrete settlements (holiday accommodation).
Rohe	Mix of Upper Lakes Rohe and Dunstan	Upper Lakes Rohe	Dunstan Rohe

Characteristic	Wānaka	Hāwea	Cardrona
Receiving Environment	Lake Wānaka Small Creeks within the Wānaka Town	Lake Hāwea	Cardrona River
Network Characteristics	Urban township including a reticulated network, attenuation and soakage. Downstream areas are impacted by lake levels.	Rural township with limited attenuation, reticulated system and a number of direct outlets to the Lake. Lake levels are controlled by a dam on Hāwea River.	Rural hamlet discharging into a river with a steep catchment. Network largely utilizes channels and overland flow.
Resident Population and Growth Projection 2023-2033 (QLDC, 2023)	Population[1]: 10,610 Growth[2]: 2.8%	Population: 2,000 Growth: 3.6%	Population: 790 Growth: 2.5% Large subdivision on Cardrona Station being built (underway included over 400 lots)
Quantity Data Availability	Recent (2024) flood modelling has been undertaken, supported by field surveys.	Old (2008) flood model and quantity analysis has been completed.	No stormwater flood modelling / quality data. Some flood modelling available from the Cardrona River.
Quality Data Availability	Stormwater quality monitoring programme is underway and annual contaminated load modelling has been completed.	Annual contaminated load modelling completed.	Limited quantity monitoring data available.

1. Total population for Wānaka is listed as the sum of populations from Wānaka Central, Wānaka North, Wānaka Waterfront and Wānaka West.
2. Population growth for Wānaka includes population from Wānaka Central

2 CHALLENGE #1: VOLATILE LEGISLATIVE ENVIRONMENT

The legislative framework in QLDC is complex and includes several draft, notified, and partially notified planning tools. Key documents that were considered when creating the CMPs are included below and illustrated in Figure 2.

- Resource Management Act (1991) (RMA)
- Spatial Planning Act (2023) (SBA)
- Natural and Built Environment (2023) (NBEA)
- National Policy Statement for Freshwater Management (2020) (NPS-FM)
- Resource Management (National Environmental Standards for Freshwater) Regulations (2020) (NESF)
- Partially Operative Otago Regional Policy Statement (2019)
- Proposed Otago Regional Policy Statement (2021)
- Otago Regional Plan: Water (2004 updated 2022)
- Queenstown Lakes District Plans (Operative 2011 and Proposed – review began in 2015)
- Queenstown Lakes District Council Land Development and Subdivision Code of Practice (2020)
- National Policy Statement for Urban Development (2020) (NPS-UD)
- National Policy Statement for Indigenous Biodiversity (2023) (NPS-IB)
- National Policy Statement for Highly Productive Land (2022) (NPS-HPL)

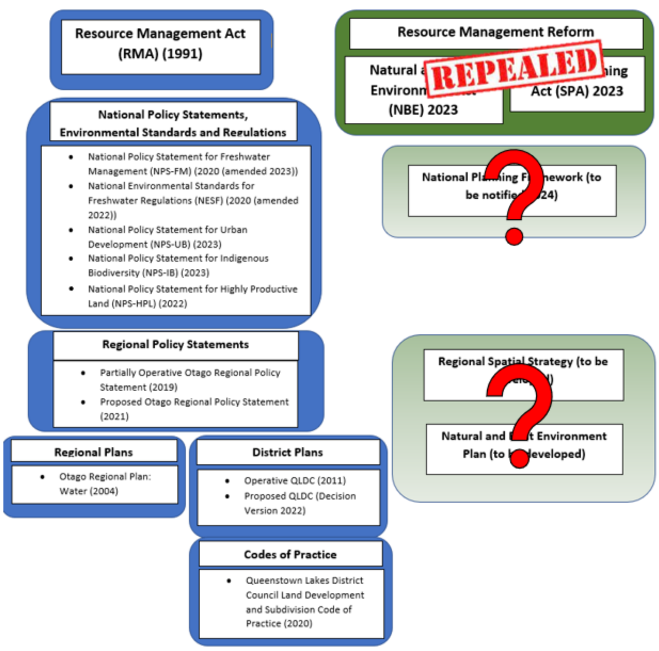

Figure 2: Legislative Framework

As a summary, the current legislative and planning framework applicable to stormwater catchment management planning in QLDC are contained in the Partially Operative Otago Regional Policy Statement (2019) and the Operative Otago Regional Plan: Water (2004). In particular, the Operative Otago Regional Plan: Water enables discharges from a reticulated network as a permitted activity (providing permitted standards are complied with). Water quality targets are set out Schedule 15 and Schedule 16 of the plan and are based on rohe and receiving environment. This is further described in Section 3.

Notwithstanding the current legislative framework, national direction under the last government (through the NPS-FM and NESF) required regional councils to address current freshwater water quality degradation across New Zealand. The NPS-FM (2020, as amended in 2023) prioritises Te Mana o te Wai and the health and wellbeing of water bodies, over the essential needs of people, followed by other uses.

In response to the NPS-FM, the Otago Regional Council has been reviewing both the regional policy statement and the regional plan. The council has established FMUs across the region and are currently working through a process of establishing the long term vision, targets and limits, working in partnership with Kāi Tahu whānui.

With the change in central government, the legislative landscape continues to be uncertain. The Resource Management Reform Acts have been repealed, fast-track consenting has been introduced, which may or may not apply to network infrastructure, and there are indications that the NPS-FM and NESF will also change in the near future.

2.1 WATER QUANTITY

Water quantity management within the district consists of specific guidelines and targets for the stormwater quantity within the district as outlined in the QLDC Land Development and Subdivision Code of Practice 2022 (DRAFT) (QLDC, 2022).

Table 2: Water Quantity Guidelines (QLDC, 2022).

Function	Minimum Target
Primary network drainage capacity	5% AEP
Discharges to an existing and unknown primary drainage network downstream	Peak flow shall be no greater than the 60-minute, 20% AEP pre-developed sites peak flow rate unless otherwise approved by Council
Discharges to a new primary drainage network	Peak flow rate shall be no greater that the 5% AEP developed site peak flow rate unless otherwise approved by Council
Secondary Protection (Overland flow)	1% AEP post-development peak flowrate shall be no greater than the 1% AEP pre-development peak flowrate. The location and type of overland flow downstream discharges are to mimic pre-development scenarios unless otherwise approved by Council.
Freeboard levels from modelled 1% AEP water levels to floor levels	• 0.5 m for habitable buildings • 0.3 m for commercial and industrial buildings, • 0.2 m for non-habitable residential buildings and detached garages
Proposed District Plan / Projected Growth	The upstream catchment shall be considered to be fully developed to the extent defined in the district plan and upstream flood levels shall not be increased by any downstream development
Discharge to private property	No QLDC Stormwater systems should discharge to private property.
Mitigate existing flood prone areas	Identify flood prone areas using hydraulic modelling and complaints and prioritise these for upgrade.

2.2 WATER QUALITY

Schedule 15 of the Otago Regional Plan: Water sets numerical limits and targets for good water quality in Otago lakes and rivers. Water bodies have been grouped to assign limits; these groups pre-date the establishment of FMUs, however a number of the boundaries coincide, with water bodies in the Upper Lakes Rohe all being in Water Quality Group 3, (with the exception of Lakes Wānaka and Hāwea being in Group 5) and those in the Dunstan Rohe being in Water Quality Group 2. Figure 3 illustrates the location of the townships in relation to the Rohe and Water Quality Groups.

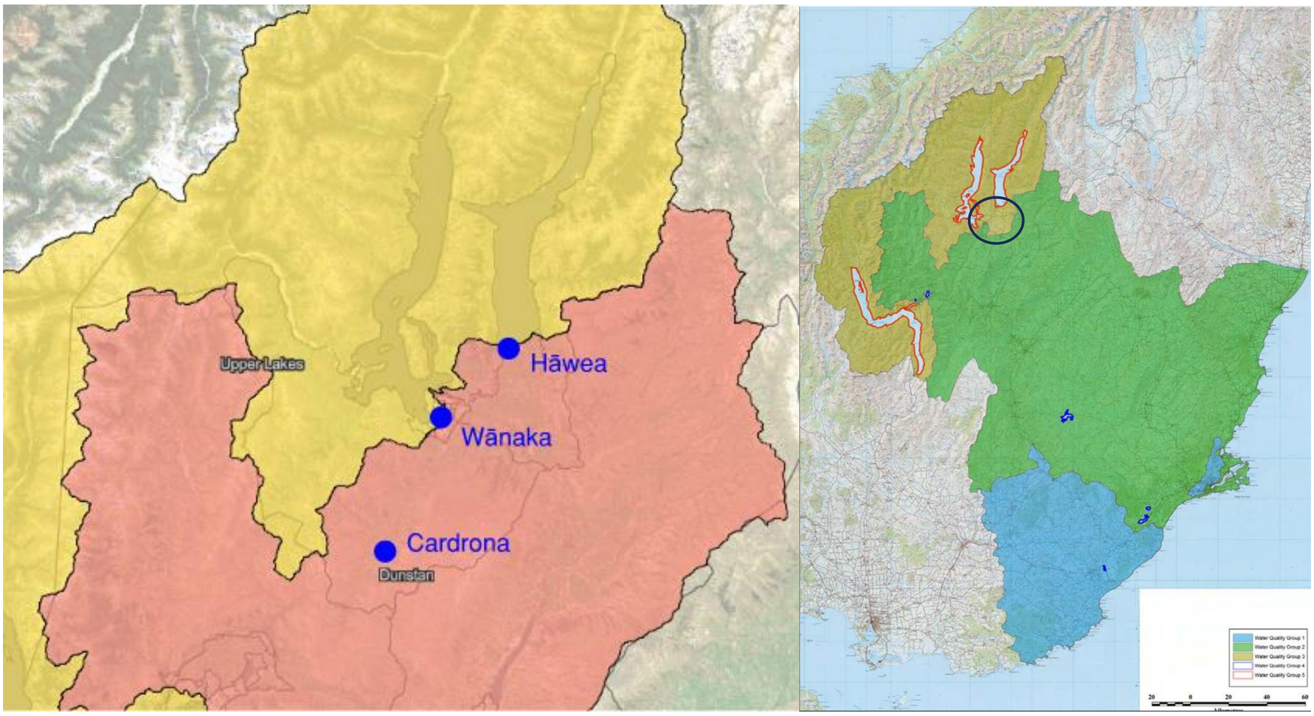

Figure 3: L: Township Locations in Reference to Rohe; R: Water Quality Groups Rohe (source: Otago Regional Plan Map 15.1)

Monitoring programmes and limits set for receiving waters are focused on the parameters likely to be affected by the predominant land uses, which in these areas are rural. To assist with determining the effects of stormwater discharge, there are other water quality guidelines and criteria that can be applied. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) includes toxicity trigger values for protection of species in freshwater. This guideline includes thresholds for both nutrient and heavy metal concentrations in receiving environments.

Target values for each receiving environment were set as part of Beca's previous work developing a water quality strategy for Wānaka (Beca , 2020). These have been used as the starting point for targets in the CMP work to date.

3 CHALLENGE #2: PRISTINE ENVIRONMENTS WITH MULTIPLE GUIDELINE VALUES AND TARGETS

Stormwater networks in Wānaka, Hāwea and Cardrona discharge into a number of different receiving environments, either directly or via tributaries. Lake Wānaka, Lake Hāwea, and the Cardrona River are the three major receiving environments for storm water discharges. Figure 1 shows the proximity of the three townships to the main receiving environments.

Some of these receiving environments have had their water quantity and quality monitored for many years, with other sites more recently monitored since the commissioning of new sites in 2018. Commonly, water quality sites have been established to monitor the condition of lakes and the river with respect to nutrient enrichment, swimming safety, and the impacts of rural land uses. Stormwater contaminants such as copper and zinc are not routinely tested, and the sites are located in places where the impacts of stormwater discharges would likely not be detected (e.g. mid-lake).

The three types of receiving environments (lakes, rivers and urban streams) all have different target states set in the various guidelines and limit setting documents. While the Hāwea and Cardrona township areas only discharge to one receiving environment, the Wānaka township stormwater discharges to three.

3.1 LAKE WĀNAKA

Lake Wānaka and its urban tributaries (Bullock Creek, Stoney Creek and Middle Creek) receive the majority of the stormwater generated in the Wānaka township. The Wānaka catchment has approximately 12 outlets into the lake. The Lake discharges via the Clutha River / Mata Au.

Lake Wānaka is a large, glacial lake covering an area of 192km², has a catchment of 2,590km² and reaches depths of 300m (QLDC, Lakes and Boating, n.d.).

There are a number of monitoring programmes measuring water quality in Lake Wānaka. Overall, the water quality results suggest excellent water quality. The challenge for stormwater management is the small comparative volume of stormwater discharges into the large lake, and the monitoring site locations; set up to monitor the effects of rural discharges rather than stormwater effects.

3.1.1 URBAN TRIBUTARIES

Bullock Creek is the largest of the three urban streams in the Wānaka township. Bullock Creek runs along the southern edge of Wānaka Township, before discharging to the lake.

Bullock Creeks is spring fed, with flows increasing significantly during rainfall. Flows and water quality have been monitored since 2018, and there are fish present including native kōaro in its downstream reaches (Rabel, 2018).

Generally, the water quality in Bullock Creek is good however, *E.coli* and periphyton levels indicate an impacted stream. *E.coli* values upstream of the urban areas are somewhat lower than those downstream, and data analysis of the limited number of samples indicates that the site may exceed the limits set by the Otago Regional Plan.

Middle and Stoney Creek are located in the southwestern parts of the Wānaka township, at the foot of Mount Alpha. Flow data is not available for either of these streams, but some limited water quality sampling has been undertaken. Data on *E. coli* does show elevated numbers in a large proportion of the samples, indicating faecal contamination of some sort.

3.2 LAKE HĀWEA

Lake Hāwea is approximately 13km northeast of Wānaka Township and has a catchment area of 1,390km² (LAWA, Lake Hāwea, n.d.). Lake Hāwea is 35km long, and covers an area of 141km². The deepest parts of the lake are almost 400m, however average depths are typically 100m (QLDC, Lakes and Boating, n.d.). As well as the recreational uses of the lake, it also provides a source for community drinking water supply. The township area extends approximately 2.3km along the southern edge of the lake front.

Lake Hāwea discharges to the Hāwea River, via Hāwea Dam, which was constructed in the 1950s. The dam controls the outflow of water to Hāwea River, which is a tributary to the downstream Clutha River/Mata-Au.

Hāwea Township's stormwater discharges to Lake Hāwea via piped stormwater networks and a number of direct outlets located at the southern end of the lake.

Water quality in Lake Hāwea is monitored in the centre of the lake and near the lake shore; results from both sites suggest excellent water quality, but as with Lake Wānaka, monitoring is designed to assess swimming water quality and detect changes in lake state driven by nutrients. This, as well as the relatively small contribution of stormwater means that changes in water quality due to stormwater discharges would not necessarily be detected.

3.3 CARDRONA RIVER

The Cardrona River has a total catchment area of 337 km², and runs from the steep sided Cardrona Valley for 40km along the south side of Wānaka Township before its confluence with the Clutha River/Mata-Au, 5km downstream of Lake Wānaka (LAWA, Cardrona River, n.d.).

Stormwater discharges to the Cardrona River from both the southeastern part of Wānaka township, and new developments at the base of Cardrona ski field.

There are two long-term water level recorders on the Cardrona River maintained by ORC; the Mt Barker site has been in place since 1976, and a recorder upstream of the Clutha confluence has been measuring water level since 2008. The river loses a significant amount of water (approximately 400-600 L/s) upstream of State Highway 6, with some tributaries running dry in the summer. The river then gains approximately 300 L/s from groundwater before the confluence with the Clutha River / Mata Au (Otago Regional Council, 2013).

ORC has two water quality monitoring sites on the Cardrona River, both above the Wānaka township; one in the upper reaches at Tuohys Gully Road, and the other at Mt Barker, near the water level recorder site. (Otago Regional Council, 2021).

As with the other receiving environments, the quantity of stormwater discharged to the Cardrona River is small in comparison to its flow. Water quality results suggest good water quality in the river, with degradation in some parameters and improvement in others. The river water quality monitoring again focuses on rurally influenced parameters.

4 CHALLENGE #3: HIGH GROWTH LEADING TO AD-HOC DEVELOPMENT DRIVEN BY DEVELOPERS

QLDC is experiencing some of the highest growth rates in the Country. Recently released Stats NZ data show the district grew by 8%, or 3900 people, in the year ending June 2023, following lower growth of 1.5% in 2022. The growth was driven by a net international migration gain of 2500 people, with net internal migration (1100) and natural increase (340) making smaller contributions (Stats NZ, 2023).

QLDC's future population projections show many areas levelling out in the next ten years. The Wanaka Ward is projecting a 2.2% resident increase from 2023-2033. However, there is anticipated to be a 5.7% increase in total visitors (average day) (QLDC, 2023). The large increase in visitors makes it difficult to fund infrastructure, as visitors do not pay rates.

Between the high growth rates and peaky projections for visitors and residents, it is challenging to construct and maintain infrastructure to meet the needs of the district. This has led to development being led by developers, and an inundation of development consent applications for a small council staff to process and review.

Each of the three areas summarised in this paper have several development and growth challenges. Wanaka is experiencing rapid land use intensification with large lots being subdivided into denser communities, Hāwea is experiencing growth that is limited by soakage and flood hazard potential, and Cardrona is experiencing a very large amount of growth in comparison to its existing population in a hilly catchment, predominantly aimed at holiday accommodation.

4.1 WĀNAKA

Wānaka is experiencing rapid land use intensification with previously large residential lots being subdivided into more dense housing. This intensification can potentially lead to increased impacts downstream. Central Wānaka and West Wānaka are the two main areas of growth with subdivisions and densification with a resident population growth increase projected at 5.2% and 4.6% respectively. Total visitors to central Wānaka are increasing significantly with an 8.3% increase of total visitor (average day) (QLDC, 2023).

QLDC is under immense pressure to quickly process consent applications which creates challenges to confirm a consistent approach.

4.2 HĀWEA

Lake Hāwea has been identified as a significant growth and has a resident population increase projected of 3.6%. Predicted areas of included south of the township, in particular to the east of the Timsfield development toward Grandview Road and a large development south of Cemetery Road that is still under construction.

Many of the existing sub catchments within Hāwea discharge to soakage which require a relatively large amount of land. With increase development south of the Town, this runs into discharge to Hāwea River or requiring additional soakage.

Additionally there is a large overland flow path east of the Town from Lake Hāwea which presents a hazard to development.

4.3 CARDRONA

Although the residential population of Cardrona is predicted to have an average growth rate in the next 10 years (2.5%), the total visitors is anticipated to increase 11.4%. This is largely driven by the construction of a large new subdivision called Mt Cardrona Station. This development is being built on a quite steep hilly catchment and there are risks of high sediment loads from construction runoff entering the Cardrona River. The development is planning to treat and detain its stormwater on site however, with 400 lots planned, this may increase the need for commercial land use in this area which results in higher loading to the river.

5 CHALLENGE #4: VARIABLE ISSUE UNDERSTANDING

As outlined above, each catchment has a variety of information available regarding quantity and quality issues, such as flood mapping and contaminant load modelling. This makes it difficult to provide a consistent approach to stormwater management across the district. Specifically, it is difficult to fairly allocate capital funding project if information is unknown in some areas.

5.1 WATER QUANTITY

The following table outlines the available information for each area.

Table 3: Water Quantity Availability

Information	Wānaka	Hāwea	Cardrona
Recently completed flood modelling data (completed by DHI)	✓	X	X
Old versions of flooding modelling data	✓	✓	X
Service Request for flood completed provided by QLDC	✓	✓	✓
NZ Historic Weather Event Catalogue (NIWA, 2018)	✓	✓	✓

5.1.1 WĀNAKA

Recent flood modelling has taken place based on updated survey data (DHI, 2024) which built on the 2021 and 2022 versions of the model completed by WSP and DHI respectively. This flood modelling can assist with identifying areas with undersized infrastructure. Reported flooding due to rivers, flooding due to rainfall, service requests, and historical flooding is shown in the figure below.

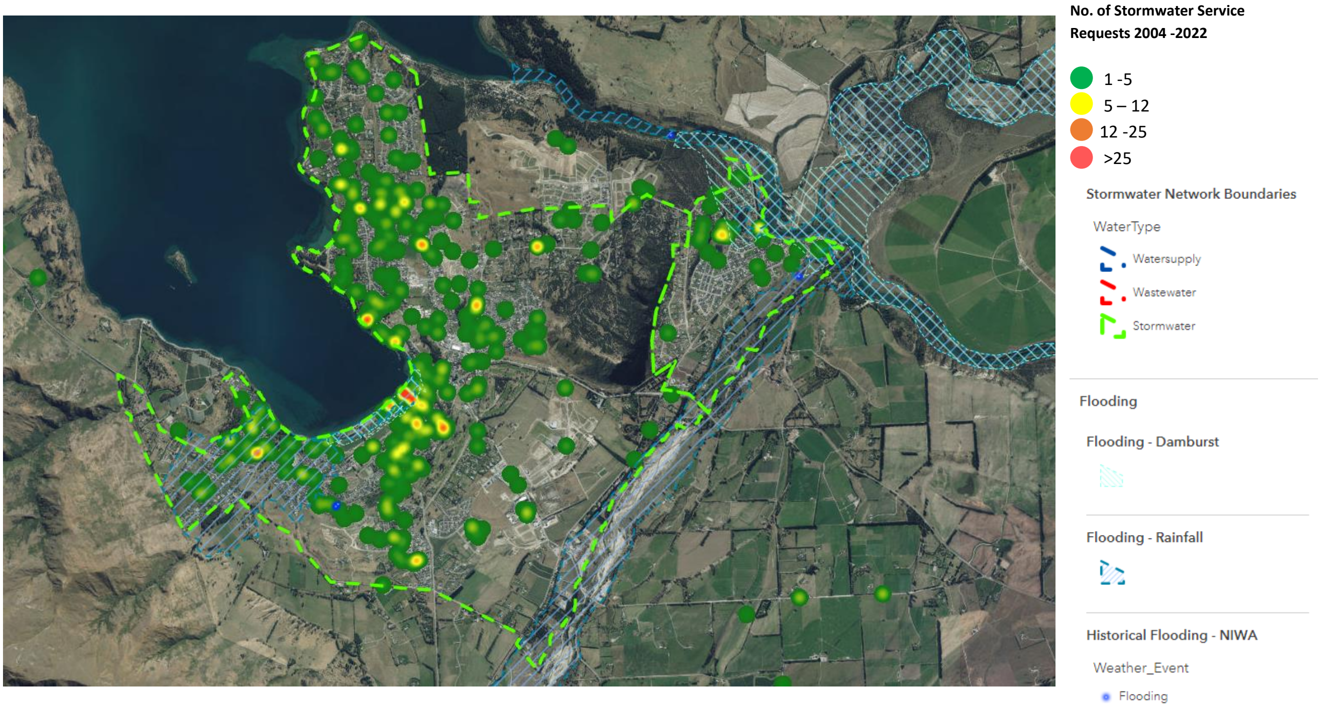

Figure 4: Flood Hazards in Wānaka

5.1.2 HĀWEA

The most recent modelling completed for stormwater in Hāwea was completed in 2009 by Aurecon as part of the last CMP update (Aurecon, 2009).

Several issues were outlined in this model such as localized ponding, and undersized pipes. However, it is difficult to understand the relevant issues today without updated asset and land use data and more detailed terrain data. Based on aerial imagery and overlay of zoning maps, there are anticipated to be several inconsistencies. Flooding due to dam burst (based on modelling), flooding due to rainfall, service requests, and historical flooding is shown below (Figure 5).

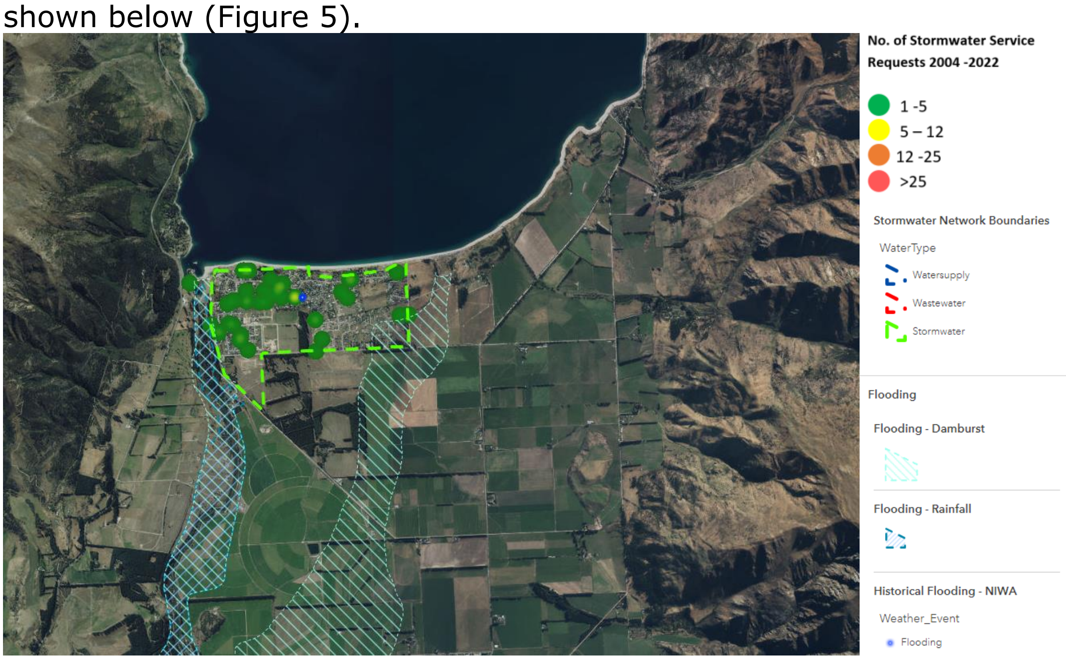

Figure 5: Flood Hazards in Hāwea

The key areas Figure 5 highlights include the developable area in the southeast of the quadrant which overlaps with the dam burst flood pathway. Additionally, the service requests were generally in line with the outcomes of the previous CMP.

5.1.3 CARDRONA

To date there has been little to no stormwater modelling within the Cardrona area. There has been some Cardrona River modelling, but this is to assess river flooding and does not consider the impacts of stormwater.

An area subject to flood hazard has been identified along the length of the Cardrona River and represents locations that may be subject to flood inundation and sedimentation during any particular flood event. The flood extents were mapped based on hydraulic modelling, historical flood extents and extensive on-site landform interpretation (Otago Regional Council , 2010).

GHD mapped flood extents for several scenarios based on existing hydrological and rainfall information. These extents were adjusted based on observations of the November 1999 flood event.

The information available for stormwater quantity in the developing area of Cardrona is very limited. However, there do not appear to be areas of high risk from a water quantity perspective.

5.2 WATER QUALITY

A mixture of data and modelling information was available regarding stormwater quality for each area. The following table outlines that data available in each area.

Table 4: Water Quality Data Availability

Information	Wānaka	Hāwea	Cardrona
Water Quality Strategy (Beca , 2020)	✓	X	X
Recent stormwater monitoring data	✓	X	X
Annual contaminant load modelling (GHD, 2020)	✓	✓	X
ORC Monitoring Data	✓	✓	✓
Proposed land use based on QLDC's Proposed district plan	✓	✓	✓

5.2.1 WĀNAKA

Contaminant Load Modelling (CLM) was completed in Wānaka which highlighted key areas of potentially high contaminant load into the receiving environments (GHD, 2020). GHD reviewed land use in the operative and proposed district plans, traffic counts, and roof types to identify areas of high contaminant load potential (Figures 6 and 7).

The key catchments of concern are starred in Figure 6 below, and include the areas with industrial and commercial land uses in Wānaka. They are in the south Wānaka catchment and discharge into the Cardrona River, and have the potential for high levels of zinc and copper generation compared to the other sub-catchments due to their land use. This model may be showing conservatively high yields from these catchments, due to the assumption of general 'industry' yield coefficients, rather than an allowance for light industry. Quality monitoring is required to confirm the actual contaminant load.

The Town Centre has high traffic volumes, high roof density and large proportions of commercial paving. There is a water quality monitoring underway in Wānaka set up following the completion of the Water Quality Strategy (Beca , 2020). This monitoring data can be used to validate the CLM.

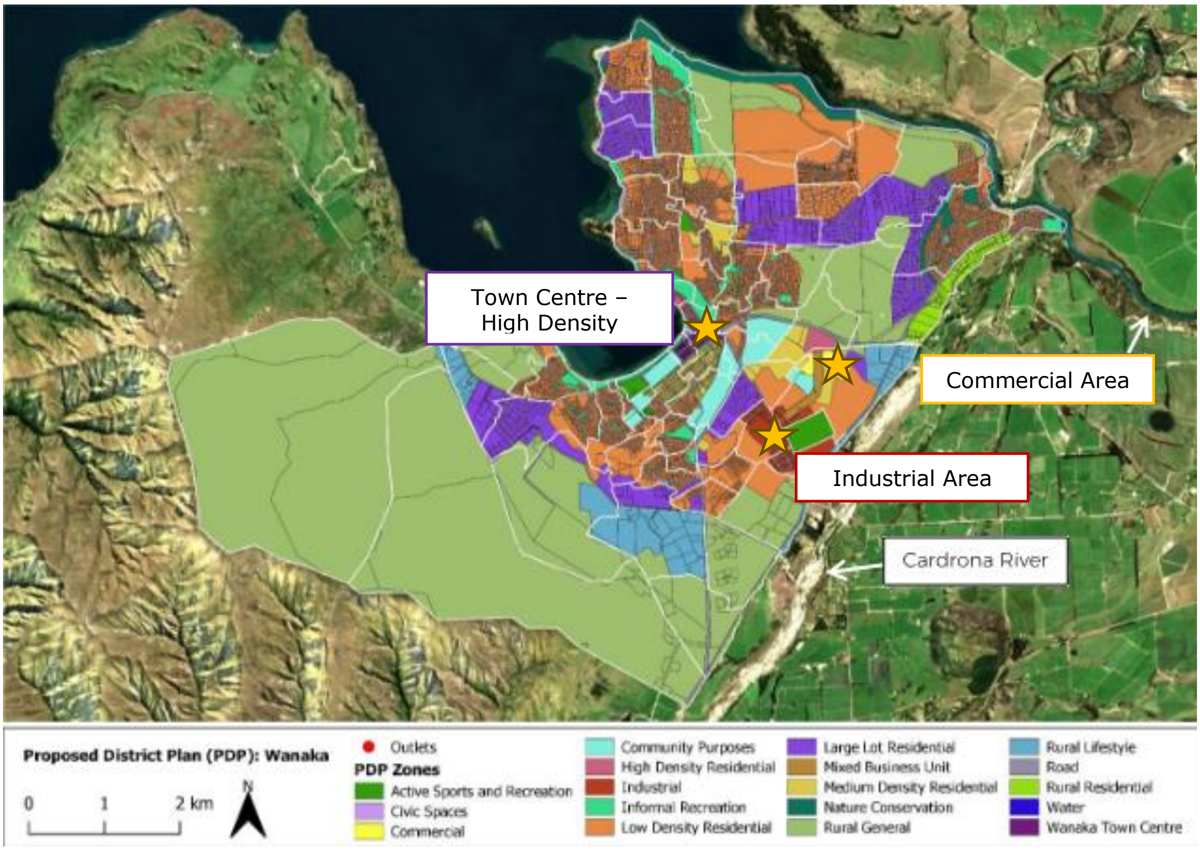

Figure 6: Wānaka Simplified PDP Zones (Produced by (GHD, 2020))

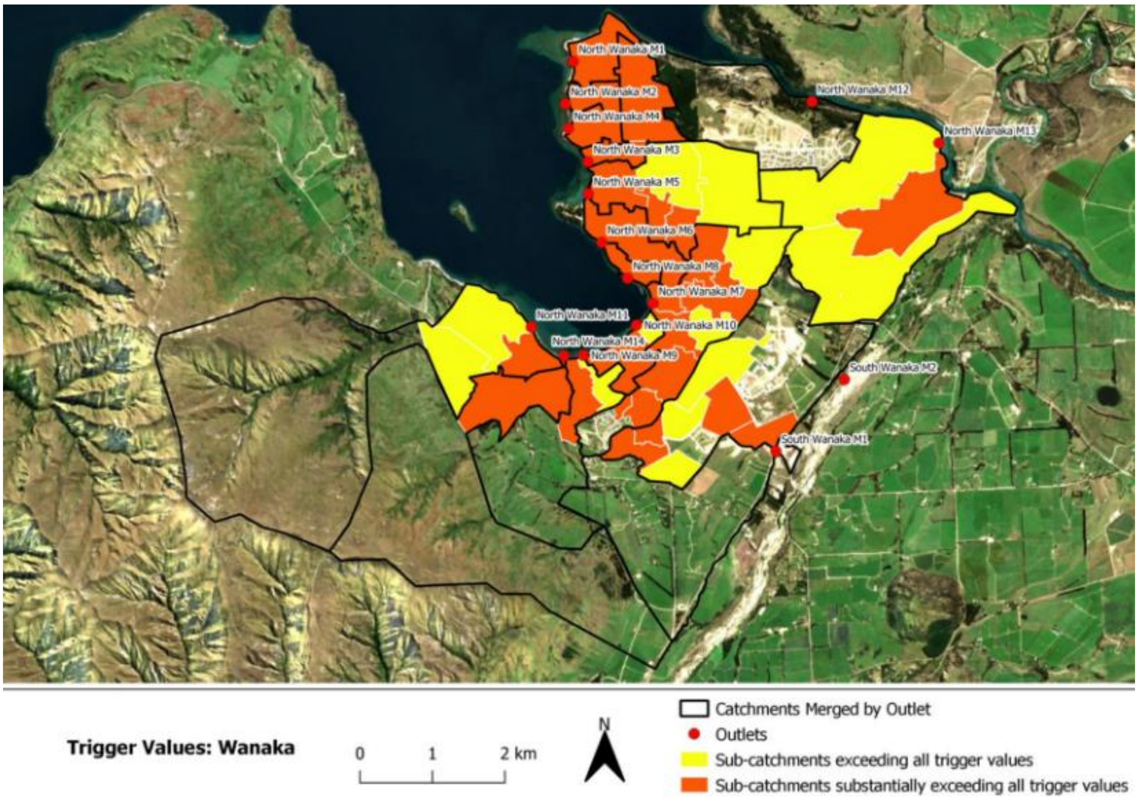

Figure 7: Wānaka Simplified PDP Zones (Produced by (GHD, 2020))

5.2.2 HĀWEA

Similar to Wānaka, contaminant load modelling was completed for Hāwea and highlighted areas of potentially high contaminant load into the receiving environments (GHD, 2020). GHD reviewed land use in the operative and proposed district plans, traffic counts and roof types to identify areas of high contaminant load potential (Figure 8 and 9).

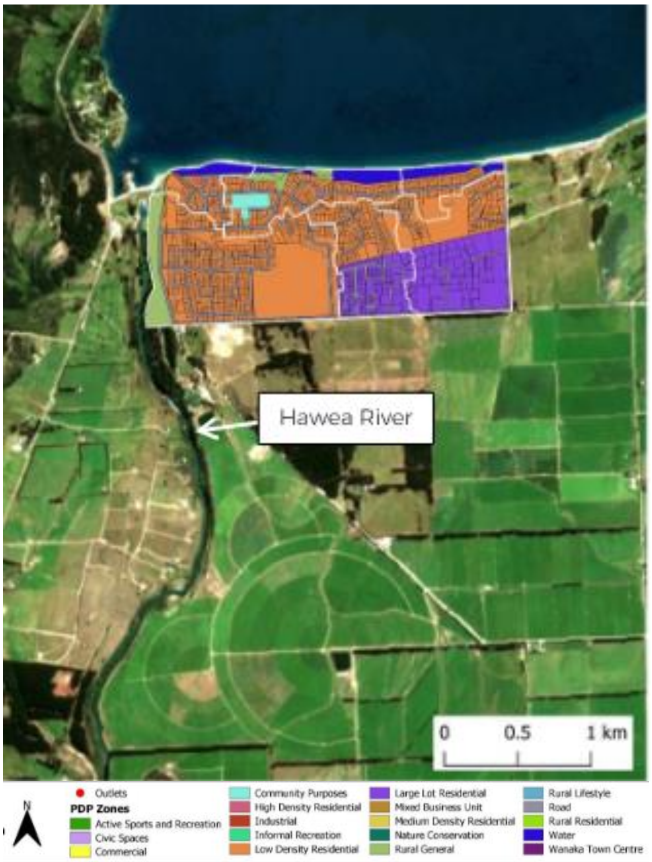

Figure 8: Hāwea Simplified PDP Zones (Produced by (GHD, 2020))

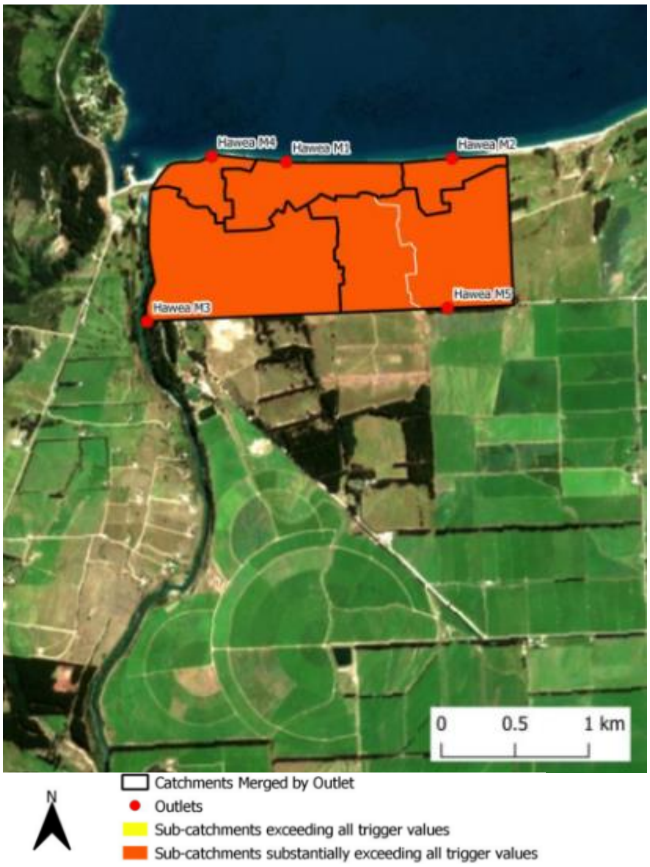

Figure 9: Hāwea Sub catchments with high contaminant load (Produced by (GHD, 2020)

As shown above, the CLM results for catchments in Hāwea suggest discharges will substantially exceed the trigger values. The sub-catchments draining directly to Lake Hāwea have high nutrient concentrations, particularly of Phosphorus. This is due to the residential land uses, however, in comparison to the rural catchments surrounding Hāwea, the Phosphorus loading from residential land uses is likely minor.

There is no sampling data available for stormwater in Hāwea, and therefore it is difficult to comment on the validity of the modelling results.

5.2.3 CARDRONA

There is no sampling data available for stormwater in Cardrona. The existing development of settlements is considered low risk for water quality from stormwater. This is attributed to the low volume of stormwater compared to the river flow, minimal existing development and relatively less sensitive receiving environment (Cardrona River). However, with the construction of the new Mt Cardrona subdivision, it may be recommended to complete an initial contaminant load model for Cardrona.

6 THREATS, RISKS AND OPPORTUNITIES

Based on each of the challenges outlined above, the following table outlines the stormwater management risks and potential mitigations for water quality and quantity in Wānaka, Hāwea and Cardrona. These risks and potential mitigation strategies are focused on the challenges outlined above on a high level district wide review with further detail (and capital projects) to be considered as part of the CMP development.

Table 5: Overview of Stormwater Management Risks and Potential Mitigations

Threats	Location and Risk			Risk	Potential Mitigation
	Wānaka	Hāwea	Cardrona		
Volatile Legislative Environment	High	High	High	Risk that rules change, and stormwater management approaches may be under or over conservative.	Development of a stormwater strategy
Construction Sediment Loading	Medium	Low	High	Risk of sediment washing into stream when development adjacent.	Robust erosion and sediment control planning and regulations.
Stream Bank Erosion	High	Low	Medium	Risk of high velocity and flows mobilising sediment, particularly in small streams	Detention and retention to reduce velocity and flow rates into streams.
Contaminant Load – Industrial	High	Low	Low	Risk of contaminants entering receiving environment directly adjacent (highest concern for Zinc, Copper, TP and TN)	Treatment
Contaminant Load – Commercial	Medium	Low	Low	Risk of contaminants entering receiving environment (highest concern for Copper, TP and TN)	
Contaminant Load – Increased Density	High	Medium	Medium	Risk of contaminants entering receiving environment directly adjacent. Risk of contaminants entering receiving environment (highest concern for E. coli)	
Sensitivity of Receiving Environments	High	High	Medium	Consequence of impacting high value receiving environments is major, despite likelihood being moderate.	
Information Gaps	Medium	High	High	Risk of unknown or emerging contaminants enter the receiving environments.	Monitoring programme to be completed in Hāwea and Cardrona
Primary Level of Service	Medium	Unknown	Unknown	Risk of properties flooding due to infrastructure having insufficient capacity.	• Upgrade network capacity, manage land use, implement low impact development practices.

					• Update (or complete) Model areas for Hāwea and Cardrona • Implement secondary flow paths.
Secondary Level of Service	Medium	Unknown	Unknown	Risk of properties flooding, unsafe transportation during floods and secondary system not being appropriately designed to safely convey water.	• Upgrade network capacity, manage land use, implement low impact development practices. • Update (or complete) Model areas for Hāwea and Cardrona • Implement secondary flow path system.
Information Gaps	Low	High	Medium	Risk of unknown LOS for area.	Flood modelling is proposed to be updated / completed for Hāwea and Cardrona

7 ADDRESSING THE CHALLENGES

Beca and DHI are currently developing a holistic CMP approach for QLDC. This paper specifically reviews challenges specific to Wānaka, Hāwea, and Cardrona. These challenges include: a rapidly changing legislative environment, several distinct receiving environments, high growth rates, and varying levels of information available. This paper outlined the key challenges that QLDC is facing in developing a district wide catchment management plan and some issues and opportunities for each of these area.

The key conclusions and recommendations are included below.

- Defining a common context for all areas that can act as a base for all areas including the legislative framework and Land Development Code of Practice.
- Providing Council a robust but flexible prioritisation framework that can be tailored to the level of information available.
- Developing capital projects based on the prioritisation framework to allow a "no regrets" approach to stormwater management.
- Using the ten Urban Stormwater Management Principles to provide a foundation for nature based solution generation. These include protecting and enhancing health of all receiving environments, addressing pressures on water bodies close to the source, increasing resilience to natural hazards and climate change etc.
- Considering a 'live' format for the catchment management plans to enable updates due to regulation change as well as asset changes due to fast growth.
- Aligning CMPs across the district in a strategic way to unify the approach to stormwater.
- Key water quality monitoring locations and a monitoring strategy should be completed across the district to enable the specific of stormwater discharges to be monitored.

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