DRY WEATHER DISCHARGES FROM A MONITORED STORMWATER CATCHMENT

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1 ABSTRACT

Stormwater is known to be a major source of contaminants to aquatic environments within urban areas. Research and monitoring over the past two decades has provided a good understanding of the types of contaminants and the concentrations of these from different land uses and land covers, such as roading, roofing and residential areas. This monitoring is the basis of many models in use in New Zealand. However, there is somewhat limited information on some land use types, including stormwater from industrial catchments. The available information suggests the stormwater from these catchments can have very high contaminant concentrations and loads. In the Auckland region there exist a high number of stormwater outflows that discharge directly to the aquatic receiving environment without any treatment. These aquatic environments are often low energy, fragile estuarine areas that are susceptible to environmental degradation. Auckland Council conducted an 11-month study (stage one of the Whau Catchment Contaminant Study) that was aimed at identifying characteristics of stormwater runoff during rain events and, as part of this, supported the collection of a continuous time-series of hydrology and basic water quality parameters. An unexpected observation from continuous monitoring was numerous dry weather flow events were measured during the project that would have otherwise gone unmonitored. Dry weather discharges have been identified as a contributing issue to environmental degradation. Often dry weather discharges are associated with a combination of illicit discharges and failing infrastructure. Illicit discharge of contaminants to stormwater networks can occur at any time, and water quality measurements targeted to storm events may not capture such activities. Information into frequency and quality of dry weather discharges is unknown and goes unmonitored.

2 BACKGROUND

The contribution of dry weather discharges on overall contaminant loads is unknown and poorly understood. Sources of dry weather discharges can be permitted, natural or illicit (Kang et al, 2009). Permitted discharges can occur from car washing, building washing, irrigation and yard wash downs. Natural discharges can be from groundwater intrusion or stream diversions that enter the stormwater network and provide a continuous flow at the outlet. Illicit discharges can occur from intentional or unintentional pollution events such as spills of materials such as chemicals, paint, or food waste. Additionally, illegal cross connection of wastewater into stormwater networks can contribute high bacteria loads amongst other contaminants (Sercu et al, 2011). Timing of dry weather discharges increases in frequency during business hours (Beck & Birch, 2014).

During dry weather discharges, high concentrations of contaminants can be delivered to the receiving environment (especially from illicit discharges) that can result in acute toxicity effects on receiving environment ecosystems. These acute effects are compounded by the lack of flushing flows that naturally accompany storm events (Gromaire et al, 2001)).

The study catchment, the Whau Catchment, is located west of Auckland's central business district (Figure 1). The tidal and estuarine Whau Creek runs from south to north through the middle of the catchment and flows into the Waitemata Harbour. Long term trends in marine sediment samples at locations in the Whau Creek and the greater Waitemata Harbour have shown an increase in copper and zinc concentrations through the latter half of the 20th century (Mills et al, 2012). Concentrations observed in coastal sediment have increased 2-3 times over a period of 50-60 years. Sites within the Whau Creek have recorded the highest concentrations within the Waitemata (Aherns et al, 2008; Mills et al 2012). The onset of increased metal concentration coincides with the mid-20th century conversion to industrial land use. Ongoing elevated concentrations of metals recorded in the marine sediment samples also highlight a need for ongoing investigation of heavy metal contamination in the receiving environment.

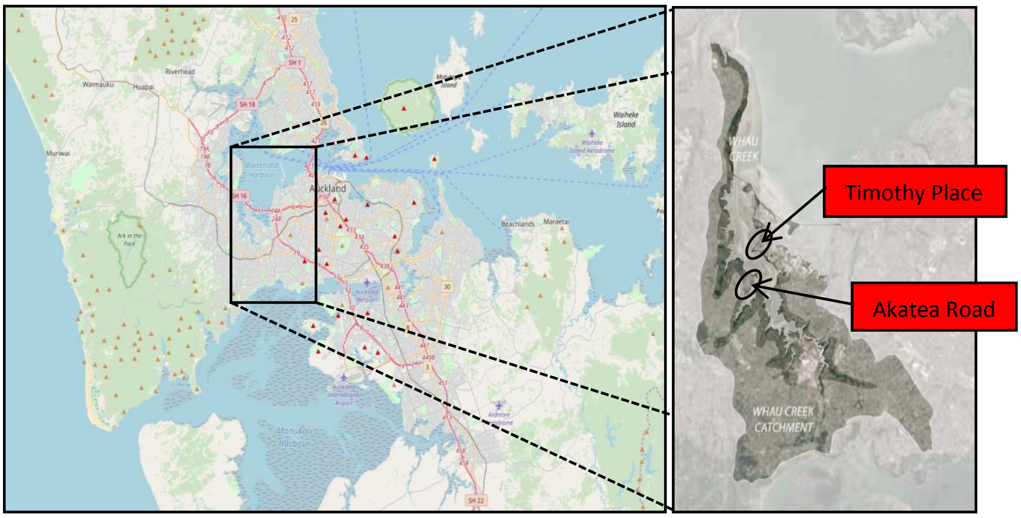

Figure 1. Site location (credits: Open Street Maps, Marshall et al, 2013)

This study investigated two sub-catchments with stormwater networks which discharge into single stormwater culverts: Akatea Road and Timothy Place. The study goal was to understand the contaminant load discharged from industrial catchments. This, in turn, will allow for more accurate inputs to the Freshwater Management Tool being developed by the Auckland Council Wai-Ora Healthy Waters department.

The land use of both sub-catchments is industrial, the industrial activity being dominated by engineering and metal work (51% for Timothy Place and 47% for Akatea Road) with the remaining areas being a mix of other industrial uses (Figure 2). Generally, the two sub-catchments are broadly indicative of other industrial land use within the wider Whau catchment. The Akatea Road study site is located on the western side of the Whau Creek and has a catchment of 8.9 ha and a fall of 32 m from the highest point in the drainage catchment to the stormwater culvert (Figure 3). The impervious surface area is 2.8 ha of which 2.6 ha are building footprints. The Timothy Place site is located to the east of the Whau Creek on Rosebank Peninsula and has a catchment of 9.2 ha and a fall of 15 m from the highest point to the stormwater culvert (Figure 4). The impervious surface coverage is 4.5 ha of which 3.8 ha are building footprints.

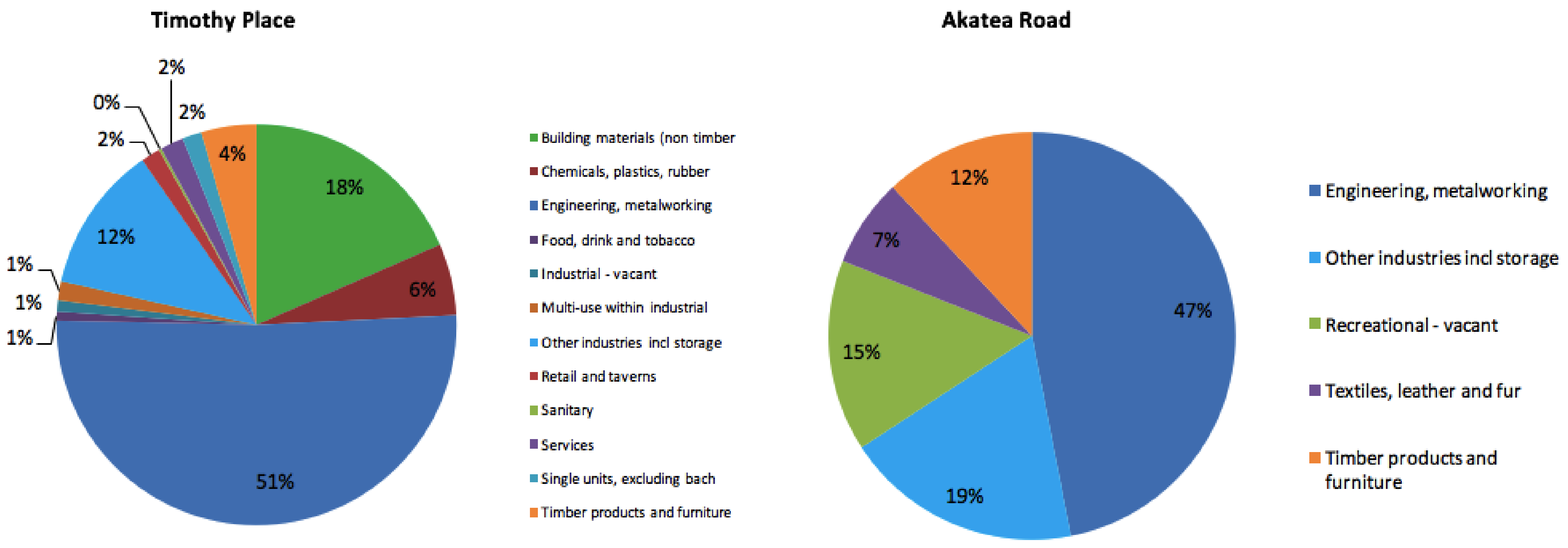

Figure 2. Land use composition from the two sub-catchments; Timothy Place (left) and Akatea Road (right). Obtained from the Auckland Council rates database

Figure 3. Akatea Road catchment and land use type. Black outline is the drainage catchment

Figure 4. Timothy Place site catchment and land use type. Black outline is the stormwater catchment

3 METHODOLOGY

A rectangular notched thin-plate weir was constructed at the outfall of each stormwater network. EXO 2 multiparameter sondes which measured temperature, turbidity, conductivity, pH, ORP and dissolved oxygen were deployed into the ponded water that formed behind (upstream of) the weir. A counterweight-and-float water level recorder was installed in a stilling well to measure water level. ISCO 3700 automatic samplers were deployed to capture water quality samples during storm events only. Flow was estimated using a theoretical rating equation derived from ISO 1438. Water level (and hence flow) and water quality parameters were recorded every 2 minutes continuously over the 11-month monitoring period. Site data was telemetered allowing for real-time review of the incoming information. Both sites were physically checked at a minimum frequency of once per month (more often if storm events were monitored). During the check, all site sensors were verified against calibrated reference instruments according to national environmental monitoring standards (where applicable). Data was stored and managed for quality assurance on Hydstra, a dedicated hydrological time-series supplied by Kisters Pty Ltd.

4 RESULTS

Fluctuations in water quality data are often associated with high flow rates, such as storm events. Data obtained during this study identified that water quality fluctuations were also occurring during dry weather. During data processing and analysis, it was observed that the monitored water quality parameters demonstrated abnormal values when there was no recorded rainfall and usually little to no change in water level. These recorded concentrations were observed to occur at a variable frequency and were dependent on the water quality parameter. Fluctuations in one water quality parameter were not always reflected in changes in other water quality parameters, i.e. independent response was observed. In addition to the fluctuations in data, observations were made when conducting field visits to the two sites confirmed that discharges were occurring in dry weather (Figure 5).

Figure 5. Two discharge events observed when monitoring staff were onsite during dry weather. Left is Akatea Road and right is Timothy Place

At Akatea Road, regular increases in the value of turbidity data were often observed during the early afternoon on weekdays (Figure 6). Visual observation within the catchment confirmed this often coincided with washdowns of a topsoil and aggregates supply yard. One of these events (named Akatea Road Event 1) was the highest recorded turbidity value for the duration of the monitoring period (Figure 7).

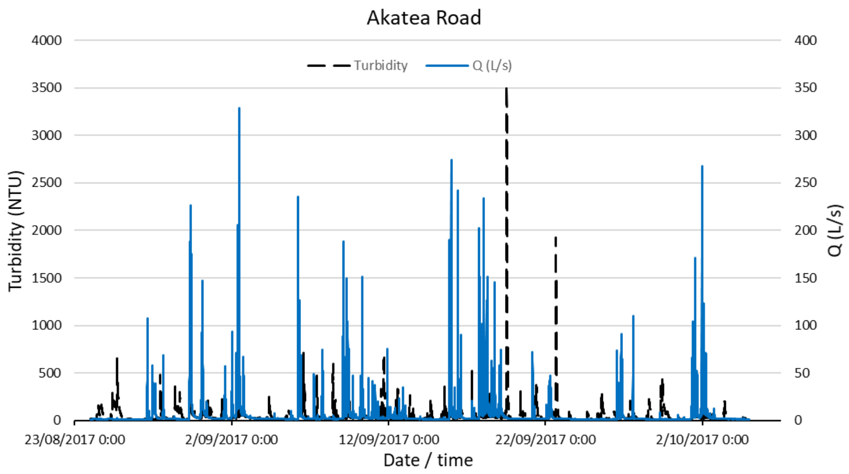

Figure 6. Akatea Road record from 23 August to 2 September, 2017

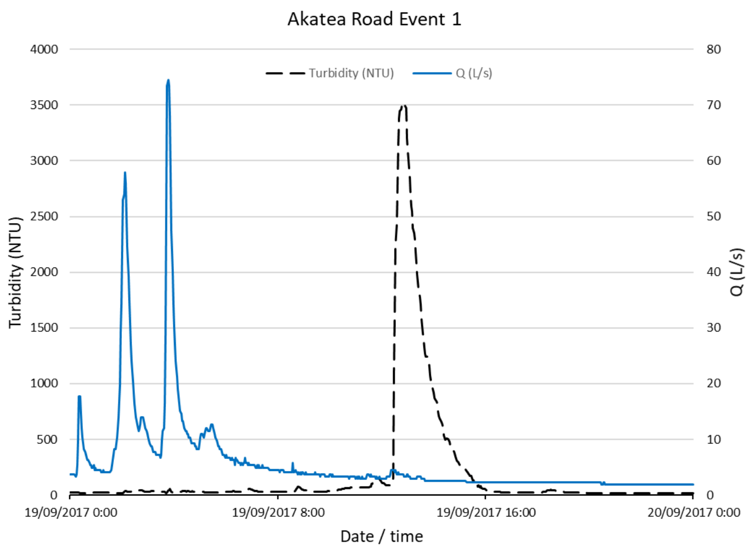

Figure 7. Akatea Road Event 1

Less frequently, periods were observed where high values for conductivity coincided with low pH, however no visual connection was made with catchment factors for this. High values for one water quality parameter did not necessarily coincide with changes in other water quality parameters. One event (named Akatea Road Event 2) demonstrated an increase in conductivity values and a decrease in pH, but no change in turbidity was observed in conjunction (Figure 8). It is also likely that different dry weather discharge events occurred simultaneously. An event in February 2018 (Akatea Road Event 3) had an increase in conductivity and decrease in pH, closely followed (2 hours) by an increase in turbidity (Figure 9). However, the timing of the turbidity increase (mid-afternoon) suggests a yard washdown event similar to Akatea Road Event 1. This was followed by another turbidity fluctuation early the next morning that coincided with a slight increase in pH.

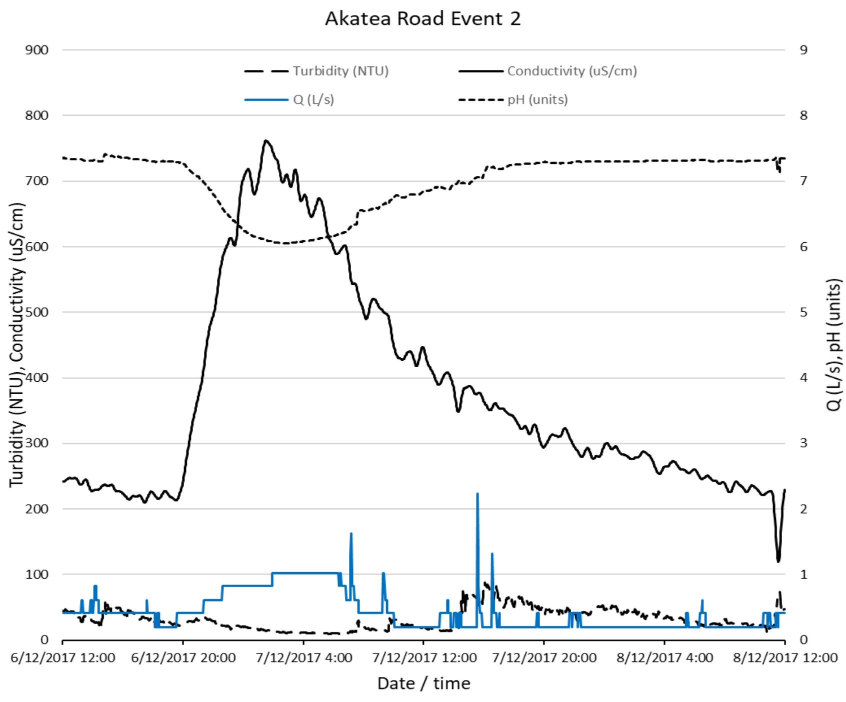

Figure 8. Akatea Road Event 2

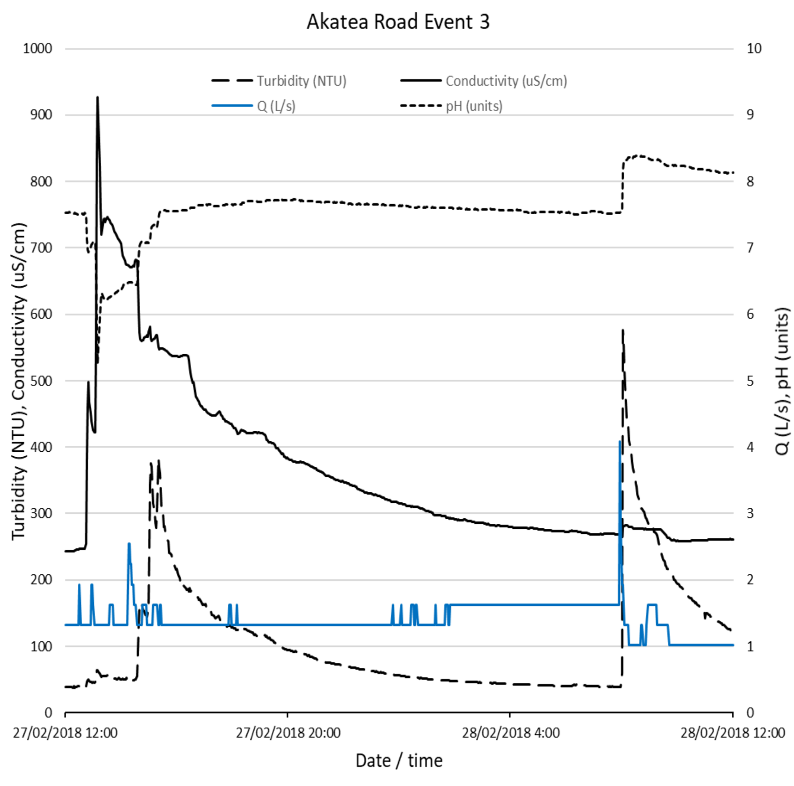

Figure 9. Akatea Road Event 3

Whilst Akatea Road had frequent dry weather discharge events, Timothy Place had less frequent, but arguably more acute discharge events recorded. The most noticeable of these events occurred over a five-day period in March 2018. A dry weather discharge event resulted in elevated conductivity measurements (highest on record) and a corresponding decrease in pH values (lowest on record) (Figure 10). Conductivity data was observed at values exceeding those normally attributed to seawater and remained elevated for around 30 hours. The pH time-series displayed an inverse relationship to conductivity, decreasing to a value similar to acetic acid. Observed flow from the site for this period was consistently around 10 L/s, compared to normal baseflow conditions of around 1 L/s. This event discharge totaled approximately 1,000 cubic meters of flow. Clearly, should elevated contaminant concentrations be present (as is likely due to elevated water quality parameters), the mass flux from such an event could be considerable. Eventually, the water quality parameters did return to more usual values, but this did not occur until several rain events had been observed almost 96 hours after the initial dry weather discharge event occurred, demonstrating the importance of rainfall in diluting any dry weather discharge.

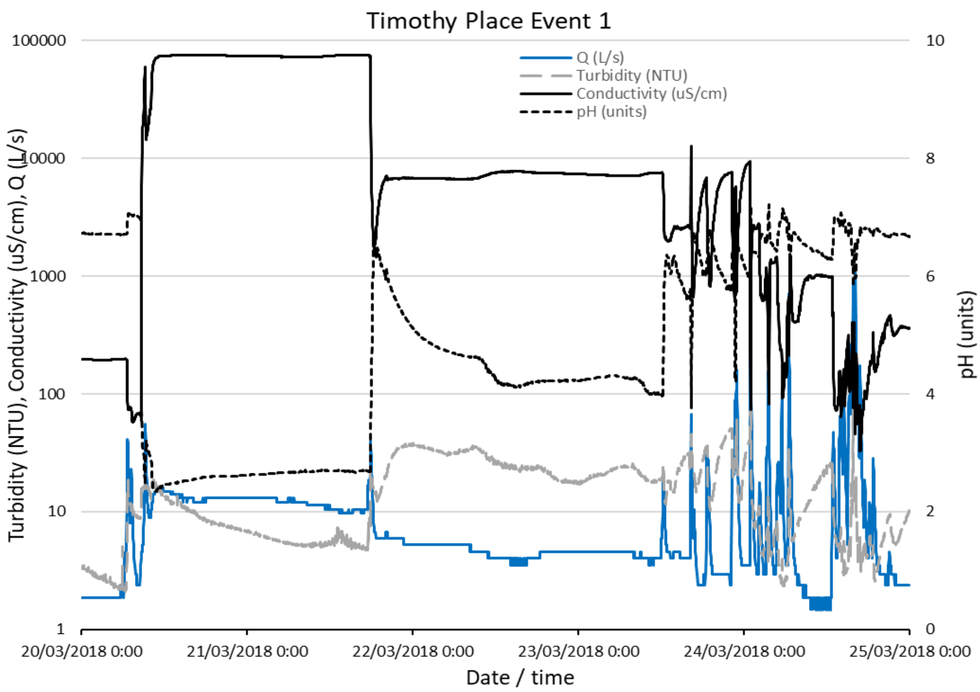

Figure 10. Timothy Place Event 1

5 DISCUSSION

As the ISCO 3700 automatic sampler was not deployed for any of the dry weather discharges, no laboratory chemical analysis is available. However, the values of the water quality parameters observed during dry weather discharges represented the most extreme values from the 11-month datasets. It is likely that had chemical analysis been available, similarly extreme results would have been observed. While no full analysis is possible, there is a contaminant flux being discharged during dry weather events to the receiving environment. Further analysis of this data will be carried out during future work to identify if these fluxes are significant enough to warrant contaminant model builds to include continuous data rather than being solely reliant on storm event data only.

The usefulness of water quality parameters at measuring a dry weather discharge therefor is twofold: firstly, they give evidence for the frequency of dry weather discharges that otherwise would go undetected; secondly, the occurrence of dry weather discharges suggests that the value of stormwater that is assigned by stakeholders within a catchment may be low. The frequency of dry weather discharges suggests that multiple sites within the catchment may be contributing. The reliance on spill response plans and environmental management plans for industrial sites may therefore be inadequate at preventing these incidents from occurring. Continued education programs and engagement with industrial site owners may contribute to lessening the potential for dry weather discharges to occur.

The frequency of the dry weather discharges was unexpected and the contribution of these events to the overall catchment contaminant load is (currently) unmeasurable. While water quality parameters recorded during storm events may be correlated to physical sample chemistry results, for the current study such a relationship cannot be extrapolated to the observed dry weather discharge events. Discharge from a rain event will carry contaminants from across the catchment impervious surfaces, whereas a dry weather discharge may represent the washdown of a spatially focused area (i.e. one yard from within the catchment), or the disposal of a homogenous chemical. This is evidenced through the differing contaminant signatures of dry weather discharges between the two studied sub-catchments and between different events. The turbidity, conductivity and pH time-series did not always respond to a dry weather discharge in conjunction with each other. It is evident multiple sources of dry weather discharges exist within these catchments and that there is a complex relationship between stakeholder behavior and dry weather discharges.

Further investigation is needed to quantify the contribution to catchment load that dry weather discharges could present. For effective recognition of dry weather discharges, a range of water quality parameters should be measured, as different sources of contaminants within catchments can have different chemical signatures (Charhkabi & Sakizadeh, 2006). Measured water quality parameters can be used to trigger an automatic sampling unit, rather than water level. Capturing physical samples for chemistry analysis, combined with a flow record, will allow for calculation of contaminant mass.

Currently, models used to assess contaminant loading to receiving environments rely on physical sampling during storm events. The magnitude of observed water quality fluctuations suggests that the mass of dry weather contaminant flux warrants more study. Should this dry weather discharge contaminant flux be significant, then models used to predict water quality and contaminant loading will need to be reviewed.

Like much of the existing stormwater infrastructure in the area the two study sites have no treatment devices in place and discharge straight into the Whau Creek, an estuarine receiving environment that is recognized as having elevated levels of pollutants in marine sediments (Mills et al, 2012). The presence of dry weather discharges suggests that effective treatment of pollution sources will require a broad approach, not just infrastructure but also encouraging stakeholder behavior change through education and business engagement.

6 CONCLUSION

Dry weather discharges were observed in two separate monitored sub-catchments of the Whau Creek over an 11-month period. The values of water quality parameters associated with these dry weather discharges included the highest results on record for conductivity and turbidity and the lowest result on record for pH (exceeding values observed during storm events). The occurrence of the dry weather discharges varied between the two sub-catchments, with one catchment having more regular turbidity fluctuations that were linked to yard washdowns observed on site. The fluctuations in water quality parameters were not always observed in conjunction with each other, suggesting that multiple sources of dry weather discharges exist within each catchment. The magnitude of the contaminant flux discharged during these dry weather discharges deserves further investigation as current water quality and contaminant load models do not account for dry weather discharges. The collection of physical samples for chemical analysis from dry weather discharges would allow for contaminant mass to be calculated and the refinement of current models.

It is likely that a complex relationship exists between catchment stakeholder behavior, the value associated with the stormwater network and dry weather discharges. Implementation of best-practice stormwater management would need to be accompanied by education and local business engagement.

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