**Before the Independent Hearing Panel appointed by the Canterbury Regional Council**

**IN THE MATTER OF** The Resource Management Act 1991

**AND**

**IN THE MATTER OF** Application CRC190445 to discharge stormwater to land and water

**Section 42A Officer's Report**

**Report of Michele Stevenson**

## Background

1. This report forms part of Canterbury Regional Council's audit of the assessment of environmental effects (AEE) provided by Christchurch City Council (the applicant) in support of a resource consent application for a comprehensive discharge permit to discharge stormwater from the reticulated stormwater network within the Christchurch City boundaries.

2. This report will provide the decision-makers with information and advice related to the actual and potential effects of the proposed discharges on surface water quality and aquatic ecosystem health.

3. My name is Michele Stevenson. I am employed by the Canterbury Regional Council as a Senior Scientist - Surface Water Quality and Ecology. I hold a Master of Science degree in Environmental Science and a Bachelor of Science in Zoology and Geography. I have 17 years work experience in environmental science with a focus on water quality and ecology, working for government and private consulting organisations in Australia, the United Kingdom and New Zealand. I am a member of the New Zealand Freshwater Sciences Society.

4. I have been employed by the Canterbury Regional Council for 11 years. In that time my work has focussed on urban waterway and stormwater issues, including the monitoring of urban waterways, catchment investigations, stormwater research projects, and advice on stormwater discharge consent applications. Recent work has included providing reports and advice to the zone committee and zone delivery teams, involvement with interagency and in-house teams on the issue of stormwater and providing expert advice at the hearings for the South West and Styx global stormwater consent applications. I maintain connections with external organisations such as other regional councils and research providers (e.g. NIWA and the University of Canterbury) to ensure that my knowledge of stormwater and urban waterway management in New Zealand is relevant and up-to-date.

5. I have read the Code of Conduct for Expert Witnesses in giving evidence to the Environment Court. I agree to comply with that code when giving evidence to the Hearing

Panel in this matter. All my evidence is within my expertise and I have considered and stated all material facts known to me which might alter or qualify the opinions I express.

## Scope of Report

6. This report is prepared under the provisions of Section 42A of the Resource Management Act 1991 (RMA). This section allows a Council officer or consultant to provide a report to the decision-maker(s) on a resource consent application made to the Council and allows the decision-maker(s) to consider the report at the hearing. Section 41(4) of the RMA allows the decision-maker(s) to request and receive from any person who makes a report under Section 42A "*any information or advice that is relevant and reasonably necessary to determine the application*".

7. The Applicant originally lodged an application for resource consent in June 2015 (CRC160056), which was publicly notified in early 2016 at the Applicant's request. Following the receipt of submissions, further information from the applicant was requested. This information was audited and there were still outstanding concerns with regard to the proposal and potential effects on the environment and inconsistency with the planning framework. An amended application was provided to CRC on 9 July 2018 (CRC190445) including details of the Contaminant Load Modelling approach and revised resource consent conditions. An additional amendment to the proposal was the authorisation of all stormwater discharges to the reticulated network from 1 January 2025 or on the expiry of individual consents held by property owners. The original resource consent application excluded 'high risk' sites.

8. This report is supplementary to the Section 42A report prepared by Nick Reuther, Senior Consents Planner at CRC, for the above consent application. Full details of the consent application are provided in that report. For my report I have reviewed the following information provided in the AEE, its appendices and accompanying technical reports:

   a. Resource Consent Application and Assessment of Effects on the Environment (June 2015)

   b. Amended Application Letter (July 2018)

   c. Proposed resource consent conditions (July 2018)

   d. Environmental Monitoring Programme (July 2018);

   e. Responses to Section 92 Further Information Requests (November 2015 and June 2016)

   f. Ōtākaro/Avon Stormwater Management Plan;

   g. Ōtākaro/Avon Stormwater Management Plan: Technical Reports;

   h. Huritīni/Halswell River Stormwater Management Plan;

   i. Pūharakekenui/Styx Stormwater Management Plan Part A;

   j. Golder Associates (NZ) Limited – Assessment of Current and Future Stormwater Contaminant Load for Christchurch: CLM Modelling Report – Best Practice Infrastructure. July 2018

9. I have also considered relevant issues raised by submitters in relation to the effects I have considered in this report.

10. In my report I will address the following aspects:
    a. Freshwater (surface water) receiving environment water quality;
    b. Freshwater aquatic habitat and ecology.

    I note that the effects of the proposed discharges on sediment quality in freshwater, estuarine and coastal receiving environments will be addressed by Dr Lesley Bolton-Ritchie.

## Executive Summary

11. The CSNDC is a comprehensive discharge consent that is proposed to cover a large number of existing and future stormwater discharges over a large geographic area, with the potential to have effects on many different receiving environments. The management of stormwater under the proposed consent relies on the development and implementation of Stormwater Management Plans (SMPs) that have been or will be developed for individual catchments (or other smaller geographic areas), as well as an Environmental Monitoring Programme that will be used to assess whether the Applicant is meeting the Receiving Environment Objectives and Attribute Target Levels (as set out in Schedules 4 to 6 of the proposed consent conditions). In addition, the Applicant has proposed a programme of stormwater quality investigations and other actions that are designed to improve the management of stormwater quality and reduce stormwater effects on the receiving environment (Tables 3 and 4 of the proposed consent conditions). In general, I support this overall approach. My report provides detail of aspects of the application that I support as well as recommendations to address areas of concern.

12. The proposed Receiving Environment Objectives and Attribute Target Levels represent the overall outcomes that the CSNDC is contributing towards and, in my view, these should be the reference point for all decisions when (a) SMPs are being developed and reviewed, and (b) stormwater management investigations, actions and other initiatives are being prioritised and implemented. The Objectives and Target Levels for waterways (Schedule 4) are well aligned with the Land and Water Regional Plan (LWRP) outcomes and standards. However, a key concern for me is the lack of certainty around implementation and efficacy of mitigation measures and thus uncertainty around when outcomes might be achieved. The adaptive management approach will require frequent review of SMPs in response to results of the EMP and the investigations programme, and potential changes to regional and national planning instruments, to ensure that there is progressive improvement towards the outcomes for each catchment within the CSNDC area.

13. The SMPs include Contaminant Load Models (CLM) as a tool to predict the likely impact of stormwater treatment options. The predicted reduction in loads of key stormwater contaminants (zinc, copper and total suspended solids) are proposed to be included in the CSNDC conditions as targets for 5, 10, 25 and 35 years into the future. I note that

these load reduction targets have no relationship to the Receiving Environment Objectives and Attribute Target Levels. An independent review of the Christchurch CLM has raised significant concerns about the suitability of this model for the purpose proposed by the Applicant.

14. The Applicant has proposed to include high risk sites under this consent post-2025, which include large development areas and sites that are proposed to initially be excluded because CCC consider them to pose an unacceptably high risk of surface water or groundwater contamination. There has been very little information provided about how these sites will be identified, managed and monitored post-2025 and I therefore have strong concerns about the potential risk to water quality and ecosystems from discharges of sediment and other contaminants from these sites, without further assessment and detail of a proposed management framework. Significant resourcing will be required for CCC to manage and mitigate the contamination risks from these sites.

## Introduction

15. The Comprehensive Stormwater Network Discharge Consent (CSNDC) applied for by CCC covers stormwater discharges within a large area, including both the city of Christchurch and urban settlement areas of Banks Peninsula. The stormwater network consists of around 158 km of waterways (main open river and tributary channels) as well as 170 km of 'utility waterways' and 860 km of reticulated pipes (CCC, 2015). The Christchurch City waterways are the receiving environment for stormwater runoff from most of the flat land in Christchurch city (CCC, 2015). These waterways then flow into estuarine environments, apart from the Halswell River that flows into Te Waihora/Lake Ellesmere. The exceptions are in the west, where the majority of stormwater is discharged to land, and to the east where stormwater is discharged directly into the Estuary of the Heathcote and Avon Rivers/Ihutai or to the sea on the open coast, e.g. at Waimairi Beach. From the hill suburbs of Christchurch City the stormwater flows into streams and creeks which then flow into the Heathcote River/Ōpāwaho or into the estuary or the sea. In the urbanised settlement areas of Te Pātaka o Rākaihautū/Banks Peninsula the stormwater flows into streams and creeks which then flow into the sea or a lake (Little River stormwater goes into Wairewa/Lake Forsyth). However, some stormwater discharges are directly into the sea, e.g. Akaroa Main Beach where there is a large stormwater pipe on the beach.

16. Stormwater runoff naturally contains numerous physical, chemical and biological constituents (from soils, plant material and aerial deposition), however urban activities introduce new constituents to water which impact the health of the receiving ecosystems (Cunningham et al. 2017). Some of the key pollutants associated with stormwater include sediment, total and dissolved metals, nutrients, hydrocarbons, pesticides, organic matter (such as leaves), micro-organisms (notably from faecal matter from domesticated animals and birds) and rubbish, e.g. cigarette butts. Section 7 of the consent application is headed 'The Nature of the Discharge'. In this section it lists five broad groups of contaminants (sediment, metals, nutrients, hydrocarbons and microbes). There is also a description of the potential impacts of these contaminants on the receiving water environment. While I agree with the information that is provided in the consent application, the list of contaminants does not include:

- organic matter which has the potential to have a significant influence on dissolved oxygen concentrations;
- rubbish (gross pollutants) which has a significant influence on aesthetics;
- a wide range of other potential ‘contaminants of concern’ (CoCs), including hazardous substances, that may enter the stormwater network through poor site management practices at industrial or commercial premises, or from earthworks on contaminated land.

17. The contaminants listed in paragraph 16 are either entrained or dissolved in rainwater as it flows over hard surfaces such as roofs, car parks, driveways and roads. The stormwater and its associated contaminants flow into the city rivers, streams, brooks and creeks through either the piped and open channel stormwater infrastructure or directly via runoff from adjacent hard surfaces. Other contributors of these contaminants, to the city rivers, streams, brooks and creeks are:
    a. sediment - dewatering water, runoff from poorly vegetated slopes, earthquake sediment, bed and bank erosion;
    b. organic matter - leaf litter, animal faecal matter, decaying aquatic plants, and wastewater overflows;
    c. faecal matter - waterfowl and wastewater overflows;
    d. nutrients - waterfowl, wastewater overflows and some industries;
    e. various inorganic and organic CoCs - industries with their own stormwater discharge consent, industrial spills, wastewater overflows, wash down runoff from hard surfaces directly into the waterways, leachate from contaminated sites such as old landfills;
    f. rubbish – direct input by humans, e.g. throwing items into a river;
    g. re-suspension of contaminated bed sediment.

18. The sources of nutrients (nitrogen and phosphorus compounds) in stormwater include fertilisers applied to urban lawns and gardens, industrial discharges, domestic animal faeces and agricultural and horticultural activities in rural areas. Nutrients are not a significant stormwater contaminant from hard surfaces such as roofs, roads and carparks. Nutrient concentrations in the city rivers, streams, brooks and creeks are also influenced by:
    - local geological characteristics, for example the relatively phosphorus rich soils of Banks Peninsula influence phosphorus concentrations in the local waterways;
    - nutrient concentrations in the groundwater that feeds the springs (the Avon River/Ōtākaro, Heathcote River/Ōpāwaho, Styx River/ Pūharakekenui, Halswell River/Huritini and Otukaikino River are spring fed). This groundwater may be sourced from land surface recharge on the Canterbury plains and can therefore be influenced by agricultural activity.

19. The contaminants in stormwater have the potential to influence dissolved oxygen concentrations, total suspended sediment concentrations, nutrient concentrations, dissolved metal concentrations, hydrocarbon concentrations and faecal indicator bacteria (FIB) and pathogenic micro-organism concentrations in receiving waters. Many contaminants, including emerging organic contaminants, also influence the quality of the receiving environment sediment that is deposited on the bed of waterways and others influence the aesthetics of the receiving environment, for example suspended sediment.

20. The effects of stormwater on receiving water quality described above have broad ranging impacts on the aquatic ecosystems that inhabit the streams, rivers, lakes, estuaries, harbours and coast downstream of stormwater inputs. In addition, stormwater inputs can directly influence habitat conditions for aquatic species by introducing fine sediments that deposit on the bed and smother coarser substrates that are used for habitat and spawning. Interactions between surface water and groundwater habitats can also be impacted by excessive fine sediment deposition. Stormwater flows can significantly change the hydrological regime of waterways, further impacting on habitat conditions for aquatic flora and fauna.

21. It is important to note that aquatic ecosystems within waterways impacted by urbanisation are affected by a range of factors that are not directly associated with stormwater discharges. As well as the additional sources of contaminants that influence water quality, listed in paragraph 17 above, these include:
    a. Bank and channel maintenance practices, including straightening and reinforcing which can reduce the heterogeneity of channel form and bed and bank habitat;
    b. Riparian vegetation management, including width of riparian buffer, types of vegetation planted, maintenance practices, which influence shading, organic matter inputs, spawning habitat for species such as inanga, and filtration of contaminants in overland runoff;
    c. Macrophyte (aquatic weed) removal practices;
    d. Flow rates from springs and interactions with groundwater through the bed of the stream.

22. My assessment of CCC's consent application considers the potential effects of stormwater discharges on surface water quality and aquatic ecosystem health in freshwater streams, rivers, lakes and wetlands within the Christchurch district and whether they are sufficiently mitigated by the proposed stormwater management approach. I will refer to the reports of Dr Lesley Bolton-Ritchie, who addresses effects on instream sediment quality, and Rowan Freeman, who discusses the issues associated with contaminated land and high-risk sites. A supplementary report by Dr Tom Cochrane is attached to this report (Attachment A) and provides an independent review of the Christchurch Contaminant Load Model report (Golder Associates 2018).

## Assessment of Receiving Environment

23. Section 3.5 of the AEE provides a description of surface waterways, section 3.6 provides an overview of their water quality state, and section 3.7 provides a brief overview of their ecological health and value. It is noted in section 3.7 that fuller information on the ecological status of waterways within each of the catchments will be detailed in their catchment-specific Stormwater Management Plans (SMPs) and I note that the same is likely to apply to the water quality assessment.

24. These sections in the AEE provide useful summaries of the physical and biological characteristics of each catchment within the Christchurch district where existing CCC water quality and ecology monitoring programmes are in place and reported by CCC (e.g. Margetts and Marshall 2015, submitted with the original consent application). Description of current state aids with assessing whether potential future changes in management are

likely to result in improvement, maintenance or degradation in condition and achievement of objectives. There is a lack of information included on the water quality and ecology of some of the other receiving environments, even where data are available that has been collected by other organisations such as Environment Canterbury. These receiving environments include the Estuary of the Heathcote and Avon Rivers/Ihutai, waterways that flow through settlements on Te Pātaka o Rākaihautū/Banks Peninsula, and the lakes Wairewa/Lake Forsyth and Te Waihora/Lake Ellesmere.

25. The current state of natural wetlands that receive stormwater discharges was also not described in the AEE. The 'Nov 2015 RFI response' (CCC 2015b) did provide a list of natural wetlands within the CSNDC area, noting those that currently receive stormwater. The response stated that existing discharges to these wetlands are already occurring and CCC do not propose to use natural wetlands for future treatment or discharge of stormwater, so no direct monitoring of wetlands is proposed. The effects of existing stormwater discharges on wetlands remains unknown.

26. The descriptions of water quality and ecological health provided in sections 3.6 and 3.7 included reference to guideline values for some parameters and provided comparison to Land and Water Regional Plan (LWRP) targets for ecosystem health (as measured by the Quantitative Macroinvertebrate Community Index; QMCI) for some catchments. However, an explicit comparison to relevant national, regional and local objectives, targets or standards was not provided in the AEE. The 'Nov 2015 RFI response' provided an analysis of current state for the catchments that, at the time, were proposed to have a goal of 'maintain water quality'. This analysis referred to the Receiving Environment Targets for Waterways that were in the proposed consent conditions, and in many cases those targets were directly based on LWRP outcomes and standards. The current state analysis table was updated in the 'June 2016 Further Information' to amend the analysis for copper, lead and zinc concentrations in surface water to use $95^{th}$ percentiles of the data instead of medians. These analyses were based on water quality data for the 2014 calendar year and ecological and habitat data from the most recent monitoring undertaken for CCC at the time.

27. I have updated and summarised the current state analysis table to provide an indication of the current state of the receiving waterways by catchment, based on the number and percentage of sites exceeding targets (Table 1). The attributes that I have used are the proposed Receiving Environment Targets for Waterways that I believe are most directly linked to the stormwater discharge activity. Note that I have not included assessment of macrophyte and filamentous algae cover. Most of these targets are directly linked to LWRP Table 1a outcomes (QMCI and % fine sediment cover) or Schedule 5 standards (copper, lead and zinc toxicant trigger values). The sediment quality targets are derived from the ANZECC (2000) interim sediment quality guidelines and are a useful measure of the long-term impact of stormwater discharges on receiving waterways. For water quality and sediment quality I have counted exceedances for more than one contaminant at a site as a single 'non-compliance', for example a site exceeding the standard for both copper and zinc will count as one site not meeting the attribute target level. Note that this method is for the purposes of demonstrating the level to which different components of the receiving environment are currently meeting their targets and is not how I envisage reporting or compliance assessment under the proposed consent being undertaken.

**Table 1. Number and percentage (%) of sites by catchment monitored by CCC that do not meet attribute target levels[1] (n.d. = no data)**

| Catchment | Water quality – dissolved Cu, Pb, Zn [2] | | % fine sediment cover [2] | Sediment quality – Cu, Pb, Zn, PAHs | QMCI [2] |
|---|---|---|---|---|---|
| | 2017 | 2015-2017 | | | |
| Avon | 1 (8%) | 5 (38%) | 14 (82%) | 8 (57%) | 9 (53%) |
| Heathcote | 5 (38%) | 6 (46%) | 12 (92%) | 7 (54%) | 7 (54%) |
| Styx | 1 (13%) | 2 (25%) | 7 (78%) | 3 (27%) | 9 (75%) |
| Halswell | 0 | 1 (33%) | 5 (100%) | 0 | 5 (100%) |
| Ōtukaikino | 1 (33%) | 3 (100%) | 2 (22%) | 3 (30%) | 1 (11%) |
| Banks Peninsula | n.d. | n.d. | n.d. | n.d. | 2 (100%) |
| TOTAL | 8 (20%) | 17 (43%) | 40 (75%) | 21 (40%) | 33 (57%) |

Data from 'June 2016 Further Information', various reports from 2013-2017 available on the CCC website, and own analysis of CCC's water quality data (see paragraph 28 for explanation of analysis).

[1] The Attribute Target Levels specified in Schedule 4 of the proposed consent conditions

[2] Derived directly from LWRP Table 1a outcomes or Schedule 5 standards

28. For the water quality assessment, I used the latest data available from CCC (up to the end of the 2017 calendar year) and calculated the 95$^{th}$ percentile of monthly data for dissolved copper, lead and zinc, using the Hazen method. Assessments of water quality state typically use three to five years of monthly water quality data to ensure that the dataset is representative of the variability in water quality at a site (Larned et al. 2015; Gadd 2016). I have used both a single year (2017) and the last three years of data (2015-2017) to demonstrate the differences in results (note further discussion of time periods for reporting in paragraph 94 of this report). The monthly monitoring data are collected regardless of weather conditions (Dr Belinda Margetts, CCC, pers. comm.) with most, but not all, sampling events occurring in dry weather. The data presented can therefore be considered representative of the range of water quality conditions that the resident aquatic biota would be exposed to over time (i.e. chronic conditions), particularly when the longer data set is used.

29. The water quality analysis shows that either 20% or 43% of sites do not meet the attribute target levels for dissolved metal concentrations in surface water, depending on whether one year or three years of data are used. All the sites not meeting the attribute target level had exceedances for dissolved zinc, with only one site also exceeding the dissolved copper guideline. There were no exceedances for dissolved lead. The high level of exceedances within this largely dry weather water quality dataset is concerning and indicates that the effect of stormwater discharges is persistent beyond the rainfall events, possibly due to contaminant remobilisation from bed sediments.

30. A much higher percentage of sites do not meet the attribute target levels for fine sediment cover, ranging from 22% for Ōtukaikino catchment to 100% for the Halswell catchment, with 75% of sites not meeting the target levels overall (Table 1). The data for this assessment are from the 5-yearly ecological and habitat assessments for each catchment, that range in date from 2014 to 2017 (Boffa Miskell 2014, 2015, 2016, 2017; EOS Ecology 2013). Some sites, particularly those in tidal non-wadeable reaches, may be natural sediment deposition areas with naturally sandy or silty beds. However, the majority of monitored sites would have coarse gravel-cobble substrates in their

unimpacted state and thus the presence of high quantities of fine sediment impacts on the benthic ecosystems present. The stormwater network is a key pathway for fine sediment to enter waterways in the urban environment, although there are other sources including upstream bed and bank erosion, erosion from hillslopes, and direct input from overland flow. In a highly urbanised environment such as the Avon catchment in Christchurch, stormwater is likely to be the main contributor of fine sediment.

31. The sediment quality targets (i.e. contaminants bound to fine sediment on the stream bed) are not met for one or more contaminants (copper, lead, zinc or polycyclic aromatic hydrocarbons (PAHs)) at 40% of the monitored sites overall (Table 1). The Avon and Heathcote catchments have the highest number of non-complying sites (15 out of the 20 that have target level exceedances), which is likely due to the higher proportion of industrial land use in these catchments (both historically and currently) as well as the history and density of residential and commercial land use.

32. QMCI scores are a metric used to summarise macroinvertebrate community data and provide an indication of the ecological health of a waterway. Low QMCI scores indicate a community that is dominated by species that are tolerant to pollution or poor habitat conditions, while a community that has a high QMCI score is likely to have greater species diversity and include a range of species that may be more sensitive to pollution or habitat degradation. The data for this assessment are from the 5-yearly ecological and habitat assessments for each catchment, that range in date from 2014 to 2017 (Boffa Miskell 2014, 2015, 2016, 2017; EOS Ecology 2013). In addition, Environment Canterbury data for two Banks Peninsula streams within the Akaroa township are included. The percentage of monitored sites that do not meet the LWRP outcomes for QMCI vary between the catchments from 11% (Ōtukaikino) to 100% (Halswell), with the total across the waterways in the CSNDC area being 57% of sites.

33. In the AEE, the applicant states that the overarching conclusion from the results of CCC's water quality monitoring programme supports the Urban Stream Syndrome phenomena, whereby lower water quality is recorded in urban areas and generally better water quality is recorded in rural areas, with the Ōtukaikino catchment having the best results (CCC 2015a). I agree with this conclusion and extend it to apply to ecological health and habitat condition as well as water quality, for waterways within the CSNDC area.

## Assessment of the Receiving Environment Objectives and Targets

34. Table 2 of the proposed consent conditions specifies modelled target reductions in stormwater contaminant loads at future time periods that will be achieved by installing stormwater mitigation facilities and devices (Condition 16). In addition, Schedule 4 outlines a suite of Receiving Environment Objectives and Attribute Target Levels for Waterways that will be used as a benchmark for progressive improvement (Condition 5a), to assess the extent of mitigation of effects (Condition 20) and, for selected Attribute Target Levels, will result in investigations and potential corrective actions if monitoring shows that the stated levels are not being met (Condition 51). In this section I will discuss both Table 2 and Schedule 4, noting that there is no connection between the two sets of targets, i.e. the contaminant load reduction targets specified do not have any relationship to the Schedule 4 objectives and target levels.

***Contaminant Load Reduction targets***

*Review of the model*

35. The contaminant load reductions outlined in Table 2 of the proposed consent conditions are derived from the Christchurch Contaminant Load Model (C-CLM) report, prepared for CCC by Golder Associates (Golder Associates 2018). A detailed assessment and review of the model approach undertaken for this purpose is beyond my area of expertise. CRC contracted Dr Tom Cochrane and Dr Aisling O'Sullivan of the Department of Civil and Natural Resources Engineering at the University of Canterbury to undertake a review of the model, and their report (Cochrane and O'Sullivan 2018) is attached to my report as Appendix A. I summarise the key issues and conclusions that Drs Cochrane and O'Sullivan identified in their report below.

36. The key issues raised by the Cochrane and O'Sullivan (2018) report are:

    a. The contaminant load rates per land use type have not been adequately adapted from the Auckland C-CLM to account for Christchurch conditions. Contaminant loads generated are highly dependent on topographic conditions, soil types, and the local climatic conditions. Both the transport and supply of contaminants are affected by these parameters and there are local data available that can assist with updating the model to make it more relevant to the Christchurch context (references provided in Cochrane and O'Sullivan 2018)).

    b. The treatment system contaminant removal rates used in the C-CLM are "the largest reductions that could be expected for well designed, installed and maintained devices". Treatment efficacy over the lifespan of a treatment system is likely to be less than optimal, which leads to an over-estimation of the contaminant mitigation that can be expected. In addition, the performance criteria used are based on only four references including half from overseas data. More recent published New Zealand data is available (references provided in Cochrane and O'Sullivan (2018)) and would provide better contextual performance. It is also not clear in the Golder Associates (2018) report whether the removal rates used capture differences in the treatment of particulate vs dissolved metals.

    c. The Golder Associates (2018) report is lacking in detail regarding rationale for some of the input parameters, e.g. rate of future land use change and areas under construction, and in particular lacks detail to explain how the contaminant load numbers were produced, e.g. how the various treatment strategies ('best practice infrastructure') were applied in each of the catchments. This makes it difficult to understand how the model results in Figures 5 to 8 were achieved and why certain patterns over time, i.e. between scenarios, are observed.

    d. There is no sensitivity analysis included within the Golder Associates (2018) report despite many of the input parameters having uncertainties around them, e.g. contaminant load rates from different land uses and removal rates for treatment systems that have a range of values in the literature. It would have been useful to include at least an indication of the variability in results using a range of inputs, as the confidence limits around the load reductions proposed for the consent conditions are clearly large.

37. The conclusions from the Cochrane and O'Sullivan (2018) report are:

    a. The C-CLM results are not an appropriate predictor of the contaminant loads to be expected or mitigated in Christchurch, as the model has not been calibrated to Christchurch conditions and the mitigation scenarios present idealistic treatment efficiencies.

    b. More realistic input values for Christchurch, calibrated to local conditions, could be used in future but this would result in different relative percent changes in reduction in contaminant loads, which would likely invalidate the reduction targets set for the proposed consent conditions. Even if used just for the purpose of assessing relative reductions, the scenario outputs for mitigated contaminant loads are presented as 'best case scenarios', which are unrealistic and could lead to over-estimation of the contaminant mitigation amounts that can possibly be achieved.

    c. It is not appropriate to use the contaminant reductions predicted using current (limited) data for applying to long term conditions, including up to a 35 year period. Input data and parameters will most likely be quite different after 5+ years as model uncertainties are reduced through calibration and validation to local conditions. It is also unrealistic and undesirable to expect the CLM to be used for the next 35 years as it will likely become obsolete as new and better technology to improve the prediction of contaminant loadings is developed.

    d. Rather than setting static targets over a long period of time, a more valid consent approach may be a requirement to model the scenarios every 5 years using the best available calibrated model at that time and from the modelled data, set the reduction targets for the subsequent 5 years in which these targets should be met.

38. As a result of the review and its conclusions I have serious concerns about the use of the C-CLM in its current form for the purposes that are proposed by the applicant.

*Stormwater Contaminant Load Modelling conditions*

39. The Advice Note under Condition 18 in the proposed consent conditions indicates that the Applicant intends for the C-CLM to be the only modelling tool used to assess relative reduction in contaminant loads for the duration of the consent and that alternative modelling technologies may only be used for other purposes, such as for research or assisting with stormwater management decisions. As suggested by Cochrane and O'Sullivan (2018), it would be far more desirable for the future modelling to make use of the best available modelling tool at the time that is calibrated and validated using the best available input data, relevant to local conditions. Fixing the contaminant load reduction assessment to ongoing use of the C-CLM, with its limitations and major assumptions, is not likely to provide a realistic picture of the load reductions actually being achieved.

40. If Table 2 is to remain in the consent conditions then it would be highly desirable for the percentage reductions to be detailed for each catchment, rather than presented as a single figure for each contaminant that applies across the whole CSNDC area. The stormwater mitigation facilities and devices that are proposed to achieve the load reductions are developed on a catchment basis by modelling that is presented in the Stormwater Management Plans (SMPs) for each catchment. It is not possible to draw

any conclusions about the level of mitigation that might be achieved within the receiving waterways when the load reductions in the proposed consent conditions are specified at such a broad level. There is also a risk that the use of a single percent reduction target across the CSNDC area could result in offsetting between catchments, with large reductions achieved in a catchment where mitigation is easier to implement and increases in contaminant loads in other catchments where mitigation is more difficult. While I do not believe this to be an intended outcome of the applicant, I think the consent conditions need to explicitly prevent this from occurring to ensure progressive improvement towards LWRP outcomes in all catchments. For these reasons I consider it more appropriate for the contaminant load reductions for the base case and future predicted scenarios to be listed in Table 2 for each of the four modelled catchments.

41. There are two 'Stormwater Quality Investigation Actions' listed in Table 3 of the proposed consent conditions that relate to the contaminant load modelling. These are:

    (6) Investigate the impacts of applying alternative modelling tools (including 'deterministic' models) to characterise the relationship between contaminant loads, concentrations and the receiving environment, and the processes which influence the relationship. Such tools may include the MEDUSA and MUSIC modelling tools; and

    (9) Conduct a monitoring programme for assessing the actual contaminant-reduction performance of selected stormwater treatment facilities and devices. Apply the results of the study in determining the feasibility and selection of proposed treatment facilities and devices, and to improve the level of certainty of performance values relating to TSS, zinc and copper in contaminant load modelling. Report findings and outcomes in annual report to CRC.

42. The intent of these investigations appears to address two of the concerns that were raised by Cochrane and O'Sullivan (2018), regarding use of best available modelling tools for assessing contaminant load reductions and using appropriate local data for treatment system contaminant removal rates. These investigations could be re-phrased and incorporated into the Stormwater Contaminant Load Modelling conditions (proposed Conditions 16-18). With the addition of an investigation to update the contaminant load rates for different land use types that are used in the C-CLM to account for Christchurch conditions, these improvements to the modelling approach could increase the level of confidence in the values used and the model outcomes. Any consent conditions written to require these investigations and updates to the model should be accompanied by a realistic but short timeframe that is agreed with CCC (e.g. one to three years) so that we have increased confidence in the modelling as soon as possible after the consent is granted.

43. As it is, the percent reduction values proposed for Table 2 represent relatively small changes beyond what is already achieved by the limited amount of stormwater treatment that currently exists across the city. In my opinion these modelled contaminant reductions are a means for the Applicant to demonstrate their level of commitment to improving stormwater over time over the whole CSNDC area, but the high-level approach means that there is no transparency about where loads are likely to reduce or increase or stay the same.

44. It is not possible to comment on what these contaminant load reductions might achieve in the receiving waterways, in terms of water quality or ecological health improvement. For water quality improvement this could be broadly estimated if more detailed spatial information on load reductions at specific locations (e.g. model nodes) were provided, which could be paired with nearby monitoring sites to provide a relative percent reduction in current concentrations for zinc and copper, for example. For ecological health the relationships between contaminant loads and ecological indicators such as QMCI are highly complex and involve a wide range of other factors and therefore attempting to predict responses is fraught with uncertainty. I note that investigations 1 to 5 in Table 3 of the proposed consent conditions involve feasibility studies, with follow on development if the feasibility shows sufficient merit, looking at developing an instream contaminant concentration model and tools for predicting the responses of the receiving environment to changes in network contaminant loads and resulting instream concentrations. I strongly support these initiatives.

***Receiving Environment Objectives and Attribute Target Levels for Waterways***

45. The Receiving Environment Objectives in Schedule 4 cover ecological values (QMCI), sediment inputs (fine sediment cover and TSS concentrations), copper, lead and zinc levels in surface water, nutrient levels (macrophyte and filamentous algae cover), instream sediment quality (zinc, copper, lead and PAHs concentrations) and mana whenua freshwater values. I will comment on each of these in the sections below, with the exception of instream sediment quality which is being addressed by Dr Lesley Bolton-Ritchie.

46. As a general comment, I think that the use of the terms 'lower limit' and 'upper limit' within the Attribute Target Level column in the Schedule 4 table is confusing, as it could be interpreted to mean that the target levels are to be applied to the minimum or maximum values within a data set. From discussions with CCC I understand that the terms have been included to indicate whether higher or lower values are desirable for each attribute and that the methods for comparing monitoring data to the target levels are outlined in the Environmental Monitoring Programme (EMP) document. I suggest that a note is added to the top of Schedule 4 that refers the reader to the EMP for details of the methodology to be used when assessing data against the Attribute Target Levels.

*Ecological values - QMCI*

47. The first Receiving Environment Objective is 'Enhance ecological values' and the corresponding Attribute Target Levels for the QMCI are derived directly from the LWRP Table 1a outcomes for different river types. I agree with the use of the QMCI as a measurable indicator of ecological health, as well as the QMCI scores that are proposed. QMCI scores are only partially driven by the impacts of stormwater and there are a wide range of factors that influence aquatic ecological health in urban streams, as outlined in paragraph 21. Therefore, I consider it appropriate to include QMCI to recognise the overall goal of stormwater management to improve ecological health but acknowledge that it will take more than a reduction in stormwater contaminant loads for QMCI targets to be achieved in many of the receiving waterways in the CSNDC area.

48. I note that a relevant component of the National Policy Statement for Freshwater Management (NPS-FM) was introduced with the 2017 amendments (MfE 2017). Policy CB3 requires that regional councils shall develop monitoring plans that include macroinvertebrates and use the Macroinvertebrate Community Index (MCI) as one measure of progress towards, or the achievement of, freshwater objectives and values. In addition, every regional council shall establish an action plan to respond to declining MCI values or values < 80. Therefore, an MCI value of 80 can be regarded as a putative national bottom line under the NPS-FM. Analysis of macroinvertebrate data collected by CRC at Spring-fed Plains Urban sites (most of which are in Christchurch) indicates that most sites have MCI values below 80 and QMCI values below 3.5 (Dr Duncan Gray, Environment Canterbury, pers. comm.). Preliminary analysis of the alignment of LWRP targets with NPS-FM requirements has determined that the national bottom line of a MCI value of 80 is equivalent to a QMCI value of 4.0, based on ecological literature, or a QMCI value of 4.5 for Spring-fed Plains Urban rivers based on regression analysis of CRC data (Dr Duncan Gray, Environment Canterbury, pers. comm.). It is therefore likely that the LWRP Table 1a outcomes for QMCI will need to be amended in future to ensure alignment with the NPS-FM, with an increase in the target value for Spring-fed Plains Urban waterways. If that occurs an amendment to the Attribute Target Levels in Schedule 4 will be required for them to remain aligned with the LWRP and I note that this would result in a higher proportion of sites not complying with the Attribute Target Levels based on assessment of current state (Table 1 of this report).

*Sediment inputs – fine sediment cover and TSS concentrations*

49. The second Receiving Environment Objective is to ‘Decrease sediment input to prevent adverse effects on water clarity and aquatic biota’. There are two attributes used to measure this objective; the fine sediment (< 2 mm diameter) percent cover of the stream bed, for which the target levels are derived directly from the LWRP Table 1a outcomes for different river types, and total suspended solids (TSS) concentrations in surface water. The TSS concentrations have target levels based on threshold concentrations during base flow and during wet weather, as well as a target of no statistically significant increase over time.

50. I agree with the use of fine sediment percent cover as an attribute, as this is strongly influenced by sediment inputs from the stormwater network. I also agree with the target levels proposed. I note however, that the fine sediment cover of many urban stream beds is at or close to 100% due to historical deposition. As such it may not be possible to distinguish the effects of current stormwater derived sediment from the historical coverage. Even in the absence of new sediment additions it may take many years, or be impossible, for fine sediment to leave a river reach due to the low gradient and lack of flushing flows that occur in the spring-fed streams and rivers of Christchurch. This target is an important one for the reasons of (a) the direct effect on aquatic biota that inhabit the stream bed, and (b) contemporary inputs being largely stormwater-driven, but the survey results will need to be interpreted with caution. I note that one of the Stormwater Quality Investigations listed in Table 3 of the proposed consent conditions relates to investigating the feasibility and techniques for addressing sediment cover of the bed and I strongly support this initiative.

51. I also agree with the use of TSS concentrations as an attribute but have some concerns about the target levels that are proposed. Different concentrations are proposed as target levels for base flow (25 mg/L) and wet weather (100 mg/L) conditions. I agree with this approach as the spring-fed river systems within the CSNDC area typically have very clear water during baseflow conditions, often with TSS concentrations less than the detection limit. During wet weather the suspended solids load to the waterways can increase significantly, particularly in catchments affected by runoff from the Port Hills and Banks Peninsula loess soils. The EMP provides some background information on the derivation of the baseflow target level but does not refer to the 100 mg/L wet weather threshold. Discussion with CCC staff has indicated that the 100 mg/L threshold has been proposed as it relates to discharge limits that are on several other CCC global consents for activities such as works in waterways and dewatering. I do not agree with this rationale as in those cases the TSS limit applies to the discharge point or immediately downstream of a particular activity and is typically not applicable to mixed downstream receiving water quality. The LWRP has TSS limits on several permitted activity rules, but these also apply at the discharge point rather than in the receiving waterway. The reason for this is that TSS in discharges can have depositional impacts within a short distance of the discharge point and therefore a mixing zone approach is not appropriate for sediment.

52. In the absence of national guidance or indeed international literature on effects-based thresholds for TSS concentrations in waterways I suggest that suitable target levels could be derived using the 80$^{th}$ percentile approach that is used in ANZECC (2000) for physico-chemical stressors. This would require analysis of existing baseflow and wet weather data for the Christchurch rivers and streams.

53. I am aware that sediment is a priority contaminant for future inclusion in the NPS-FM National Objectives Framework (NOF) and the Ministry for the Environment has commissioned work to develop sediment attributes for inclusion in this framework. There have been a number of reports released to date that highlight the complexity of deriving criteria for suspended and deposited sediment, largely because effects on aquatic values depend not just on concentration but other properties such as grain size, composition and particle shape (Davies-Colley *et al.* 2015; Depree 2017). The latest report (Depree 2017) recommends that turbidity is the preferred suspended sediment attribute for further development. I suggest that TSS concentrations be included as an attribute in Schedule 4 of the consent conditions at this stage, but that in future this may need to be amended to include an alternative sediment attribute with target levels that may be specified in the NPS-FM NOF.

54. The Attribute Target Levels for sediment inputs also include a target of no statistically significant increase in TSS concentrations and I agree with the use of this additional trend measure. The TSS target levels are a component of the proposed Responses to Monitoring clauses under Condition 51 of the proposed consent conditions and I provide further comment on this in paragraph 99 and 112.

*Zinc, copper and lead concentrations in surface water*

55. The third Receiving Environment Objective is to ‘Reduce copper, lead and zinc levels in surface water to prevent adverse effects on aquatic biota’. These are the key stormwater contaminants that are primarily derived from runoff from the dominant urban impervious

surfaces of roofs, roads and carparks. It is therefore appropriate that reduction in their concentrations is an objective of stormwater management under this consent, and that they are part of the Responses to Monitoring outlined in Condition 51 of the proposed consent conditions. The Attribute Target Levels are derived from the ANZECC (2000) trigger levels for toxicants and include adjustment for water hardness in accordance with methods outlined in ANZECC (2000). They also consider the levels of ecosystem protection that are required for different river types in Schedule 5 of the LWRP. The target levels are therefore different for each catchment, due to varying hardness and different river types, and are different to those outlined in Schedule 5 of the LWRP. Modification for local water quality conditions is appropriate and I agree with the Attribute Target Levels that are proposed. I do note however, that Schedule 4 does not include a separate target level for the Cashmere Stream catchment and recommend that this is included as listed in Table 3 of the EMP. Based on my analysis of CCC's data presented in Table 1 of this report, reductions of between 23% and 89% in 95$^{th}$ percentile concentrations are required for the sites that did not meet the Attribute Target Levels in 2017.

56. There is a process underway to revise the ANZECC (2000) toxicant trigger values for copper and zinc in freshwater and coastal waters, and draft guidelines that have been circulated propose changes to the default trigger values and water quality modifiers (e.g. hardness, pH, dissolved organic carbon) for copper and zinc (Gadd et al. 2017). It is also possible that copper and zinc will be introduced to the NPS-FM NOF as an attribute in future. It is important that there is a mechanism available for the Attribute Target Levels in Schedule 4 to be amended if the national guidance changes, and I note that this is provided for by Conditions 45 and 46 of the proposed consent conditions.

57. There is also an Attribute Target Level that states 'No statistically significant increase in copper, lead and zinc concentrations'. I agree with the inclusion of this target level based on analysis of the longer-term data set as it will ensure that there is no significant increase at sites that currently have concentrations below the target level, i.e. a no significant degradation policy.

*Macrophyte and algae growth – nutrient levels*

58. The fourth Receiving Environment Objective is to 'Reduce nutrient levels to limit excessive growth of macrophytes and filamentous algae'. This objective aligns with two of the freshwater outcomes in Table 1a of the LWRP, with the Attribute Target Levels derived from the values set for total macrophyte cover and filamentous algae cover for different river types. Macrophyte and algae cover are only partially driven by the impacts of stormwater, but they are indicators of aquatic habitat quality. I agree with the inclusion of this objective but consider that assessment of data against the target levels will need to be undertaken with caution.

59. Macrophytes and algae in a spring-fed system are regulated by the availability of light and nutrients, primarily nitrogen and phosphorus. In hill-fed streams, such as on Banks Peninsula, the time accrued since the last flush or flood flow is also important. The majority of nitrogen found in CSNDC streams is likely to come from agriculture via surface flow or groundwater upwelling, although there are some industrial sources that could contaminate stormwater runoff if poorly managed. As such the role of stormwater in regulating nitrogen-promoted macrophyte and algal growth in most catchments is likely to

be small. Phosphorus is more likely to derive from stormwater, particularly where there are high rates of fertiliser use and detergents from car washing that may be entrained by stormwater runoff. Phosphorus in urban catchments may also derive from surface runoff from unsealed surfaces, non-stormwater discharges, such as dewatering, and exist within the stream bed bound to historically deposited sediments. Stormwater management, particularly community education, may play a role in reducing phosphorus concentrations in urban receiving waterways but due to the range of other nitrogen and phosphorus sources it is quite possible that macrophyte and algal growth rates will change irrespective of stormwater quality. Riparian planting and subsequent waterway shading will also influence macrophyte growth. In addition, due to the existing high growth rates of biomass in Christchurch urban streams macrophytes are mechanically cleared from the river bed. It will be important to time macrophyte cover assessment such that results are not influenced by the clearing.

60. I note also that the NPS-FM NOF requires that algal growth is monitored through the measurement of chlorophyll *a* biomass. The Attribute Target Level for algal growth in Schedule 4 uses the cover of filamentous algae. While chlorophyll *a* monitoring would provide useful information and compliance with the NOF it would be highly resource intensive and costly. As the macrophyte and algal growth objective is not directly linked to the stormwater discharge activity I do not consider it necessary to divert resources to the monitoring and assessment of chlorophyll *a* biomass.

*Other Schedule 4 objectives*

61. The two remaining objectives in Schedule 4 relate to sediment quality, which is discussed by Dr Lesley Bolton-Ritchie in her s42A report, and the enhancement of mana whenua freshwater values. I support the inclusion of the mana whenua values objective and the use of existing methodologies (the Cultural Health Index and the State of the Takiwā) as attributes in Schedule 4 of the proposed consent conditions.

62. It is often debated whether faecal contamination, as measured by *E. coli* bacteria in fresh waters, is a stormwater management issue. *E. coli* may also be derived from wastewater overflows or wild fowl on the river and targets for *E. coli* might therefore be exceeded irrespective of the contribution of the stormwater network. The degree to which stormwater management can reduce *E. coli* concentrations is also limited, as treatment approaches are not designed to reduce microbiological contaminants and may in fact increase faecal contamination by attracting wild fowl, e.g. wet ponds and wetlands. For these reasons I agree with the approach taken by the Applicant to not include a Receiving Environment Objective related to faecal contamination or *E. coli* concentrations but note that *E. coli* is included as a parameter in the EMP and will be reported on against relevant guideline values.

***Additional water quality standards***

63. Proposed consent conditions 23, 24 and 25 state the broad goals for management of different types of stormwater discharge source areas. These are that the consent holder shall use *reasonable endeavours* to ensure that:

- Construction phase stormwater quality mitigation is implemented for all development sites prior to commencement of stripping of vegetation or earthworks on the site;
- Operational phase stormwater quality and quantity mitigation is implemented for all development and re-development (where required) prior to issuing certification under the relevant legislation; and

and that the consent holder shall provide retrofit water quality and quantity mitigation for existing development *where practicable*. I note the difference in terminology used to describe the standard for existing development areas and am concerned that this is an indication that reduced effort will be applied to the management of stormwater in these areas.

64. I also note that there is no standard specified for the management of stormwater from high risk sites that are proposed to be included within the scope of this consent after 1 January 2025 (proposed consent condition 3). High risk sites have the potential to introduce unacceptably high concentrations of a wide variety of contaminants to the stormwater network which could have detrimental effects on receiving waterways, however the only contaminants included in the Receiving Environment Objectives are copper, lead, zinc and suspended sediment. In my opinion, the consent conditions should include either a Receiving Environment Objective or a standard similar to those stated in proposed Conditions 23 and 24 that addresses sites with a higher risk of contaminating surface water or groundwater, whether they be industrial sites or sites with contaminated land.

***Overall conclusion***

65. The model approach using the C-CLM and the resulting uncertainty in the contaminant load reduction figures provided in Table 2 of the proposed consent conditions is a significant concern (based on the Cochrane and O'Sullivan (2018) review) and I question whether the C-CLM is fit for the purpose proposed by the applicant in its current form. It is not possible to draw any conclusions about the level of water quality mitigation that might be achieved within the receiving waterways because the contaminant load reductions refer to the modelled catchments in combination rather than individual catchments and have a reference point in the future so comparison to current state is difficult. It is also not possible to comment on what these contaminant load reductions might achieve in the receiving waterways in terms of ecological health improvement.

66. I agree with the majority of the Receiving Environment Objectives and Attribute Target Levels proposed for waterways in Schedule 4 of the proposed consent conditions and have provided suggestions for improvement for some of them in paragraphs 52 and 55 above. I note that there is no connection between the proposed contaminant load reduction figures in Table 2 of the proposed consent conditions and the Receiving Environment Objectives and Attribute Target Levels. The contaminant load reductions are the modelled outcome of current and proposed stormwater treatment and have no relationship to the level of reduction that may be required to achieve the objectives and target levels in Schedule 4.

67. The future inclusion of high risk sites under the CSNDC raises concerns about a wide range of other contaminants that may enter the stormwater network if sites are not suitability managed. I suggest that a Receiving Environment Objective or a standard similar to those stated in proposed consent conditions 23 and 24 should be included to make clear the Applicant's intentions for mitigating potential effects from these sites.

## Assessment of Stormwater Management Plans and other mitigation

68. Methods to mitigate the potential effects of the stormwater discharges from the CSNDC area are outlined in section 9 of the application. The methods that relate to mitigation of effects on surface water quality and ecology include best practice stormwater treatment for greenfield development, retrofitting treatment in developed areas, robust erosion and sediment control for construction sites particularly on hillsides, on-site pre-treatment for industrial sites discharging to the CCC's network, and exclusion of sites where construction is to take place on contaminated land. Additional non-infrastructural approaches include close coordination of monitoring and enforcement efforts between CCC and CRC staff, community education, and working with industry. I note that condition 3 of the proposed consent conditions removes the exclusion of high risk sites from 1 January 2025 and that further information or proposed consent conditions to address how these sites will be managed has not been provided. I comment on the issue of high risk sites further in paragraphs 82 to 85.

### *Stormwater Management Plans*

69. The details of how the mitigation methods will be prioritised and implemented within a catchment are proposed to be outlined within Stormwater Management Plans (SMPs) for each catchment. Conditions 4 to 11 of the proposed consent conditions detail the programme for developing and reviewing SMPs, the purpose of them, details of what they must include, consultation requirements, and the triggers and process for amending SMPs.

70. Condition 5(a) states that a purpose of the SMPs is to 'Demonstrate the means by which the quality of stormwater discharges will be progressively improved towards meeting the Receiving Environment Objectives and Attribute Target Levels…'. This statement does not provide for the situation where a receiving environment may already meet and be well below the Attribute Target Levels. Dr Lesley Bolton-Ritchie suggests that the wording should be amended to include a 'maintain' requirement to prevent future degradation of high quality receiving environments and I agree with this suggestion.

71. Three SMPs have been developed by CCC to date; the South-West Christchurch SMP, which originally included the Halswell and upper Heathcote catchments and was revised and re-submitted with the CSNDC application as the Huritini/Halswell River SMP (operative in mid-2016); the Puharakekenui/Styx River SMP (operative in mid-2014); and the Ōtākaro/Avon River SMP (submitted in mid-2015 with the CSNDC application). The objectives in these SMPs were developed before the Receiving Environment Objectives and Attribute Target Levels in the proposed CSNDC conditions and in some cases are different. I believe it will be necessary to review the objectives in these SMPs to align them with those in the consent conditions, if the consent is granted, as the proposed review dates are at least six years away. Where objectives are currently not included in

an SMP these should be revised and appropriate measures to address the revised objectives will need to be included within the SMP. For example, the Huritini/Halswell River and Ōtākaro/Avon River SMPs do not have an objective that refers to instream sediment quality so this should be included and a catchment-specific assessment undertaken with mitigation measures proposed where required.

72. Condition 6 of the proposed consent conditions outlines the information that is to be included in SMPs submitted to CRC after the operative date of the consent. As well as the types of information already listed I think this list should include:

    a. Assessment of the impact of development and land use change planned for the catchment on catchment characteristics such as the percent impervious surface area, as well as characterisation of the pathways for stormwater within different parts of the catchment (e.g. treated vs untreated, to ground or to surface water);

    b. Identification of areas of high aquatic ecological or cultural value, including but not limited to springs and wetlands, and habitat for threatened species;

    c. Assessment of water quality modelling results in terms of potential impact on the state of the receiving water quality and ecology, specific to the catchment and the proposed mitigation measures, with reference to Receiving Environment Objectives and Attribute Target Levels and LWRP outcomes;

    d. A broad options assessment to clearly demonstrate the key drivers behind the mitigation measures selected for implementation;

    e. A list of sites identified as 'high risk' within the catchment, including the likely contaminants and their risk to receiving environments, based on the processes that CRC staff suggest are developed to mitigate the risks on large construction sites and contaminated sites that will be within the scope of the CSNDC after 2025 (see paragraph 84 below);

    f. Details of the process to be implemented to ensure that risks are sufficiently mitigated from 'high risk' sites within the catchment to prevent unacceptable negative effects on receiving environments.

73. I note that any amendments to SMPs must be certified by CRC before they can replace the previous version, however there is no certification process outlined for the SMP when it is initially submitted. I recommend that a consent condition is added after proposed Condition 7 that requires the SMP to be audited and approved by a Technical Advisory Panel. The CSNDC application has not included the detailed information that would typically be required for a discharge consent application due to the large spatial scale and diversity of receiving environments. The CSNDC is proposed to adopt an adaptive management framework and therefore it is at the catchment SMP level that details of specific receiving environment effects can be addressed. If the CSNDC is granted it is my opinion that each new SMP will require the equivalent level of scrutiny as given prior to the CSNDC, when an individual catchment consent was applied for. Proposed Condition 7 outlines a collaborative process for the development of SMPs, with input from key stakeholders. The proposed Technical Advisory Panel would complete this process by

reviewing the final document to ensure that best practice has been applied in all technical areas covered. The panel could include a range of independent technical experts with expertise covering stormwater engineering, stormwater modelling, water quality, sediment quality, aquatic ecology, groundwater quality, erosion and sediment control, flood hazards and hydrological modelling, and contaminated site management.

74. The SMPs are the key tool proposed to investigate catchment-specific issues and develop a programme of measures to mitigate effects of stormwater discharges and it is important that these are informed by up-to-date and relevant sources of information. Frequent reviews will be required to incorporate the results of the programme of stormwater quality investigations (discussed further in paragraphs 78 to 81) and the Environmental Monitoring Programme, including any changes to regional and national planning instruments that may require amendments to the Receiving Environment Objectives and Attribute Target Levels. I suggest that the SMP review period is decreased from 10 years to 5 years to ensure that effective and responsive feedback loops are in place.

***Implementation***

75. An Implementation Plan is proposed in Conditions 12 to 14. The purpose of the Implementation Plan is to give effect to the SMPs, with review every 3 years to align with the CCC Long Term Plan (LTP). This is an appropriate review period due to the importance of CCC funding to the ultimate implementation of the proposed stormwater mitigation measures and actions. Condition 13 outlines the matters that *shall* be included in the Implementation Plan and 13(e) states "Reporting on any testing or water quality monitoring undertaken that is used to check the performance of facilities or to inform prioritisation of areas for mitigation". I query whether this should refer to a plan or programme for additional testing or water quality monitoring to check the performance of facilities or to inform prioritisation of areas for mitigation, with the associated reporting better placed within the Annual Report required by Condition 53 of the proposed consent conditions.

76. Condition 14 of the proposed consent conditions states a separate requirement that *may* also be included in the Implementation Plan, which refers to details of maximum stormwater contaminant concentrations that CCC, as owner and operator of the stormwater network, will accept into the CCC network. This parallels a clause in the CCC Water Supply, Wastewater and Stormwater Bylaw 2014 ('the Bylaw'), which under section 35(1) states that "The Council may by resolution specify minimum standards for stormwater discharges into the public stormwater system". In my opinion, the use of this clause in the Bylaw to specify minimum standards for discharges could be a robust and effective means of managing discharge quality into and from the stormwater network. I query why the Bylaw has not been referred to at all in the consent application or AEE, or indeed as a potential tool within the proposed resource conditions (with the exception of indirect reference in Condition 6(c)).

77. I strongly support the inclusion of an Implementation Plan with regular review periods.

***Stormwater quality investigations and 'other actions'***

78. Conditions 35 to 38, including Tables 3 and 4, outline a suite of 'other actions' that are proposed to be undertaken by the applicant that will complement the infrastructural

measures detailed in the SMPs. These investigations and other actions provide an indication of CCC's commitment to improving the management of stormwater quality and reducing stormwater effects on the receiving environment, and I strongly support their inclusion in the consent conditions. I do however, suggest that the wording of many of the actions listed in Tables 3 and 4 should be amended to ensure that the purpose and desired outcome of each action is clear. The inclusion of start and completion dates for each action provides a level of confidence that they will be implemented, and I note that a summary of outcomes from the actions listed in Table 3 is part of the reporting requirements under Condition 53(a). I think that the actions in Table 4 should also be reported on, which would require the addition of Condition 38 to the group of conditions listed under Condition 53(a).

79. Many of the actions listed in Table 3 are contingent on whether the consent holder considers that a previous feasibility investigation indicates, provides or shows 'sufficient merit'. It is not at all clear how 'sufficient merit' would be assessed and what criteria would be applied. I consider there to be a high risk of many of the actions beyond feasibility studies not being progressed due to lack of CCC funding and staff resourcing, unless there is some independent input into the decision making for these investigations. I have recommended the use of an independent Technical Advisory Panel for the certification of SMPs and I suggest that relevant members of that advisory panel could be called on to provide independent opinion on the results of feasibility studies (e.g. actions 1, 4 and 7 in Table 3) and the development of the scope of works for further actions if they are deemed to be worthwhile.

80. Tables 3 and 4 contain a broad range of actions with the potential to contribute to an increased understanding of and a reduction in the effects of stormwater discharges on receiving environments. The Communication, Education and Awareness actions at the bottom of Table 4 are a particularly important component of the suite of actions in my view, but I am aware that funding for the proposed Community Water Partnership programme was not approved in the recent LTP round. I hope that funding setbacks such as this will not prevent CCC from continuing to use 'reasonable endeavours' to implement these actions.

81. I suggest that an additional investigation should be included in Table 3 or 4 that requires the development of maximum stormwater contaminant concentrations that CCC will accept into the stormwater network, as referred to in Condition 14 of the proposed consent conditions and also provided for by clause 35(1) of the Bylaw (see paragraph 76 above for further details). Discharge standards into the network would provide a robust tool to aid CCC with managing the quality of stormwater leaving their network.

***Removal of exclusions – large construction sites, high risk contaminated sites and industrial sites***

82. In previous CCC network stormwater consent applications (e.g. for the South-West and Styx areas) the approach to managing discharges from 'high risk' sites, including large construction sites, certain contaminated sites and sites with high risk HAIL (Hazardous Activities and Industries List) activities, has been to exclude them from the network consent and thus require separate consent from CRC. Condition 3 of the proposed consent conditions states that sites excluded from the CSNDC consent by Condition 2

will be within the scope of the CSNDC from 1 January 2025, or when current discharge permits expire for those sites, whichever is the latest. This is a new proposal that aligns with LWRP Policy 4.16A. The Applicant has not provided any new information or proposed any additional consent conditions to indicate how these sites will be managed post-2025. These ‘high risk’ sites pose a significant risk to receiving environments if their discharges are not adequately managed.

83. CCC currently have a methodology in place for implementing an Industrial Site Audit Programme, which is a requirement under the South-West and Styx stormwater network consents and is also proposed for inclusion in the CSNDC under Condition 41 of the proposed consent conditions. There is also a requirement for an Erosion and Sediment Control Plan (ESCP) to be prepared and implemented for the construction phase stormwater discharge from any development area that is covered by the CSNDC (proposed Condition 39). These processes and requirements will need to be significantly expanded to ensure that the increased risk of contamination from high risk sites will be adequately mitigated. CRC staff have discussed what steps these processes may need to include, both for erosion and sediment control on large construction sites and for the identification and management of high risk contaminated or industrial sites. Details are included within the s42A report of Nick Reuther (paragraph 269 for construction sites and paragraph 314 for operational discharges from HAIL and industrial sites) and I strongly agree with these recommendations. CCC will need to develop and resource robust processes to be approved by CRC prior to 2025 to provide confidence that the contamination risk is sufficiently mitigated to prevent effects on receiving environments.

84. In addition to the inclusion of consent conditions that outline details of the processes that will need to be developed for managing high risk sites, the existing SMPs will need to be amended to include details at a catchment scale as suggested in the points listed above in paragraph 72 (points (e) and (f)).

85. The monitoring proposed by the Applicant in the EMP does not account for the additional contamination risks posed by these high-risk sites post-2025. I suggest that there should be performance or discharge standards and monitoring requirements developed for inclusion on site management plans that address the key contaminants that are identified as a high risk on each site. This may include contaminants that are not included as parameters in the EMP and are also not included in the definition of ‘stormwater contaminants’ for which standards may be developed under Condition 14 of the proposed consent conditions. It is important that when the role of managing these high-risk sites shifts from CRC to CCC the level of site management and monitoring does not decrease. For large uncontaminated construction sites, for example, this will mean that sediment limits and monitoring should continue to be required, using either turbidity or clarity up and downstream of the discharge point and TSS at the discharge point.

***Overall conclusion***

86. The SMP approach to developing stormwater treatment mitigation measures at a catchment scale, combined with the investigations and actions proposed in Tables 3 and 4 of the consent conditions, indicate the broad spectrum of initiatives that the CCC are proposing to mitigate the effects of the network stormwater discharges on receiving environments. The success of these initiatives is highly dependent on effective

implementation and I have recommended that an independent Technical Advisory Panel is used to ensure that decision making within both the SMP process, including robust options analysis and selection of treatment devices, and implementation of stormwater investigations is based on best practice principles. I also recommend that more frequent review of the SMPs will be required to take into account relevant findings from the stormwater quality investigations and the Environmental Monitoring Programme

87. The Applicant has not addressed the increased risk of stormwater contamination that will occur post-2025 with the inclusion of high-risk sites under the CSNDC. It is critical that robust processes are developed and resourced prior to 2025 to ensure that sufficient mitigation is in place to prevent effects on receiving environments.

## Assessment of the Environmental Monitoring Programme, Reporting and Responses to Monitoring

88. The Environmental Monitoring Programme (EMP) is a key tool proposed for the CSNDC to monitor whether the Receiving Environment Objectives and Attribute Target Levels are being met. CRC technical staff have been involved in discussions with CCC staff in developing previous versions as well as the currently proposed version of the EMP (Version 4.0, July 2018). Overall, I consider the sections of the EMP that are relevant to freshwater quality and ecological health monitoring to be very comprehensive and give an appropriate level of detail regarding site locations, frequency of monitoring, methods, and reporting requirements.

89. It is important to note that the EMP sites are widely distributed across the receiving waterways, including tributaries of the main rivers, rather than targeting areas immediately downstream of specific discharges or attempting to monitor stormwater discharge quality itself. This is because there are too many individual stormwater discharge points to monitor them all and because the LWRP Table 1a outcomes and Schedule 5 standards relate to receiving waterways downstream of mixing zones, i.e. once discharges have mixed with ambient water quality. While stormwater discharges are the predominant source of some of the monitored contaminants, e.g. copper, zinc and sediment, it will be difficult to conclusively identify the origin of contaminants detected from the routine monitoring and additional targeted monitoring will be required for more detailed investigation of hotspot source areas and to assess the direct impact of stormwater treatment measures (as discussed further in paragraphs 98 and 101)..

90. The EMP states that its primary purpose is "to assess the extent of mitigation of effects of stormwater discharges from the CCC stormwater network on the receiving environment". In addition, some of the monitoring will inform the refinement and improvement of waterway health and stormwater management practices in general. Some sections of the EMP, e.g. soil quality monitoring and surface water levels and flows, begin with a more specific description of the purpose for monitoring under this consent for that component. I recommend that a specific purpose description is added to all sections of the EMP so that it is clear how each component is related to the stormwater discharge activities that fall under the CSNDC.

91. In the sections below, I provide comments and suggestions regarding specific details of components of the EMP that relate to freshwater quality and ecological health. I note that

comments on the instream sediment quality component of the EMP are provided in the s42A report of Dr Lesley Bolton-Ritchie.

***Surface water quality – monthly monitoring***

92. CCC have proposed to monitor 47 waterway sites monthly across the CSNDC area for water quality, which I consider to be a very comprehensive network of monitoring sites. This is an increase on the 42 sites currently monitored (Margetts and Marshall 2018) and includes four new sites on Banks Peninsula, Steamwharf Stream in the Ōpāwaho/Heathcote River catchment, and an additional Huritini/Halswell River site at Wroots/Halswell Roads. I note that the Heathcote River at Templetons Road site has been removed from the site list and understand this is due to the site often being dry in recent years (e.g. from January to July 2017; Margetts and Marshall 2018). I agree with monitoring at this location being discontinued but recommend that the site be re-located downstream to a suitable location with permanent flow that is upstream of Haytons Stream, so that there remains an upper Heathcote River site that is not influenced by the Haytons Stream inflow. I strongly support the continuation of monitoring at the 41 ongoing sites as the majority of these now have a dataset that spans 10 or 11 years which is very helpful for detecting trends in the data. I do note however, that many of the guidelines specified in Table 3 of the EMP are not applicable to all sites, particularly tidal sites that are exposed to variations in salinity throughout a tidal cycle. This applies for example to the metal toxicant trigger values that are used for compliance purposes. It would be useful if the EMP and subsequent annual reports clearly identify which sites are tidal and have variable salinity for this reason.

93. Monthly sampling is a suitable frequency for the collection of water quality data used to describe the general state of receiving environment water quality. The use of monthly monitoring data collected over time is also appropriate for a general assessment of trends over time. The CCC monthly monitoring data are collected regardless of weather conditions (Dr Belinda Margetts, CCC, pers. comm.) with most, but not all, sampling events occurring in dry weather. With most of the water quality samples collected in dry weather the data predominantly represents the ambient or baseflow water quality conditions, rather than the water quality during or soon after rainfall when stormwater discharges are occurring.

94. Water quality is inherently variable through time and the sample size (i.e. the number of sampling dates) used to calculate estimates of water quality state, whether using medians or other percentiles, will affect the statistical robustness of the assessment. Recent assessments of water quality state for national reporting have highlighted a sample size of 30 as the point at which the rate of increasing confidence for estimates of population statistics levels off, and thus used a period of 3 or 5 years of monthly data depending on the frequency of data gaps (Larned *et al.* 2015; Gadd 2016). The national Land Air Water Aotearoa (LAWA) portal also uses 3 years of monthly data to describe water quality state. I have had discussions with Dr Belinda Margetts at CCC about the period of data that should be used for reporting of the monthly water quality data collected under the EMP. For annual compliance assessment purposes, we agree that a single year of data is appropriate so that the responses to monitoring required by the consent conditions (proposed Condition 51) are in response to breaches of Attribute Target Levels that have occurred within the relevant monitoring year. The EMP has broader purposes than

compliance, however, and the majority of parameters monitored are not linked to compliance with proposed CSNDC consent conditions. In my opinion, it would be appropriate for the annual reporting on the monthly water quality monitoring to assess data collected over the previous 3-year period to ensure that a robust statistical assessment of receiving environment state is provided. In practice this would mean that water quality state analyses would use a 3-year dataset, with a subset of parameters (TSS, copper, lead and zinc) also analysed using just the most recent year of data for compliance assessment purposes.

95. Table 3 of the EMP lists the water quality parameters to be analysed and the corresponding guideline levels that results will be compared to. This is a comprehensive list of standard water quality analytes for urban streams and I consider this an appropriate list to be used to describe the receiving environment. I note that only the 25 mg/L guideline is listed for TSS, which in Schedule 4 of the consent conditions is listed as the Attribute Target Level for baseflow conditions, with an additional target level of 100 mg/L for wet weather conditions. Both target levels should be included in Table 3 and the EMP needs to include details of how the monthly data will be analysed to assess compliance with the two target levels.

96. There is an inconsistency with the dates proposed for commencing the five-yearly reviews of the hardness data that are used for modifying the trigger values for copper, lead and zinc. On page 35 of the EMP it states that the first review will be undertaken in 2020, while in Appendix D of the EMP the date is 2023. Condition 45 of the proposed consent conditions also refers to 2023. I note that the 'June 2016 further information' gave a first review date of 2017, in response to question 5. The hardness data that was used to calculate the Hardness Modified Trigger Values (HMTVs) that are currently used was collected between December 2010 and March 2012 for most catchments (Appendix C of the EMP). In my opinion it is necessary for the first review to be carried out as soon as possible to check whether there have been any significant changes in hardness since that time and therefore 2019 would be an appropriate date.

97. With reference to HMTVs, I note that the ANZECC (2000) trigger values for copper and zinc are currently under revision and the draft advice that has been circulated indicates that additional modifiers will be included for these metals. For copper it is likely that the hardness modifier will be replaced with dissolved organic carbon, while for zinc the modifiers may be hardness, pH and possibly also dissolved organic carbon (Gadd *et al.* 2017; Jenni Gadd, NIWA, pers. comm.). I recommend that dissolved organic carbon is added to the list of parameters to be tested in Table 3 of the EMP, at least for the first year to develop a local data set from which future HMTVs can be derived.

***Surface water quality – wet weather monitoring***

98. CCC have proposed to undertake wet weather monitoring at 26 sites within the five main Christchurch river catchments on a five-yearly rotation, in the same year as the sediment and ecological monitoring for each catchment. Two wet weather events are proposed to be monitored each year in the relevant catchment. This monitoring will result in a small data set of wet weather data that will provide some useful information on first flush impacts of stormwater. However, it is important to note that the dataset provided will not be sufficient to assess the impacts of stormwater treatment initiatives on receiving water

quality during rainfall events and such an assessment would require additional targeted monitoring.

99. It is not clear whether the Attribute Target Level for TSS in wet weather conditions will be assessed using these data or whether only a subset of the monthly data will be used for this purpose. This requires clarification in the EMP and is important because Condition 51 of the proposed consent conditions includes responses to monitoring for TSS, which I assume will be triggered by exceedances of both the baseflow and wet weather TSS target levels.

100. The EMP specifies rainfall event criteria that are to be used to determine when wet weather sampling should be carried out. I understand that using these criteria have proven problematic for wet weather monitoring undertaken by CCC (or their consultants) to date, due to the difficulties with resourcing grab sampling during defined rainfall events. There is a research project currently underway with the goal of developing new cost-effective methods for collecting stormwater and urban waterway water quality data (Jenni Gadd, NIWA, pers. comm.) and I suggest that the results of that project could be incorporated into the EMP if considered appropriate.

101. The concentrations of many contaminants peak during the first flush after rainfall and spikes of toxicants such as metals and hydrocarbons may reach levels that are directly toxic to aquatic life. Substances may also accumulate in sediments or bind to organic particles and enter the food chain. The direct impacts of stormwater are therefore most detectable during high flows and it could be argued that wet weather monitoring is more appropriate for assessing the effects and thus compliance of stormwater discharges on receiving environment outcomes. More intensive routine monitoring during wet weather would require significant resources and I would not support a greater level of this monitoring on a routine basis due to the opportunity cost in terms of actual stormwater mitigation and retrofitting. However, I would encourage CCC to undertake discrete investigations of ‘first flush’ characteristics associated with new stormwater developments and retrofits. Automatic water samplers triggered by changes in flow are a useful way to characterise rainfall event changes in stormwater quality and I would encourage CCC to invest in auto-sampler technology, or the alternative methods being investigated by NIWA in the project discussed above in paragraph 100.

102. In my view the longer-term effects of contaminants introduced to the receiving waterways by stormwater discharges are best measured using sediment quality sampling. I support the inclusion of five-yearly sediment quality monitoring in the EMP, subject to the comments provided in the s42A report of Dr Lesley Bolton-Ritchie. I also encourage CCC to consider further targeted sediment quality in sub-catchments with elevated contaminant levels to aid with deducing contaminant sources and treatment options.

***Monthly fine sediment monitoring***

103. The EMP includes a proposal to introduce monthly fine sediment monitoring at 10 sites within the Christchurch waterways. These include two sites within each of the five main river catchments and the rationale for the site selection was provided in Table 2 of the ‘Nov 2015 RFI response’. I agree with the proposed methodology which is adapted from

methods used by CRC and Clapcott *et al.* (2011). As this is a new aspect of monitoring for CCC staff there will need to be adequate training to ensure that the results are robust and useful for assessing trends over time.

104. I strongly support the inclusion of this monthly fine sediment monitoring within the routine monitoring programme but consider that a greater number of sites is required to monitor the issue and assess changes over time at a suitable spatial scale to assist with management decisions. Deposited fine sediment is an important indicator of sediment inputs from stormwater discharges and regular monitoring at a range of locations will aid with identification of hotspots for sediment loads and potential areas for remediation. I understand that this additional component to the monitoring will add to the time taken for each monthly monitoring run and recommend that four or five sites within each of the river catchments will be manageable rather than just two sites as proposed.

***Aquatic ecology monitoring***

105. CCC have proposed to monitor a range of aquatic ecology parameters on an annual basis at four sites (two in Cashmere Stream and two in the Ōtūkaikino River), with a total of 61 waterway sites in Christchurch and four in Banks Peninsula to be monitored on a five-yearly rotation. The annual sites have been chosen because they are downstream of substantial proposed development, with the intention that regular annual monitoring will inform on stormwater management efficacy. The large number of sites included in the aquatic ecology monitoring programme provides good spatial coverage, but the five-yearly frequency is not sufficient for identifying trends that may require interventions and additional actions for mitigation. I understand that resource constraints mean that a balance is required between coverage and frequency and support there being a mix of annual and less frequently monitored sites, with annual sites targeted at locations in higher quality receiving environments where there are higher risks of degradation due to the level of development occurring in the catchment. In my opinion the proposed five-yearly frequency of monitoring for the majority of aquatic ecology sites will be insufficient to enable assessment of likely drivers for changes identified between monitoring periods. The aquatic ecology data will be suitable for assessing state and comparing to Receiving Environment Objectives for QMCI and fine sediment cover, but will be less useful for assessing trends and identifying where stormwater discharges may be influencing the aquatic ecosystem.

106. The aquatic ecology monitoring is proposed to be undertaken using standard methods which are broadly comparable and complementary to those used by CRC for State of the Environment (SOE) monitoring. The only exception is the occurrence of sampling in late summer, whereas CRC SOE monitoring occurs between November and early January. I support the continuation of CCC sampling in March as it will be important to continue with a consistent approach to ensure comparability with past results and many other councils in New Zealand undertake aquatic ecology monitoring in late summer. In the past the annual ecological monitoring done for the South-West and Styx network stormwater consents has only involved macroinvertebrate monitoring, but the CSNDC EMP proposes to include the full suite of ecological and habitat parameters at these sites, except for fish monitoring. I support this extension of the current monitoring.

107. I agree with the reporting approach for ecological monitoring presented in the EMP. I think it will be essential for the annual reporting to integrate the components of the EMP to aid with determining influencing factors for any spatial or temporal trends seen in the data. For example, the five-yearly rotational cycle of monitoring (as outlined in Appendix D of the EMP) includes wet weather water quality monitoring, instream sediment quality, aquatic ecology and Mana Whenua monitoring within the same catchment so the results from each should be considered together to help with identifying relationships between parameters and potential links to stormwater discharge effects. This requirement for integrated reporting could be incorporated into the EMP or into the wording of Condition 53(a) of the proposed consent conditions.

***Lakes and wetlands***

108. Despite the existence of several lakes and wetlands within the confines of the CSNDC, no monitoring of lake or wetland condition or water quality is proposed in the EMP. An exception is Mana Whenua cultural monitoring which includes sites on Ōruapaeroa/Travis Wetland and Te Oranga/Horseshoe Lake. The outlet from Horseshoe Lake is also part of the monthly water quality monitoring programme. The largest lakes involved are Te Waihora/Lake Ellesmere and Wairewa/Lake Forsyth. While both these lakes are the ultimate receiving environment for stormwater from parts of the CSNDC area (from Halswell and Little River, respectively), the urban areas comprise only a very small proportion of the lake catchments. This point is made in the initial CSNDC application which concludes that the effects of storm water on the lakes are likely to be less than minor. I agree with this assessment. The catchment of Te Oranga/Horseshoe Lake is entirely urban, and stormwater likely has an overriding influence on the state of the lake. The discharge point of the lake is monitored, and results are part of the reporting and responses to monitoring in the proposed consent conditions. However, this monitoring will not entirely assess the condition of the lake. Nutrients in lakes may behave differently to in flowing water bodies and as such different components of nitrogen and phosphorus are typically measured. Specifically, total nitrogen and total phosphorus are typically recorded in lakes rather than the dissolved fractions. While I consider that water quality and ecological monitoring of Te Waihora and Wairewa should not be required for the CSNDC it is my opinion that water quality and ecological health should be measured, and appropriate criteria established to assess the impact of stormwater on Te Oranga/Horseshoe Lake.

***Responses to monitoring***

109. Both ambient and wet weather water quality data are useful when assessing compliance for a network stormwater consent. The Attribute Target Levels for copper, zinc and lead, which along with TSS are the key stormwater contaminants proposed to be used for compliance purposes in the CSNDC (proposed Condition 51(a)), are derived from the ANZECC (2000) toxicant trigger values modified for local hardness conditions. These trigger values are based on chronic toxicity data and are therefore most appropriate for assessing long-term risk (Gadd *et al.* 2017). There are currently no New Zealand guidelines to protect against short-term effects (acute toxicity), although I understand that some are being developed (Jenni Gadd, NIWA, pers. comm.). Stormwater discharges are intermittent and therefore represent an acute risk, however the potential exists for discharges to increase chronic risks because the repeated nature and large

number of discharges may mean that organisms are not able to fully recover from one event before the next event occurs. In addition, metals from the stormwater discharges can build up in sediment, representing an on-going source to the water column that can be exacerbated under low oxygen conditions (Gadd *et al.* 2017).

110. In my opinion, in the absence of acute toxicity trigger values that are applicable to New Zealand or more robust national guidance on appropriate compliance standards or procedures for stormwater discharge monitoring, it is appropriate to compare the monthly monitoring data to the Attribute Target Levels for compliance purposes. The annual data set is likely to contain data collected during or soon after at least one rainfall event but ideally the monthly monitoring should incorporate a number of days of rain event sampling that is reflective of the frequency of rain events, so that the data represent the range of concentrations that ecosystems are typically exposed to. For example, Christchurch experiences on average 84 days of rainfall per year (where 1 mm or more of rain falls; Macara 2016)) which is 23% of the time, so at least 2 out of 12 monthly samples should include a rainfall day. The 95$^{th}$ percentile statistic is proposed to be compared to the target levels and this will mean that more than one exceedance of the target level within the annual data set for a site will trigger a non-compliance and require investigation. In future, when acute toxicity trigger values are available it may be best practice to partition the data set and compare chronic trigger values to samples taken in baseflow conditions and acute trigger values to samples taken in stormflow conditions, so it will be important that information on rainfall conditions is retained with the water quality data to enable this analysis.

111. Ideally, this assessment of chronic water quality conditions would be complemented by the use of longer-term indicators of sediment and contaminant inputs within the compliance framework, such as sediment quality and fine sediment cover. However, current sediment quality and fine sediment cover conditions in Christchurch waterways are poor and strongly affected by historical contaminant inputs and sediment deposition. It would therefore be difficult to directly infer any influence of current stormwater discharges or change due to current and future stormwater management practices. This situation could change if fine sediment deposits were removed from the beds of the rivers, which is an investigation proposed in Table 3 of the proposed consent conditions (action 7 and 8). It is important to note that the current poor condition of sediment quality and fine sediment cover is largely a result of urbanisation and historic stormwater discharges from the CCC stormwater network, and thus demonstrates that improved future management of stormwater is critical to improving the state of urban waterways in Christchurch.

112. The response to breaches of Attribute Target Levels for TSS, copper, lead or zinc in surface water is outlined in Condition 51 and involves an investigation and report on whether the monitoring results are due to stormwater network discharges and an assessment of options for correction/remediation. The proposed condition does not include any timeframes for the investigation or the report and I recommend that the investigation report should be included within the annual report of the year following the exceedance. It is also not clear how the Applicant will prioritise issues that arise from non-compliance with Condition 51, which could require investigations at multiple sites within a year. I suggest that the Implementation Plan proposed in Condition 14 of the

proposed consent conditions could include details of a process that prioritises how CCC will respond to issues that are highlighted via the monitoring programme.

***Overall conclusion***

113. The EMP outlines a comprehensive monitoring programme for assessing the state and trends in water quality and ecological health of receiving rivers and streams in the CSNDC area. Given current resource constraints I believe that an appropriate balance has been reached for most components of the monitoring programme, between spatial distribution (number of sites) and sampling frequency. Responses to monitoring outlined in the proposed consent conditions are limited to assessment of the key stormwater contaminants in receiving water samples that are most directly associated with runoff from impervious urban surfaces (TSS, copper, lead and zinc). I agree with this approach given the legacy effects of historical inputs on other relevant measures, such as fine sediment cover and sediment quality. I have provided some recommendations on improvements to the EMP and also to the proposed consent conditions regarding responses to monitoring to ensure that response actions are timely and appropriately prioritised.

## Assessment of Potential Effects

114. In the Assessment of Effects on the Environment section of the application (Section 8), the Applicant concludes that:

- *The effects on surface water quality will be mitigated by treatment measures and estimated in the SMPs by contaminant load models.* A conclusion on overall effects and the potential level of achievement of receiving environment outcomes is not provided but it is predicted that water quality will improve or be maintained at current state in different catchments across the city. I agree with this, based on the estimated reductions presented in the application, but note that there is a high level of uncertainty around these figures, as they are dependent on the accuracy of the models used. Monitoring results will be a key factor in determining whether improvements are being realised.

- *The effects on aquatic ecology from stormwater contaminants will be minimal as a result of the reduction in contaminant loads predicted in the SMPs.* The AEE states that 'if instream and riparian habitat conditions are also improved, then the proposed improvements to water quality could significantly improve the overall ecosystem health of streams in the CSNDC area'. I disagree with the conclusion of 'minimal effects on aquatic ecology' due to the complexity of aquatic ecosystems and their influencing factors. In my opinion, there is insufficient information to be able to fully assess effects of the stormwater discharges on ecological health.

- *It is unlikely that there will be any measurable effects of stormwater discharges on Te Waihora/Lake Ellesmere and Wairewa/Lake Forsyth due to the distance from the initial discharge points to the tributary rivers and then the lakes, and the mixing of the discharges with river and then lake water.* I agree with this conclusion. However, the potential effects on other smaller lakes and wetlands within the CSNDC area, such as Horseshoe Lake and Travis Wetland, have not been considered.

115. In general, I consider that the approach proposed by the Applicant is likely to result in an overall improvement in the receiving waterways across the CSNDC area. Key to this are the SMPs, which outline catchment- or area-specific stormwater issues and mitigation measures, and a research programme to investigate knowledge gaps and implement other actions that will aid with improving waterway outcomes. However, there is insufficient spatial detail within the application and too much uncertainty around the model approach and future implementation, particularly around the management of high-risk sites post-2025, to be able to make any conclusions about the potential scale of likely effects of stormwater discharges on receiving environments into the future. The Applicant has demonstrated a commitment to improvement through the proposed consent conditions and the proposed Receiving Environment Objectives and Attribute Target Levels for Waterways are well aligned with the LWRP outcomes. There remains a high level of uncertainty around the outcomes that will actually be achieved and by when, that is dependent on the accuracy of modelled contaminant loads and effective implementation of the many measures and processes that have been proposed to mitigate potential adverse effects. The model review (Cochrane and O'Sullivan 2018) has identified significant assumptions that raise questions about the suitability of the C-CLM for the purposes proposed by the Applicant, and also about the appropriateness of using the C-CLM into the future.

116. In my opinion, for the adaptive management approach to be successful at reaching the objectives of the consent there need to be more checks and balances, with mitigation measures reviewed and adapted more frequently in response to the monitoring and research that is proposed to be carried out (see paragraph 74 above). The consent also needs to be mindful of future changes to stormwater and urban waterway management that have been signalled at a regional and national level and include review clauses in response to potential amendments to regional (LWRP) and national (NPS-FM) planning instruments.

## Summary of recommendations

117. The list below summarises the recommendations that I have made throughout this report (with reference to the relevant paragraphs), for the benefit of the Reporting Officer, the Hearing Commissioners and other readers.

a) Paragraph 39: Future modelling should make use of the best available modelling tool at the time, that is calibrated and validated using the best available input data, relevant to local conditions. The consent conditions should allow flexibility in the model to be used for assessment against Table 2, rather than being fixed to the use of the C-CLM for the duration of the consent.
b) Paragraph 40: Table 2 should detail percent reductions for each of the modelled catchments rather than being presented as a single figure that applies across the whole CSNDC area.

c) Paragraph 42: Include additional consent conditions under Stormwater Contaminant Load Modelling that address the following concerns about the C-CLM (making use of two of the investigation actions listed in Table 3):
   - Investigate the impacts of applying alternative modelling tools
   - Assess contaminant reduction performance of stormwater treatment facilities and devices in Christchurch (may involve review of existing information as well as monitoring of installed facilities and devices)
   - Update the contaminant load rates for different land use types to account for Christchurch conditions
   - Updates to the C-CLM (if chosen as the most appropriate modelling tool for the foreseeable future) to improve the model assumptions around contaminant load rates for different land use types and treatment system performance should be undertaken within 1 to 3 years of the consent being granted.

d) Paragraph 46: A note should be added to the top of Schedule 4 that refers the reader to the EMP for details of the methodology to be used when assessing data against the Attribute Target Levels, to avoid confusion with the use of 'lower limit' and 'upper limit' within the Schedule 4 table.

e) Paragraphs 51-52: Appropriate target levels for TSS concentrations in baseflow and wet weather conditions could be derived using the 80$^{th}$ percentile approach that is used in ANZECC (2000) for physico-chemical stressors, using existing CCC and CRC data sets.

f) Paragraph 55: Schedule 4 should include a separate target level for copper, lead and zinc concentrations for the Cashmere Stream catchment, as listed in Table 3 of the EMP.

g) Paragraph 64: The consent conditions should include a Receiving Environment Objective or a standard similar to those stated in proposed Conditions 23 and 24 that addresses sites with a higher risk of contaminating surface water or groundwater.

h) Paragraph 70: The purpose of the SMPs stated in Condition 5(a) should be amended to include a 'maintain' requirement to prevent future degradation of high quality receiving environments.

i) Paragraph 71: The objectives in the existing SMPs for the Huritini/Halswell River, Puharakekenui/Styx River and Ōtākaro/Avon River catchments will need to be reviewed to ensure alignment with the CSNDC Receiving Environment Objectives and Attribute Target Levels. This review, in advance of the programmed review date listed in Table 1, should include revision of objectives and inclusion of appropriate measures to address the revised objectives within the SMP.

j) Paragraph 72: Information that is to be included in SMPs, listed in proposed Condition 6, should also include:
   - Assessment of the impact of development and land use change planned for the catchment on catchment characteristics such as the percent impervious surface area, as well as characterisation of the pathways for stormwater within different parts of the catchment (e.g. treated vs untreated, to ground or to surface water);

   - Identification of areas of high aquatic ecological or cultural value, including but not limited to springs and wetlands, and habitat for threatened species;

- Assessment of water quality modelling results in terms of potential impact on the state of the receiving water quality and ecology, specific to the catchment and the proposed mitigation measures, with reference to Receiving Environment Objectives and Attribute Target Levels and LWRP outcomes;
- An options assessment, to clearly demonstrate the key drivers behind the mitigation measures selected for implementation;
- A list of sites identified as 'high risk' within the catchment, including the likely contaminants and their risk to receiving environments, based on the processes that CCC will need to develop to mitigate the risks on large construction sites and contaminated sites that will be within the scope of the CSNDC after 2025;
- Details of the process to be implemented to ensure that risks are sufficiently mitigated from 'high risk' sites within the catchment to prevent unacceptable negative effects on receiving environments.

k) Paragraph 73: There needs to be a certification process for SMPs when they are initially submitted and I recommend that this involves a Technical Advisory Panel.

l) Paragraph 74: The SMP review period should be decreased from 10 years to 5 years to ensure that relevant findings from the monitoring and research proposed under this consent are incorporated into the selection, design and implementation of mitigation measures for individual catchments.

m) Paragraph 75: Change proposed Condition 13(e) to refer to a plan or programme for additional testing or water quality monitoring to check the performance of facilities or to inform prioritisation of areas for mitigation. Subsequently, add the reporting on this plan or programme to the annual reporting requirements listed in proposed Condition 53.

n) Paragraphs 76 and 81: Strengthen the requirement that *may* be included in the proposed Implementation Plan (Condition 14) for details of maximum stormwater contaminant concentrations that CCC will accept into the network. This aligns with an existing mechanism through the CCC Water Supply, Wastewater and Stormwater Bylaw 2014 (section 35(1)) and would be a robust and effective means of managing discharge quality into and from the stormwater network.

o) Paragraph 78: Amend the wording of the investigations and actions proposed in Tables 3 and 4 of the consent conditions to make the purpose and desired outcome of each action clear. Also include outcomes from Table 4 in the reporting requirements, i.e. add Condition 38 to the group of conditions listed under Condition 53(a).

p) Paragraph 79: Include independent input to the decision making for feasibility studies and additional investigations in Table 3 of the proposed consent conditions, which I suggest is through use of relevant members of the Technical Advisory Panel that I recommended in paragraph 69.

q) Paragraphs 83 and 84: Additional consent conditions are required to address the increased contamination risk that will be introduced post-2025 when high risk sites are included under the CSNDC. These may outline the steps that CCC will need to go through in developing a process for identifying, assessing, managing and monitoring these sites. Details of these processes will need to be included at the catchment scale in SMPs, which will require amendment of existing SMPs prior to 2025.

r) Paragraph 90: A specific purpose description should be added to each section of the EMP to make it clear how each component is related to the stormwater discharge activities that fall under the CSNDC.

s) Paragraph 92: The Templetons Road site on the Ōpāwaho/Heathcote River should be re-located downstream to a site with permanent flow that is upstream of the inflow from Haytons Stream.

t) Paragraph 92: The EMP should identify tidal river sites where salinity is highly variable as many guideline values will not be applicable to these sites.

u) Paragraphs 95 and 99: The EMP needs to include the wet weather Attribute Target Level for TSS and should include details of how the monthly data and wet weather monitoring data will be analysed to assess compliance with both the baseflow and wet weather target levels.

v) Paragraph 96: The proposed five-yearly reviews of the data for modifying the trigger values for copper, lead and zinc should commence as soon as possible given that the current HMTVs were derived in 2012 based on 2010-2012 data, and I suggest this should be in 2019.

w) Paragraph 97: Dissolved organic carbon should be added to the list of parameters for testing in Table 3 of the EMP.

x) Paragraph 104: The number of monthly monitoring sites at which fine sediment monitoring is undertaken should be increased to four or five rather than just two in each catchment, to provide a greater spatial coverage of the data gathered on this important monitoring component.

y) Paragraph 107: A requirement for integrated reporting of the monitoring components that are part of the five-yearly rotational cycle of monitoring should be incorporated into the EMP or into the wording of Condition 53(a) of the proposed consent conditions.

z) Paragraph 108: Water quality and ecological health should be measured, and appropriate criteria established to assess the impact of stormwater on Te Oranga/Horseshoe Lake.

aa) Paragraph 112: Condition 51 outlines the requirement for an investigation if Attribute Target Levels are breached for TSS, copper, lead or zinc and this should be amended to include a timeframe for the investigation report, which I suggest should be within the annual report of the year following the breach. I also suggest that the Implementation Plan proposed in Condition 14 should include details of how the Applicant proposes to prioritise issues that are highlighted by the monitoring programme.

## Response to Submissions

118. There have been a number of submissions on this resource consent application that relate to potential effects on surface water quality and ecology. I briefly summarise and respond to the issues raised in the paragraphs below.

119. Many submitters have raised concerns with the inclusion of high risk sites and the lack of an assessment of effects associated with these additional sites. I agree with these concerns and the increased risk of contaminants entering surface waterways if these

sites are not appropriately managed. Paragraphs 82 to 85 of this report outline my concerns and I suggest that a robust framework for the identification, management and monitoring of these sites needs to be developed prior to 2025 to ensure that sufficient mitigation is in place to prevent effects on receiving environments.

120. Many submitters have recognised the critical role that SMPs have in identifying catchment-specific values and issues and determining appropriate mitigation measures to address stormwater management issues at the smaller geographic scale. These submitters, including community river care groups, industry (NZ Steel Ltd, Ravensdown Ltd, Oil Companies), and the Department of Conservation (DOC), have requested involvement in the development of SMPs. I am supportive of input to these documents coming from a wide range of stakeholders, as I believe that getting buy-in from relevant parties throughout the process is likely to increase the efficacy of implementation. Greater communication of the issues involved with stormwater management amongst the residential and industrial community of Christchurch will hopefully make people more aware of the role that we can all play in reducing the load of contaminants entering CCC's network, and thus contribute to achieving objectives for our surface waterways.

121. The submission from DOC also stated that they can provide specialist technical advice to processes such as the development and review of the SMPs and Implementation Plan and requested that they be provided with the annual receiving environment monitoring reports. Their expertise includes knowledge of freshwater fish and invertebrates and their habitat, fish passage regulations and fish passage barriers, fish spawning sites, and limits on contaminant discharges under the Conservation Act within a conservation area. I agree that DOC is a key stakeholder that could contribute technical expertise and suggest that they could be a part of the Technical Advisory Panel that we have recommended to provide advice for SMP certification and decision making on the results of stormwater management investigations, for example (see paragraphs 73 and 79 of this report).

122. There were a number of submitters, including community river care groups and DOC, who expressed concern that the C-CLM in its current form has not been adapted for Christchurch conditions. I support this concern and the review of the Golder (2018) report that is attached to this report outlines some of the potential implications of using Auckland-derived inputs on the model results. It is likely that updated inputs that take into account topographic conditions, soil types and local climatic conditions could be used across the CSNDC area rather than having to be developed at a catchment scale, and there are existing local data that can assist with this process (see references in Cochrane and O'Sullivan 2018, attached to this report). Also regarding the C-CLM, the Oil Companies submission seeks further clarification of the treatment efficiencies used and I agree that the values used need to be reviewed and a sensitivity analysis included in the Golder (2018) report that is part of the proposed consent conditions (see paragraph 36 and Cochrane and O'Sullivan 2018, attached to this report).

123. The Ōpāwaho Heathcote River Network (OHRN) and Ravensdown have raised related points around requirements for discharge monitoring, with OHRN suggesting that in-pipe monitoring should be required to establish the contributions of toxic contaminants from pipes and Ravensdown requesting greater certainty around the expectations for industrial sites in terms of water quality targets for discharge quality. Condition 14 of the

proposed consent conditions provides the potential for the proposed Implementation Plan to include maximum stormwater contaminant concentrations that CCC will accept into their network, and in paragraph 76 of this report I have suggested that the Bylaw would be a useful tool for implementing such measures. I have also suggested that direct monitoring of discharges from high risk sites will be required to manage the additional contamination risks posed by these sites (sediment and other site-specific contaminants) and needs to be part of site management plans that are developed for those sites that are identified as potentially contributing to the contaminant load entering the CCC network (paragraph 85 of this report)

124. The OHRN submission noted that the ‘maximum allowable contaminant levels’ for copper, lead and zinc are higher for the Ōpāwaho Heathcote River than most other Christchurch waterways and appear to have assumed that this is due to the higher degree of degradation of this waterway. I would like to clarify that the higher Attribute Target Level for metal toxicants for the Ōpāwaho Heathcote River relates to the higher hardness levels that are present in this waterway, which reduce the toxicity of metals to aquatic organisms and thus result in a higher concentration trigger value (as calculated following ANZECC (2000) procedures) providing for ecosystem protection (see paragraph 55 of this report).

125. The OHRN submission seeks a maximum time for action to be taken to address breaches of this consent. I support this as outlined in paragraph 112 of this report.

126. The OHRN submission also seeks that areas outside of the piped stormwater network be included within the scope of this consent, for example runoff from grazed or forested land. The Cashmere Stream Care Group has additionally requested that CCC set up ongoing measurement of sediment entering Cashmere Stream and apply an annual percentage improvement requirement over the 25 years of the consent. These requests relate to the high sediment loads entering the Cashmere Stream and Ōpāwaho Heathcote River and the desire for greater coordinated management for reduction in these loads. In my view, this stormwater network consent is not the appropriate tool to provide this coordinated management and the LWRP sub-regional planning process that is proposed to commence in the Christchurch-West Melton zone in three to four years will be an appropriate mechanism to address this issue. In the meantime, there are a number of initiatives underway to reduce sediment inputs from the Port Hills, including planting of hillslopes and construction of stormwater basins and wetlands to settle out and filter contaminants before they reach receiving waterways.

127. A number of submissions, including from community river care groups, DOC and the Oil Companies, are supportive of the proposed non-infrastructural initiatives and CCC’s position on source control. The river care groups generally seek a greater commitment to these initiatives, including the Community Water Partnership, through measurable and enforceable conditions to ensure that such actions are undertaken and adequately resourced. I agree that the implementation of these initiatives is an important part of the stormwater mitigation toolbox and have suggested that the wording of many of the investigations and actions listed in Tables 3 and 4 of the proposed consent conditions needs to be amended to improve their clarity and certainty (paragraph 78). I have also suggested that there should be independent input to decision making around these proposed investigations and actions, which will improve the certainty that best practice

and up-to-date knowledge is being applied, rather than decisions purely based on funding (paragraph 80). More specifically, the Oil Companies submission seeks that car brakes and tyres are added to the first action proposed under source control in Table 4 of the proposed consent conditions. DOC have suggested that industry behaviour change is added to the list of non-infrastructural measures. I agree with both of these suggestions.

128. The submission from DOC has highlighted the need for the proposed consent to be consistent with the NPS-FM 2017, including monitoring and reporting of *E. coli*, nitrate, ammonia and dissolved oxygen. I agree with this point and note that the EMP does include these parameters within the routine monthly water quality monitoring programme and subsequent annual reporting. I have also raised the issue in this report (paragraphs 48, 53, 56, and 116) of changes to regional and national planning instruments, including the NPS-FM, during the lifetime of the proposed consent and the need for amendments to Receiving Environment Objectives and Attribute Target Levels when these arise. I note that Condition 46 of the proposed consent conditions provides for such updates through amendment of the EMP.

129. The DOC submission has raised concern regarding the appropriateness of using the existing receiving environment in the assessment of effects of the application and states that the method of assessment needs to be alignment with the LWRP. This opinion aligns with my assertion in paragraph 12 of this report, that the Receiving Environment Objectives and Attribute Target Levels (which are well aligned with the LWRP) are the overall outcomes that the CSNDC is contributing towards and should be the reference point when assessing management options and making decisions around stormwater mitigation, investigations and other actions.

130. The submission from New Zealand Steel Ltd has raised concern about the classification of roofing products in relation to stormwater and contaminants and seeks involvement to ensure that the company's technical knowledge is utilised and there are no business implications for their company, for example through unnecessary constraints to the use of zinc-coated roofing products. They wish to be involved in any engagement with Central Government regarding the use of metal roofing and the formulation of water quality trigger values. I note that the trigger values proposed for use in the CSNDC are based on effects on aquatic biota, rather than with reference to any specific contaminant sources. I am aware that New Zealand Steel has undertaken substantive research on the issue of zinc roofs and comparative leaching rates from different zinc-coated steel roofing products in the Auckland context and consider it entirely appropriate that they would be involved in any discussions or approaches to Central Government regarding roof products.

Signed: Date: 28/09/18

*Michele Stevenson*

*Senior Scientist, Environment Canterbury*

Reviewed by:

Signed: Date: 28/09/18

*Helen Shaw*

*Surface Water Science Section Manager, Environment Canterbury*

# References

ANZECC 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality: Volume 1 The Guidelines.* October 2000.

Boffa Miskell Limited 2014. *Ecological Values of the Avon River Catchment: An ecological survey of the Avon SMP catchment*. Report prepared by Boffa Miskell Limited for the Christchurch City Council.

Boffa Miskell Limited 2015. *Aquatic Ecology of sites within the Heathcote, Estuary & Coastal, and Avon SMP catchments: Informing the Comprehensive Discharge Consent*. Report prepared by Boffa Miskell Limited for Christchurch City Council.

Boffa Miskell Limited 2016. *Halswell River sediment and aquatic ecology survey: Aquatic Ecology Technical Report*. Report prepared by Boffa Miskell Limited for Christchurch City Council.

Boffa Miskell Limited 2017. *Ōtūkaikino River Catchment Aquatic Ecology: Long-term monitoring of the Ōtūkaikino River catchment*. Report prepared by Boffa Miskell Limited for the Christchurch City Council.

Cochrane, T. and O'Sullivan, A. 2018. *Review of the "Assessment of Current and Future Stormwater Contaminant Load for Christchurch. CLM modelling report – Best Practice Infrastructure" by Golder Associates (July 2018) on behalf of Environment Canterbury*. Hydrological and Ecological Engineering Group, University of Canterbury. 24 August 2018.

Cunningham, A., Colibaba, A., Hellberg, B., Silyn Roberts, G., Symcock, R., Vigar, N. and Woortman, W. 2017. *Stormwater management devices in the Auckland region.* Auckland Council guideline document, GD2017/001.

Davies-Colley, R., Hicks, M., Hughes, A., Clapcott, J., Kelly, D., Wagenhoff, A. 2015. *Fine sediment effects on freshwaters, and the relationship of environmental state to sediment load: A literature review*. Prepared for the Ministry for the Environment, June 2015. NIWA Client Report No. HAM2015-104.

Depree, C. 2017. *Sediment Attribute Stage 1b: Proposed classification for suspended sediment*. Prepared for Ministry for the Environment, March 2017. NIWA Client Report No. 2017076HN.

EOS Ecology 2013. *Long-term Monitoring of Aquatic Invertebrates and Fish: Styx River catchment 2013.* Prepared by EOS Ecology for Christchurch City Council.

Gadd, J. 2016. *Urban Streams Water Quality State and Trends*. Prepared for the Ministry for the Environment, June 2016. NIWA Client Report No. AKL2016-018.

Gadd, J., Milne, J. and Hickey, C. 2017. *Copper and zinc aquatic toxicity: Frequently Asked Questions*. Prepared for Environment Canterbury, May 2017. NIWA Client Report No. 2017129AK.

Golder Associates. 2018. *Assessment of Current and Future Stormwater Contaminant Load for Christchurch: CLM Modelling Report – Best Practice Infrastructure*. Submitted to Christchurch City Council, July 2018.

Gray, D. 2018 *in draft*. *Ecosystem Health LWRP – NPS-FM alignment*. Draft memorandum, dated 17 May 2018.

Larned, S., Snelder, T., Unwin, M., McBride, G., Verburg, P., McMillan, H. 2015. *Analysis of Water Quality in New Zealand Lakes and Rivers.* Prepared for Ministry for the Environment, February 2015. NIWA Client Report No. CHC2015-033.

Macara, G.R. 2016. *The Climate and Weather of Canterbury: 2nd edition.* NIWA Science and Technology Series: Number 68.

Margetts, B. and Marshall, W. 2015. *Surface Water Quality Monitoring Report for Christchurch City Waterways: January – December 2014.* Christchurch City Council.

Margetts, B. and Marshall, W. 2018. *Surface Water Quality Monitoring Report for Christchurch City Waterways: January – December 2017.* Christchurch City Council.

Ministry for the Environment 2017. *National Policy Statement for Freshwater Management 2014: Updated August 2017 to incorporate amendments from the National Policy Statement for Freshwater Amendment Order 2017.* New Zealand Government.

# APPENDIX A: C-CLM review report

**Review of the "Assessment of Current and Future Stormwater Contaminant Load for Christchurch. CLM modelling report – Best Practice Infrastructure" by Golder Associates (July 2018) on behalf of Environment Canterbury (report ref. 1378107576-7403-024-R-Rev0).**

**Review report prepared by:**
Tom Cochrane and Aisling O'Sullivan
Hydrological and Ecological Engineering Group
University of Canterbury

**24 August 2018**

**Scope of Work:**

The purpose of this report is to provide a written review of the report entitled "Assessment of Current and Future Stormwater Contaminant Load for Christchurch. CLM modelling report – Best Practice Infrastructure" produced by Golder Associates on behalf of the CCC and the relevant set of consent conditions proposed by the CCC as part of their application for stormwater discharge consent.

The review scope as agreed with Environment Canterbury includes assessments on:

- Model assumptions (are they considered best practice and appropriate for Christchurch)
- Model inputs and baseline data (are the data used adequate for the model)
- The CLM model's suitability for the purposes delineated in the report
- The potential range of uncertainty in modelling outcomes (what range of variability would be expected in the model results and how may this impact on conclusions/recommendations)
- Interpretation of results (is the interpretation of results and limitations adequate and is the validation/calibration adequate)
- Risks / practicalities of the use of model results in consent conditions
- Level of information provided in the report to adequately describe the model and potentially replicate its application
- Other potential options for achieving better results.

# Contents



## 1. Overview

The Auckland Contaminant Load Model (CLM) was applied to the Christchurch City area to estimate pollutant loads of Total Suspended Solids (TSS), Total Zinc (TZn) and Total Copper (TCu) amounts that would originate from 89 subcatchments across the four main river catchments for Christchurch (Styx, Avon, Heathcote and Halswell). The model did not include stormwater runoff from all areas west and north of State Highway 1 because these areas are predominantly rural and runoff is discharged directly to ground.

Four different model scenarios were run – Base case (Jan 2017), and after 5, 10 years and 35 years of future urban development and landuse change as well as implementing treatment measures. The reduction in stormwater contaminant load (proposed in item 16, Table 2, of the consent requirements) are calculated from the difference between simulations of "no-treatment" and implemented treatment measures for each scenario (Base case, 5, 10, and 35 years).

The model outputs provide a Christchurch-wide indication of the consequences of urban development and land use change, as well as *relative* potential best-case scenario, of proposed treatment scenarios.

The Golder report acknowledged that "most of Christchurch's stormwater runoff will enter urban streams, with dissolved and suspended contaminants impacting the receiving water quality." CCC's proposed consent conditions propose to reduce (or mitigate) current and future inputs of the key stormwater contaminants (sediment, zinc and copper) over the next 35 years, but no specific targets for improving the instream water quality are set.

The calibration, validation or verification of the model and its parameters applied for Christchurch conditions is not directly addressed, but some limitations and assumptions in the model are acknowledged. It is stated that "the predicted loads should be considered as an indication for comparison and are not intended to be used as a precise measurement of contaminant loads entering the downstream receiving environment."

## 2. CLM assumptions, related limitations, and recommended alternatives

The report covers the main model assumptions below, listed generally in order of their importance.

2.1 Contaminant load rates per land use type
2.2 Treatment system contaminant removal rates
2.3 Contaminant source reductions for various scenarios
2.4 Rate of future land use change
2.5 Areas under construction

Because of the assumptions in the modelling approach undertaken (detailed below in each sub-section), it is not possible to explicitly assess whether the model results could lead to an over or under-estimate of the contaminant loads and their potential reductions. This is because the modelled results are only as accurate as their input data and some critical input parameter data were not used for the Christchurch context, rendering the model outputs uncertain for these local conditions.

Comments on each of these assumptions follows.

### 2.1 Contaminant load rates per land use type

**a.** It is acknowledged the ARC Contaminant Load Model (CLM) was developed for the Auckland region climate and applicable to catchments > 20 ha. Contaminant loads generated are highly dependent on topographic conditions, soil types, and the local climatic conditions – rainfall duration (depth), intensity and even pH. For instance, the shear forces of precipitation intensity has been correlated to TSS loads and precipitation duration related to metal loads from roofs (because of material dissolution) e.g. Davie et al. (2011) and Liu *et al.* (2015). For Christchurch conditions, significant variance in roof and road quality was measured for different precipitation events (e.g. Charters *et al*., 2016) highlighting the importance of the climate context on contaminant loads.

Because Christchurch has more semi-arid climatic conditions, including lower annual runoff volumes, fewer number of precipitation days, shorter duration of precipitation events as well as flatter topography (in the city) and different soil types, contaminant loads adopted for Auckland conditions are a major assumption of the C-CLM. The C-CLM adopted contaminant load rates from the Avon SMP (Golder 2014), whose input values were directly taken from the Auckland CLM model. The only difference applied to the C-CLM was a proportional reduction in TSS loads – this was achieved by applying a factor of 0.6 (instead of 1.0 for Auckland's assumed 1,000 mm/yr precipitation) to account for less annual precipitation volume. However, the different precipitation *intensities* and *durations* experienced in Christchurch will also influence the TSS generation rates and these were not considered in the C-CLM. Furthermore, TSS "available from erosion" is also heavily influenced by soil types (e.g. Loess), and topography (including slope). TSS related to *erosion* may be relevant only to the categories of "Grass land" and "Construction" yet TSS *supply* for other surfaces (e.g. roofs, roads, paved areas) originate from other sources (wind-blown dust, tyre degradation, traffic patterns, etc.) some of which have been quantified for Christchurch (i.e. Charters *et al*., 2015, Murphy *et al*., 2015)

Of particular note is that zinc and copper are well reported to originate from metal roofs in predominantly in the dissolved form, irrespective of location (e.g. Davie et al. (2011), Liu et al. (2015) and in the Christchurch context (Charters *et al*., 2016). These data confirm that metals from roofs are transport limited and <u>not supplied limited</u> (as assumed in the Golder report) because the amount washed off in stormwater runoff is highly dependent on the precipitation contact time (measured in rainfall duration and frequency thereof) on the roofs surfaces. Rainfall volume, duration, intensity and frequency is very different in Auckland to that measured in Christchurch.

For these reasons, using the CLM without calibrating input parameters to Christchurch climate and soil conditions renders it inappropriate for predicting stormwater contaminant loads in Christchurch. One example of the consequence of this assumption is the amount of TSS that was predicted for a 'Construction' source annually at 1500 $g/m^2/yr$ - which may be an over-estimate of TSS generation for the flatter Christchurch topography and an underestimation for the Loess Port Hills area. It is important to note that if more realistic values (calibrated to the local conditions) are used for Christchurch in the future, different relative percent changes in reduction in contaminant loads will be obtained and therefore likely invalidate the "targets" set for the proposed consent condition.

It may be argued that there are no alternative pollutant yield rates to use at present for Christchurch. In which case, then simulations with a range of possible values defining uncertainties in the modelled results, along with sensitivity analyses of the model parameters, would be much more appropriate than using a deterministic approach – as was the C-CLM undertaken. An alternative approach could be to employ an event-driven model, which also derives its pollutant loads from cadastral records of specific impervious surface types (followed by some 'ground truthing') and importantly is calibrated to local climatic conditions. The UC's MEDUSA model (Charters *et al*., 2016 and Fraga *et al*., 2016,) has been applied to some catchments throughout Christchurch for this purpose. Also the National Institute of Water and Atmospheric Research (NIWA) has expanded upon the CLM model with the Catchment Pollutant Annual Loads Model (C-CALM), a GIS-based model for calculating annual pollutant load post-treatment (Semadeni-Davies et al. 2009). C-CALM identifies the rates and effects of long-term pollutant delivery and accumulation in receiving environments, while MEDUSA predicts contaminant load per individual surface per event so can offer insight into where contaminant 'hotspots' occurs as a strategy for targeting. Elliott and Trowsdale (2007) reviewed models for low impact urban stormwater drainage in New Zealand that could also be helpful.

### *2.2 Treatment system contaminant removal rates*

**a.** The assumed treatment system contaminant removal rates selected for the model are identified as being "the largest reductions that can be expected." An explanation of why these "largest reductions" values were chosen is warranted as they set the consent conditions in Table 2. A limitation with choosing the best case scenario outputs is that in practice, treatment systems are highly unlikely to be optimally installed, operated, maintained and functioning throughout their lifespan so actual treatment efficacy is less. These likely reduced treatment efficiencies, especially over time and during rare events (e.g. 1/100 year ARIs), were not accounted for in the C-CLM, leaving to possible over-estimation of contaminant mitigation to be expected.

**b.** Performance criteria for the treatment systems appear to be only the ones built into the ARC CLM and were cited on only 4 references including half from overseas data. It is acknowledged that performance data is limited for Christchurch, however, there are more recent published available data for the NZ context (Charters *et al*., 2015, Fassman *et al*., 2011, Moores *et al*., 2012, Fifield, R., 2011, Good *et al*., 2012, Trowsdale and Simcock, 2011 and Zanders 2005) that can offer better contextual performance. Furthermore, most of the systems summarized in

Table 6 appear to be soil-based yet the performance data is not derived from soils or systems in Christchurch to provide a realistic estimation of their effectiveness to mitigate stormwater contaminants.

**c.** It is not clear if Table 6 in the report captures differences in the treatment of particulate vs. dissolved metals (especially relevant to zinc given the dominance of (dissolved) zinc loads in Christchurch's urban environment). For instance, 71 % removal of total zinc and total copper is reported for a soil adsorption basin across these variabilities in surface type, metal type and metal speciation yet published data shows there is a difference in these performances.

***2.3 Contaminant source reductions for various scenarios***

**a.** It was recognized that source reduction and selected treatment systems could assist towards achieving a reduction in stormwater runoff contaminants. However, it was unclear why treatment options were primarily considered over source reduction – a combination of these is likely to be most effective and pragmatic to implement over the next 35 years.

**b.** The source reduction option focuses only on roof replacement and this was considered by assuming roofs would be routinely replaced after 70 years. This is a valid assumption given roofs would likely degrade by 70 years (or earlier) and so be replaced due to leaking. However, other source control modifications such as roof maintenance by painting, could also offer pragmatic and achievable zinc source control, which were not considered. Furthermore, there was no consideration of contaminant source reduction approaches for copper such as targeting copper via copper-free brake pads to reduce copper loads.

***2.4 Rate of future land use change***

**a.** Land use data for the Base Case and future scenarios used in the C-CLM were provided by CCC based on the long term plan for expected future development. These land use areas will influence the predicted contaminant loads and mitigation thereof. Some discussion is needed on whether the land use values selected for the model will still be relevant in the distant future (i.e. up to 35 years) and how sensitive these values are with respect to the final modelled results.

***2.5 Areas under construction***

**a.** The report did not mention the basis for assuming that 10 % of each building consent application will involve major earthworks. Why 10 % - is this based on previous consent monitoring?

## 3. Report analyses and presentation of results:

**a.** Section 5.2 needs more detail to explain how the reduced contaminant load numbers were produced. The contaminant reduction values stated on page 22 are not referenced in any table and do not correspond to the summary table in the appendix, from where consent condition 16 seems to be derived. For instance, the stated 2 % TSS, 9 % copper and 22 % total zinc reduction mentioned in the text seems to be derived from the percentage difference between the Base case and the 35 year scenario, but this is not clear. Also, there was no explanation as to how the various treatment strategies ('best practice infrastructure') were applied in each of the (sub)catchments (i.e. within or between subcatchments). It is unclear if these mitigation strategies were blanketly applied to all subcatchments to produce the results in Figures 5-8 inclusive. Detailed explanation is needed to show how the mitigation strategies were applied. This is a critical point as the results in these figures produce the net contaminant reduction values presented in Table 2 of the main proposed consent condition 16.

**b.** The report does not explicitly reveal how the 'rural' contaminant loads for 'Base Case' scenario were derived (Figures 5-8 inclusive). We have adopted a simple approach of using the net catchment area stipulated in Table 1 (27,212 ha) and multiplied it by the assumed contaminant load rates from Table 2 (Grassland, rural/urban), to provide TSS, Total Zinc and Total Copper loads (kg/year) for comparison, but the numbers do not match and in the case of metals are greater than an order of magnitude different (i.e. 190 kg/year for TZn using values for rural grassland in Table 2 vs. 3,642 kg/year presented in the figures). An explanation of how "Rural Christchurch" values were calculated would be appropriate to help clarify this.

**c.** Other questions pertaining to values in Table 2 include clarification of the following:

a. Why is the loading for Paved Industrial TSS (13.2) less than for Paved Commercial/Residential (19.2)? Is this a peculiarity for Auckland?
b. Why is Paved – Commercial – Zn loads = 0? Is this just a typographical error?
c. Why is Roofs – Unknown – Zn loads = 0.02 (lowest in Roof category), but Roof – Unknown – Cu loads = 0.002 (highest in roof category)?
d. Why were Roof-Unknown Zn values selected to be lowest, but Cu value the highest in that category?

**d.** A range of results for each scenario was not presented. A deterministic modelling approach was employed, yielding only an absolute, static, number for each scenario. The confidence limits surrounding the final percentage reduction values presented are clearly large, but some attempt should be made to quantify the variability which will impact on the values proposed for the consent conditions.

**e.** The report also did not indicate how sensitive specific surface loading rates or treatment efficiencies were to the model outputs (i.e. model sensitivities).

**f.** It is unclear why the 'performance' of mitigation strategies was reduced over time between the scenarios (e.g. Sw from 55 to 43 to 41 tn/year for TSS in Figure 5) when the assumption was made that they were performing optimally throughout the 35 year modelled period. There was no information provided as to possible changes in the extent of mitigation measures (i.e. Sw) used between the scenarios. The drop in treatment may be a reflection of reduced contaminant input to the treatment system (i.e. Sw), and thus reduced treatment efficiency, but this cannot be evaluated because information on treatment systems used for each catchment for each scenario was not provided.

**g.** The scenario outputs for mitigated contaminant loads are presented as 'best-case scenarios' so should be considered to be this – the best likely outcome. It is understood that this may have been done for consistency, however the risk with presenting solely the idealistic scenario, is that this could lead to over-estimation of contaminant mitigation amounts that can be achieved.

## 4. Other considerations.

**a.** The Golder report objective was to assess "the expected current and future annual contaminant load that enters urban streams in Christchurch…" for each of the three key contaminants. However, it should be acknowledged that a legacy of untreated stormwater inputs already deposited in the stream bed are an existing source of these key contaminants and that with increased discharge alone (flow, velocity or frequency) from stormwater inputs caused by future development and climate change, these contaminants could become more bioavailable through resulting resuspension and/or change in stream physio-chemical conditions. Furthermore, pollutant transformations within the stormwater network itself may occur, thereby modifying the actual contaminant loads entering the streams.

**b.** The C-CLM model was based on a subcatchment or catchment scale. While this is valuable for larger catchment-scale planning (as in the scope of the Golder report), this approach does not support individual property owners to implement optimal source reduction measures or on-site treatment to meet their stormwater discharge requirements or to reduce their pollution footprint. Subcatchment scale models are also limited in their ability to spatially identify the distribution of pollutant loads across a catchment, including 'hotspot' areas that would benefit most from targeted stormwater management improvements.

**c.** Heavy metal partitioning between dissolved and particulate forms is an important indicator of the potential environmental effects of stormwater runoff, as well as directing the types of treatment processes that would be effective at reducing the pollutant loads. The C-CLM (or CLM) does not model dissolved metals as distinct from total metals (although these were accounted for in part by the different load reduction factors for specific surfaces likes roofs - to acknowledge the limited removal of dissolved metals in treatment systems). Dissolved metal loads (the most bioavailable form) are more indicative of aquatic ecotoxicity and therefore there is value is representing dissolved metals within a stormwater quality model. Additionally, the treatment technologies that are effective at removing dissolved metals differ significantly from those that can remove particulate metals, and therefore modelling of the dissolved portion will assist with appropriate treatment selection. Furthermore, assuming a homogenous particle size when applying sediment mitigation in treatment systems is risky due to the variation of particle size distribution, both during an individual rain event and between multiple events, in different land use catchments.

## 5. Proposed CCC consent conditions relevant to the modelling report

This section assesses the specific consent conditions 16, 17, 18, the advice note below 18, and 49 (responses to modelling), including Table 2, in relation to the Golder report (the specific sections are listed in Appendix).

### 5.1. Consent conditions 16-18 – contaminant load reductions to be met up to a 35 year period compared with base case scenario.

**a.** The results presented in Table 2 represent modelled values using only current, somewhat limited, knowledge (including some major model assumptions outlined earlier). In predictive and comparative models, the input data is updated as regularly as possible in order to produce more robust modelled scenarios and comparisons. Therefore, the values in Table 2 represent un-verified, static values and may only be applicable in the short-term (e.g. < 5 years). For this reason, it is not appropriate to use the modelled contaminant reductions presented in the scenarios in the report for long-term application, including up to a 35 year period. This is because the input data and parameters will most likely be very different after 5+ years as model uncertainties are reduced through calibration and validation to local conditions (with refinement of land use areas, surface type, local soils and climate, developments, mitigation performance, etc.). We realize that setting targets for consent compliance is desirable, but when current data is limited as in this case, dynamic targets are more appropriate. Dynamic targets could be set and revised every 5 years as new input information becomes available to increase the robustness of the modelling application.

**b.** Therefore, it would be more valid to include a consent condition requiring the scenarios to be modelled every 5 years and compared to data from the environmental monitoring programme(s) in the intervening years. This would enable the model to be calibrated to the local conditions and to performance data from appropriate mitigation systems, as a better indicator of their effectiveness.

**c.** Because the C-CLM in its current form represents a deterministic, as opposed to a probabilistic, model, there is an absence of a range of results presented for each scenario in Table 2. A range of probabilistic reductions in the contaminant loads would be more realistic (and achievable) based on different proportion of mitigation strategies adopted in each subcatchment.

**d.** The advice note following consent 18 states that "*The C-CLM is the primary means of assessing the relative reduction in contaminant loads for copper, zinc and TSS which would enter the receiving environment as a result of the structural measures used by the Council.*"

It seems unrealistic and undesirable to expect the CLM to be used for the next 35 years. By that time, there will be new and better technology to improve the prediction of contaminant loadings which will undoubtedly overcome the CLM's limitations. The CLM was developed for Auckland conditions and initially used to assess possible contaminant loads predicted from stormwater in that region. More recently, the Auckland Regional Council has moved away from using the CLM in their Auckland Unitary Plan (AUP) for predicting contaminant loads as it recognizes the best international practice of "increased focus on targeting treatment requirements for *high contaminant* generating areas/land-uses" and considering the *specific receiving environment sensitivities*. The AUP has new stormwater treatment performance requirements for a range of contaminants rather than the de facto 75 per cent TSS removal requirement, recognizing that dissolved metals such as zinc are not co-removed with TSS, as previously assumed.

**e.** The second note following consent 18 states that "*A range of alternative contaminant modelling technologies may be used for research purposes or to assist with stormwater management and contaminant load reductions. These could include (but are not limited to) event-based models and methods of assessing predicted improvement in receiving environment water quality, if or when such tools become available.*"

As explained earlier, models such as the CLM are only as valid as their input data reliability. Therefore, in order to be reliable predictor tools, they require updating frequently for the modelled conditions, as new data becomes available. It is also highly likely that the CLM will become an obsolete model in 35 years' time, as newer tools are developed to predict contaminant loads and their mitigation, in which case the consent conditions 16-18 will become inappropriate. For these reasons, we suggest a more valid consent condition to include could be a requirement to model the scenarios every 5 years using the best available calibrated model at that time and from the modelled data, set the reduction targets for the subsequent 5 years in which these targets should be met.

### 5.2. Consent condition 49 – responses to modelling.

**a.** Because the requirements set out in consent condition 49 related directly to Table 2, it is not valid to include this condition as currently stated for the reasons outlined above relating to consent conditions 16-18.

## 6. Key Conclusions

1. The C-CLM tool was employed to predict the key stormwater contaminant loads (TSS, zinc and copper) from future developments across Christchurch and to assess reduced contaminant loads by assuming specific mitigation scenarios. The model used climatic and soil parameters embedded within it (as the CLM), which are only valid for Auckland conditions. Because the input parameters were not calibrated to Christchurch conditions (although a factor of 0.6 was applied to estimating TSS loads to represent a proportional reduction in total precipitation in Christchurch compared to Auckland) and the mitigation scenarios presented idealistic treatment efficiencies, the C-CLM results were not an appropriate predictor of the contaminant loads to be expected or mitigated in Christchurch.

2. If there are no alternative pollutant yield rates to use at present for Christchurch, uncertainty around the modelled results (ranges of possible values) and sensitivity analyses of the model inputs affecting the modelled results could reduce the uncertainties around the numbers predicted. Nonetheless, if more realistic values (calibrated to the local conditions) are used for Christchurch in the future, different relative percent changes in reduction in contaminant loads will be obtained and therefore likely invalidate the "targets" set for the proposed consent conditions as they are currently defined. An alternative approach could be to employ an event-driven model such as MEDUSA, which also derives its pollutant loads from cadastral records of specific impervious surface types (followed by some 'ground truthing') and importantly is calibrated to local climatic conditions.

3. If the results are to be used just for the purpose of assessing relative reductions, the scenario outputs for mitigated contaminant loads are presented as 'best-case scenarios', but these are unrealistic. It is understood that this may have been done for consistency, however the risk with presenting only idealistic scenarios, is that this could lead to over-estimation of contaminant mitigation amounts that can be possibly be achieved.

4. It is not appropriate to use the contaminant reductions predicted using current (limited) data for applying to long-term conditions, including up to a 35 year period. This is because the input data and parameters will most likely be quite different after 5+ years as model uncertainties are reduced through calibration and validation to local conditions. Furthermore, because models are being improved all the time, the CLM will likely become obsolete in 35 years (likely earlier) and therefore is not an appropriate reference tool to which long-term consent conditions should be set. We realize that setting targets for consent compliance is desirable, but when current data is limited as in this case, dynamic targets are more appropriate. Dynamic targets could be set and revised every 5 years as new input information becomes available. This would afford a great certainty around the numbers predicted and provide flexibility in using the best predictor tools available at the time of review.

5. For these reasons, we suggest a more valid consent condition could be a requirement to model the scenarios every 5 years using the best available calibrated model at that time and from the modelled data, set the reduction targets for the subsequent 5 years in which these targets should be met.

## 7. References cited.


1. Charters F. J., Cochrane T. A. and O'Sullivan A. D. (2015). Particle size distribution variance in untreated urban runoff and its implication on treatment selection. *Water Research* 85, 337-45. Christchurch City Council (2003). Waterways, wetlands and drainage guide. Part B: Design.
2. Charters F. J., Cochrane T. A. and O'Sullivan A. D. (2016). Untreated runoff quality from roof and road surfaces in a low intensity rainfall climate. *Science of The Total Environment* 550, 265-72.
3. Davis A. P., Shokouhian M. and Ni S. (2001). Loading estimates of lead, copper, cadmium, and zinc in urban runoff from specific sources. Chemosphere 44(5), 997-1009.
4. Digman C., Ashley R., Balmforth D. J., Balmforth D. W., Stovin V. and Glerum J. (2012). Retrofitting to manage surface water. CIRIA, London
5. Elliott A. H. and Trowsdale S. A. (2007). A review of models for low impact urban stormwater drainage. Environmental Modelling and Software 22(3), 394-405.
6. Fassman E. A. and Blackbourn S. D. (2011). Road runoff water-quality mitigation by permeable modular concrete pavers. Journal of Irrigation and Drainage Engineering 137(11), 720-9.
7. Fifield R. L. (2011). Integrated Stormwater Management in the Avon River Catchment. Masters in Landscape Architecture, Landscape Architecture, Lincoln University.
8. Golder (2014). Avon River/Otakaro stormwater management plan. Contaminant load modelling assessment – Final Report. Prepared by Golder Associates (NZ) Limited for Christchurch City Council, November 2014.
9. Good J., O'Sullivan A., Wicke D. and Cochrane T. (2014). pH Buffering in Stormwater Infiltration Systems—Sustainable Contaminant Removal with Waste Mussel Shells. Water, Air, & Soil Pollution 225(3), 1-11.
10. Liu A., Egodawatta P., Guan Y. and Goonetilleke A. (2013). Influence of rainfall and catchment characteristics on urban stormwater quality. Science of The Total Environment 444, 255-262.
11. Moores J., Gadd J., Pattinson P., Hyde C. and Miselis P. (2012). Field evaluation of media filtration stormwater treatment devices, New Zealand Transport Agency Research Report 493.
12. Murphy, L., Cochrane, T. and O'Sullivan, A. (2015). Build-up and wash-off dynamics of atmospherically derived Cu, Pb, Zn and TSS in stormwater runoff as a function of meteorological characteristics. Science of the Total Environment. 508: 206-213.
13. Semadeni-Davies A., Altenberger A. and Wadhwa S. (2009). C-CALM - Catchment Contaminant Annual Loads Model. In: 6th South Pacific Stormwater Conference.
14. Trowsdale S. A. and Simcock R. (2011). Urban stormwater treatment using bioretention. Journal of Hydrology 397(3), 167-74.
15. Zanders J. M. (2005). Road sediment: Characterization and implications for the performance of vegetated strips for treating road run-off. Science of The Total Environment 339(1-3), 41-7.


## 8. Appendix – Consent Conditions 16, 17, 18, and 49

**Stormwater Contaminant Load Modelling**

16. The consent holder will install stormwater mitigation facilities and devices that achieve the reductions in contaminant load specified in Table 2 below as measured by the

Golder Associates (NZ) Ltd 2018 Christchurch Contaminant Load Model (C-CLM) report which is attached to this resource consent as Schedule 2:

**Table 2: Reductions in stormwater contaminant load**

| | Contaminant load compared to no treatment as at 2018 | 5 years from 2018 compared to no treatment (as at 2023) | 10 years from 2018 compared to no treatment (as at 2028) | 25 years from 2018 compared to no treatment (as at 2043) | 35 years from 2018 compared to no treatment (as at 2053) |
|---|---|---|---|---|---|
| **TSS** | 12 % | 21 % | 25 % | 27 % | 29 % |
| **Total Zinc** | 10 % | 15 % | 18 % | 20 % | 21 % |
| **Total Copper** | 16 % | 23 % | 28 % | 30 % | 31 % |

17. The base case against which reductions are to be assessed is the modelled untreated contaminant load.

18. The C-CLM will be run at five yearly intervals starting in 2023 for comparison with the targets set in Table 2 above and reported to Canterbury Regional Council in the annual report for those years.

*Advice note:*
*The C-CLM is the primary means of assessing the relative reduction in contaminant loads for copper, zinc and TSS which would enter the receiving environment as a result of the structural measures used by the Council.*

*A range of alternative contaminant modelling technologies may be used for research purposes or to assist with stormwater management and contaminant load reductions. These could include (but are not limited to) event-based models and methods of assessing predicted improvement in receiving environment water quality, if or when such tools become available.*

**Responses to Modelling**

49. Where the C-CLM results show that the percentage contaminant reductions required by Table 2 in Condition 16 are not met, the consent holder will be in breach of this consent, and will undertake the following:

a. Investigate the reasons for not achieving the modelled contaminant load reductions and describe what measures will be implemented (if necessary) to improve stormwater discharge quality;

b. Assess whether reasonable endeavours to mitigate the adverse effects of stormwater have been carried out;

c. If the assessment in (b) determines that reasonable endeavours have not been carried out, assess options for correction / remediation to mitigate any adverse effects, and provide a timeline for the correction / remediation (if necessary);

d. Prepare a report, provided to Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager, detailing the matters set out in (a) to (c) above.