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 Zeb Etheridge

INTRODUCTION

1. The Christchurch City Council (CCC) has applied for a resource consent (CRC190445) to discharge stormwater from the CCC stormwater network. The application covers the Christchurch City area (to the summit of the Port Hills) and within settlement areas of the Te Pātaka o Rākaihautū/Banks Peninsula side of the Port Hills.

2. My report provides information and advice related to the effects of the proposed activity on groundwater quantity and quality, which is within my field of expertise. I have broken the report down into the following components:

   a. A summary of the consent application as it pertains to groundwater effects;
   b. The scope of my review and an overview of potential effects;
   c. A description of the receiving environment for each of the catchments with completed Stormwater Management Plans;
   d. An assessment of the potential and actual effects of the proposed activity; and
   e. A review of the consent conditions and monitoring programme proposed by the applicant.

3. This report is supplementary to the overview Section 42A report prepared by Nick Reuther for the resource consent application. Full details of the consent application by the CCC are provided in that report.

4. I am employed by Environment Canterbury as a Senior Groundwater Scientist, a position I have held since November 2014. My work with Environment Canterbury includes investigating, monitoring, modelling and reporting on the chemical and microbiological quality of groundwater in the region and assessing the effects of land use activities and water resource usage on groundwater quantity and quality.

5. I hold a first-class Master of Science degree in Water Resources from the University of Wales. I have been employed as a hydrogeologist since 1999 and have a broad experience base in water resource development, management and protection. Prior to my employment at Environment Canterbury, I spent 15 years working as a consultant on water resource, contaminated land and minewater management projects. I have worked on various stormwater projects throughout my career.

6. 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.

SUMMARY OF APPLICATION

8. The CCC proposes to manage stormwater discharges from a variety of land uses under the proposed Comprehensive Stormwater Network Discharge Consent (CSNDC) using a series of Stormwater Management Plans (SMPs) and an environmental monitoring programme, the scope of which are defined under consent conditions put forward as part of the application.

9. The SMPs cover seven catchments or groups of catchments and are at various stages of development, from “underway” to “completed”. Completed plans are available for the Styx, Avon and Halswell catchments. Plans for the Outer Christchurch, Estuary and Coastal, Heathcote and Banks Peninsula are either “underway” or “partially complete”. The application does not include any specific information on stormwater management or future development in these catchments. The completed SMPs describe how the catchments are to be managed to achieve the requirements of the proposed consent conditions for the CSNDC application.

10. CCC hold existing stormwater discharge consents for the Styx and South West Christchurch areas: CRC131249 and CRC120223 respectively. The Halswell catchment is included in the latter. I have therefore limited the scope of my review for these catchments to a consideration of whether the nature and scale of stormwater discharge proposed under this current application is similar to that presented for the existing consents, and whether the assessment of groundwater effects provided for those consent applications is adequate for the purposes of the CSNDC application.

11. 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 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.

12. In my report I have reviewed the following information provided in the AEE, its appendices and accompanying technical reports (delete or add information that you looked at):
    - Resource Consent Application and Assessment of Effects on the Environment (June 2015)
    - Amended Application Letter (July 2018)
    - Proposed resource consent conditions (July 2018)
    - Environmental Monitoring Programme (July 2018)
    - Responses to Section 92 Further Information Requests (November 2015 and June

2016)

- Ōtākaro/Avon Stormwater Management Plan;
- Ōtākaro/Avon Stormwater Management Plan: Technical Reports;
- Huritīni/Halswell River Stormwater Management Plan;
- Pūharakekenui/Styx Stormwater Management Plan Part A;
- Pūharakekenui/Styx Stormwater Management Plan Part B;
- Ōtākaro/Avon Surface Water Plan;
- and
- Golder Associates (NZ) Limited – Assessment of Current and Future Stormwater Contaminant Load for Christchurch: CLM Modelling Report – Best Practice Infrastructure. July 2018

Information provided

13. The SMP for the Styx catchment is split into two components: Part A is an Investigations and Planning Framework and Part B a Blueprint for Surface Water Management. Part A includes summary information on the groundwater receiving environment. A 2008 PDP report entitled Groundwater Assessment for Belfast Area Plan and Styx Catchment provides information on the receiving environment and the potential effects of stormwater discharge. Further information on potential effects is provided in the Resource Consent Application and Assessment of Environmental Effects for the Styx River/Parakaunui Area report, dated October 2012. The Styx blueprint provides details of a proposed surface water management scheme for the catchment.

14. The Halswell SMP references groundwater quality and quantity assessments undertaken in support of the consent application for the South West Christchurch stormwater discharge consent, which includes the Haswell catchment, but does not provide an assessment of effects on groundwater, or a summary of the findings of the studies undertaken for the South West area stormwater consent application.

15. The Avon SMP includes groundwater quality and quantity effects assessments undertaken by PDP Ltd. These technical documents provide descriptions of the receiving environment, contaminants of concern, information on a surface water management strategy and an assessment of effects. The SMP is accompanied by a surface water plan, which includes a summary of the various technical documents developed to underpin the SMP.

16. The applicant has also included an assessment of the current and future stormwater contaminant load for Christchurch to assess the expected current and future annual contaminant load that enters urban streams in Christchurch.

Proposed activity

Types of activity included in application

17. The application includes certain discharges from the consent commencement date; an additional set of discharges are also included in the application post 2025.

18. Inclusion/exclusion of sites on the Hazardous Activities and Industries List (HAIL) is based a risk classification system. The risk is determined based on whether the site is known to be or likely to be contaminated from previous land use activities, and whether this contamination could potentially be mobilised into the stormwater discharge. The

risk does not relate to the operational HAIL activity. This means that a new HAIL activity (e.g. a chemical manufacture developed on a greenfield site) would be classified as Low Risk.

19. The pre-2025 discharges of greatest relevance from a groundwater effects perspective are:

Non-HAIL sites and Low Risk HAIL sites

- Construction phase discharges from residential, commercial and industrial developments to land within the site boundaries for site areas up to 1 ha on hill land and 5 hectares in other areas
- Operational phase discharges from residential, commercial and industrial hardstand and roof areas to land within the site boundaries

20. All High Risk HAIL site discharges are excluded pre-2025. The post-2025 discharges from High Risk HAIL sites of greatest relevance from a groundwater effects perspective are:

- Operational phase residential roof and hardstand areas to land within the site boundary
- Operational phase stormwater from new development commercial and industrial roof and hardstand areas to land within the site boundary

21. Existing commercial/industrial discharges from hardstanding to land within the site boundaries are not included in the application, either pre or post-2025. Construction phase discharges to ground from High Risk HAIL sites are also excluded.

Land development potential

22. The Styx SMP covers an area of approximately 7,000 ha, of which 34% is currently urbanised. The plan notes that some rural areas within the catchment are under pressure to be developed. The proposed Styx surface water management scheme outlined in the blueprint involves treatment of stormwater from a 1,350 ha area. I discuss this further in paragraph 51. The SMP states that the treatment proposed for new and existing urban areas is an off-line sedimentation basin followed by a constructed wetland. The SMP also notes that two small infiltration basins are present within the catchment, which meet current best practice design criteria according to the SMP. The blueprint (p 26) notes that a relatively small area in the west with permeable strata and groundwater deeper than two metres is likely to be conducive to stormwater soakage systems discharging to ground, but it is my understanding that the consent application does not include construction of any new infiltration basins in this catchment. On this basis it appears that, with regard to groundwater discharges, the activity proposed under the CSNDC application is no different to that already consented under CRC131249.

23. Under the Halswell SMP, the preferred stormwater disposal option is soakage to ground where possible. The SMP advocates the use of soil adsorption basins, where suitable soakage conditions exist (i.e. permeable near-surface strata and sufficient depth to groundwater). Where soakage is not feasible, sedimentation basins, followed by wetlands (or wet ponds) will be used to treat stormwater before discharge to surface water systems. The SMP design principles avoid the use of pipes and concrete channels, preferring a 'natural' system. Contaminant load modelling was undertaken for five development scenarios, ranging from existing (2004) development to maximum possible development (2054). A preliminary surface water management scheme has been provided for one of these scenarios, referred to as Scenario 2 – sustainable for 2024 growth projections. The maximum probable development scenario would provide

a more representative basis for assessing the potential effects of the application given the consent duration sought (25 years). I discuss the maximum probable development scenario further in paragraph 54.

24. The Avon SMP comprises installation of stormwater treatment and detention facilities to mitigate the adverse effects of a small amount of urban development (approximately 165 ha) proposed in the post-earthquakes Land Use Recovery Programme, smaller treatment devices retrofitted within the previously developed catchment, source controls and some other practices. An area of 332 ha was assumed for the Maximum Probable Development scenario for the catchment, although it appears that not all of this would occur in the Avon catchment: Table 7 of the SMP indicates that the Styx catchment may be included in this scenario. I discuss this further in paragraph 57.

SCOPE OF REVIEW AND POTENTIAL GROUNDWATER EFFECTS

Scope of review

25. This S42a report comments on the possible groundwater quality effects associated with discharge of potentially contaminated water to land. I also discuss the groundwater quantity effects that could occur as a result of interception, diversion and discharge of rainwater that would otherwise infiltrate into the groundwater system over a diffuse area.

Summary of potential effects

26. Urban stormwater control and management can affect both groundwater quantity and groundwater quality. The principal considerations are:

- Where stormwater is intercepted by impervious surfaces and discharged to surface water, rainfall infiltration and groundwater recharge can reduce. This can lower the water table, lessen the aquifer storage capacity and deplete spring and stream base flows.
- Where stormwater is discharged to ground the potential effects on groundwater are:
    - Surface flooding, if groundwater mounding around infiltration basins intercepts the land surface
    - Groundwater quality impacts from contaminants present in stormwater discharges
    - Mobilisation of any existing contamination present in the soil in the vicinity of infiltration basins.

27. Spillages and discharges of toxic substances from HAIL sites represent the greatest, and in my opinion only major risk to groundwater quality associated with stormwater discharges. These discharges are included in the consent for sites developed post-2025. Unmanaged spillages of these contaminants onto hardstand areas of these sites have the potential to result in significant contaminant discharges to groundwater.

28. Possible groundwater quality effects relate to stormwater infiltration (soakage to ground) through soil adsorption basins, rapid soakage chambers and trenches and unlined channels in the stormwater network, which will allow stormwater to reach the unconfined groundwater. Infiltrated stormwater, especially stormwater infiltrated by rapid soakage, has the potential to affect groundwater quality because stormwater runoff contains dissolved contaminants that can be transported into the groundwater.

29. Groundwater mounding around stormwater infiltration basins also has the potential to mobilise any contaminants present in the soil profile, principally on contaminated land and former landfill sites.

30. Contaminants infiltrated with or mobilised by stormwater could pose a threat to the untreated drinking-water supplies or stream ecosystems.

31. Urban development and associated stormwater management can intercept and drain water that would otherwise discharge to springs and groundwater-fed streams.

Contaminants of concern

32. The CNSDC Assessment of Environmental Effect (AEE) includes an assessment of stormwater quality and categorises contaminants into five groups: suspended solids, nutrients, hydrocarbons, metals and microbes. Summary information is provided on stormwater contaminant discharge concentration data collated from a range of sources. Results indicate that of the four metals listed (cadmium, copper, lead and zinc), only lead has been recorded at a concentration exceeding the drinking water standard (33 µg/L compared to the drinking water limit of 10 µg/L).

33. The assessment of groundwater quality effects is based primarily on the expected concentrations of nutrients, faecal coliform bacteria, zinc, and copper. The AEE has focused on these parameters because the applicant considers them to be more mobile and to have the highest concentration relative to the drinking-water standards. They conclude that if these contaminants do not show an adverse effect, it is unlikely that any other contaminants would cause a problem. I will discuss this assessment later in my report.

34. Environment Canterbury's Land and Water Resource Plan (LWRP, 1.2.2) notes that common pollutants discharged to stormwater systems include: swimming pool or spa pool water; detergents and chemicals from outdoor cleaning; pet faeces; paint; garden sprays; oil from roads and car parks; and fine particles of heavy metals from vehicle brakes and tyres.

35. A study into stormwater quality and effects commissioned by Hawkes Bay regional council in 2011 summarised analytical results for a wide range of organic and inorganic stormwater contaminants. The results show that only lead was recorded at concentrations in excess of the drinking water standard.

36. Scott (2011) explained that stormwater contains a variety of microorganisms, some of which are infectious to humans. Faeces from domestic animals and wild birds are probably the main sources of microorganisms in stormwater in sewered catchments. Zhang et. al. (2004) report faecal coliform concentrations of up to 200,000 cfu/100 mL) in wet weather events based on monitoring in Australia. The same dataset reports cadmium concentrations up to 0.09 mg/L, which is roughly 20 times higher than the drinking water limit of 0.004 mg/L. Mean pathogen concentrations of 280 PFU/10 L have been recorded in stormwater sampling in urban catchments (e.g. USEPA, 1977).

37. Scott (2011) reviewed an AEE submitted in support of the CCC stormwater discharge consent application for the south west Christchurch area and presented the findings in her Section 42A Officers Report. She noted that high volumes of suspended sediments in stormwater are typically not a serious concern for groundwater quality, but construction phase discharges (which are included in the consent application) could cause short-term increases in the loading of hydrocarbons and heavy metals from

earthwork vehicles and machinery.

38. The contaminant analysis above is based on monitoring of typical stormwater discharges; the potential list of contaminants associated with HAIL sites (which are proposed to be included in the consent post-2025) is extensive.

Potential effects on groundwater quantity

39. The CSNDC AEE notes that urban development changes the natural pattern of rainfall infiltration by creating less pervious surfaces (roof and hardstanding areas), which generate more stormwater. The use of stormwater retention basins and stormwater discharges to surface waterways reduces rainfall infiltration into the ground. The AEE states that this type of stormwater management tends to occur in areas where rainfall infiltration does not reach the underlying gravel aquifers. I presume that this refers to the deeper parts of the aquifer system, where groundwater is confined under artesian pressure (hence downward recharge cannot occur) rather than to near surface gravels, which are found in some parts of Christchurch.

40. The CSNDC AEE considers that development of rural land and discharge of stormwater to ground via infiltration basins can result in a net increase in groundwater recharge. This is because replacement of pasture with hardstanding reduces evapotranspiration rates, and is generally seen as a positive change that offsets some of the effects of groundwater abstraction, according to the application. Concentrated groundwater recharge through infiltration basins during rainfall events can cause local mounding, however, which could potentially cause or exacerbate surface inundation where the water table is shallow. These effects can also occur around detention basins, from which some seepage to groundwater would generally be expected.

41. I agree that rainfall in the CNSDC area does not recharge the artesian aquifer, but consider that groundwater resources are also present in the shallow unconfined aquifer system, and this shallow groundwater receives recharge from rainfall in areas where this is not diverted into stormwater systems. I believe that this shallow aquifer has the potential to provide a baseflow contribution to local springs and streams. Weeber (2008) explains that relic channels of the Waimakariri River connecting with the Styx, Avon, Halswell and Heathcote rivers are recognised on the present-day land surface of the floodplain. These former river channels have left pockets of coarse grained strata within the finer grained strata, potentially with a locally significant groundwater storage capacity. The Weeber report also clarifies that although the near surface deposits in the Christchurch area are generally referred to as confining layers, each of these formations is made up of an assemblage of different sediment types representing a variety of co-existing depositional environments including offshore, beach, aeolian dune, estuarine, swamp and floodplain environments. It therefore follows that increasing the area of impervious surfaces during urban development, and diverting stormwater runoff from these surfaces to retention basins and surface water, will deplete these local shallow groundwater resources. This could, in turn, reduce base flows in groundwater-fed streams and rivers.

42. Foster *et al.* (1994) investigated the effects of urbanisation on groundwater recharge and showed that stormwater drainage arrangements determine whether there will be a net change in the overall groundwater recharge rates. This could range from a major reduction to a moderate increase. A detailed study in New York City showed that in areas where stormwater is discharged to ground, the overall effect of urbanisation with 20-30% impermeable area (including reduced evaporation) was a 12% increase in groundwater recharge and a 1.5 m rise in the water table. For areas

where stormwater was routed directly to the sea, groundwater recharge reduced by 10% and the water table declined by 0.9 m. Stormwater management practices can therefore have a critical effect on groundwater levels and hydraulically connected surface waters, which can be highly sensitive to local groundwater level changes. The effects of stormwater management can be offset by domestic and municipal irrigation and by mains water and sewer leakage. Urban irrigation on free-draining soils can provide significant groundwater recharge, and mains water leakage from older infrastructure can also play a major role in the urban groundwater balance.

43. In the western parts of Christchurch, where stormwater drainage to infiltration basins is proposed and where higher rates of urban irrigation are likely to occur due to the poor water-holding capacity of the soils, I expect groundwater recharge rates and water table elevations to rise to some extent beneath developed land. In the rest of the city, where stormwater discharge to surface water is proposed and where urban irrigation rates are lower due to the predominance of lower permeability soils, it is possible that the water table will decline. The extent of this decline will depend on the relative importance of local land surface recharge and upward seepage from the deeper confined aquifer system on the shallow aquifer water budget.

DESCRIPTION OF RECEIVING ENVIRONMENT

44. The CSNDC area includes the Christchurch city water supply aquifers and associated Christchurch Groundwater Protection Zone, as well as numerous private and community water supply wells. The abundant springs and various wetlands and groundwater-fed streams and rivers across the Christchurch area, such as the Avon, Heathcote and Halswell rivers also form part of the receiving environment.

45. The Styx SMP considers that groundwater quality at depth is very good, but can be more variable at shallower depth due to the influence of land use activities. The Halswell SMP considers that this catchment is endowed with an abundant and high quality groundwater resource, with no existing groundwater quality issues identified.

46. The Avon SMP Groundwater Quality Effects technical report includes a review of nitrate, electrical conductivity and microbiology data in order to evaluate existing groundwater quality in the catchment. The document shows that nitrate concentrations are highest in the southern and western parts of the catchment, reflecting agricultural land use further inland. The spatial variability of electrical conductivity, which reflects the concentration of dissolved solids in groundwater, and faecal coliforms/ *E. Coli* are similar to that of nitrate. The report references the 2011 Environment Canterbury Christchurch Groundwater Quality Monitoring Report, which concludes that the best groundwater quality occurs in the northern areas of the city, due to seepage from the Waimakariri River, but is still good in the south. The authors of the 2013 Christchurch Groundwater Quality Monitoring Report "*found very little evidence of changing groundwater quality in Christchurch over the last ten years".*

47. The S92 response for the CSNDC application addresses a question on whether water quality data collected from CCC's water supply wells show any adverse effects on groundwater quality attributable to the discharge of stormwater. The applicant considers that the only groundwater quality monitoring data that could be associated with stormwater management activities "*are occasional and isolated E. coli detections in the CCC monitoring programme for their public supply wells"*. Five *E. Coli* detections occurred between 1989 and 2014, two of which were in deep wells (>100 m) and two were from shallow wells to the west of the city. The results do not indicate any obvious or consistent pattern of stormwater discharges affecting the CCC public water supply

wells according to the applicant, although the risk of contamination is present for shallow wells in the western area of the City and could have occurred for the one detection at the Burnside pumping station.

48. The S92 response also cites a report on sampling of the Kirkwood Infiltration Basin in Halswell, south west Christchurch, which concludes that the sampled stormwater generally had lower concentrations of contaminants than would be expected from published literature. Whilst the groundwater did show some adverse groundwater quality effects, including *E. coli* detections, this was not attributable to the stormwater discharge and seemed to be more related to activities upgradient of the subdivision. The S92 response concludes that there are no documented groundwater quality effects directly attributable to the discharge of stormwater. I concur with this: I am not aware of any groundwater quality effects which have been attributed to stormwater discharges.

49. The information presented in the AEE and associated documentation is consistent with my understanding of the state of groundwater quality in Christchurch. The shallow groundwater beneath parts of the city has been affected by a range of contaminants, including nitrate, bacteria, and hydrocarbons (BTEX, PAH and chlorinated solvents), but stormwater discharges are not considered to be the main source of these contaminants. Leakage from sewers and leakages and spillages from sites where hazardous substances are stored or used are likely to be some of the main sources of these contaminants. Although the applicant considers that there are no documented groundwater quality effects in Christchurch directly attributable to the discharge of stormwater, absence of evidence is not evidence of absence. Stormwater discharges to ground clearly have the potential to cause groundwater contamination. No detailed investigations have yet been undertaken in the city to provide a rigorous assessment of actual contamination associated with stormwater discharges to ground. The groundwater quality investigation undertaken for the Kirkwood Infiltration Basin report cited by the applicant was very limited.

ASSESSMENT OF ACTUAL AND POTENTIAL EFFECTS

Groundwater quantity

50. Because CCC already holds stormwater discharge consents for the Styx and Halswell catchments, which are of similar duration to that proposed for the CSNDC, I have limited my review of effects to a high level cumulative effects assessment for these catchments.

51. The development scenarios outlined in the 2012 Styx River Resource Consent Application and Assessment of Environmental Effects show increases of 1,223 and 336 ha for residential and commercial land use coverage respectively. The AEE document considered that increasing impervious surfaces in parts of the catchment where infiltration is not feasible is less likely to impact baseflow, as recharge is significantly lower in these areas. The document did not provide any information to quantify or substantiate this statement, however. The assessment of effects on the hydrological flow regime of the Styx River concluded that it is difficult to maintain the hydrological flow regime following development. Although stormwater basin outlet structures can be designed to release water at a set rate for various levels, this is generally targeted at specific rainfall events.

52. In order to evaluate the applicant’s assumption that effects on groundwater quantity are unlikely for the Styx catchment, I have applied the confined aquifer recharge rate and impervious area estimates provided in the AEE for the Avon catchment (PDP, 2013a, discussed further in paragraph 55 below) to this development scenario as follows:

a. The Styx River catchment is mainly located over the area classified as a confined aquifer system. In my opinion a land surface recharge rate estimate of 85 mm/year or 2.3 m³/d/ha would be appropriate for this area.
b. 1,223 ha of new residential development with 45% impervious area equates to a recharge reduction of around 15 L/s.
c. 336 ha of commercial development with 80% impervious area would be expected to give a groundwater recharge reduction of around 7 L/s.
d. The combined reduction in groundwater recharge would therefore be approximately 20 L/s.
e. For comparison the seven-day mean annual low flow in Styx River Which will be sustained by groundwater discharge) is in the order of 1,100 L/s. 20 L/s represents approximately 2% of this flow.

53. The above estimate makes no allowance for recharge to the shallow groundwater system overlying the confined aquifer via swales and detention ponds, and is therefore to some degree conservative. Determining the effect of a groundwater recharge reduction of this order on flows in the Styx River, or any of the Christchurch spring-fed streams and rivers, is not straightforward. In the first instance it should be noted that most of the baseflow to the rivers and streams around Christchurch is fed by groundwater discharges from the aquifer system in the spring zone to the west of the city. Secondly, given the nature of the geology here, a significant proportion of recharge to the shallow aquifer within the confined aquifer area of the Styx River surface water catchment may discharge to the surface water system relatively rapidly following rainfall events and hence the baseflow, and in particular the summer low flow contribution, may be relatively small. If this is the case, diversion of water from relatively rapid flow pathways through the shallow aquifer into detention basins may not change the low flow rates in the Christchurch rivers significantly.

54. The Halswell SMP does not include an assessment of effects on groundwater quantity but includes a list of background reports for the South West Christchurch stormwater discharge consent. Groundwater recharge effects for the south west area of Christchurch (which includes the Halswell SMP catchment) were assessed in association with the application and hearing for that consent. Having reviewed the S42A officers report by Paul Goff for the south west stormwater consent application (CRC120223), I do not consider that the potential effects on groundwater quantity were clearly understood or appropriately assessed as part of that application. No information was provided in the application on the maximum possible development scenario, nor on the possible increase in impervious area and whether all stormwater would be discharged to surface water via detention basins. I have estimated the maximum development area within the Halswell catchment based on the Greenfield Priority Areas shown in the 2013 Canterbury Regional Policy Statement (Map A, Appendix 1). The map shows approximately 775 ha of development area in the Halswell catchment. The applicant has indicated that stormwater from approximately 285 ha of this land will be discharged to ground via infiltration basins. Stormwater from the remaining 490 ha of new development area will be discharged to surface water. Taking the 85 mm/year land surface recharge estimate in paragraph 52, I estimate reductions in groundwater recharge within the Halswell SMP are as follows:

a. 500 ha of new residential development with 45% impervious area equates to a recharge reduction of around 7 L/s.
b. For comparison, the seven day mean annual low flow of the Halswell River is approximately 400 L/s. A 7 L/s reduction would represent approximately 2% of this flow.

55. The Groundwater Quantity Assessment for the Avon catchment (PDP, 2013a) provides an estimate of the impact of urbanisation on groundwater recharge for the areas of the

zone classified as having confined aquifer conditions and unconfined aquifer conditions. The estimate is based on groundwater recharge rates of 40% and 10 % of the ~600 mm annual average rainfall respectively, i.e. 240 mm/year and 60 mm/year. An impervious area of 45% for residential development is assumed in the Avon catchment groundwater quantity assessment, whilst the overall AEE submitted with the CSNDC application refers to 40% impervious coverage for residential area. Industrial and commercial land is generally around 80% impervious. Further details were provided in *CRC160056 – Additional Explanation on Various Matters*

56. I consider 240 mm/year (which is equivalent to 6.6 m^3/d per hectare of land) to be at the upper end of the possible recharge rate. Land surface recharge rates measured with a lysimeter at Christchurch airport (where soils are very thin and stony) average around 145 mm/year, which indicates that the 240 mm/year estimate is probably an over-estimate. Recharge rates recorded with two lysimeters installed in heavy soils at Lincoln University are likely to be more representative of the eastern parts of Christchurch. Average measured rates are around 85 mm/year, which equates to approximately 2.3 m^3/d per hectare of land. I discuss this further below.

57. The Avon catchment groundwater quantity assessment includes a catchment water balance. The assessment concludes that the overall effect of urbanisation on groundwater recharge across the confined aquifer area is unlikely to result in significant adverse effects on groundwater quantity. In order to test this conclusion, I have reviewed the development scenarios detailed in the Avon SMP and considered the potential for effects on flows in the Avon River as follows:

a. The maximum probable development (MPD) scenario discussed in the Avon SMP assumes an additional urban development area of around 330 ha. As I explained previously, however, it seems that some of this would actually occur in the Styx catchment. Based on information provided in Table 7 of the SMP, around 100 ha of new development is expected to take place in the Prestons Subdivision (classified as a confined aquifer area) and 50 ha in the west of the zone, over the unconfined aquifer. The Table 7 data do not represent the MPD scenario, in which approximately 30% more land is developed. Factoring these areas up by 30% gives 130 ha of new development over the unconfined aquifer and 70 ha over the confined aquifer system.

b. Applying the conservative 240 mm/year recharge rate estimate to the 45% impervious area of the 130 ha development area over the unconfined aquifer, and assuming that all runoff is discharged to surface water during or immediately after periods of rainfall (i.e. no discharge to infiltration basins), this equates to a reduction in recharge of approximately 400 m^3/d, or 4.5 L/s.

c. Applying the lower 60 mm/year recharge rate to a 70 ha development scenario with 45% impervious area over the confined aquifer would give a 70 m^3/d reduction, or around 0.8 L/s.

d. The combined reduction in recharge would therefore be around 5 L/s.

e. If all stormwater runoff from new development in the western part of the catchment is discharged to ground via infiltration basins, the reduced recharge associated with new development in the Avon catchment is likely to be less than 1 L/s. By way of context, the minimum flow for the Avon River defined in the Land and Water Regional Plan is 1,100 L/s. The recharge reduction represents 0.5% of the minimum flow. If groundwater recharge rates to the unconfined aquifer are less than the 240 mm/year assumed above, which is likely to be the case, the potential reduction is stream flows would be lower still.

f. It is also worth noting that the reduction in grassland associated with urban development reduces evapotranspiration losses, and hence groundwater recharge can actually increase when stormwater is discharged via infiltration basins.

g. I therefore consider that the catchment-scale effects of the development scenario outlined in the Avon SMP on groundwater recharge are likely to be negligible.

58. In my opinion the potential stream flow depletion effects associated with interception and diversion of groundwater recharge could be mitigated by a consent condition which requires infiltration basins to be installed wherever it is technically feasible to do so, and by requiring the effects of stormwater interception and diversion to surface water courses to be assessed as part of each SMP. I discuss the proposed consent conditions in paragraph 73.

59. For the four remaining SMP areas, where management plans have not yet been completed, it is necessary to consider the overall scale and broad potential effects of new development together with the proposed framework for avoiding, managing and mitigating the potential adverse effects. The main components of the framework are the over-arching objectives for stormwater management presented as part of the consent application, the proposed consent conditions and the monitoring programme. The main objectives listed in the application of relevance to groundwater quantity and quality effects are:

a. Meet Canterbury Natural Resources Regional Plan (NRRP) and Land and Water Regional Plan (LWRP) groundwater quality criteria at public drinking wells and springs.
b. Maintain a high-quality groundwater resource.
c. Design soil adsorption basins and soakage systems to avoid contamination of deep confined aquifers and land drainage problems caused by high groundwater levels.
d. Protect or enhance the water quality and quantity of springs that contribute to waterway baseflows.

Groundwater quality

60. The groundwater quality effects assessment for stormwater discharge in the Avon catchment (PDP, 2013b) discusses stormwater disposal via infiltration basins. The report explains that shallow groundwater in the western areas of the catchment, where the potential for stormwater discharge via infiltration is greatest, flows in a generally easterly direction, with most of the groundwater emerging at springs which provide baseflow to the Avon River. Contamination of upgradient groundwater could pose a risk to users of shallow groundwater (<60 m depth) in the immediate vicinity of any discharge point and to spring-fed waterways. The report considers that if infiltration basins are designed appropriately, allowing sufficient space beneath the basins for attenuation of contaminants, then contaminant concentrations are expected to be significantly reduced before they reach the underlying groundwater. Broader groundwater quality effects associated with the proposed stormwater discharge consent are discussed in Section 8.4 of the application and AEE, which states that the main contamination risks from stormwater are likely to arise from bacterial contamination and risks from hazardous substance spillages. Having reviewed various stormwater quality data and given consideration to contaminant treatment and attenuation in infiltration basins and the underlying aquifer, I agree with this conclusion for the discharge of typical stormwater, in the absence of any spillages. However, it should be noted that the applicant did not propose to include discharges from High Risk

HAIL sites in the application when the PDP study was undertaken.

61. Some contaminants in stormwater are removed before reaching the groundwater. Removal processes include adsorption to soil media, chemical precipitation and adsorption to particulates (which are filtered out during infiltration), degradation and microorganism die-off. The construction of stormwater treatment systems, such as the proposed soil adsorption basins, is intended to enhance these processes. Pitt *et al.* (1996) concluded that most stormwater contaminants pose only a low to moderate threat to groundwater quality. This is especially true if the stormwater discharge is via surface percolation (soil infiltration) as is proposed for this application, rather than sub-surface injection. The contaminants with the highest risk to groundwater identified by Pitt *et. al.* (1996) were pathogens, particularly enteroviruses and soluble nutrients, such as nitrate, if these were present in stormwater at high concentrations (Scott, 2011). Again it is important to distinguish between stormwater contaminants and unmanaged spills from HAIL sites, which could enter the stormwater discharge system via rainfall runoff.

62. I understand that no new infiltration basins are proposed for the Styx catchment within the CSNDC application, and on this basis no further assessment of effects on groundwater quality are required for these catchments. Information provided in the *CRC160056 – Additional Explanation on Various Matters* document indicates that stormwater from an additional 285 ha of land will be discharged to ground in the Halswell SMP area. I discuss the potential for new infrastructure to be developed under the proposed consent conditions, and how the effects of this could be assessed and controlled in my discussion of the proposed consent conditions, below.

Community and private water supply wells

63. The Avon catchment groundwater quality effects assessment cites previous studies, the results of which indicate that *E. coli* concentrations are likely to reduce significantly a few hundred metres downgradient of the discharge point. With regard to Community Drinking Water Supply Protection Zones, the effects assessment concludes that the zones in the west represent areas where infiltration basins would be more difficult to consent due to the higher aquifer vulnerability to contamination here. Our records show that 35 provisional Community Drinking Water Supply Protection Zones (CDWSPZs) are present within the areas which are highlighted as being likely or potentially suitable for large scale infiltration basins. Interrogation of our Wells database shows that some of these protection zones encompass shallow community water supply wells less than 20 m deep (although some of these may have recently been replaced by deeper wells). The main AEE submitted as part of the CSNDC application suggests that *E. coli* concentrations above the drinking water standard could affect shallow groundwater quality over distances of up to 500 m, although other studies indicate that effects could extend further than this (see below). The provisional CDWSPZs are defined based on microbial contamination protection; they do not account for chemical contaminant transport distances, which can be much longer. Unmanaged spillages of chemical contaminants from HAIL sites, from which stormwater discharges will be allowed for under the proposed consent conditions, have the potential to cause significant adverse effects on shallow community drinking water supply wells. The detailed investigations into groundwater flow paths to Christchurch water supply wells that Environment Canterbury has recently undertaken suggest that deeper wells are likely to receive most of their water from north of the Waimakariri River, and from the Waimakariri River itself.

64. I have reviewed various other information on the risk to potable water supplies associated with stormwater discharges. A 2007 WHO study entitled *Chemical safety of drinking water: assessing priorities for risk management* identifies disposal of

stormwater to ground close to wells used for potable water supply as a risk factor. The risk associated with microbial contamination in stormwater discharges to ground were also discussed in the S42a report for the South West stormwater discharge consent (Scott, 2011). The report references the AEE submitted in support of the South West consent application, which suggested applying a separation distance of 1,000 metres between a soil adsorption basin and down-gradient public drinking-water supply wells less than 60 metres deep. No technical information was provided with the application to show how this distance was determined.

65. Scott (2011) provided evidence to demonstrate the prudence of imposing a separation distance between stormwater infiltration basins and drinking water wells. She also explained that potential water quality effects on private drinking-water wells is a significant groundwater quality issue arising from the proposed stormwater discharges.

66. Moore et al. (2010) show that a five-log reduction in viruses could theoretically occur in a gravel aquifer with a 3 m vadose zone over a 1 km distance. Taking the example of an infiltration basin receiving water from a 1 ha development, and using the 280 PFU/10 L pathogen concentration referenced in Paragraph 36, the viral load discharged to an infiltration basin during a storm which generates 50 mm of runoff would be 1.4E+08 PFU (plaque forming units). A five-log virus removal would leave 1.4E+03 PFU in groundwater. This estimate is not conservative because lower removal rates can occur in the open framework gravels of Canterbury. This shows that a separation distance greater than 1,000 m is required.

67. The CNSDC proposes the following separation distances between soakage basins and wells constructed after the consent commencement date (condition 30):

- *Infiltration devices shall maintain a separation distance of 2,000 m when located up-gradient of domestic drinking water supply wells; and*
- *Infiltration devices shall maintain a separation distance of 500 m when located down-gradient or cross-gradient of domestic drinking water supply wells;*
- *Or as an alternative to a) and b), a shorter separation distance may be utilised based on an assessment of site specific information undertaken by the consent holder and certified that it will not have an adverse effect on a domestic drinking water supply well by the Canterbury Regional Council, RMA Monitoring and Compliance Manager.*

I discuss this condition in Paragraph 76.

68. The Avon catchment groundwater quality effects assessment highlights the risks associated with mobilisation of contaminants due to groundwater mounding if detention basins are located close to contaminated land, such as landfills. The CSNDC AEE concludes that it is important to locate infiltration systems away from all landfill sites or contaminated land to minimise the risk of contaminant mobilisation. I discuss this further in terms of consent conditions in Paragraph 79.

Groundwater discharge to Spring-Fed Streams

69. The Avon catchment groundwater quality effects assessment (PDP, 2013b) explains that contamination of upgradient groundwater could pose a risk to spring-fed waterways, but considers that widespread groundwater contamination risk is unlikely based on past land use patterns and observed groundwater quality data. The document concludes that if infiltration basins are designed appropriately then contaminant

concentrations are expected to be significantly reduced before they reach the underlying groundwater. However, as I noted previously, the application did not include the provision for HAIL sites to be included in the consent post 2025 at this time. It is possible that any unmanaged spills of contaminants on HAIL sites could enter the stormwater system, and thence contaminate groundwater and downgradient spring-fed streams.

70. The projected small overall changes to groundwater quality from non-HAIL sites are supported by a mass balance calculation presented in the PDP (2013a) in which the contribution of rainfall recharge in the Avon catchment is relatively small (less than 10%) when compared to the volume of groundwater through-flow. This means that a significant dilution potential is available for the catchment as a whole (although local variations are likely).

71. My previous caveats around unmanaged spillages from High Risk HAIL sites also apply in regard to contamination risks to spring-fed streams: the technical analysis submitted in support of the application did not consider this possibility since these sites were originally excluded.

PROPOSED CONSENT CONDITIONS

Stormwater management plans

72. Condition 5 b. explains that one of the purposes of the SMPs is to demonstrate the means by which the stormwater contribution to groundwater and spring-fed streams will continue by discharge of stormwater to land where reasonably practical. This is somewhat vague; more detail should be included in the conditions to explain how the *means* will be demonstrated. This should include assessment the effects of stormwater interception and diversion to surface water courses on groundwater and spring-fed streams as part of each SMP, as per my suggestions in Paragraph 58. I discuss this matter in relation to condition 6j below.

73. Condition 6 of the proposed consent conditions outlines the proposed scope of the SMPs for those four catchments with no information submitted in the application. The two components of most relevance to groundwater effects are 6i, which requires results from and interpretation of water quantity and quality modelling and 6j, which requires consideration of effects of stormwater discharge and diversion on baseflow in springs and streams. I find these conditions vague and foresee implementation/compliance assessment difficulties.

For 6i it would be far better to provide specific requirements for how groundwater quality effects will be assessed for infiltration basins within the catchment, particularly if new HAIL site discharges to ground are possible within the duration of the SMP. The requirements should include: assessment of potential contaminant loads (including consideration of contaminant spillage scenarios on operational HAIL sites), specification of the performance standard of the infiltration basin for removal of contaminants and assessment of risk to downgradient receptors. I recommend that this condition should be modified accordingly.

For 6j it should be made clear in the conditions that the assessment should comprise evaluation of both the direct local effects (e.g. impact of stormwater interception for new development proposed within the SMP period on flows in local watercourses) and the cumulative effects (e.g. the combined effect of the interception and diversion of rainfall on groundwater levels and stream baseflow associated with all stormwater management within the catchment). The assessment should be for the maximum probable development that could feasibly occur. The SMP should provide details of how any such effects will be avoided, remedied or mitigated.

The SMPs should also include a map of all perennially flowing springs within the catchment to ensure that effects on these waterbodies are considered during stormwater management planning. Again, if the analysis shows that a significant effect is possible, the SMP should detail the measures that will be implemented to avoid, remedy or mitigate the effect.

Management of discharges from HAIL sites

74. The definition of stormwater provided at the start of the proposed conditions excludes discharges of spilled or deliberately released hazardous substances and/or washdown activities. The proposed conditions include the following measures which attempt to ensure that this definition is achieved when the consent is implemented:

- Condition 38 (Table 4) states that "*operational inspection of a sample of stormwater treatment and/or retention devices on non-industrial sites will be undertake*n" from July 2020 onwards. I am not clear what this means in practical terms.

- Condition 41 b requires the applicant to audit a rolling list of at least 10 industrial sites and report progress on an annual basis

75. I do not consider that these measures are adequate to manage the risk to groundwater quality in the city water supply aquifers and spring-fed streams from operational or new HAIL sites with hardstand stormwater discharge to ground after 2025. I have significant concerns about inclusion of these sites in the consent, particularly given the lack of information provided by the applicant on how they would be managed. If these sites are ultimately included, a rigorous set of controls should be put in place via appropriate consent conditions. The controls could include, but not be limited to the following:
    - New HAIL sites after 2025 should also be assigned a risk rating based on site activities and hazardous substance usage/storage at the site. The risk classification method should be documented and issued to CRC for review.
    - The risk rating should determine the scale of stormwater risk management for the site.
    - High risk sites with discharge to ground of stormwater from hardstand areas should be subjected to a very stringent set of controls, including:
        1. Regular audits of the site to ensure that staff are aware of and implementing spill management procedures where required, and understand the importance of good stormwater management
        2. Definition of a set of discharge limits for the specific substances used/stored on the site
        3. Regular sampling of stormwater and soil sampling from infiltration basin (latter as per section 6 of the Monitoring Programme for South West Christchurch SMP) to confirm that discharge limits are being met
        4. Notification of CRC and development and implementation of an action plan if discharge limits are exceeded in stormwater or soil samples from the infiltration basin
    - No. 1 above should also apply to medium risk sites.
    - Low risk sites would not require any specific actions.

Implementation of a management regime of this nature would require assessment of and commitment to the staff resources needed to undertake the regular audits. Even with this structure in place, several matters would still need to be considered. A mechanism would be required to ensure that the applicant is made aware of any change in site operations which would change the site risk rating from low to medium of high, for instance. In the event that new high risk HAIL sites are ultimately included in the consent as has been proposed by the applicant, details of the audit outcomes for the medium and high risk sites should be provided to CRC as part of the annual reporting proposed under Condition 53 of the proposed conditions.

Protection of water supply wells

76. Condition 30 requires a minimum separation distance between new infiltration facilities and domestic drinking water supply wells, as discussed in Paragraph 63 - 68. The following points are noteworthy:

- A 2,000 m separation distance may not be sufficient. The applicant has not provided any information to show that this separation distance is sufficient to remove microbial contamination from stormwater discharged to ground.
- The condition only applies to domestic water supply wells; it does not refer to community water supply wells.
- No actions are proposed to manage risk to private water supply wells within the influencing distance of *existing* infiltration devices, and the risk to these wells (if there are any) has not been assessed.
- A clearer definition of the methodology for providing an *assessment of site-specific information* described in Condition 30c is required.

I recommend that:

- The separation distance should be increased to 2,500 m as a default (in line with the findings of the most recent research in this field), with the option of reducing it as per condition 30c.
- condition 30 should apply to both domestic and community water supply wells, and that measures should be put in place to assess and if necessary remedy or mitigate the risk to any existing private water supply wells within the specified separation distances of existing infiltration basins. I recommend that a consent condition should be included which gives effect to this by requiring the following:
    - For private and community water supply wells located within the default or site-specific separation distances of existing infiltration basins, the consent holder should undertake further investigations to determine whether the water supply/supplies are at risk from contamination. These investigations could include, but not be limited to determination whether the well is still in use or could be used in the future, more detailed analysis and modelling and regular water quality monitoring. If these investigations identify a significant contamination risk, a remedy should be put in place. These could include upgrades to the infiltration basin to reduce contaminant discharges, upgrade of the water supply well (e.g. deepening) or provision of an alternative water supply.
- The *assessment of site-specific information* should be based on up-to-date research of microbial transport in aquifers and a conservative modelling approach.

77. I also recommend that the consent conditions should require appropriate separation distances between infiltration basins and landfills or other contaminated land where contamination could potentially be mobilised by groundwater mounding.

78. The information I provided in paragraph 36 shows that cadmium concentrations up to

0.09 mg/L can be present in stormwater runoff, which is roughly 20 times higher than the drinking water limit of 0.004 mg/L. I recommend that this contaminant should be added to the list of attributes in Schedule 6 of the proposed consent conditions, with a target level of 0.001 mg/L (one quarter of the drinking water limit).

Water Quality and Quantity Standards

79. Condition 21 requires the consent holder to use *reasonable endeavours* to mitigate the effects of the discharge of stormwater on groundwater and spring water quality. I do not consider that this provides an appropriate level of assurance that the city water supply aquifers and spring-fed streams will be adequately protected, particularly given that the applicant proposes to include discharges from high risk HAIL sites within the consent after 2025. Use of *best practice* stormwater management would be more appropriate, as the applicant has proposed in Condition 32.

80. Condition 51 provides details of actions to be undertaken if the Attribute Target Levels are not being met. I recommend that *E. coli* and cadmium should be added to condition 51 b (which only list copper, lead and zinc at present).

Schedule 6: Receiving Environment Objectives and Attribute Target Levels for Groundwater and Springs

81. Schedule 6 of the proposed consent conditions provides objectives and attribute target levels for groundwater and springs. The proposed attributes are copper, zinc, lead, *E. coli*. and I am happy that these attributes cover the main parameters of concern for discharges from non-HAIL sites, but recommend that cadmium should also be added to the table with a target level of 0.001 mg/L, which is one quarter of the drinking water limit of 0.004 mg/L (and therefore consistent with the target levels proposed by the applicant, which are also set at one quarter of the drinking water limit) . I consider the attribute target levels are appropriately conservative.

82. I do not believe that electrical conductivity is a useful indicator of variations in the concentrations of metals, particularly at the concentrations that can be expected in stormwater. Variations in the concentrations of metals within the range expected within stormwater will have a negligible impact on the electrical conductivity of the stormwater, and any impact will not be discernible in the measured data. This is because the conductivity of water is determined by the total dissolved solid (TDS) concentration. Dissolved metals comprise a tiny fraction of the TDS. I do not endorse use of this parameter as a surrogate for monitoring the metals listed above since it will provide no useful information. I recommend that this should be deleted from Schedule 6.

Environmental Monitoring Programme

83. The stated the objective of the CNSDC groundwater and spring monitoring programme (Section 3 of the Environmental Monitoring Programme [EMP]) is to provide ongoing information on groundwater levels, spring flows and groundwater quality so that current trends can be determined and compared with historical patterns. In order to achieve this objective CCC propose to:

a. Monitor groundwater levels in a network of 30 shallow monitoring wells across the city;
b. Investigate any complaints from the general public on spring flow or quality;

c. Observe drainage rates in infiltration basins and respond to any complaints regarding land drainage issues;
d. Undertake a detailed investigation of three infiltration basins in 2019 to assess localised changes in groundwater levels and the flow and quality of any nearby springs arising from the facilities; and
e. Review the results of existing water quality monitoring undertaken by Environment Canterbury and in CCC community water supply wells

84. The proposed monthly groundwater level monitoring programme seems to be a continuation of CCC's existing monitoring programme rather than something that specifically targets potential stormwater effects. The monitoring well locations are not targeted in areas where new development is proposed. Furthermore, monthly monitoring is too infrequent to show whether the groundwater level response to periods of rainfall, and groundwater levels generally, are changing as a result of urban development and associated stormwater management. When analysing groundwater level data it is often very difficult to differentiate the effects of anthropogenic water level impacts from climatic variability and trends. I would expect untargeted monthly monitoring data to be particularly ambiguous in this regard.

85. Given the issues associated with the proposed monitoring programme I recommend that the Detailed Investigation proposed in Section 3.1.3 of the EMP should be modified as follows:

a. The investigation scope should be expanded to include an investigation of the effects of urban development and stormwater interception and diversion to surface water on groundwater levels and base flows in groundwater-fed streams within that catchment. This would also mean investigating a new development where stormwater is to be managed using detention basins and surface water discharge, rather than infiltration basins. The applicant has indicated in the document entitled CRC 160056 – Additional Explanation of Various Matters that a new development is currently underway that could be investigated in this way.
b. Monthly manual water level readings should be supplemented with data loggers installed at five locations where significant new development is expected to take place within the consent duration. Data from those loggers would show how groundwater levels respond to individual rainfall events at different times of the year and could therefore provide some meaningful information on groundwater quantity effects. The cost of these loggers would be negligible within the context of this application.

I consider that these amendments to the monitoring programme will provide a better understanding of the effects of stormwater management on groundwater quantity and help CCC to develop Stormwater Management Plans which are more likely to avoid groundwater impacts.

86. I do not consider a complaints-driven approach to spring monitoring would provide a satisfactory level of protection of this culturally and socially valued resource. I recommend that this part of the monitoring programme should be changed such that specific spring flow and water quality monitoring is required for springs within the potential zone of influence of new stormwater infrastructure developments. The requirement and scope of this monitoring would need be agreed between CCC and Environment Canterbury on a case by case basis.

87. The proposed groundwater quality monitoring programme is not actually a consent monitoring programme because no monitoring is proposed which is specific to the activities proposed under this consent application. The scope is limited to reporting on

the results of other programmes, which are not designed to monitor the effects of stormwater discharges. I do not believe that this will provide useful information on the effects of the proposed activity. A better approach would be to:

I. Undertake the detailed study proposed in Section 3.2.1 of the EMP
II. If the results of the detailed study identify the potential for stormwater discharges to ground to result in contaminant concentrations at the site boundary being above the appropriate environmental standards (including, but not limited to, the attributes listed in Schedule 6 of the proposed consent conditions), undertake a broader investigation of the effects of the consented activity on groundwater quality.
III. The broader investigation should consider the locations of existing stormwater infiltration basins in relation to drinking water supply wells and undertake water quality monitoring in any wells within influencing distance of an infiltration basin.

88. Section 3.3 of the EMP provides details of the proposed reporting of the groundwater monitoring undertaken for the consent. I note the following:

- No reporting is proposed in relation to spring monitoring. I recommend that reporting should include a summary of any reports/complaints received by CCC in relation to spring flows and quality, together with the monitoring results from any specific flow and water quality monitoring for springs within the potential zone of influence of new stormwater infrastructure developments as per my recommendation in Section 86 above.
- No reporting is proposed for groundwater levels. Given the ambiguity of this dataset in relation to the potential effects of the proposed activity, I do not consider that annual reporting of these data is necessary. However, if data loggers are installed as per my recommendation in Section 85b above, this information should be included in the annual report.
- No reporting is proposed in relation to the regular monitoring proposed in Section 3.1.3 of the EMP. I recommend that a summary of this monitoring should be provided in the annual report.

My additional reporting recommendations above will help to ensure that the monitoring proposed in the EMP, together with the additional monitoring I have recommended, continues to happen and can be acted upon where appropriate.

CONCLUSIONS

89. Stormwater management has the potential to cause adverse effects on both groundwater quantity and groundwater quality. Previous studies and investigations have shown that interception of rainfall by impervious surfaces and discharge of this water to surface waterways can reduce groundwater levels and baseflows in spring-fed streams. Discharge of stormwater to infiltration basins can cause localised mounding and groundwater inundation of the land surface in some circumstances. Stormwater from roads, roofs and urban areas can contain elevated concentrations of dissolved metals and microbial contamination. Stormwater from industrial hardstand areas where hazardous substances are used and stored can potentially have a wide variety of organic and inorganic contaminants.

90. Information provided by the applicant suggests that the expected future land development in some of the catchments is unlikely to cause a significant reduction in groundwater quantity in the shallow aquifer. I agree with this assessment but note that

Stormwater Management Plans have not yet been completed for all catchments. I also note that the applicant has applied for a 25 year consent duration and hence actual land development within the duration of the consent may not align with the assumptions made for the applicant's effects assessment. This means that the potential effects on groundwater quantity are greater than the applicants assessment might suggest.

91. A similar situation exists for groundwater quality effects: the assessment of effects provided by the applicant indicates that significant impacts are unlikely, but the assessment does not reflect the full potential effects. In the case of groundwater quality this is mainly because the applicant proposes to include HAIL sites within the consent post 2025, but has not provided an assessment of the potential effects of stormwater discharges from these sites. Furthermore, the impacts of stormwater discharges from non-HAIL sites on groundwater quality has not yet been investigated properly in Christchurch.

92. The applicant has proposed a set of consent conditions and provided an Environmental Monitoring Programme which together aim to address the potential effects outlined above. I consider that these provisions need to be strengthened and expanded to reduce the potential for effects on groundwater to an acceptable level. Some of the key areas for improvement are as follows:

    - Strengthen the Stormwater Management Plans by providing a clearer scope for assessment of potential groundwater effects and more detailed information on the local environment
    - Expand the scope of the proposed detailed investigations of groundwater effects to provide a better understanding of the actual effects of the proposed activity.
    - Improved protection of drinking water supply wells
    - Modification of the proposed groundwater monitoring programme and improvements in the annual reporting provisions

93. The most important area for improvement is in the provisions for management of new HAIL sites with discharges from hardstand areas to ground post 2025. I have made several key recommendations in this area, including:

- Risk analysis for individual sites and a mechanism for updating the risk assessment if site practices change
- A regular audit programme for high risk sites with information from the applicant on how these audits will be resourced
- Regular monitoring and sampling of discharges from high risk sites

94. If the recommendations I have made for improvements to the Stormwater Management Plans and Environmental Monitoring Programme are made, and the consent conditions are also amended in line with my advice, I consider that the proposed activity can be managed such that the likelihood of significant adverse effects on groundwater will be low.

Signed: Date: 28/9/18

Zeb Etheridge

Senior Scientist, Environment Canterbury

Reviewed by:

Signed: Date: 28/9/18

Carl R Hanson

Groundwater Section Manager, Environment Canterbury

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