Before the Hearing Panel appointed by Canterbury Regional Council

IN THE MATTER OF	The Resource Management Act 1991
AND	
IN THE MATTER OF	Applications CRC192408, CRC192409, CRC192410, CRC192411, CRC192412, CRC192413 and CRC192414 by Fulton Hogan Limited for a suite of resource consents to establish a quarry operation

Section 42A Officer's Report

Report of Lisa Caryn Scott

EXECUTIVE SUMMARY

1. The proposal by the applicant for excavation and filling of Roydon Quarry is likely to cause localised changes to the aesthetic quality of groundwater below the site and immediately downgradient. It is unlikely to cause adverse health effects by contamination of drinking water in existing private domestic wells or public supply wells.
2. The highest risks for adverse effects on groundwater quality come from discharges of contaminated water (mostly stormwater) and potential leaching of the fill materials.
3. Management of fill quality is the most important mitigation measure for the long-term protection of groundwater quality. Decision-makers need to be confident that compliance with the proposed cleanfill management plan[1] is achievable and enforceable.
4. Removal and disturbance of the soil and sediments in the unsaturated zone (above the water table) will increase the vulnerability of the groundwater to contamination by hydrocarbons, metals and microbial pathogens. Discharges containing such contaminants should be minimised as far as possible within the quarry pit.
5. The increased vulnerability to microbial contamination could persist even after rehabilitation. Post-quarry land use should recognise the changes to the natural attenuation potential of the unsaturated zone.

INTRODUCTION

6. Fulton Hogan Limited (the applicant) have applied for a suite of resource consents to establish a new aggregate quarry (known as 'Roydon Quarry') within the site bounded by Curraghs Road, Maddisons Road and Jones Road (the site).
7. My report provides information and advice related to the effects of the proposed activity on groundwater. I have set out my report as follows:
    a. A summary of the consent application as it pertains to groundwater;

[1] Fulton Hogan 2019: Roydon Quarry Draft Cleanfill Management Plan (8 March 2019) or future revisions.

b. The scope of my review;

c. A summary of the groundwater environment, water levels and water quality

d. Assessment of actual and potential effects;

e. Responses to submissions; and

f. An assessment of mitigation and monitoring proposed by the applicant and my recommendations for additional measures.

8. This report is supplementary to the overview Section 42A Report prepared by Ms Hannah Goslin for the resource consent application. Full details of the consent application by Fulton Hogan Limited are provided in that report.

9. I have been employed by the Canterbury Regional Council (CRC) for eight years as a groundwater scientist and currently hold the position of Senior Scientist: Groundwater. I have over twenty years' experience in groundwater quality investigations. My formal qualifications include a Master of Science in Environmental Geochemistry and a PhD in Geology, both from the University of Cape Town, South Africa. I have also been employed as a postdoctoral research fellow and research scientist at the University of New Brunswick, Canada working on groundwater contamination projects.

10. I have provided advice on behalf of the CRC for several resource consent applications and consent monitoring enquiries relating to quarries and cleanfill operations in Canterbury since 2012. Some of the larger projects included providing expert evidence for the Canterbury Aggregate Producers Group hearings (CRC155160 – CRC155169) and Road Metals Burnham quarry direct referral to the Environment Court (CRC110671).

11. From 2015 to 2017, I conducted a groundwater sampling investigation for CRC into the effects of quarry and cleanfill operations on groundwater quality around a large block of quarry and fill operations in the Miners Road area near Yaldhurst. The results from the Yaldhurst investigation were published in an externally-reviewed CRC technical report.[2]

12. I visited the Roydon Quarry site on 25 June 2019 and viewed the existing land use, water race soakage pits, existing domestic supply, irrigation and monitoring wells and the proposed gravel processing location in the centre of the property.

13. I have read the Code of Conduct for Expert Witnesses[3]. 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

14. The following is a summary of the application as I understand it, and as it relates to groundwater:

15. The applicant is proposing to excavate the entire site, in stages of up to 26 ha at one time, down to a maximum depth of 9.9 metres (m) below ground level. The applicant intends to maintain a minimum separation at any time of one metre to groundwater. I will discuss the groundwater levels and separation to groundwater in this report.

[2] Environment Canterbury, 2019: Groundwater quality investigation at Miners Road quarries, Yaldhurst Christchurch, Technical Report R19/05 prepared by Lisa Scott, January 2019.

[3] Environment Court Consolidated Practice Note 2014 – Expert Witness Code of Conduct.

16. After the aggregate resource is extracted it will be processed and stockpiled on site in a seven-hectare central processing area. Groundwater and water race water taken from the site is proposed to be used for:

    a. dust suppression;

    b. foggers around the process plant and stockpile, truck washing and amenities in the processing plant area; and

    c. irrigation of vegetation on bunds and rehabilitated areas.

17. Washing of trucks is proposed to occur at the site on a covered and bunded concrete pad. Washdown water will be collected in a holding tank with oil-water separation. All water and oil collected in holding tanks will be treated as trade waste and will be transported offsite for disposal.

18. Most of the site will be uncovered with rainfall infiltrating directly to ground. Stormwater from impervious surfaces on the site (roof, road, parking and loading areas, etc.) is proposed to be infiltrated directly to ground, although some stormwater may be captured for irrigation or dust suppression uses.

19. Fuel and lubricants for vehicles and machinery will be stored on site, including a maximum volume of 15 000 litres of diesel fuel, stored in a double skinned tank. Up to a maximum of 250 kilograms of lubricants (e.g. engine oil) will be stored in the workshop. Refuelling will take place above the bottom of the quarry floor from mobile tankers at the start of operations and be replaced by a fixed diesel tank with covered concrete refuelling pad within two years.

20. The applicant proposes to partially backfill the excavated areas with cleanfill. Cleanfill material will be brought into the site from locations in Christchurch and Selwyn District and is planned as an important component of the site rehabilitation. Cleanfill loads will be visually inspected at a "tip head" and then spread across a working area, if the fill material is deemed acceptable. Unacceptable loads will be refused and removed from the site. After site rehabilitation, the cleanfill areas will be contoured to drain freely, covered with topsoil and vegetated.

21. In my report I have reviewed the following information provided in the Assessment of Environmental Effects (AEE), its appendices and accompanying technical reports:

    a. Resource Consent Application to Establish 'Roydon Quarry', Templeton (November 2018);

    b. Roydon Quarry Draft Quarry Rehabilitation Plan (Fulton Hogan, November 2018) – Appendix G

    c. Preliminary and Detailed Site Investigation (Golder Associates, November 2018) – Appendix H

    d. Roydon Quarry Proposal (Reference CRC192408-192414, RC185627) – Response to Request for Further Information (March 2019);

    e. Roydon Quarry Draft Cleanfill Management Plan (Fulton Hogan, 8 March 2019)

    f. Roydon Quarry RFI Response, Reeftide Environmental & Projects Ltd memo dated 10 March 2019

    g. Roydon Quarry Proposal (Reference CRC192408-192414, RC185627) – Response to additional Requests for Further Information (Golder Associates, August 2019)

SCOPE OF REVIEW

22. 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'*.

23. In this review I will focus on the potential effects of the proposed activities on groundwater quality, which is within my field of expertise. I will cover:

    a. the vulnerability of the groundwater to contamination and how this may be changed by the applicant's proposals;

    b. planned and accidental discharges on the site that may release contaminants to groundwater;

    c. potential effects on the groundwater environment and existing users of groundwater; and

    d. proposed mitigation and monitoring.

24. I will not cover any planning aspects relating to the change of use of a groundwater take from well M36/0257 on the site; reasonable use of water or restrictions on water takes.

25. Issues relating to contaminated land are also not covered here but are discussed in the evidence of Mr Rowan Freeman.

DESCRIPTION OF THE GROUNDWATER ENVIRONMENT

Aquifer system

26. The site is located on the Canterbury Plains which form a vast aquifer system of gravel, sand and silts deposited as coalescing alluvial fans. These alluvial sediments can be several hundred metres thick. They were formed over many thousands of years by braided rivers carrying eroded material from the Southern Alps/Kā Tiritiri o te Moana to the coast.

27. The loose, well-sorted alluvial sediments make a desirable source of aggregate materials. They are also ideal for hosting high-yielding groundwater resources. But the unconsolidated, highly permeable nature of the sediments also make them more vulnerable to infiltration and rapid transport of groundwater contaminants from the land surface than 'tighter' rock formations.

28. Although geologists identify a series of different formations with depth, comprising differing compositions of finer and coarser grained sediments, the layers in the alluvial sedimentary sequence are all connected and permeable to water. I do not think it is valid to consider them as separate aquifers and, in this report, I talk about one aquifer system.

29. Groundwater in the aquifer system is primarily replenished (recharged) by land surface recharge, i.e. the infiltration of rainfall and irrigation water draining downwards through the soil. Leakage losses through the gravel beds of alpine rivers, such as the Waimakariri River, are also a source of groundwater recharge but are less important at this distance from the river. Leakage from unlined water races may locally affect groundwater recharge, for example where the Selwyn District Council water races terminate by draining away on the site.

30. Recharge water drains downwards under gravity leaving an unsaturated zone below the soil. This zone ranges in thickness from approximately 10 to 15 metres as the water table fluctuates over time. All the pore spaces in sediments below the water table are saturated.

31. The groundwater flows in a general south-easterly direction, but it is prevented from discharging directly to the coast by the volcanic rocks of Banks Peninsula. Instead the groundwater flow diverges around the base of the peninsula, mainly flowing towards Te Waihora/Lake Ellesmere from this location or discharging to springs feeding the Halswell River. Groundwater also discharges via abstraction from wells used for domestic supply, irrigation, commercial, public supplies and other uses.

Groundwater quality

32. CRC has been monitoring the groundwater quality from two wells within one kilometre downgradient of the site, one 25 m deep (M36/0271) and the other 163 m deep (M36/3071). The water testing results show good quality groundwater with low dissolved solids, suitable for a range of uses.

33. The groundwater from the shallower well is slightly more acidic (pH <7) and contains slightly elevated concentrations of dissolved ions (sodium, magnesium, chloride, sulphate), causing marginally higher electrical conductivity and total hardness than the deeper well water. The elevated ion concentrations are typical of groundwater affected by land surface recharge near the water table and are below health and aesthetic quality thresholds for drinking water as per the Drinking-water Standards for New Zealand[4].

34. The shallower groundwater samples show some effects of contamination from past or current land uses. Samples from M36/0271 had moderately high and increasing concentrations of nitrate nitrogen, reaching around 8 g/m^3 when it was last sampled in 2016, compared to the deeper well with less than 2 g/m^3 nitrate nitrogen. Two historical samples were at or above the drinking-water maximum acceptable value (MAV = 11.3 g/m^3 nitrate nitrogen), one from 1992 and another in 2008. The shallower well also had two low detections of *E. coli* bacteria (1 MPN/100 ml detected in two samples out of over 200 samples collected) versus none in the deeper well. Contamination with nitrate and *E. coli* are typical of groundwater affected by rural land uses, such as farming, animal effluent and septic tanks. Elevated nitrate and *E. coli* are observed in many groundwater monitoring wells screened near the water table across the Canterbury Plains[5].

Groundwater levels

35. The applicant's AEE has provided a review of available data on the depth to groundwater, with more detail given in the response to the request for further information. Measured highest groundwater levels in nearby shallow wells south east of the site are around 9 to 9.5 m below surface. Because all these water level measurements are on the downgradient side and the land surface slopes more steeply than the water table in this area, the land surface is higher and water levels are likely slightly deeper under the site itself.

36. The applicant has estimated the highest groundwater levels below the site based on long-term water level monitoring of wells in the general area; the groundwater gradient (taken from long-term average piezometric contours across the site) and

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[4] Ministry of Health. 2018. Drinking-water Standards for New Zealand 2005 (revised 2018). Wellington: Ministry of Health.

[5] Environment Canterbury Annual Groundwater Quality Survey 2018 https://api.ecan.govt.nz/TrimPublicAPI/documents/download/3588758

ground surface elevations. The highest levels range from around 41.5 m above sea level (10.9 m below surface) in the northwest to 31.5 m above sea level (9.1 m below surface) in the south east of the site. Maps of the projected highest groundwater levels and indicative quarry floor levels, one metre above highest groundwater levels, appear in the applicant's response to the request for further information report[6]. In general, I agree with their assessment of the data, which looks relatively conservative.

37. Managing the quarry depth to one metre above the highest groundwater level is generally expected to provide some buffer between the quarry floor and highest groundwater. However, it should be recognised that the errors in extrapolating groundwater levels at this scale are probably greater than the one metre buffer itself[7]. The projected highest groundwater levels are likely to be more accurate for the south east side of the site, because the monitoring wells used in the analysis are all on this side. There will be greater uncertainty about the highest groundwater level on the north west side.

38. There is also uncertainty about how the levels may behave in future. Climate-driven declines in recharge and increased abstraction over the past few decades have contributed to general decreasing trends in groundwater levels across the Central Canterbury Plains.[8] But the Central Plains Water Scheme is also anticipated to cause some small future increase in groundwater levels that may reach this area[9] from irrigation recharge and farmers switching from groundwater abstraction to scheme surface water.

39. The applicant intends to refine the highest groundwater level estimates with measurements from on-site monitoring wells over the first 5 years of the consent and use this information to guide the depth of excavations. This could help to reduce the uncertainties about the depth to highest groundwater, if water levels in the onsite wells can be correlated with long-term monitoring wells further away. But, given the variability in groundwater levels over time, 5 years of monitoring from the site alone would be unlikely to provide a high level of confidence that groundwater will not be able to rise into the excavations or the backfilled materials in future, especially if the entire quarry is excavated to 9.9 m deep.

ASSESSMENT OF ACTUAL AND POTENTIAL EFFECTS ON GROUNDWATER

40. In my assessment of effects, I have relied heavily on the data collected from Environment Canterbury's investigation of groundwater quality around the Miners Road quarry blocks in Yaldhurst[10] approximately 4 km to the north of the Roydon Quarry site. Both sites are located over unconfined groundwater dominated by land surface recharge in the same alluvial gravel aquifer system. The depth to highest

[6] Golder 2019: Roydon Quarry Proposal (Reference CRC192408-192414, RC185627) – Response to Request for Further Information Report 1781870-010-R-Rev0 prepared for Fulton Hogan Ltd by Golder Associates (NZ) Ltd, March 2019, Figure 1 and 2.

[7] Environment Canterbury, 2019: Groundwater quality investigation at Miners Road quarries, Yaldhurst Christchurch, Technical Report R19/05 prepared by Lisa Scott, January 2019, Appendix 1.

[8] Alkhaier, F, M Hanson and H Zarour 2019: Trends in groundwater levels in the Central Plains of Canterbury, Environment Canterbury Technical Report No. R19/18, February 2019.

[9] Weir, JJ 2009: Supplementary Evidence of Julian James Weir. Hearing evidence for applications by Central Plains Water Trust to Canterbury Regional Council for resource consents to take and use water from the Waimakariri and Rakaia Rivers.

[10] Environment Canterbury, 2019: *ibid*.

groundwater (around 10 m below surface) and intended excavation to one metre above highest groundwater are similar in both cases, as are the depths of neighbouring private wells (typically 30 to 40 m deep). Therefore, the vulnerability of the groundwater and of the neighbouring wells are similar at both sites.

41. The Yaldhurst quarries cover a slightly larger area of around 300 hectares, and I estimated that about 20% had been backfilled at the time of the investigation. This application covers a smaller total area of approximately 170 hectares. Current operations at Miners Road are generally controlled by resource consent conditions for excavation and cleanfill that are similar to the conditions proposed here. Some sites at Yaldhurst have, however, been in operation for several decades and historically there was less control over what was filled. Because of the smaller area and no historical filling, I expect that, if granted, the Roydon Quarry operations would likely have a lower impact on groundwater quality than the localised degradation of water quality observed at Yaldhurst.

Effects of excavation changing the groundwater environment

42. The activity of digging, crushing and screening of aggregate poses a low risk to groundwater because it involves chemically unreactive (mostly silicate mineral) materials. The major contaminant generated is fine sediment, which can cause dust issues in air[11], but is generally not a problem for water where there is no surface water receiving environment. There may be some very fine suspended sediment from crushing that could be flushed into groundwater when it rains and transported short distances through highly permeable gravels. But small amounts of suspended sediment should be filtered out before reaching any nearby wells.

43. There should also be no changes to groundwater flow patterns around the site because quarrying is not proposed to occur below the groundwater table at any time.

44. The reasons for restricting the maximum depth of quarrying to one metre above highest groundwater level in Canterbury are not widely documented, but I understand they were introduced as a measure to prevent future flooding hazards for post-quarry land use[12]. Managing the quarry to this depth is important because it helps to minimise the risk of excavators working directly in groundwater during periods when the water table is high. It also minimises the chance of fill materials being periodically saturated with groundwater after the excavations are filled, which decreases the leaching risk.

45. As discussed above, the depth to highest groundwater is often imprecisely known and the relatively small “buffer” of one metre above makes some allowance for this uncertainty. Having one metre of permeable alluvial sediments at times of high groundwater table, however, does not provide for much treatment of contaminants, especially after the finer grained and more reactive soil materials are removed.

46. The main effect from the quarrying operation will be a change to the unsaturated zone (also called the vadose zone). The proposed excavation will remove all the vegetation, soil and much of the sediment to a depth of 8 metres or more across the site. This will markedly reduce the thickness of the unsaturated zone above the water table and will change the vulnerability of the underlying groundwater to contamination.

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[11] See air quality evidence of Ms Deborah Ryan for Canterbury Regional Council.

[12] Richard English, *pers. comm.,*13 May 2019: *The 1m rule*, by email to Lisa Scott, Don Chittock and Adele Radburnd.

47. A thick layer of topsoil and an unsaturated zone of several metres above the groundwater can have beneficial effects in removing some types of contaminants. Metals and hydrocarbons are attenuated by adsorption on mineral coatings and organic matter in the soil and sediments. Microbial pathogens are filtered out, adsorbed, predated or desiccated and die-off if they travel through a thick unsaturated zone before reaching groundwater[13].

48. Working and filling directly in groundwater poses the highest risk of contaminating groundwater because there is no attenuation above the water table.

49. Some cleanfill deposition sites in Canterbury have been found to have faecal bacteria contamination in shallow groundwater. It is unlikely that cleanfill materials would be a significant source of faecal material and the bacteria are likely coming from other sources such as stormwater, animals, septic tanks, etc. However, the excavation and deposition of fill material does have the potential to increase the vulnerability of groundwater to bacterial contamination, especially at sites where the soil and most of the unsaturated zone above the groundwater that helped to adsorb and filter out bacteria have been removed.

50. Because of restrictions on the type of material, the availability of cleanfill material is limited. The applicant is not proposing to fill the entire quarry back up to the original ground surface. Instead they will likely partially fill then contour the sides of the excavated site and leave a depression in the landscape. After filling (or partial filling) of the excavation, the nature of the unsaturated zone (e.g. its thickness, porosity permeability, chemical reactivity) will be different from the prior undisturbed state.

51. Activities over this modified landform could pose a greater risk to groundwater quality than the surrounding land uses which occur over unmodified ground. High loading of bacterial contamination (e.g. intensive grazing or effluent discharges) and high volumes of water applied (inefficient irrigation) over rehabilitated fill, especially fill with the separation to groundwater decreased, could lead to greater risks of groundwater contamination after the site is closed. I recommend that these effects are taken into consideration in rehabilitation and post-closure plans and consent conditions.

Effects of changes to water races

52. Two Selwyn District Council water races currently terminate to soakage via boulder pits on the site. These races may cause localised elevation of the groundwater table (mounding) around the soakage points, although the gravels are highly transmissive, so any mounding effects would be minimal. The quality of the water in the races is not known but similar water races in the Waimakariri District have had relatively high concentrations of *E. coli* at times, especially after rain events[14].

53. The water that currently soaks to ground is proposed to be used for irrigation or other permitted purposes on the quarry site. This could reduce any localised groundwater mounding (if there is any) but is unlikely to cause significant change in the amount of recharge to groundwater. Removing the direct soakage will also reduce the existing contamination risk which could be present from *E. coli* and other contaminants in the race water.

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[13] Pang, L 2009: Microbial removal rates in subsurface media estimated from published studies of field experiments and large intact soil cores, *J. Environ. Qual*. 38:1531–1559.

[14] Data from Horrellville/Bennetts water race sampling supplied by Sophie Allen, WDC, June 2019

Effects of discharges of contaminated water

54. Some contaminated water discharge is likely to arise from the proposed activities on the site, but the levels of contaminants and risk to groundwater quality should be relatively low.

55. The main source of contaminated water would be stormwater from surfaces that carry vehicle traffic (roads and parking areas) and roof surfaces. Stormwater typically contains higher levels of contaminants in the first flush after a dry period, then generally low levels of metals, hydrocarbons and pathogens.

56. The truck wash pad will likely contain higher levels of contaminants, but the concrete pad is proposed to be roofed, so stormwater should not contact with this area.

57. Stormwater from unsealed areas will infiltrate to ground and runoff from the roads will be allowed to infiltrate along the road edges. Directly infiltrated stormwater will have minimal treatment but will rely on natural attenuation in the ground to protect groundwater.

58. Runoff from hardstand, carparking and rooves will be conveyed to detention basins, lined with soil before infiltrating. Some metals and hydrocarbon contaminants will be adsorbed to silts that settle out in the infiltration basins. The applicant has indicated that these basins will be dry ponds with no ponding for more than 48 hours. Because the basins will not be permanently wet, there is a low risk they would become contaminated with faecal pathogens and nutrients from wildfowl.

59. In their initial response to the request for further information, the applicant has provided some assessment of the contaminant levels and treatment expected for the stormwater discharges[15].

60. I generally agree that the type of contaminants from these sources (sediment, metals, hydrocarbons) are mostly able to be attenuated, provided the initial concentrations are low and there is enough filtration and adsorption capacity and slow enough travel times before the contaminants reach the groundwater.

61. There is less certainty around the potential removal of pathogens from the discharges, particularly since the applicant's assessment has relied on overseas studies that are not necessarily relevant to Canterbury. Published data from Burnham and Templeton point to lower removal rates for microbial pathogens in coarse gravels[16]. Using conservative removal rates, I calculated that the estimated bacterial loads indicated in the application (i.e. 4200 MPN/100 ml faecal coliforms), should be removed within less than 200 hundred metres from the source, if discharged at least one metre above the water table. Higher bacterial loads, for example in a heavy first flush event, would be less frequent, but could travel further from the site.

62. The location of stormwater basins has not been indicated in the application. Removal of contaminants to background levels before reaching any offsite wells will be more likely if the discharge points for stormwater can be located on the upgradient side of the site and above a thick unsaturated zone (i.e. at or close to the original ground level).

63. Contaminants in stormwater adsorb to the soil in the basins and their concentrations can build up over time. These soils should be removed periodically and tested for

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[15] Roydon Quarry RFI Response, Reeftide Environmental & Projects Ltd memo dated 10 March 2019 from Victor Mthambo

[16] Pang. L 2009: Microbial removal rates in subsurface media estimated from published studies of field experiments and large intact soil cores, J. Environ Qual. 38:1531 – 1559.

leachable metals and hydrocarbons to ensure that they continue to provide treatment. Any contaminated soils removed from the stormwater basins would not be suitable for disposal as cleanfill.

64. Water used for dust suppression will contain sediment, but the water applied in dry, windy conditions will evaporate and not infiltrate to groundwater.

65. I note that there are no proposed concrete batching operations and no washing of concrete truck barrels in the application, so no concrete wash water should be discharged on the site.

66. Wastewater from staff amenity blocks is proposed to be discharged to holding tanks and trucked off site for disposal, so there are also no anticipated onsite wastewater discharges that form part of this application.

67. I expect a small amount of fertiliser may be used for landscaping or re-vegetation, but no farming activities or effluent disposal are proposed that would pose a risk of any significant discharge of nitrate occurring on the quarry areas. Higher concentrations of nitrate are likely to be discharged from the current grazed pasture and other farming activities on the site than the proposed land uses in the application.

68. I have been asked for comment on whether the proposed discharges are likely to breach any limits in Table 11(m) *Water Quality Limits for Groundwater* in the Canterbury Land and Water Regional Plan (CLWRP). Based on my assessments above, the risk of breaching these limits is low.

Effect of accidental contaminant discharges

69. Hydrocarbon spills or leaks from machinery and vehicles, from hazardous substance (diesel) storage and refuelling operations also pose a potential risk to groundwater.

70. Both mobile fuel tankers and later a fixed above-ground double skinned diesel tank (up to 15 000 litres) are proposed for the site. Other hazardous substances (e.g. oil and lubricants will be stored in smaller quantities in a workshop. A spill management plan is proposed for the site incorporating "*management and inspection of the fuel tank (including fuel reconciliation, spill management and containment, and visual inspection of the tank)*"

71. Refuelling from the fixed tank is proposed to occur on a concrete refuelling pad with interceptor system, which allows some ability to clean up a spill before it reaches the ground. Therefore, the greater risk of effects from a significant spill would come from the mobile tankers used on site in the earlier stages of operation.

72. In the event of a large spill, there is a risk that petroleum product and dissolved hydrocarbons could percolate down, and groundwater could become contaminated if the spill is not detected and cleaned up quickly, especially if the spill is in the base of the pit and groundwater levels are high.

73. Based on other sites in Canterbury with passive discharge consent monitoring of historical fuel leaks[17], free product and dissolved contaminants such as benzene, toluene, ethylbenzene and xylene have tended to travel short distances (less than 100 metres) in groundwater before being attenuated, unless there is a rapid transport pathway for them to take, such as a drain. These examples were also generally ongoing undetected leaks from underground tanks or fuel lines rather than one-off accidental spills during refuelling. In comparison, I think the risks from the quarry activities are low.

[17] CRC054190, CRC 146572, CRC157347

74. As a precaution, I recommend that no refuelling of vehicles should take place within the excavated quarry pit where the groundwater is more vulnerable and there is less time to capture or treat a spill before it reaches the water table. Catch trays should also be used under refuelling connectors when there is a risk of a spill over unsealed ground.

Effects of discharge from cleanfill

75. In our investigation of quarry and deposition sites in Yaldhurst[18] we found that the associated discharges from fill materials can have a measurable effect on the quality of groundwater in an alluvial gravel aquifer. Attachment 1 shows how dissolved ion concentrations in groundwater beneath the sites (labelled "*consent monitoring downgradient*") and in downgradient private wells were measurably higher than in groundwater upgradient. The most notable changes were in alkalinity, hardness (calcium + magnesium), chloride, sulphate and silica concentrations. These changes can result from leaching of soils, untreated wood and hard materials that are generally considered "clean" or "inert" such as bricks, tiles, paving materials and concrete. There were also areas beneath the quarry sites where dissolved oxygen in groundwater was depleted.

76. Some materials allowed in the fill at certain Yaldhurst sites are more likely to contribute to observed changes in the groundwater quality, including:

    a. uncured concrete slurries causing increases in hardness (calcium + magnesium) and alkalinity

    b. gypsum board - causing increased hardness and sulphate concentrations, and decreased dissolved oxygen from reaction with decomposing cellulose, and

    c. vegetative material in soils - causing decreased dissolved oxygen from decomposing organic matter.

77. Uncured concrete and gypsum board are not included in either list of "acceptable" or "unacceptable" cleanfill material in the draft Cleanfill Management Plan[19] for Roydon Quarry. Vegetative material is restricted to "*less than* three *percent of any load by volume*", but I do not know how feasible it is to quantify the vegetative content of a truckload of fill.

78. I consider that, even with strict cleanfill management, contaminants released from the proposed Roydon Quarry and cleanfill may cause some degradation in the aesthetic properties (e.g. hardness, taste, potential discoloration) of high-quality groundwater below the deposition site. However, this contamination would likely be low impact, localised and dissipate within a few hundred metres of the fill areas. I am not aware of any sites where truly 'clean' fill deposition has had a significant adverse effect on groundwater quality or caused exceedances of health-based drinking-water limits.

79. Uncontrolled filling of waste materials can have adverse effects on groundwater, as seen in many old rubbish pits around Canterbury. Careful management of the fill materials for both obvious and unseen contaminants (e.g. contaminated soils) is critical for the long-term protection of groundwater quality.

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[18] Environment Canterbury, 2019: Groundwater quality investigation at Miners Road quarries, Yaldhurst Christchurch, Technical Report R19/05 prepared by Lisa Scott, January 2019.
[19] Fulton Hogan 2019: Roydon Quarry Draft Cleanfill Management Plan, 8 March 2019.

Potential effects on existing users of groundwater

80. The AEE identified 36 active wells within 500 m of the site with an average depth of 38 m, based on CRC's well records. Around half of those wells are either up-gradient or across gradient from the site and should not experience any effects from the site at normal domestic rates of pumping. Another two wells within the site itself supply domestic and irrigation water for tenants of the applicant. These closest onsite wells are most likely to experience a decline in the aesthetic quality of the groundwater (e.g. increased alkalinity and hardness), especially the shallower domestic well once quarry and fill operations move to the adjacent area north west of the house.

81. I extended the well search to one kilometre downgradient (to the south east of the site). This is the furthest distance we could distinguish any possible effect above background concentrations in the Yaldhurst study. I consider it highly unlikely that any noticeable difference in groundwater quality will be found beyond this distance. Attachment 2 shows the wells surrounding the site which are registered in Environment Canterbury's wells database. Excluding the two wells on the site, there are 30 wells within the one-kilometre downgradient zone.

82. Five of the wells are registered for "domestic" and eight for "domestic and stock water" supplies. Some of the wells may no longer be in use if the records have not been updated. There could also be other wells within the area that are not recorded in CRC's database as these records are not field checked. In general, I assume that every dwelling not on a water reticulation network is supplied by a private domestic well.

83. Some domestic wells very close to the downgradient side of the site (along Jones Road/Main South Road) might be able to notice a small change in the quality of water from the proposed activities. A further 12 wells are recorded as being used for irrigation supply, which could also possibly be affected by scaling/hardness issues if close to the quarry sites.

84. The Templeton area to the east of the site is supplied by reticulated water from Christchurch City. The Christchurch public supplies are not at any risk from this proposal.

85. There is one public water supply well, M36/7575, within the 1-km downgradient area where I have focussed my assessment of potential effects. Selwyn District Council uses this well to supply the Devine Drive area (Source G01673, Claremont Bore). None of the proposed excavation, deposition or discharges from the site will occur within the designated Community Drinking Water Supply Protection Zone for the well.

86. I have looked at the information that the CRC holds in their databases for M36/7575 to assess the risk to the public drinking-water supply. The well is 600 m directly downgradient from the closest point on the Roydon Quarry property and the water supply is untreated but is regularly tested for the presence of bacteria[20].

87. The well is 108 m deep with screens from 105 m below surface. Age tracer data was collected for the well in 2006 and 2010, showing the mean recharge age of the groundwater is greater than 80 years, although some gas tracers (CFCs and SF_6) indicate younger water ages from 20 years old in the 2010 results. The bore supply is considered by Selwyn District Council to be secure. The discharges from proposed activities should not be a significant source of either *E. coli* or nitrate nitrogen, the two contaminants of highest concern for a public water supply. Typical contaminants from the quarry site, such as metals or hydrocarbons are highly

[20] Selwyn District Council website: https://www.selwyn.govt.nz/services/water/water-supplies/water-schemes-under-chlorination/water-quality-in-selwyn-district/water-quality-tests-results

unlikely to persist or migrate over the time and distance it takes for groundwater to reach the deep supply well. In my opinion, the potential for contamination of this well from the proposed activities is very low.

88. If the consents are granted and the public supply well does show changes in detections of bacteria once the site is operational, I think it would be reasonable to investigate any potential links to the quarry and require any sources of faecal contamination, if found, to be removed.

89. There are no mapped springs within one kilometre of the site and no effects are expected for any spring-fed streams or lakes.

RESPONSES TO SUBMISSIONS/MATTERS RAISED

Effects on groundwater and wells

90. Various submitters have raised general concerns about the potential effects on water levels and groundwater quality in private and public wells. I have already covered the potential effects on groundwater and wells in my evidence.

91. The proposed quarry activities should not have an impact on water levels in the area because no changes are proposed to groundwater abstraction and because the quarry itself should not intercept the water table. As discussed before, there could be a very small, local change because there would no longer be any local groundwater mounding effects where the water race soakage is removed. There could also be a small increase in recharge though the exposed gravels on the site (from less evapotranspiration). These local effects are unlikely to extend beyond the boundary of Roydon Quarry.

92. Water quality effects have been discussed in the previous sections. In my opinion, only wells screened near the water table within a few hundred metres downgradient of the site are likely to experience any effects. The type of effect could be a small change in the aesthetic quality of the water, typically increased hardness and alkalinity. There are unlikely to be any health risks to private or public wells. Microbial contamination (indicated by *E.coli*) is a risk for private shallow wells in the existing environment.

93. I note that Selwyn District Council have made a submission raising concerns about their community supply bore, M36/7575, including the potential for contaminants to enter the groundwater and subsequently affect M36/7575. As discussed, I consider the risk of adverse effects on the quality of water supply to the well from the proposed activities to be very low.

Silica dust in water

94. Specific concerns have been raised about silica dust (crystalline silica) entering groundwater. I understand that silica dust is a potential air contaminant of concern[21], but I am not aware of any issues relating to either dissolved or particulate silica in groundwater. There are no health or aesthetic thresholds for silica in the Drinking-Water Standards for New Zealand. Given the use of silica as a food additive, it is generally regarded that silica can be ingested safely.[22]

95. Crushing of aggregate may result in finer grained silicate minerals with a higher surface area for reaction with water. This could explain why a small increase in

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[21] Evidence of Ms Deborah Ryan for Canterbury Regional Council.

[22] Martin, KR 2007: The chemistry of silica and its potential health benefits, *J Nutr Health Aging,* 11(2):94-7.

concentrations of dissolved silica in wells on the quarry sites at Yaldhurst was observed (see Attachment 1). But the effect was negligible in downgradient private wells and would not be expected to cause any adverse effects on domestic water supplies, such as precipitation of silica scale, beyond what is typical for groundwater in Canterbury.

96. Particulate silica is not likely to travel far in groundwater. CRC did not specifically measure particulate silica in groundwater at Yaldhurst, but total suspended solids was measured in the wells, of which particulate silica would be a component. Only one sample had total suspended solids above the laboratory detection limit in that study. The sample was collected in the summer of 2016 when water levels were very low and may have come from sediment in the bottom of the well itself. All other samples were clear, so there was no evidence of silt from the quarries migrating to private wells[23].

Effects of stormwater and accidental discharges

97. Te Taumutu Rūnanga have raised valid concerns about "*heavy metals from brake pads and other contaminants including but not limited to machinery oil and fuel leaks that may be transported during rain events*". These contaminants are likely to be present in stormwater on the site and could infiltrate to groundwater if there is no treatment prior to discharge. However, they are not likely to migrate very far in groundwater. The truck wash water and sludge from the separator is likely to contain higher concentrations of these contaminants but is proposed to be removed to trade waste rather than discharged to land.

Separation to groundwater

98. Several submitters have requested that the depth of excavation be limited to increase the separation to groundwater by varying amounts, some requesting up to 5 metres. Taumutu Rūnanga would prefer if at least a separation of 1.3 metres was required.

99. It is important to bear in mind that the level of the groundwater table in this area can rise and fall by five metres or more in response to the amount of recharge and abstraction occurring. The highest water level for quarry management is a level that has only been reached less than 5% of the time over the past 10 years. All the rest of the time the water level has been lower. Average piezometric contour levels plotted across the site are at least 2 metres lower than the maximum levels. Within the limits of uncertainty of our projections, most of the time there should be more than 3 metres of undisturbed material above the groundwater.

100. Coarse gravel materials are not all that good at filtering out contaminants. The original removal of the soil probably has a greater effect on the groundwater's vulnerability to contamination than whether the quarry is excavated to 2 or 1.3 metres rather than one metre above the highest groundwater, provided the water table itself is not exposed. However, increasing the thickness of the unsaturated zone by several metres would likely have benefit for the removal of some types of contaminants such as bacteria and hydrocarbons, which is why I have recommended that refuelling activities and, wherever possible, contaminated water discharge points should be sited at higher levels outside the excavated areas.

101. Other issues raised by submitters have been covered in my evidence including diesel spills and contamination of groundwater via ponds.

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[23] Environment Canterbury, 2019: Groundwater quality investigation at Miners Road quarries, Yaldhurst Christchurch, Technical Report R19/05 prepared by Lisa Scott, January 2019.

MITIGATION AND MONITORING

Mitigation

102. Various mitigation measures are proposed in the AEE and the proposed consent conditions for the Use of Land for Mineral Extraction and Cleanfill Deposition that could help to minimise any effects on groundwater quality. Many of the reasons for these have already been covered in my evidence. If the consent is granted I support the inclusion of these measures in conditions:

   a. No excavation below one metre above the highest groundwater level defined for quarry management.

   b. Establishment of a surveyed datum point and regular surveys of quarry depth to ensure that the excavation depths are within agreed limits. The applicant should also prepare an annual contour map showing the surveyed maximum quarry depth relative to the highest groundwater level in their reporting for compliance monitoring.

   c. No machinery working in accidentally exposed groundwater.

   d. Maintaining vehicles and equipment to prevent oil and fuel leaks.

   e. Requirement for a spill management plan and spill kit on site at all times.

   f. Staged rehabilitation of the site after quarrying including the application of a minimum 300 mm thick layer of topsoil.

103. If excavation depths have been over-estimated, and groundwater does rise into the quarry during a period of unusually high groundwater levels, the applicant proposes to fill the areas with “virgin material” sourced from the quarry and remove all heavy machinery from the area. In my opinion, the applicant should notify CRC of groundwater being encountered and the source of the material they propose to use for filling. I agree that machinery should be kept away from the flooded areas to reduce the risk of spills or leaks near the water. Once water levels have subsided the area should be filled with material from within the quarry pit that is of comparable quality and composition to that which was excavated, or preferably, replace the same original material if it has not yet been processed.

104. Some mitigations against contamination of groundwater are proposed in the AEE and response to the requests for further information reports which I recommend be required. These include:

   a. Washing trucks on a covered, bunded concrete pad and the washdown water collected in a holding tank with oil-water separation prior to discharge as ‘trade waste’ at a suitable facility offsite.

   b. All sludge from the separator removed from the site for disposal offsite at a suitable facility.

   c. All refuelling of vehicles to take place above the bottom of the quarry floor.

   d. Using catch trays under the fuel filling points and all quickly detachable connections on all equipment serviced by mobile tankers to mitigate against spill risks.

   e. Use of appropriate swales or soil-lined sedimentation basins to treat stormwater from hardstand areas before discharge.

105. I would also consider implementing measures for controlling birds on the site, especially around infiltration ponds, because birds are a likely source of faecal bacteria that could be present during site operations.

106. Making sure that cleanfill materials do not leach high levels of contaminants is, in my view, the most important measure for protecting groundwater quality from long-term adverse effects. Keeping all imported fill at the site above a level where it could be saturated by a rising water table will help to mitigate the risks. But rainfall will still infiltrate down through the fill, so the fill itself must be clean.

107. The applicant has included lists of acceptable and unacceptable fill in their Draft Cleanfill Management Plan[24]. Some other materials that I consider unsuitable, which are not included on the "unacceptable list" are roading materials containing coal tar, road-derived sediments (road sweepings and catch pit sediments), medium density fibreboard (MDF), uncured concrete, wet cement or any other liquid containing waste or slurries, such as hydro-excavated soils.

108. Vegetative material is restricted to less than 3% per load. Such conditions are generally included to account for the difficulty in excluding all incidental vegetation from a load of soil. A high content of organic matter (e.g. vegetation), especially if buried deeper in the fill, is a risk to groundwater because the decomposition of organic compounds can create anoxic conditions which enhance the mobility of metal contaminants. I recommend that suitable fill should not contain any visible wood or plant matter.

109. Contaminants from stormwater can build up to high concentrations in the soils at the base of stormwater basins and they will require periodic replacement. Contaminated soil material with high levels of leachable contaminants from the basins should not be allowed as fill in the base of the quarry excavations.

110. Cleanfill management is not my field of expertise and I cannot say how effective the proposed measures will be. However, I do support the requirements for fill inspections, record keeping, tracking the source of the material and exclusion of inappropriate fill or any fill from potentially contaminated sites. These measures sound sensible to me.

111. I have discussed the effects of decreasing the unsaturated zone and the impact this may have on groundwater vulnerability even after the quarry is rehabilitated and closed. Irrigation and wastewater discharges which may be permitted on surrounding land might no longer be appropriate over the modified site. A potential mitigation against this is to plan for and control, to the extent possible, the eventual land use of the site.

Monitoring

112. Monitoring itself is not mitigation against adverse effects, but groundwater monitoring is recommended to:

   a. improve knowledge of the highest groundwater level and ensure compliance with depth restrictions; and

   b. measure that the effects on groundwater quality are low, as anticipated, or take corrective action if they are not.

113. Four monitoring bores have already been installed at the site: BX23/0833 and BX23/0836 upgradient and BX23/0834 and BX23/0835 downgradient (See Attachment 2 for locations). The bores are narrow diameter (50 mm) observation wells installed to 21 m depth with slotted PVC casing from 12 to 21 m below ground level and concrete seal around the wellhead. The bores should be appropriate for measuring water levels and taking groundwater samples at the water table where any potential effects will be most evident. The 9 m long screen length is not ideal for

[24] Roydon Quarry Draft Cleanfill Management Plan (Fulton Hogan, 8 March 2019)

collecting discrete water depth samples by pumping, but it is necessary to cover the range of potential water levels and ensure that samples can be collected even when groundwater levels are low. Low flow sampling would be my preferred sampling technique for sampling these long-screened bores.

114. Water levels will be measured for the first 5 years so that a groundwater specialist can refine the highest groundwater table and recommend a maximum excavation depth. No frequency of monitoring is given in draft conditions, although continuous water level loggers are mentioned in the AEE. I recommend a minimum frequency of daily water level measurements. There should also be a requirement to correlate data with other wells with longer term records after 5 years, before establishing the highest groundwater level for the site.

115. I propose that water level monitoring should continue over the lifetime of the quarrying activities on site, to act as an early warning system for rising groundwater levels that may approach the bottom of the pit. There should be a requirement to provide this data annually to CRC in a format suitable for automated upload to a water level database, or on demand at other times if CRC decides that high water table conditions in the catchment represent a risk for the quarry. I recommend that a water level trigger is set if levels rise close to the base of the quarry so that timely plans can be made to move equipment and prepare to backfill, if necessary.

116. The applicant proposes to sample the same bores for water quality at six-monthly intervals for a period of two years, then annually. I recommend that the onsite shallow domestic well, M36/2743, be added to the water sampling programme because this is the drinking-water well most likely to be affected by the proposed activities.

117. I also recommend that the sampling frequency be increased to quarterly, at least for the first 5 years of site operation, to track seasonal changes and allow quicker response to any initial issues that may arise when the site is excavated. After that, six monthly sampling in spring and autumn should continue to track any longer-term effects from reaction of the fill.

118. The groundwater quality monitoring programme may need to be adapted over time for more effective coverage of the potential risks from the site. In my opinion, because the site is to be excavated in stages, additional downgradient monitoring wells could be needed to measure the actual effects. The existing bores at the site boundary may indicate what is moving off site, but they are likely to be some distance away from both the excavation/fill areas and from discharges of contaminated water in the initial stages when the central processing area is established, so they may not give any early warning of contamination. The downgradient bores are better positioned to monitor effects from Stage 1, which I understand is proposed to occur in the south east corner of the site.

119. Proposed monitoring parameters are included in the draft conditions and are based largely on the Drinking-Water Standards for New Zealand. The same parameters and trigger levels are used for monitoring at several other quarry/cleanfill sites near Christchurch. I think the triggers are generally acceptable and there are only minor changes that I would recommend.

120. From my experience with this type of sites, I would recommend removing acidity and nitrate nitrogen from the list of monitoring parameters. These sites generally produce elevated alkalinity and I have never seen any acidity reading above the detection limit from them. Nitrate is already elevated in the groundwater and if concentrations were to change, it would most likely be coming from sources outside the quarry.

121. The trigger for alkalinity in the draft conditions is more appropriate for areas of river recharge. Environment Canterbury's monitoring data from M36/0271 in the

Templeton area show groundwater consistently exceeding 50 g/m^3 as $CaCO_3$ for alkalinity and I recommend that the trigger be raised to 100 g/m^3 as $CaCO_3$.

122. Triggers values for parameters of aesthetic significance should be set at the drinking-water Guideline Values (GV). I also recommend setting triggers for dissolved parameters of health significance at a value of half the Maximum Acceptable Value (MAV) to protect against effects on drinking-water to align with with Table 11(m) in the CLWRP. Similarly, following the approach of Table 11(m), the *E. coli* trigger of 1 MPN/100 ml should be applied as a median value over the duration of monitoring for each bore, rather than a trigger for each sample.

123. In summary, I recommend the following changes be made to trigger levels:

Parameter	Proposed trigger	Recommendation	Reason
Acidity	12 g/m^3 as $CaCO_3$	No testing	No acidity problem
Alkalinity	50 g/m^3 as $CaCO_3$	100 g/m^3 as $CaCO_3$	Elevated background
Ammoniacal N	1.2 g/m^3 as N	1.2 g/m^3 as N	No change - GV
Chloride	125 g/m^3	250 g/m^3	GV
Electrical Conductivity	50 mS/m at 25°C	50 mS/m at 25°C	No change
E.coli bacteria	1 MPN/100 ml	1 MPN/100 ml median of samples	Consistent with CLWRP Table 11(m)
Total Hardness (calcium + magnesium)	100 g/m^3 as $CaCO_3$	100 g/m^3 as $CaCO_3$	Taste threshold
Dissolved Iron	0.1 mg/L*	0.2 g/cm^3	GV
pH	8.5	8.5	No change - GV
Dissolved Zinc	1.5 mg/L*	1.5 g/cm^3	GV
Total Petroleum Hydrocarbons	Any detection >0.1 g/m^3	Any detection >0.1 g/m^3	No change
Dissolved Aluminium	0.1 g/m^3	0.1 g/m^3	No change - GV
Dissolved Arsenic	0.01 g/m^3	0.005 g/m^3	50% MAV consistent with Table 11(m)
Dissolved Boron	0.5 g/m^3	0.7 g/m^3	50% MAV
Dissolved Cadmium	0.003 g/m^3	0.002 g/m^3	50% MAV
Dissolved Chromium	0.05 g/m^3	0.025 g/m^3	50% MAV
Dissolved Copper	1 g/m^3	1 g/m^3	No change - 50% MAV
Dissolved Lead	0.01 g/m^3	0.005 g/m^3	50% MAV
Dissolved Manganese	0.04 g/m^3	0.04 g/m^3	No change - GV is lower than 50% MAV
Dissolved Nickel	0.08 g/m^3	0.04 g/m^3	50% MAV
Nitrate-Nitrogen	11.3 g/m^3 as NO_3	No testing	From other sources
Dissolved Sodium	200 g/m^3	200 g/m^3	No change - GV
Sulphate	250 g/m^3	250 g/m^3	No change - GV

* Note: at low salinity concentrations in mg/L and g/m^3 are generally interchangeable, but I have made them all g/m^3 for consistency.

124. In accordance with new data management processes being developed, all analytical results should be sent to CRC in an electronic format suitable for automatic upload

to a water quality database, preferably directly from the analytical laboratory immediately after quality checking.

125. Exceedance of a trigger value should be followed by confirmation sampling within one month to check that the exceedance is real/persisting, then an investigation and remedy of the cause as proposed in the draft conditions.

126. If monitoring shows persistent exceedance of guideline levels for aesthetic parameters at a downgradient monitoring bore, then nearby private domestic bores within 500 m should also be tested for that parameter with the bore owners' approval. The applicant may be expected to compensate for any treatment required to remove the nuisance, e.g. a water softening system, if the problem persists.

127. Exceedance of any health-related trigger in a downgradient monitoring bore should also similarly trigger sampling of potentially affected domestic wells within 500 m downgradient of that bore. If private wells are also found to exceed the same health-based trigger, immediate provision of an appropriate treatment system or alternate water supply should be required.

CONCLUSIONS

128. Aggregate quarries and cleanfill sites that do not intercept groundwater generally pose a low risk of causing significant groundwater contamination.

129. In this proposal, discharges of contaminated water (primarily from stormwater) and leaching of fill materials could release low levels of metals, hydrocarbons, bacteria, salts and other contaminants of aesthetic significance (e.g. hardness) to the groundwater.

130. Some well owners on properties adjacent to the downgradient boundary of the site could experience a small change in the aesthetic quality of their water from the proposed activities. The risk to the public supply from the Selwyn District Council Claremont bore is very low.

131. Shallow groundwater in the area is already affected by microbial contamination, but the proposed excavation activities could also increase the vulnerability of groundwater to this type of contamination, which affects the health of drinking water, even after the site is remediated.

132. There is no expected effect on surface waterways or Te Waihora/Lake Ellesmere.

Signed: L Scott   Date: 27 August 2019

Name: Lisa Caryn Scott

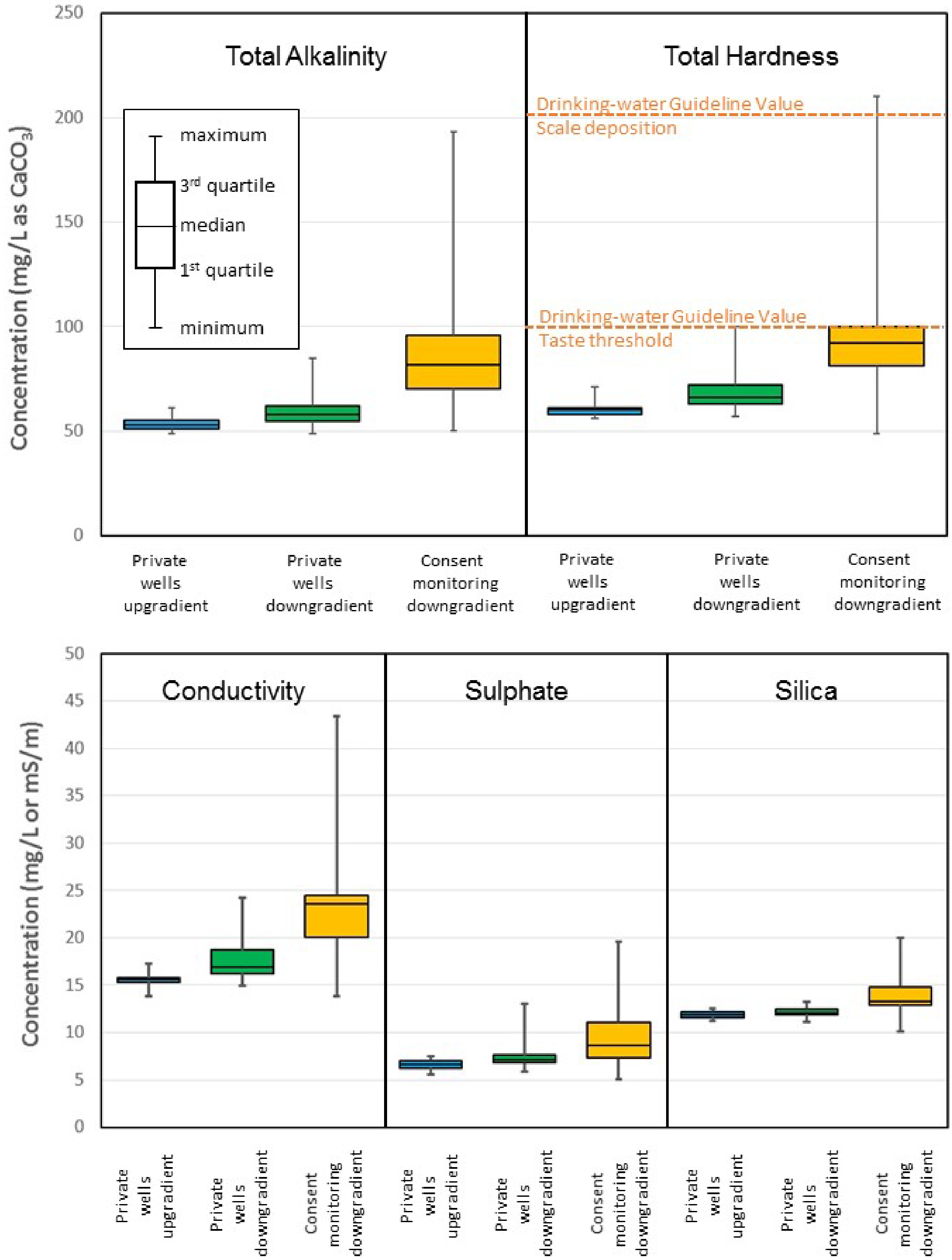
Senior Scientist: Groundwater

Reviewed by: Maureen S. Whalen   Date: 27 August 2019

Maureen Sue Whalen

Science Team Leader: Groundwater

ATTACHMENT 1



Attachment 1: Summary of key results from the nearby Yaldhurst investigation of groundwater quality around operating quarry and cleanfill sites (Environment Canterbury, 2019). Concentrations of alkalinity, hardness (calcium + magnesium), conductivity, sulphate and silica were elevated in wells within the site boundaries (consent monitoring wells – shown in yellow) and slightly elevated in private wells downgradient (shown in green) in comparison to the unaffected upgradient groundwater (blue boxes). Only hardness exceeded Guideline Values and then in less than 25% of samples.

ATTACHMENT 2

Attachment 2: Location of wells and their registered water uses near the proposed Roydon Quarry (sourced from Environment Canterbury's wells database).