Before Hawkes Bay Regional Council and Hastings District Council

In the matter of	the Resource Management Act 1991
And	
In the matter of	Application by Hastings District Council and Napier City Council to Hawke's Bay Regional Council for resource consents authorising the operation of Area B at Omarunui Landfill (**consent application**)
And	
In the matter of	A notice of requirement by Hastings District Council to Hastings District Council for alteration of designation for the Omarunui Regional Landfill (**NoR**)

Statement of evidence by Tony Reynolds on behalf of Hastings District Council and Napier City Council

Dated 2 September 2021

INTRODUCTION

1. My name is Tony Ian Reynolds. I am a hydrogeologist at Tonkin & Taylor Ltd (T+T). I hold the qualifications of Bachelor of Engineering (Engineering Science) and Master of Science in Hydrology for Environmental Management. For the Omarunui Landfill Project (Area B or the Project) I have been responsible for the hydrogeological investigations of, and reporting for, the proposed landfill extension into Area B of the overall landfill site.

2. I have been employed as a hydrogeologist at T+T since February 2005. I have over 25 years' experience as a hydrogeologist. Prior to my current role, I was a hydrogeologist with the Environment Agency in England from 1995 to 2001, the Greater Wellington Regional Council from 1991 to 1993, and the Gisborne District Council from 1986 to 1991.

3. At T+T I have:

   (a) Provided technical inputs to the hydrogeological reporting for:

- Extensions to the Whitford and Redvale landfills.
- Development of steel waste landfills at New Zealand Steel Ltd.
- The proposed Auckland Regional Landfill.
- An additional landfill cell at Tirohia (near Te Aroha).

(b) Managed consent officer reports for the former Auckland Regional Council in respect of groundwater takes from the Kaawa aquifer in South Auckland and assessed the groundwater available for allocation from:

- the basal Waitemata aquifer at Beachlands;
- dune sands at Okahukura Peninsula in the Kaipara Harbour;
- basalt aquifers in Central Auckland; and
- various Waitemata aquifer catchments throughout Auckland.

(c) Managed groundwater pumping tests throughout New Zealand, Australia, and England and analysed the results for resource consent applications and assessments of borehole yields.

(d) Reviewed groundwater flow models for effects assessments in Northland, Auckland, Hawke's Bay, Wellington, Christchurch, and the South Island's West Coast.

(e) Provided hydrogeological evaluations of the groundwater drawdown effects of dewatering. This work contributed to effects assessments of trenching and shafts to permit installation of wastewater and stormwater infrastructure in Mairangi Bay, Warkworth, Otara, Huia, and Milford in Auckland.

4. I am a member of the International Association of Hydrogeologists (New Zealand Chapter), the Hydrological Society of New Zealand, and the National Groundwater Association (USA).

5. This evidence relates to planning approvals which are being sought to authorise the operation of a landfill at Ōmarunui Regional Landfill (**Landfill**) in Area B, specifically:

(a) Application by Hastings District Council (**HDC**) and Napier City Council (**NCC**), as owners of the Landfill, for regional consents from Hawke's Bay Regional Council (**HBRC**); and

(b) A notice of requirement (**NoR**)by HDC as requiring authority to HDC to alter Designation D123 – Ōmarunui Landfill in the Hastings District Plan.

6. I refer to HDC in its capacity as requiring authority and applicant, and **NCC** as applicant, together as the **Applicants**, and the application and notice of requirement together as the **Proposal**.

7. I have been engaged by the Applicants to provide hydrogeological advice in relation to the Proposal.

8. I was the primarily the reviewer of the Ōmarunui Landfill Area B, Hydrogeological Assessment Report (**Hydrogeology Report**), which was attached as Appendix K to the Assessment of Environmental Effects (**AEE**) for the Project. The Hydrogeology Report covers the potential effects on groundwater by the construction and operational phases of the Project.

9. In preparing this statement of evidence I have read the application documents and the submissions received on the Proposal. I have also read the section 42A reports prepared by Mr McKay on the NoR, and that prepared by Mr Shirras in relation to the consent applications.

10. I have met with submitters on two occasions, the first on 29 March 2021 at the landfill with local submitters and the second on 31 July 2021 at the landfill and the Waiohiki marae, where I met with the Ngati Parau Hapu.

CODE OF CONDUCT

11. I confirm that I have read the Expert Witnesses Code of Conduct contained in the Environment Court of New Zealand Practice Note 2014. My evidence has been prepared in compliance with that Code in the same way as I would if giving evidence in the Environment Court. In particular, unless I state otherwise, this evidence is within my sphere of expertise, and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

SCOPE OF EVIDENCE

12. My evidence addresses the following matters:

    (a) Description of the field of hydrogeology and environmental setting of Area B.

    (b) Description of the site investigation and assessment methodology.

    (c) Potential hydrogeological effects.

    (d) Consideration of:

        (i) Section 42A reports.
        (ii) Proposed conditions.
        (iii) Comment on submissions.

13. In summary my conclusions are:

    (a) Potential contaminant concentrations in groundwater are predicted to be less than the relevant guideline values after mixing with flowing groundwater beneath the Area B landfill liner and below the relevant guideline values at the Upokohino Stream.

    (b) The effects on nearby water users of groundwater take and diversion are assessed as being inconsequential.

    (c) Saline intrusion is not considered to occur as a result of the proposed works to install and operate the Area B landfill.

    (d) Settlement beyond the site boundary is considered as negligible as dewatering for the purposes of landfill construction will be short term and occurring within bedrock, which is not prone to groundwater related settlement.

    (e) Based on the foregoing I consider that no groundwater user within the 2 km assessed area will have water quality or quantity adversely effected as a result of the Area B extension to the landfill.

HYDROGEOLOGY

14. Hydrogeology is a field of hydrology and geology that deals with the distribution and movement of groundwater through soil and rock. Aquifers are layers of permeable

material such as sand or fractured rock which hold groundwater that can be extracted. Some of the physical properties of the aquifer control how fast groundwater moves and in which direction it flows. Aquifer properties are generally determined by drilling boreholes and through analysis of in-situ testing undertaken in the boreholes (e.g. pumping tests).

15. The aquifer characteristics that are referred to in my evidence include the water table, confined groundwater and piezometric surface. The water table is the upper surface of a zone of saturation and is exposed to atmospheric conditions. The piezometric surface is an imaginary surface that defines the level to which the water level rises in a confined aquifer when it is intercepted by drilling. If the piezometric surface is above ground, then artesian flow will prevail. Figure 1 illustrates these aquifer characteristics.

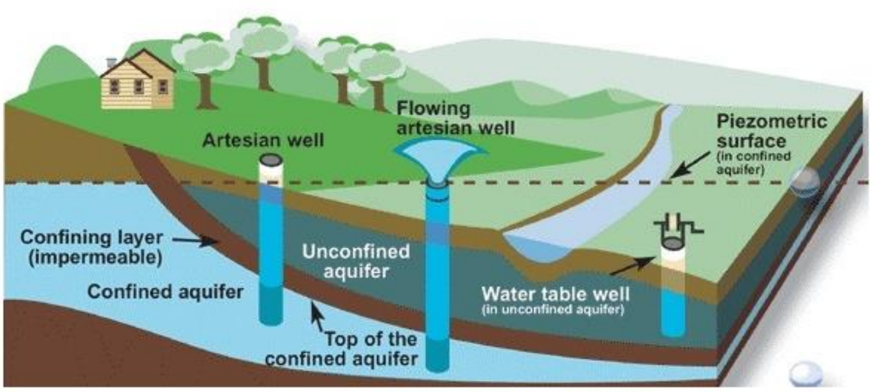

Figure 1 Sketch illustrating the water table and piezometric surface. Source: Geoscience, Groundwater Resource: Important facts you must know, 15 October 2019.

16. The hydrogeology beneath Area B and the surrounding area is important in understanding the potential groundwater-related effects of the Proposal. The hydrogeology controls the movement of groundwater beneath and away from the site, and toward receiving environments such as streams, wetlands, and rivers.

17. In particular, understanding the movement of groundwater beneath Area B means that, in the unlikely event of the leakage of leachate, the migration of leachate impacted groundwater can also be predicted, and the potential environmental effects identified and assessed. I have addressed these and other potential hydrogeological effects in the Hydrogeology Report and summarised these in my evidence below.

ENVIRONMENTAL SETTING

18. The Landfill is located approximately 10 km south-west of Napier and approximately 10 km north-west of Hastings in the Hawkes Bay region. The location is shown on Figure 2 (below). The Landfill is situated to the north of the Heretaunga Plains, which formed as a result of basin infilling from sediments derived from the Tutaekuri, Ngaruroro and Tukituki rivers, along with coastal and marine deposits. The settlement of Puketapu is located approximately 3.5 km north of the Landfill.

Figure 2 Landfill Location Plan

19. The published regional geology of the area indicates that the foothills, on which the Landfill is located, comprise alternating mudstone, sandstone, conglomerate, and limestone beds of the Petane Formation. Subsequent erosion, faulting and infilling has resulted in the formation of alluvial basins (basins infilled with material deposited by rivers or streams) and flat bottomed valleys, such as that of the Moteo Valley (the valley immediately west of the Landfill) and the current course of the Tutaekuri River (the valley immediately east of the Landfill and referred to here as the Tutaekuri River flood plain).

20. The Moteo Valley (a historical flow path of the Tutaekuri River) and Tutaekuri River flood plain consist of gravel, sand, silt, and mud deposits. These deposits are

understood to be derived from infilling by the historical and current courses of the Tutaekuri River and overlie the underlying bedrock (Petane Formation) and older sediment deposits. The way in which these deposits have been laid has resulted in a sequence of alternating coarse- and fine-grained layers.

21. The layered deposition of these historical river deposits from the Tutaekuri River within its current flood plain and the Moteo Valley has resulted in a shallow aquifer system comprising unconfined and semi-confined to confined aquifer conditions, at times with flowing artesian pressures. There is little readily available information regarding groundwater within the bedrock (i.e. the Petane Formation) beneath and surrounding the Landfill.

22. Previous reporting by HBRC presents groundwater contours based on piezometric groundwater data for the river deposits in the Moteo Valley and Tutaekuri River flood plain. The groundwater contours indicate groundwater flow in the river deposits is typically from north-west to south-east.

23. The Tutaekuri River has an estimated naturalised mean annual low flow (MALF) at Puketapu of 3.9 m^3/s (3900 L/s), with a reported median flow of 8 m^3/s (8000 L/s). There are notable water losses upstream of Puketapu, which are considered to provide recharge to groundwater in the Moteo Valley. This recharge from the Tutaekuri River has been estimated to be on the order of 0.82 m^3/s (820 L/s).

24. Surface water in the Moteo Valley includes the Repokai te Rotoroa Stream and open drains and swales. In the Tutaekuri River flood plain, the Upokohino Stream flows along the base of the hills to the east of the Landfill.

Area B

25. Area B comprises a series of steep narrow gullies in a larger broad valley within the north-eastern portion of the Landfill site. The valley is surrounded by ridgelines on the western, southern, and eastern sides. The valley opens up toward the north onto the flood plains of the Tutaekuri River.

26. The southern and central portions of Area B comprise level plateaus, which have been heavily modified by landfill operations (obtaining liner soils and cover soils for Area D development). Some natural material has been removed from site by contractors. A small contractor's compound and aggregate stockpile yard forms the south-eastern corner of Area B.

27. Ponds observed in the valley heads in Area B form sediment ponds for the cut areas above. It is possible that these ponds are providing groundwater seeps from rock exposures in elevated parts of the site. However, at lower elevations I consider that the observed difference between groundwater and surface water elevations suggests that the ponds are more likely to be a result of surface water run off ponding in low lying areas, rather than perching of groundwater.

28. The geology underlying Area B is explained in detail within the T+T geotechnical report and the evidence of Mr Yule. In summary, the higher topography within Area B consists of rock comprising interbedded and interfingering limestone, siltstone, and sandstone beds. The valley floor consists of alluvium comprising sandy organic silts and silty sands, which is indicated to be up to 9 m in thickness. Near the base of the gully slopes is a layer of colluvium (i.e. material that accumulates at the foot of a steep slope), comprising reworked weathered sandstone and loess (windblown deposits) with minor boulder-sized limestone blocks.

29. The hydrogeological characteristics of Area B are detailed in the Hydrogeology Report. I developed the conceptual hydrogeological model for Area B based on the information available within published articles, as well as interpretation of the investigation and monitoring data collected within the area. In summary, the aquifer system beneath Area B comprises:

    (a) A water table in the Petane Formation at about 19 to 26 m RL, and

    (b) Perched groundwater seeps at higher elevations.

SITE INVESTIGATION AND ASSESSMENT METHODOLOGY

30. The method for assessing the effects of the Proposal on groundwater has been undertaken in accordance with standard industry best practice. A desktop study was completed to develop a broad understanding of the underlying ground conditions and to collect other important information in the public domain. This involved collating and reviewing published reports, maps, and data from HBRC, HDC, Geological and Nuclear Sciences (**GNS**), National Institute of Water and Atmospheric Research (**NIWA**) and academic journals.

31. Site groundwater investigations were undertaken by T+T[1] to validate the desk-based information and to further develop the conceptual understanding of the hydrogeology beneath Area B. The locations of the monitoring wells used in the investigations are shown in Figure 2 below and Appendix A in the Hydrogeology Report. The groundwater investigations included the following activities:

(a) Continuous groundwater level monitoring using automated data loggers.

(b) In-situ testing to estimate hydraulic conductivity (otherwise referred to as permeability).

(c) Sampling of groundwater.

(d) Laboratory testing of the groundwater samples.

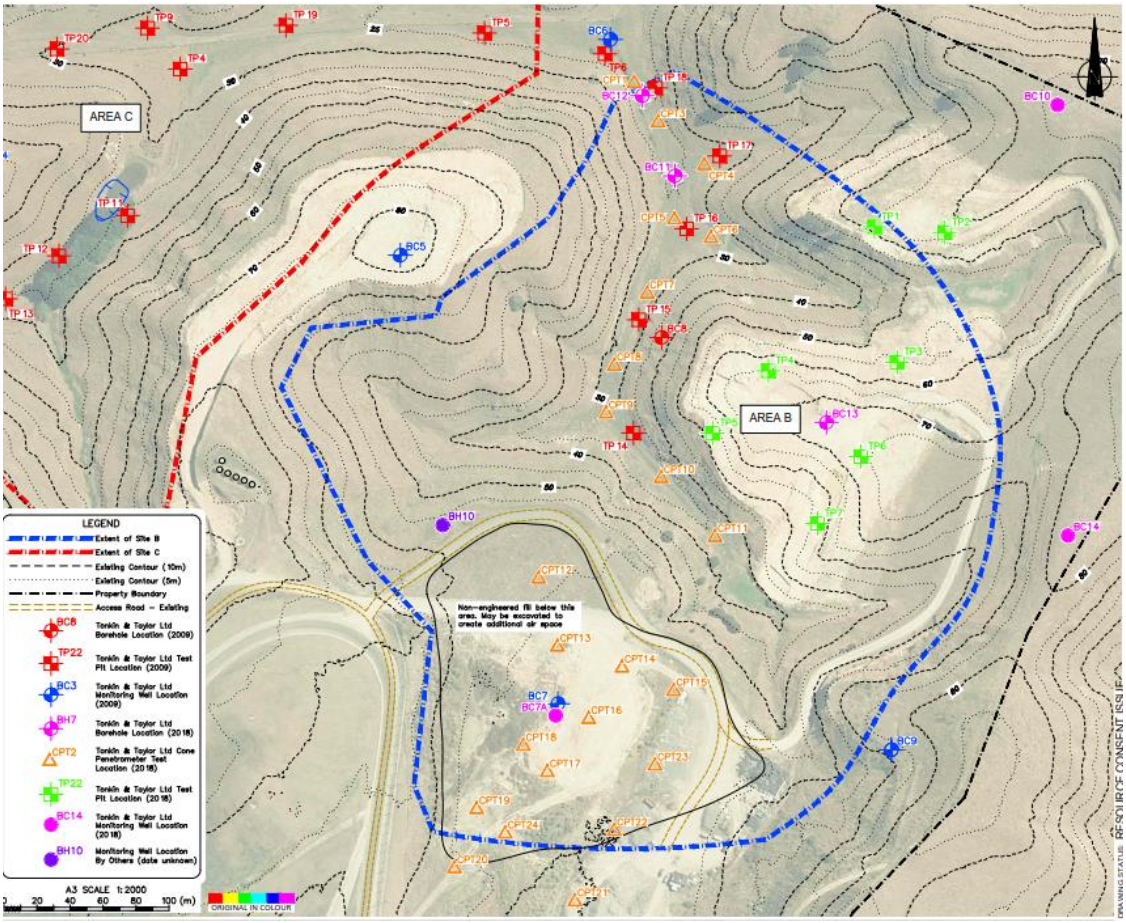

Figure 3 Locations of site investigations in and around Area B.

32. Groundwater levels within nine monitoring wells were recorded manually in August 2018 and June 2020 using an electronic dip meter (refer to Table 3.2 in the

1 Refer to the geotechnical evidence of Jamie Yule.

Hydrogeology Report). Continuous groundwater level monitoring was undertaken in six of the monitoring wells (reported in Appendix B of the Hydrogeology Report). Solinst brand Leveloggers and a Solinst brand Barologger were used to collect the continuous groundwater level readings and barometric pressure readings, respectively.

33. Groundwater surface contours were developed from the groundwater monitoring information collected for annual consent compliance monitoring for the Landfill, and the additional groundwater monitoring undertaken for Area B (described above).

34. To understand aquifer properties around Area B, I oversaw in-situ testing that consisted of ten falling-head and eleven rising-head tests (commonly referred to as slug tests). Slug tests are used to estimate the hydraulic conductivity of an aquifer (commonly referred to as permeability or the ease at which groundwater flows through the rock mass). The slug tests were undertaken in May 2009 and during 2018.

35. Groundwater samples were collected from seven of the monitoring wells to determine the background groundwater quality beneath Area B (refer Table 3.4 and Appendix C of the Hydrogeology Report).

36. Groundwater samples were collected by a variety of methods as the groundwater is very deep below the ridgelines where a number of monitoring wells were installed. The sampling methods are in accordance with industry standards[2] and involved the use of bladder pumps, bailers and proprietary sampling devices known as Hydrasleeves.

37. Field water quality measurements (i.e. temperature, electrical conductivity, and pH) were recorded during sampling using a YSi brand water meter. (YSi) to ensure that the water being sampled was representative of the surrounding aquifer. Each sample was collected into bottles provided by R J Hill Laboratories Limited (an International Accreditation New Zealand ("IANZ") laboratory). The samples were transported to the laboratory under chain of custody documentation and kept chilled until delivered to the laboratory.

38. The groundwater samples were tested by the laboratory for a suite of determinands which include typical leachate indicators (e.g. ammonia, chloride, and boron), as well

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2 MfE guidelines 2006.

as heavy metals and organic compounds. The results were evaluated against the 2008 Drinking-water Standards for New Zealand[3] (DWSNZ), as well as the ANZECC (2000)[4] 95% guideline trigger values (now ANZG, 2018) for freshwater species. The groundwater quality results are reported in the Hydrogeology Report.

SITE CONCEPTUAL HYDROGEOLOGICAL MODEL

39. The information gathered on the existing geological and hydrogeological setting for Area B and the data from the desk-top study and groundwater site investigations were used to develop the conceptual model of the existing groundwater regime for Area B and the Landfill. This is set out in detail in the Hydrogeology Report. I summarise the key aspects of the conceptual hydrogeological model below.

40. An illustrated conceptual hydrogeological model for Area B is presented in Sketch 1 attached in Appendix A of the Hydrogeology Report and reproduced as Figure 3 below (Figure 4 shows the location of the cross section in map view). In summary the aquifer system beneath Area B comprises:

    (a) A bedrock water table in the Petane Formation at about 19 to 26 m RL, and

    (b) Perched groundwater seeps at higher elevations (e.g. at around 37 mRL at BC7A).

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3 Ministry of Health, 2008. Drinking-water Standards for New Zealand 2005 (Revised 2018).

4 ANZECC & ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, now ANZG 2018.

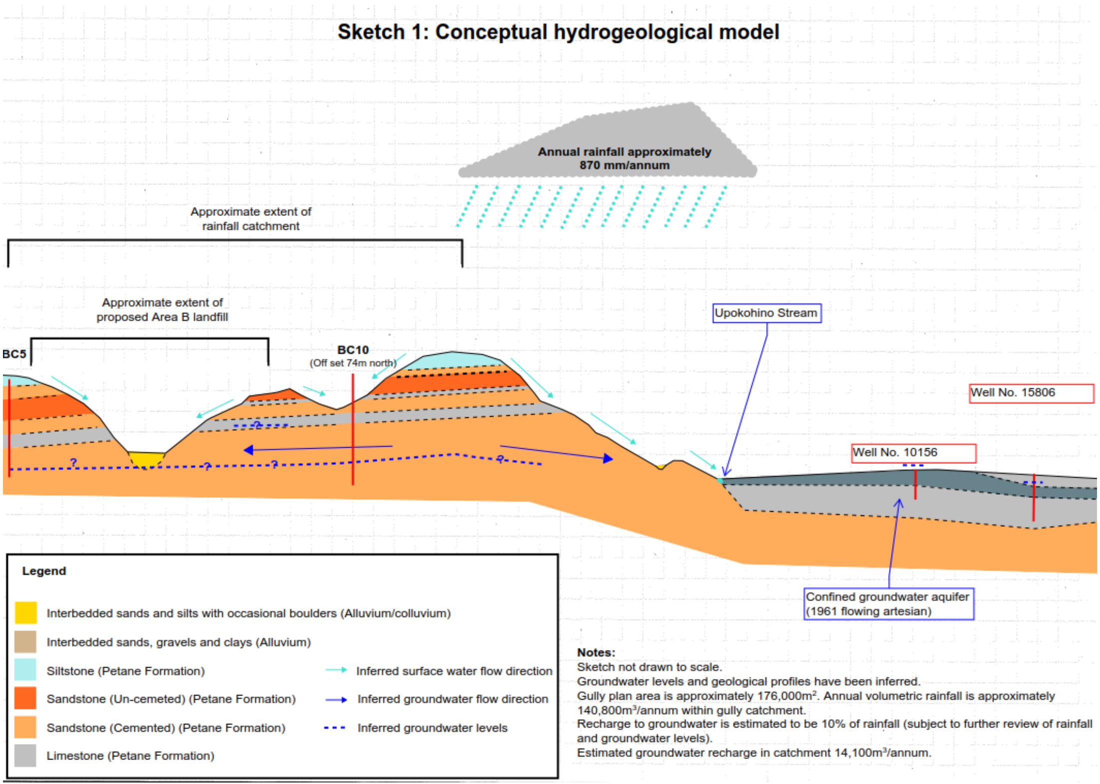

Figure 4 Conceptual hydrogeological model (cross section A-A' shown on Figure 4 below).

Figure 5Location of cross section in plan view.

41. The groundwater level monitoring data indicates that groundwater within the underlying sandstone/limestone rock below Area B is typically at elevations of

between approximately 19 and 26 mRL. On the basis of these levels, I infer that the bedrock aquifer system is unconfined or semi-confined.

42. Where groundwater seeps exist at levels above the regional water table (observed at rock exposures in the valley walls) my interpretation is that these seeps primarily occur where there are recharge sources adjacent to the seep location. For example, in the vicinity of BC7A (Figure 3), my view is that seeps at around 37 mRL are supported by nearby recharge sources including:

(a) The adjacent sediment pond.

(b) Rainfall on the overlying fill material.

(c) Rainfall on the dipping rock outcrop located at a higher level.

43. Where these groundwater seeps are currently observed my view is that as potential recharge sources are removed and covered by landfill liner the seeps will no longer occur. However I expect that the bedrock water table level and flow direction will remain similar to flow directions and levels observed historically. While the bedrock water table is likely to exist at around 19 to 26mRL and flow in a south-westerly direction, the effect of the higher ground east of Area B will continue to support groundwater flows to the southwest, west, and north-west beneath Area B.

44. I consider the main recharge to Area B groundwater is from rainfall via direct recharge and via fractured rock outcrops. There may also be a small component of recharge to groundwater from streams in the valley floor, however, this would only occur when water levels in the stream are above the surrounding groundwater level.

45. Recharge to the regional groundwater in the vicinity of the Landfill is indicated to be from flow losses from the Tutaekuri River into the alluvial aquifer at the head of the Moteo Valley.

46. The groundwater flow direction away from the Landfill and Area B is an important part of the hydrogeological model to understand, as it allows for the identification of the potential off-site receiving environment. Refer to Figure 6 (below) and Appendix A in the Hydrogeology Report for groundwater level contour plans, which indicate the direction of groundwater flow (groundwater flows from high levels to low levels).

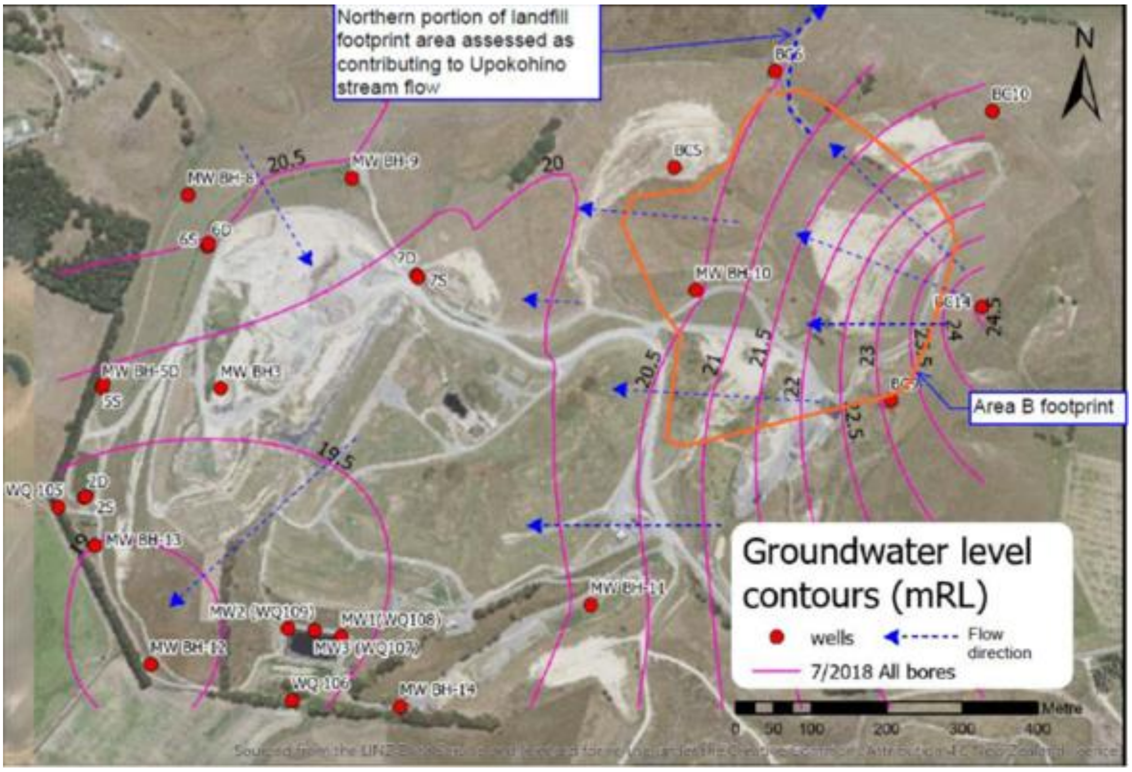

Figure 6 Groundwater contour plan for groundwater below the Landfill, including Area B. The plan shows groundwater contours derived from groundwater levels measured during July 2018.

47. Based on the contour plans and monitoring data, the groundwater flow direction beneath the Landfill is generally towards the west and south-west, toward the Moteo Valley.

48. Groundwater flow beneath Area B is predominantly toward the west and south-west, toward the Landfill, with some flow toward the north-west and north beneath the northern half of Area B (Figure 6). This northerly flow may ultimately discharge to the Upokohino Stream.

49. The groundwater contours indicate that the groundwater flow direction beneath the Landfill has remained stable (has not changed) since 2010, with some minor seasonal variations (when groundwater levels in the monitoring wells have risen during the winter months or fallen during the dry summer months).

50. The groundwater flow regime appears to be controlled by the topography of the Landfill and Area B. The groundwater surface roughly follows the topography, with highest groundwater elevations corresponding with topographical high points and groundwater flow directions towards topographical lows.

51. As the Area B footprint will be progressively developed, I expect that these flow directions may change. Accordingly, ongoing groundwater level monitoring

recommendations are made to assess any changes in the groundwater flow direction (refer Section 6 in the Hydrogeology Report).

52. As well as groundwater flow direction, I have assessed other aquifer properties including hydraulic conductivity (permeability) of the rocks beneath Area B. The rock permeability at Area B is strongly influenced by the variably cemented and fractured limestone and sandstone beds.

53. In summary, the permeability testing undertaken indicates that the overall in-situ rock mass permeability in the limestone units or sandstone ranges between 3×10^{-6} to 7×10^{-7} m/s, which is considered to be slow to very slow by the Technical Guidelines for Disposal to Land[5].

54. For the purposes of my assessment, I calculated the geometric mean of the Bouwer-Rice permeability (reported in Table 3.2 of the Hydrogeology Report). The calculated permeability is 0.27 m/day or 3.1×10^{-6} m/s for the unconfined bedrock aquifer.

55. However, at the proposed toe of the landfill, I consider it to be appropriate to use the hydraulic conductivity of 8.6×10^{-5} m/s measured at monitoring well BC6 (Figure 3) in 2009 to assess the dewatering discharge required to assist with the installation of the proposed shear key and toe bund (refer section 5.2 of the Hydrogeology Report).

56. The groundwater quality beneath Area B recorded exceedances of the DWSNZ and ANZG guideline values at some of the sampled locations (refer to Table 3.5 of the Hydrogeology Report). I also identified a number of organic contaminants that were detected above the laboratory limit of detection. These are summarised in Table 3.6 of the Hydrogeology Report.

57. My interpretation is that these exceedances in the DWSNZ and ANZG guideline values represent the natural background groundwater quality at Area B. However, the detection of organic contaminants (volatile fatty acids (VFA), methylphenol, toluene, xylene, and carbon disulphide) indicates that groundwater affected by off-site activities is flowing from off-site into Area B. Therefore, I recommend one year's baseline monitoring before landfilling commences in Area B.

POTENTIAL HYDROGEOLOGICAL EFFECTS

5 Technical Guidelines for Disposal to Land, Waste Management Institute New Zealand (WasteMINZ) August 2018, ISBN 978-0-473-35718-4 (PDF).

58. The potential environmental effects of the proposed landfill construction and operation including potential effects on the local hydrogeology are reported in section 5 of the Hydrogeology report and are related to:

(a) Groundwater take and divert resulting from construction of the Area B landfill extension liner.

(b) Groundwater take and divert effects (i.e. dewatering and discharge of pumped water) associated with installation of toe bund and shear key.

(c) Potential discharge of contaminants to groundwater i.e. potential leakage through possible lining system defects to the bedrock water table.

(d) Potential discharge of contaminants to subsoil drains and therefore discharge to the stormwater system.

(e) Cumulative effects of landfill construction and operation in Area B.

59. I have assessed these potential effects in terms of effects on:

(a) Nearby groundwater and surface water users in relation to groundwater level and quality.

(b) Stream depletion.

(c) Saline intrusion.

Groundwater take and divert

60. The proposed basegrade level in the floor of the valley will be constructed with the top of the liner level between approximately 25 and 30 mRL. Excavation below these levels will be required for removal of unsuitable soils and construction of the soil components of the lining system. The proposed north toe bund will be constructed across the narrowest point of the valley B where it opens out onto the mouth of the valley of Area C.

61. Site investigations indicate that typical groundwater levels are at least two to three metres beneath the proposed landfill liner in the base of the valley. As such, groundwater flows and seeps are not expected beneath the majority of the landfill during construction.

Control of seeps from above the bedrock groundwater level

62. A number of seeps above the bedrock groundwater level were encountered during the construction of the Area D landfill. I recommend that a precautionary approach be adopted to provide a means of draining any seeps that may be found. Mr Bryce has noted in his evidence that the pressures resulting from these seeps beneath the lining system (prior to waste filling) have the potential to damage the lining system. He notes that subsoil drains will be installed where groundwater seeps are identified to avoid the possibility of damage to the lining system.

63. The subsoil drainage system as described by Mr Bryce may comprise:

    (a) A central drain beneath Stage 1 and Stage 2 if seeps are found during Stage 1 and Stage 2 development. This drain could be sealed once filling in Stage 2 is complete.

    (b) Possible additional subsoil drains on benching above Stage 1 and Stage 2 (only if required) to collect any seeps observed during construction of Stages 3 and 4.

    (c) Possible subsoil drainage to the south for any seeps discovered during Stage 5 construction that cannot be drained to any existing remaining subsoil drains draining to the north.

64. Groundwater has been observed at around 37 mRL in the vicinity of the southern fill area and sediment control pond related to the southern borrow area for Area D. Groundwater seeps, if encountered from this area, may need to be collected in subsoil drains beneath Stage 1 and 2. Alternatively they could be drained to the south of the Area B landfill footprint if these seeps are still present during development of Stage 5.

65. Bedrock groundwater levels in the vicinity of the north toe bund (at BC6) were reported as approximately 20 mRL during site investigations. The highest groundwater level in the proposed landfill footprint is mapped as 26 mRL adjacent to the BC14 monitoring well. Based on groundwater levels observed during the site investigations groundwater will not be encountered by the basegrade or subgrade excavations for the landfill development. This means that while vertical recharge to the groundwater system will be prevented by installation of the landfill lining system, with the exception of the proposed toe bund installation (refer following section),

there will be no other dewatering effects on bedrock groundwater levels as a result of the landfill basegrade construction.

Dewatering effects during construction of the north toe bund

66. The landfill toe bund will be constructed as part of Stage 2 of landfill development. Construction of the toe bund will require excavation of up to 9 m of alluvial material overlying limestone. This will permit the toe bund, associated shear key and engineered fill to be constructed to the limestone. Dewatering will be required to allow work to be undertaken in dry conditions as groundwater may be expected to be encountered up to 4.5 m above the base of the excavation. Dewatering down to a level of 16 mRL is expected during these proposed works. My assessment is based on the dewatering discharge being disposed of via the proposed stormwater system from the landfill toe towards the Upokohino Stream.

67. I have assessed potential inflows to the excavation using the expected hydraulic conductivity at BC6 and assessed the radius of influence using an analytical method and a plausible selection of hydraulic conductivities. Often in natural systems the vertical hydraulic conductivity may be much lower than the horizontal hydraulic conductivity as a result of layering and/or deposition processes forming the geology. The parameters used are set out below and assume steady state conditions are achieved:

- Hydraulic conductivity K_h = 8.6 x 10^{-5} m/s.
- Drawdown s = 4.5 m.
- Rainfall recharge = 87 mm/year.
- Excavation size = 60 m x 60 m = 3600 m^2.

68. If the horizontal and vertical hydraulic conductivities are identical the estimated total discharge to maintain dry conditions within the excavation is expected to be over 50 L/s with a radius of influence extending 500 m from the edge of the excavation under steady state conditions.

69. If the vertical hydraulic horizontal hydraulic conductivity is 10 times less than the horizontal hydraulic conductivity (i.e. groundwater flows preferentially in the horizontal direction rather than the vertical direction) the estimated total discharge to maintain dry conditions within the excavation is expected to be over 8 L/s with the same calculated radius of influence noted above under steady state conditions.

70. In both cases initial inflows in the excavation are expected to be higher until steady state conditions are achieved. Based on these data the dewatering effects will not extend to nearby pumping wells.

71. In addition, the pumped volume will be discharged to the stormwater network and in turn discharge to the Upokohino Stream, after treatment to remove sediment. This discharge will mitigate potential stream depletion caused by this pumping and accordingly the potential effect of stream depletion is assessed as inconsequential.

Potential discharge of contaminants to groundwater

72. The discharge of contaminants to groundwater may occur via two possible mechanisms through the base of the landfill:

    (a) Leakage of leachate through potential lining system defects to the bedrock water table ultimately discharging towards Areas A and D or towards the Upokohino Stream.

    (b) Leakage of leachate into perched groundwater entering the subsoil drains and therefore discharge to the stormwater system ultimately discharging to the Upokohino Stream.

73. The details of my assessment of these discharges are described below. In summary, from my evaluation of a representative range of leachate contaminants, any contaminants that may discharge to the regional water table and subsequently reach the Upokohino Stream, would be at concentrations below the relevant guideline value.

74. While subsoil drains may be installed to facilitate drainage of perched groundwater during liner installation my assessment is that these should be sealed following installation of the liner and sufficient waste placement. On that basis any contaminants that may seep through the lining system will be unable to discharge to the stormwater system.

Potential leakage through landfill lining system

75. The proposed landfill lining system is described in Mr Bryce's evidence. He describes modelling undertaken to determine the possible rate of leakage through the lining system. Mr Bryce reports that for the worst case, i.e. at full development of the Area

B landfill, the potential theoretical leakage from Area B for the peak year over a 50 year modelling period is assessed as:

(a) Liner including HDPE over a geosynthetic clay liner (GCL).

The average annual seepage is reported as 0.24 L/day and the average seepage in the maximum year is 0.39 L/day.

(b) Liner using HDPE over 10^{-9} m/s permeability clay.

The average annual seepage is reported as 1.07 L/day and the average seepage in the maximum year is 1.70 L/day.

76. In the unlikely event that leachate seeps through defects in the lining system will move vertically through the unsaturated subgrade and underlying bedrock. Ultimately the leachate would enter the groundwater system within the bedrock, mixing with the groundwater flowing beneath Area B. The leachate and groundwater mixture would ultimately flow towards Areas A and D with a portion from the northern part of Area B flowing towards the valley exit beyond the toe of the landfill towards the Upokohino Stream.

77. The leachate quality characterisation used for my assessment has been determined from the maximum reported leachate monitoring concentrations provided by HDC from monitoring at the leachate pond in the existing landfill. The existing leachate pond is located near the toe of Area A and receives leachate from both the Area A and Area D portions of the landfill.

78. I have set out details of my assessment below which considers nitrate-nitrogen, ammoniacal nitrogen, dissolved metals, and organic compounds. Metals contained in particulates are not considered. I have assumed that the nature of the bedrock aquifer and velocity of the groundwater means that particulates will not be carried by the groundwater.

Leachate dilution modelling

79. Groundwater throughflow beneath Area B has been estimated based on available groundwater data. Groundwater levels measured during August 2018 were used to calculate the hydraulic gradient which is assessed as 9×10^{-3}. The calculated permeability of the unconfined bedrock aquifer is reported as 0.27 m/day or 3.1×10^{-6} m/s (refer Section 3.5 of the Hydrogeology Report). We have conservatively assumed that:

(a) Leachate concentrations (dissolved metals) are the maximum reported by HDC between 2001 and 2018.

(b) Group 3 parameters are the maximum concentrations of organic compounds reported by HDC between 2004 and 2018 and which have relevant ANZG trigger values.

(c) Groundwater flows through a 2 m thick aquifer sequence. This assumption has the effect of reducing the volume of groundwater that may mix with the leachate.

(d) The cross-sectional width of the landfill area is assessed conservatively as 375 m, based on the surface area of the landfill liner as being approximately 14.05ha.

80. This assessment presented in the Hydrogeology Report has shown that, based on the conservative assumptions of the model, that dilution of 1400 times is required to achieve the required groundwater quality at the site boundary near the Upokohino Stream. The dilution calculation can be found at section 5.2.1.2 of the report. In order to achieve this dilution, at least 35% of the overall lining system must be underlain by GCL, i.e. a Type 2 lining system. This is different to the proportion of 10% described in the report. To provide a level of conservatism, Mr Bryce has proposed (at his paragraph 35) that the consent conditions be amended to require a minimum of 50% coverage by the Type 2 liner. I have updated my dilution calculations to reflect this 50% coverage, and these are provided in **Attachment A** as an update to the table presented in section 5.2.1.2 of the Hydrogeology Report.

81. The calculated groundwater throughflow is 1800 L/d (0.02 L/s or 1.8 m^3/d). Allowing for 50% of the lining system to comprise a Type 2 liner then the updated dilution available during the peak year is 1700 times.

82. The calculated contaminant concentrations after mixing with groundwater indicate that there is no exceedance of the ANZG 95% guideline values for this modelled case.

83. This assessment is very conservative as it considers the modelled leakage rate in the peak year and the maximum recorded leachate concentration. It also considers that all of the groundwater from below Area B flows towards the Upokohino Stream, which is not indicated to be the case by the current hydrogeological model. If the median contaminant concentration in leachate is considered, then the calculated contaminant concentrations are less than half of the ANZG guidelines considered. If the average year leakage (rather than peak year) was considered with the median contaminant concentration, then the calculated contaminant concentrations would be less than one quarter of the ANZG guidelines considered

84. Also, my assessment does not allow for dispersion or for any attenuation of contaminants and achieves the ANZG 95% guidelines before any discharge into the Upokohino Stream. On this basis I consider my assessment to be conservative.

Discharge of contaminants to subsoil drains and therefore discharge to the stormwater system

85. The subsoil drainage system is described at paragraph 62 et seq. which describes aspects of the groundwater take and divert. Experience during construction of the Area D landfill showed that isolated seeps were present following excavation of the liner subgrade. Subsoil drains were installed to drain these seeps to outside the landfill footprint. I anticipate that similar seeps will be found in Area B and a limited system will be installed to drain any identified isolated seeps. These seeps will drain to the stormwater system and any discharge will be monitored for leachate indicator parameters. I would expect this monitoring to occur at the drain outlet.

86. The subsoil drainage system will remain operational until waste has been placed above the lining system to load the liner to prevent possible uplift. Therefore, the drains can be sealed once waste has been placed and replaced with higher level drains (if required) for subsequent stages of development.

87. Each drain will collect seepage from a relatively small area of liner. In the rare event that leakage might occur above the drain then the groundwater collected in the drain may become contaminated. As soon as any such contamination is detected options to prevent discharge to the stormwater system may include:-

(a) Seal the drain to prevent further discharges to the stormwater system; or

(b) Divert the drainage to the leachate system.

Nearby surface and groundwater users

88. There are approximately 120 wells within approximately 2 km of the centre of Area B. Of the wells identified, 35 are indicated to lie within the curtilage of the Ōmarunui landfill area (investigation wells), 41 are indicated to lie within the Moteo Valley, and 44 are indicated to lie within the Tutaekuri flood plain.

These wells are typically screened within alluvial gravel beds situated between layers of lower permeability clays. Some wells located on the foothills of the Moteo Valley are indicated to lie within the underlying bedrock aquifer.

89. There are approximately 27 consents related to groundwater (referred to as groundwater takes or stream depleting groundwater takes) and surface water takes within the 2 km radius, with a combined annual take of 3,906,994 m3/year. A list of the relevant consent numbers considered as part of our assessment is provided in Appendix D of the Hydrogeology Report.

90. The uses for groundwater in the surrounding area are predominantly for irrigation, frost protection, wash down purposes and domestic water supply. Two consented domestic water supplies are indicated to be taken from Well No. 4328, approximately 1.6 km to the northwest of Area B, and Well No. 16779, approximately 1.1 km to the east-southeast.

Effects on nearby surface and groundwater users

91. Effects on nearby groundwater and surface water users include:

(a) Effects of the groundwater take and diversion at Area B on groundwater levels at nearby user sites.

(b) Changes in groundwater quality at the nearby surface and groundwater takes.

92. Based on the preceding evaluations there are no effects on nearby surface and groundwater users as the result of the groundwater take and divert activities associated with construction, and installation of the landfill and potential leachate discharge to the bedrock water table beneath the landfill.

Stream depletion effects

93. It is proposed that the landfill basegrade be installed at least two metres above the bedrock water table. While the completed landfill will prevent recharge to groundwater beneath the landfill the potential recharge will be intercepted over the landfill cap and discharged as stormwater. My review of groundwater level monitoring data for boreholes located upstream and downstream of Area D confirms that downstream groundwater levels do not appear to be affected following landfill installation at Area D. On this basis no stream depletion effects are expected to be observed following construction of the landfill in Area B.

Saline intrusion/settlement/other effects

94. The nearest coastline is approximately 11.5 km to the east of the site. The groundwater level at the site is at approximately 19 m above sea level. It is therefore highly unlikely that sea water intrusion will occur as a result of the abstraction as any groundwater take will be above mean sea level and for short duration during construction of the landfill.

95. No measurable settlement effects are expected beyond the site boundary as the landfill basegrade will be installed at least two metres above the bedrock water table and will therefore not affect the water table, except by intercepting recharge over the area of the landfill cap.

HDC SECTION 42A REPORT

96. The HDC s42A report refers to a notice of requirement to alter the current site designation to enable waste placement within Area B of the Ōmarunui Regional Landfill site. There is no proposal to change the boundaries of the designation - only the area for waste placement within the designation and the conditions applying to the designation in providing for the use of Area B. Where submitters have provided submissions relating to effects on groundwater, I have addressed these submissions following the conditions section of this evidence.

HBRC SECTION 42A REPORT

97. The HBRC report addresses groundwater quality at paragraph 7.27 et. seq. and groundwater take diversion and drawdown at paragraph 7.34 et. seq.

98. I concur with the report assessment at paragraph 7.33 which describes the likely reason for the elevated concentration of arsenic above relevant standards at the Breckenridge groundwater take (now replaced by bore number 16779). HBRC has determined that the likely reason for the high concentrations of arsenic was due to reducing conditions in the Breckenridge groundwater resource.

99. I concur with the report assessment at paragraph 7.37 which states that *"it is expected that the activities associated with construction Area B and the subsequent landfilling will have a less than minor effect on the quality and quantity of groundwater"*. I provide comments on groundwater monitoring conditions in the following section of my evidence.

CONDITIONS

100. I refer to the draft recommended consent conditions provided in Appendix 1 of the HBRC s42A report dated 26 August 2021. Comments on these conditions from the Applicants perspective are included with the evidence of Ms Brabant. My main comments are set out below with reference to conditions 42 – 52 inclusive.

    (a) Condition 47 refers to development of trigger levels for those determinands relevant to potential landfill leachate effects. The condition notes that trigger levels shall be two standard deviations from the mean of at least ten baseline samples. My recommendation is that the trigger levels be set at three standard deviations from the mean of the baseline samples for Group 1 and Group 2 determinands. I consider that my recommendation provides more certainty that a trigger level exceedence is related to a leachate effect and is not a false positive.

    (b) In condition 48 there is a requirement to undertake additional works including items such as re-sampling, providing results to HBRC, and preparation of a risk assessment report if the sample exceeds the relevant trigger levels or relevant standards or guideline levels. I note that a number of the samples collected to date already exceed relevant guideline levels (refer paragraphs 56 and 57). As the existing groundwater quality exceeds guideline levels at some locations and for some determinands and is below guideline trigger levels at other locations I recommend that Group 1 and Group 2 determinands have trigger levels set and that samples be compared against those trigger levels only (rather than against relevant standards or guideline levels).

(c) I propose that condition 48 set out in the s42A report be reworded as follows:

> "*The consent holder shall review all sample results within two weeks of receipt of results and*
>
> *a) Compare Group 1 and Group 2 determinands with trigger levels (as defined in condition 47) to the trigger levels established in condition 47*
>
> *b) Compare Group 3 determinands to relevant drinking water standards or water quality guidelines.*
>
> *The consent holder shall then undertake actions etc ..."*

The actions a, b, c, and d remain unchanged.

COMMENT ON SUBMISSIONS

101. The submissions are summarised in Appendix 3 of the HBRC s42A report. I address those submissions relating to potential contamination of groundwater and its movement towards the Upokohino Stream, water supply wells, and the Tutaekuri River, albeit noting that some of these were made in respect of the NoR.

102. The main submitter themes relating to groundwater potentially affected by landfilling activities as I understand them are:

(a) Cultural effects of groundwater discharge to the Upokohino Stream.

(b) Potential for leachate to affect the quality of groundwater taken from water supply bores for stock water and domestic water supply

(c) Discharge of leachate contaminated groundwater to the Upokohino Stream

(d) Potential for arsenic contamination of the new Breckenridge Water Company water supply bore, and

(e) Potential for water contamination to the surrounding water supply bores.

103. Groundwater discharge to the Upokohino from the vicinity of Area B could potentially occur by two mechanisms during landfill construction and operation:

(a) During construction dewatering will be undertaken to permit dry working conditions. I have assessed the effects of this activity in paragraphs 66 to 71. In summary:

(i) the dewatering effects will not extend to nearby pumping wells,

(ii) the pumped groundwater will be discharged to the stormwater network and in turn discharge to the Upokohino Stream, after treatment to remove sediment, and

(iii) This treated groundwater will mitigate any potential stream depletion caused by the dewatering activities.

(b) During operation of the landfill some groundwater will continue to discharge towards the stream. I have assessed the potential effect of contamination in the unlikely event of leakage through the landfill liner. My assessment is set out in paragraphs 79 - 84. I conclude that for the modelled case the calculated contaminant concentrations after mixing with groundwater indicate that there is no exceedance of the ANZG 95% guideline values. As the groundwater moves beyond the site boundary there will be further dilution and likely decrease in contaminant concentrations.

104. Based on this description of the landfill operation my assessment is that the predicted effect on nearby groundwater users of the groundwater take and diversion, and the modelled change in groundwater quality, is inconsequential. Accordingly, the potential effect of the Proposal on the Breckenridge potable water supply (bore number 16779) is assessed as inconsequential.

CONCLUSION

105. The site is underlain by an unconfined aquifer comprised of bedrock (sandstone/limestone) and is overlain by alluvium and colluvium in the base of the valley within Area B.

106. Groundwater has been measured and monitored within the underlying bedrock to be at around 19 to 26 mRL with higher levels to the east of the Area B boundary. Water levels measured within BC7A indicate a water level at around 37 mRL. I have

inferred that the nearby sediment pond (located to the east) supports the perched groundwater level.

107. Groundwater flow beneath Area B generally flows from east to west. To the west of Area B, groundwater is inferred to potentially flow to the southwest.

108. Recharge of the groundwater at the site is inferred to occur through rainfall infiltration through the bedrock. Recharge to the alluvial groundwater system is by rainfall infiltration and losses from the Tutaekuri River to the northwest of the site at the head of the Moteo Valley.

109. Permeability of the underlying bedrock has been measured to be in the range of 1×10^{-4} to 3×10^{-8} m/s. The calculated permeability is 0.27 m/day or 3.1×10^{-6} m/s for the unconfined bedrock aquifer.

110. With the exception of BC6 (August 2018) sample exceedances outside relevant trigger values (DWSNZ and ANZG for protection of 95% of species) were reported at all other sample locations (BC6, BC7A, BC9, BH10, BC10, and BC14) for one or more of pH, total hardness, nitrate, iron, copper, zinc, manganese, and arsenic.

111. Groundwater contours indicate that groundwater flow is from the vicinity of BC14 to the southwest towards BC9, towards the north-west and to the north towards BC10. This groundwater flow direction supports our assessment that the elevated parameters (e.g. TKN, TOC, chloride, sodium, EC) in the sample from BC10 may have been affected by off-site activities. While parameter concentrations measured at BC5, BC6, and BC9 indicate that these locations may be representative of some background groundwater quality the results from BC14 and BC10 must also be considered representative of groundwater of a different quality flowing from off-site.

112. Of note, the detected concentrations at BC10 of VFA, methylphenol, toluene, xylene, and carbon disulphide are well below the relevant ANZG trigger values and DWSNZ maximum acceptable or guideline values.

113. Potential leachate leakage from Area B has been modelled (assuming 50% Type 1 and 50% Type 2 liner) as having a theoretical average annual daily rate of 0.66 L/day and an average day rate of 1.1 L/day in the peak year.

114. Based on our assumed mixing model, should leachate leakage occur at the modelled rate, leachate concentrations are predicted to be less than the relevant guideline value after mixing with flowing groundwater beneath the landfill liner and below the relevant guideline value at the Upokohino Stream.

115. The Moteo Valley and the Tutaekuri flood plain have numerous groundwater wells and groundwater and surface water take consents. A review of the consented takes indicates that the water is used for irrigation, frost protection, wash down purposes and domestic supply.

116. The effects on the closest nearby water users of groundwater take and diversion are assessed as being inconsequential. Therefore, it is considered that no groundwater user within the 2 km assessed area will have water quality adversely effected as a result of the Area B extension to the landfill.

117. Saline intrusion is not considered to occur as a result of any proposed works as any diversion of groundwater would occur above mean sea level. Therefore there are no effects at the site associated with saline intrusion.

118. Settlement beyond the site boundary has been considered as negligible as dewatering for the purposes of landfill construction will be short term and occurring within bedrock.

Tony Ian Reynolds
2 September 2021

ATTACHMENT A

Parameter	Units	Leachate Median	Leachate Maximum	ANZG 95%	Maximum after allowing for 50% Type 2 liner coverage	Maximum above ANZG after dilution?	Notes
Nitrate N	g/m^3	0.03	8.00	2.4	4.65E-03	no	"Grading" guideline values[6].
Total Ammoniacal-N	g/m^3	645	1220	0.9	7.09E-01	no	
Dissolved Iron	g/m^3	2.30	4.20	NA	2.44E-03	NA	
Dissolved Manganese	g/m^3	0.81	2.97	1.9	1.73E-03	no	
Dissolved Aluminium	g/m^3	0.10	0.27	0.055	1.57E-04	no	
Dissolved Arsenic	g/m^3	0.15	0.54	0.024	3.14E-04	no	Assume As III
Dissolved Cadmium	g/m^3	0.0003	0.0010	0.0002	5.81E-07	no	
Dissolved Cobalt	g/m^3	0.04	0.07	0.0014[7]	4.07E-05	no	Refer footnote
Dissolved Chromium	g/m^3	0.37	1.11	0.0033	6.45E-04	no	Assume Cr III, does not exceed DWSNZ limit of 0.05 g/m^3
Dissolved Copper	g/m^3	0.002	0.014	0.0014	8.14E-06	no	
Dissolved Mercury	g/m^3	0.00004	0.00015	0.0006	8.72E-08	no	
Dissolved Nickel	g/m^3	0.13	0.24	0.011	1.40E-04	no	
Dissolved Lead	g/m^3	0.0011	0.0050	0.0034	2.91E-06	no	
Dissolved Boron	g/m^3	4.95	11.80	0.37	6.86E-03	no	
Dissolved Selenium	g/m^3	0.005	0.010	0.011	5.81E-06	no	
Dissolved Zinc	g/m^3	0.022	0.140	0.008	8.14E-05	no	

6 Hickey, C. W., January 2013, *Updating nitrate toxicity effects on freshwater aquatic species*, prepared by NIWA for MBIE.

7 Note that level of species protection listed as unknown for cobalt default guideline value (DGV).