IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER OF	a review of resource consent conditions under 128 of the Resource Management Act 1991
BY	**MANAWATU-WANGANUI REGIONAL COUNCIL**
AND	an application for change of consent conditions under section 127 of the Resource Management Act 1991
BY	**HOROWHENUA DISTRICT COUNCIL**

STATEMENT OF EVIDENCE OF
STEPHEN JOHN DOUGLASS
ON BEHALF OF HOROWHENUA DISTRICT COUNCIL

2 September 2016

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EXECUTIVE SUMMARY

1. My name is **Stephen John Douglass**. I am the National Service Group Manager for Environment at GHD Limited.

2. I am a Principal Hydrogeologist. I have been employed at GHD since May 2015. Prior to joining GHD I was a Principal Hydrogeologist for URS New Zealand (**URS**). I worked for URS for a period of nine and a half years. Between August 2004 and November 2005 I worked for Environment Canterbury as a Consents Investigating Officer, and prior to that I worked for the Ministry of Education as a planner/analyst for a period of two and a half years.

3. My evidence is given in relation to the review of resource consent conditions initiated by Horizons Regional Council ("**Horizons**") and the application for change of consent conditions by Horowhenua District Council ("**HDC**") in relation to the Levin Landfill located at 665 Hokio Beach Road (the "**Landfill**").

4. Specifically, my evidence addresses the effects of the unlined landfill on the groundwater system. I consider that there has been a considerable amount of information collected on the groundwater system to enable a robust assessment of effects to be undertaken. This includes the investigations and monitoring data that was available at the time the new landfill was consented in 1998.

5. Notably;

   (a) The monitoring data confirms that the shallow groundwater system down-hydraulic gradient of the unlined landfill (now closed and capped) is affected by leachate discharging to the groundwater system. These effects of the unlined landfill were known at the time of the original consent decision.

   (b) The groundwater quality has been relatively consistent over time, with the wells located closest to the unlined landfill showing the highest concentrations of analytes associated with leachate.

   (c) Shallow groundwater flows in a northerly direction, towards Hokio Stream. Along this flow path a shallow drain (the Tatana Drain) intercepts the groundwater system. This has resulted in contaminated groundwater discharging to the drain.

   (d) The location of the upstream monitoring site on Hokio Stream is likely to be down-hydraulic gradient of the unlined landfill. It is recommended that a new upstream monitoring site is established.

   (e) I consider that the drain does not fully intercept the groundwater plume. Shallow groundwater is discharging to the Hokio Stream. However, the flux of groundwater entering the stream is likely to be very small relative to the flow in the stream.

   (f) Contaminant mass load modelling presented in the recent annual reports indicates that the mass of contaminates entering the stream is unlikely to result in adverse effects. The discharge to the Hokio Stream was also considered

during the original consent hearing. However, I consider that the modelling is based on conservative assumptions with natural attenuation processes not taken into account.

(g) The deep groundwater system (the Gravel Aquifer) is likely to flow to the west. Monitoring wells installed in the Gravel Aquifer show no impact from the unlined or lined landfill cells.

(h) I recommend that additional monitoring sites for shallow groundwater adjacent to the Hokio Stream be established. This would enable the extent of the contaminated groundwater to be better understood. In addition, a new deep groundwater monitoring well to the west of the unlined landfill would enhance the understanding of deep groundwater flow and water quality effects.

6. In summary, I consider that the Tatana Drain is affected by contaminated groundwater discharging to the drain. However, further work would be required to determine if the Horizons new proposed Condition 2A can be met without resulted in unforeseen effects on the drain itself. I am not aware of any analysis undertaken by Horizons to support the effectiveness of this Condition.

7. I consider that additional monitoring and modelling would assist all parties to better understand the significance of the effects and the potential management options. This approach is already provided for in the Conditions.

QUALIFICATIONS AND EXPERIENCE

8. I have the following qualifications and experience relevant to the evidence I shall give:

(a) I hold:

(i) a Graduate Diploma of Engineering from the University of Technology, Sydney in hydrogeology and groundwater management;

(ii) a Master of Science with honours from the University of Auckland in Geography (geomorphology); and

(iii) a Bachelor of Science from the University of Auckland in environmental science.

(b) I have also obtained certificates of proficiency from the University of Auckland in Legal and Institutional Context of Law (700 Level) and Planning Theory and Method (700 Level).

(c) I have acted as the project director and reviewer of closed landfill monitoring programmes in Christchurch and Banks Peninsula between 2011 and 2013, undertaken groundwater investigations associated with industrial landfill and cleanfill sites, acted as an independent peer reviewer of effects of roading projects on closed landfills in Christchurch, and designed and directed investigations for groundwater monitoring networks associated with closed landfills for the Christchurch City Council.

9. I am a member of a number of relevant associations including:

(a) the Groundwater Association (USGA) since 2006,

(b) the Australasian Land and Groundwater Association (ALGA) since 2014, and

(c) a general member of the Hydrological Society of New Zealand since 2005.]

10. I confirm that I have read the 'Code of Conduct' for expert witnesses contained in the Environment Court Practice Note 2014. My evidence has been prepared in compliance with that Code. 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

11. My evidence addresses the following matters:

(a) history of the groundwater issues related to the Levin Landfill

(b) detail of the groundwater quality monitoring requirements as provided for in the conditions of consent for the Landfill;

(c) a description of the existing groundwater environment;

(d) my comment on the amendments to conditions relevant to groundwater quality proposed by both councils (Horizons and HDC);

(e) my response to the relevant questions posed by the community members of the Neighbourhood Liaison Group through the Whakawatea Forum; and

(f) response to the Horizons report.

- **HISTORY OF THE GROUNDWATER ISSUES RELATED TO THE LEVIN LANDFILL**

12. The 1998 Horizons decision to grant resource consents for the Landfill and the 2010 decision on the review of consent conditions both addressed groundwater quality issues. I have reviewed the original application and the 2010 review documents to better understand the history of the site in terms of the groundwater issues that have been raised and addressed over time. In particular, I have focused on the findings of the review of consent 6010 (discharge of landfill leachate onto and into land).

13. The 1998 hearing panel relied upon the evidence of Mr Martin Robertson (an Environmental Scientist), who presented a conceptual model of the groundwater system and discussed the results of groundwater monitoring that had occurred at the site.

14. Mr Robertson considered that the local groundwater system consisted of a shallow and deep aquifer unit. He referenced a 1997 report which addressed the leachate effects from the landfill. The groundwater flow direction in the shallow aquifer was interpreted to be in a north-northwest direction, towards the Hokio Stream. The shallow aquifer was also noted by Mr Robertson as has having poor natural water quality. Groundwater within the deep aquifer flows towards the coast, in a westerly

direction. This aquifer was noted as being the used for potable and stockwater supply. Mr Robertson also stated that iron concentrations in the deep aquifer were elevated.

15. Based on the results of the sampling and the conceptualisation of the groundwater system, Mr Robertson noted that groundwater samples taken from monitoring wells installed within 50 m of the landfill showed evidence of landfill leachate within the groundwater. He stated that the metal concentrations recorded in the monitoring wells were generally low.

16. Mr Gabor Bekesi (Underground Water Scientist) of Horizons stated that groundwater was affected by the landfill. He noted that on-going monitoring of groundwater was important, but considered that the proposed monitoring plan was adequate to manage the wide spread contamination of groundwater.

17. Several submitters during the hearing raised concerns with regard to groundwater quality and groundwater flow direction. Notably, Mr Huia considered that groundwater would flow in a westerly direction, towards Hokio Beach, transporting contaminated groundwater. Mr Broughton noted concerns regarding the potential impacts of the new landfill on Hokio Stream and Lake Horowhenua. Mr Jones was concerned with water ponding on his property, which adjoined the landfill site, and considered that the ponding was the result of the discharge of leachate from the existing landfill.

18. I have reviewed the information that was presented at the time the original consent was considered against the monitoring data that has been collected since. I provide a fuller discussion of the findings of my review in the following sections. However, I note that there has not been any significant change in the functioning of the aquifer systems (i.e. change in flow directions) nor in the monitoring results that would render the original assessment invalid.

The 1998 decision to grant consent

19. The hearing panel considered the potential for leachate from the old landfill to be transported via groundwater and discharged to surface water. Based on the information presented to the panel they were satisfied that the impact to groundwater was limited spatially to that within close proximity to the landfill itself. Furthermore, the panel considered the monitoring data of the Hokio Stream, and considered that there was no “discernible discharge of leachate to the Hokio Stream via groundwater”.

20. Some of the monitoring wells referenced in the evidence of Mr Robertson and Mr Bekesi as having evidence of contamination in shallow groundwater where down-hydraulic gradient of the unlined landfill. This indicates that the hearing Panel were aware that the unlined landfill was impacting groundwater. In addition, the Panel considered the monitoring programme would address the uncertainty with regard to offsite contamination of groundwater in the deep and shallow aquifer. While the Panel agreed with the applicant and Regional Council expert’s, that based on the monitoring results from the Hokio Stream that there was contamination of the waterway, the Panel considered the source of the contamination was not associated with the existing landfill.

The 2010 review of consent conditions

21. A review of the Levin Landfill consent conditions was initiated in September 2008, with the decision issued in 2010[1]. The decision document provides a background to the history of the landfill, which provides a useful context from which to assess potential for adverse effects arising on groundwater and surface water environs. The review included the groundwater quality and the discharge of landfill leachate to ground, groundwater, and surface water. I note that there were previous investigations, initiated by Horizons and HDC with respect to the scheduled 2005 review[2], with Golder Associates providing a review in 2010 which considered these two former reports and Tonkin and Taylor (2008[3]) providing an independent review of the landfill on behalf on the Parliamentary Commissioner for the Environment (PCE). All of this information was considered by Horizons during the last review of consent conditions.

22. During the 2010 review process there were numerous meetings held between experts, where the effects of leachate on groundwater and surface water quality was discussed. While the information reviewed at the time did not indicate that the contaminants within groundwater were affecting the Hokio Stream, the experts agreed that additional groundwater monitoring should be undertaken. Of particular interest was the potential migration of contaminants from the unlined landfill into groundwater and surface water.

23. The decision stated that the review of the monitoring data had found no evidence of significant adverse effects from the landfill operation. However, the review did introduce additional monitoring locations, specifically on the Hokio Stream and shallow and deep groundwater. The purpose of the new monitoring locations was to confirm that water quality was not declining between upstream and downstream locations on the Hokio Stream.

24. The decision included the additional provisions for groundwater monitoring and reporting. I will now discuss these conditions.

MONITORING AND OTHER MEASURES CURRENTLY PRESCRIBED BY THE CONSENT CONDITIONS

25. The conditions of the resource consents that allow for the operation of the Levin Landfill require HDC to undertake groundwater monitoring and surface water monitoring, and provide all the results within an annual monitoring report. Condition 11 also requires the HDC to inform Horizons in the event that a monitoring result(s) indicate a deterioration of water quality which can be attributed to the landfill. The HDC and Horizons are to consult on any further investigation or remedial measures to be undertaken. These requirements are targeted at ensuring the effects of leachate from the Landfill are addressed appropriately, so that groundwater quality is maintained.

[1] Levin Landfill review of consent conditions, 31 May 2010. Horizons Regional Council
[2] MWH (2008): Levin Landfill – Commentary on the Kingett Mitchell July 2006 Report & review of resource consent conditions. Report prepared for Horowhenua District Council, November 2008.
[3] Tonkin and Taylor (2008): Levin Landfill – Operational and Environmental Impact Review. Letter report for Parliamentary Commissioner for the Environment. T&T Reference 25117. Dated 25 March 2008.

26. In this section of my evidence I explain the monitoring and other actions required by the conditions, and the results obtained from the monitoring and other work to date.

Monitoring required by conditions of consent

27. I will briefly describe the conditions of 6010 that are relevant to the monitoring of groundwater quality, which I have considered when reviewing the existing and proposed consent conditions. I have not repeated the conditions verbatim as these are already attached to the evidence of Mr Edwards.

Condition 3

28. Condition 3 of 6010 provides specifics on the groundwater, surface water, and soil monitoring programme. This condition was updated following the 2010 review, with the inclusion of additional monitoring well locations, a restructuring of Table A (wells and monitoring frequency) and inclusion of Table B. I note that the monitoring regime for shallow and deep monitoring wells differs slightly.

29. The shallow wells are monitored for indicator analytes (defined in Table F) on a quarterly basis, with the comprehensive suite (as defined in Table E) undertaken annually (as stipulated in Table B). It is noted that the comprehensive suite was required to be undertaken every six months for the first two years (which has been completed). Pesticides and VOC are to be analysed for where the shallow monitoring wells indicate leachate is affecting groundwater quality over three consecutive rounds. This is to occur on an annual basis. The condition also allows for changes to the frequency and analytes sampled for. However, I understand that no changes to the sampling regime for the shallow wells have been sought to date.

30. Table A provides the monitoring regime for the deep monitoring wells. This provides a similar approach to the shallow wells, with the exception of the first two years of monitoring. During this period the samples collected every quarter were to be analysed for the full suite (i.e. Table E). I understand that this was to address some of the uncertainty raised by Golder (2010) with regard to the water quality in the deep aquifer.

31. Table D provides a list of the monitoring locations to be sampled. I consider that this table is largely redundant and adds little to the interpretation of the consent condition. Alternatively, it could be improved by including information on the grid reference and elevation of the sampling point (i.e. top of casing), well depth and screened interval. Some of this information is contained in Drawing 80500713-01-001-G001 (herein referred to as Monitoring Well Location Plan).

32. Tables E and F provide the Comprehensive and Indictor list of parameters to be analysed for. I understand that the Comprehensive list was amended during the 2010 review to include additional parameters including alkalinity, hardness, suspended solids, Chemical Oxygen Demand (COD), magnesium, calcium, potassium, sodium, Total Organic Carbon (TOC), total phenols, and volatile acids. The indicator list is

considered to be appropriate and is generally consistent with the MfE (2002) Closed Landfill Guidelines.

33. I note that there are no substantive changes sought by HDC or Horizons as part of this review with respect to groundwater monitoring.

Monitoring results

34. I have reviewed the groundwater monitoring data and recent monitoring reports[4].I have also reviewed the monitoring data collected from Tatana Drain and Hokio Stream.

35. The results of the groundwater monitoring are presented in the monitoring reports based on the depth and locale of the monitoring wells as follows:

    (a) Gravel Aquifer (deep wells E1D; C2DD; E2D, G1D);

    (b) Sand Aquifer up-hydraulic gradient from old landfill (shallow wells G1S; D1; D2; D3r; D4; D5; D6; and E1S); and

    (c) Sand Aquifer down-hydraulic gradient from old landfill (shallow wells E2S; B1; B2; B3; C2; C2DS; G2S).

36. A plan showing the location of the wells is provided as my **Appendix A**. I have not been able to review any bore logs from these monitoring wells to confirm the lithology. However, I understand that the gravel aquifer wells are only screened across gravel deposits which are distinct from the overlying sand aquifer. I have corrected the well depths to the surveyed relative level to provide a better understanding of the depth range of the wells relative to the surveyed datum. A table is provided as my **Appendix B** which shows the relative level of the well depths. The well depths stated on the monitoring bore plan for the Gravel Aquifer wells indicate that the wells are installed at depths between -4.5 and -16.89 m RL. This is at a level which is generally well below the Sand Aquifer wells.

37. For the Gravel Aquifer wells, the monitoring data indicates that the landfill is not having a discernible effect on groundwater quality. However, the aquifer has elevated concentrations of dissolved iron and manganese, which is not uncommon where the lithology includes evidence of organic peats and clays. There are occasional outliers in the indictor suite for the gravel aquifer wells. However, I do not consider that these outliers indicate the presence of leachate migration into the Gravel Aquifer.

38. The monitoring results from the wells installed in the Sand Aquifer up-hydraulic gradient of the unlined landfill have generally been consistent over the entire monitoring period. Again, there are some outliers in the monitoring record for some

[4]MWH (2016): Levin Landfill Annual Compliance Report for July 2015-June 2016. Report prepared for Horowhenua District Council, August 2016.
MWH (2015): Levin Landfill Annual Compliance Report for July 2014-June 2015. Report prepared for Horowhenua District Council, August 2015.
MWH (2015a): Levin Landfill Water Quality Investigation. Report prepared for Horowhenua District Council, March 2015.
MWH (2016a): Levin Landfill July 2016 Quarterly Monitoring Results. Report prepared for Horowhenua District Council, August 2016.

wells, particularly with boron. However, the concentrations are an order of magnitude lower than the concentrations recorded in the down-hydraulic gradient wells. I note there are some results for wells D1, D6, and G1S that require some discussion.

39. Monitoring wells D1 and D6 have shown an increasing concentration of nitrate nitrogen (NO_3-N) over the past four years. I have attached a copy of the nitrate graph as my **Appendix C**. The most recent results from these two wells have NO_3-N concentrations in excess of 30 mg/L and 20 mg/L, respectively. Monitoring wells D2, F1, D4, and G1, which are located up or cross hydraulic gradient of D1 and D6 do not show the same concentration of nitrate. MWH (2015) state that the levels are due to gorse being present in the area, which a nitrogen fixing plants. It has been documented that nitrogen leaches from areas of gorse, and during periods of burning elevated concentrations of NO_3-N have been measured[5]. However, I consider that additional investigations should be undertaken if NO_3-N concentrations persist following the gorse removal to determine if there are other potential sources. I note that the concentrations of ammonia-N, chloride, and boron in D1 and D6 are at low concentrations and stable. If there was leakage from the leachate pond I would expect to also see a significant increase in the Chloride concentrations.

40. There have been increases in Chloride concentrations measured in G1S between 2012 and 2013, peaking at more than 300 mg/L, before declining to be approximately 100 mg/L at July 2016. G1S is considered to be an up-hydraulic gradient well. The cause of the increase in conductivity is not known. However, it appears to be affected by contaminants that affect the hardness and alkalinity of the water.

41. The monitoring data from the shallow wells installed down-hydraulic gradient of the unlined landfill show the effects landfill leachate entering groundwater, with the exception of E2s. This has been reported in previous monitoring reports and was discussed during the 2010 consent review process.

42. The highest concentrations of contaminants are typically recorded in the wells located closest to the unlined landfill and down-hydraulic gradient of the landfill. The data indicates that the contaminant concentrations in the monitoring wells have been relatively stable, if not slightly declining in recent years for some parameters. However, the concentrations of some indicator parameters measured in the C wells are of a similar magnitude to those in the B wells. That is, whilst concentrations of Boron, Ammoniacal-N, and Chloride are highest in B1, B2, and B3, the concentrations measured in C1 and C2 have increased over the past decade (**Appendix C**). This indicates contaminants are migrating down-hydraulic gradient, towards the Hokio Stream.

43. The monitoring results from E2s, which is located to the NW of the landfill, show no discernible effect from the landfill. This supports the interpreted groundwater flow direction, which is towards the north where the Hokio Stream drains the shallow

[5] Magesan, G., Wang, H., and Clinton, P. (2011): Nitrogen cycling in gorse dominated ecosystems in New Zealand. http://newzealandecology.org/nzje/3013.pdf

aquifer. However, I note that the most easterly shallow monitoring well has water quality which is likely to be affected by the unlined landfill. It would be prudent to delineate the lateral extent of the groundwater contamination by installing additional monitoring wells. This is discussed further below.

44. The shallow groundwater system is intercepted by the Tatana Drain, which is adjacent to the shallow monitoring wells. The surface water quality is discussed by Dr Ausseil and has been reported in MWH (2015a). I note that the concentrations of Chloride and Ammoniacal-N in the drain at the upstream monitoring point (SW1) were similar to those recorded in the adjacent shallow monitoring wells. This indicates that contaminants from the landfill are being transported via the groundwater system, discharging as seeps to the drain.

45. I understand that the invert[6] of Tatana Drain has not been surveyed along its length. However, survey levels were taken for the drain bank and the water level in the drain, groundwater level in C2, and the water level in a ponded area as the drain leaves the Tatana property. This information was reported in MWH (2015a). In addition, photographs of the drain contained in MWH (2015a) indicate that the drain is relatively shallow, with an inferred depth of 0.3-0.5 m below existing ground level.

46. The survey data indicates that the difference between the top of the drain bank and the water level was approximately 0.3 m. The difference between the groundwater level measured in C2 was approximately 0.28 m higher than the surveyed water level in the drain. This indicates that there is a hydraulic gradient and a discharge pathway to the drain. However, the depth of the drain is unlikely to intercept the full thickness of the groundwater which is impacted by the landfill. In other words, some leachate will travel via groundwater under the drain and towards the Hokio Stream.

Other relevant actions required by conditions

Condition 11

47. Condition 11 contains the clauses which provide actions for the HDC depending on the results of the groundwater monitoring. Importantly, the review process is not seeking to make substantial changes to this condition, albeit with the exception of the surface water monitoring undertaken in Tatana Drain and Hokio Stream. I do not specifically address the proposed changes to Condition 11(a) – including the proposed Horizons inclusion of 11(aa). However, I will discuss the interrelationship between the unlined landfill cell, groundwater, and surface water, including the shallow drain on the Tatana property shortly.

48. Of note for groundwater monitoring and reporting are the relevant standards to be applied to the monitoring results. For shallow groundwater, which is of low quality and not used for potable purposes, the guidelines applied are the Environment and Conservation Council Water Quality Guidelines (2000) for Livestock Watering. . This was accepted during the 1998 hearing and the subsequent 2010 review. For the

[6] Invert refers to the base of the drain.

monitoring results obtained from the deep monitoring wells, the Ministry of Health's Drinking Water Standards for New Zealand (DWSNZ) are to be applied.

49. I note that the reference to the standards is a 2000 version. The DWSNZ has been updated since, with the most recent version being the 2008 Revised edition.

50. The 2010 review resulted in clause (c) being added to Condition 11 to improve the understanding of the term "further investigation", which is used in clauses (a) and (b) to refer to what investigations (if any) the Regional Council may require to address the exceedance of the relevant guideline values. In addition, clause (d) was added, which requires HDC to evaluate the contaminant mass load discharging from the landfill and entering the Hokio Stream. The clause enables the HDC to determine the method of undertaking the assessment, including an evaluation of the impact of the mass loading to the stream on water quality. These aspects are covered in Dr Ausseil's evidence.

51. Condition 11(e) provides detail on the process for review of the mass transport model whereby the results indicate that the Hokio Stream water quality is affected by the landfill. Importantly, the review by Horizons of the mass transport model would require the regional council to determine if the effect is more than minor. The purpose of the modelling is to determine if there is likely to be a future effect on water quality that could be mitigated or remediated. However, I consider that the monitoring data collected in the stream provides the best indication of the effects of any potential mass discharging into the stream.

Results and observations from those other actions

52. I understand that the HDC provided mass load contaminant assessment in April 2011, which has been subsequently updated and refined since. The 2016 and 2015 Annual reports provided a summary of the mass balance calculations as required under Condition 11(d). However, I have not had the opportunity to thoroughly review the model or its outputs.

53. Nevertheless, it is expected that mass attenuation along the groundwater flow path will occur through the processes of adsorption, diffusion, dispersion, dilution, chemical oxidisation and reduction, and biodegradation. These attenuation processes have not been accounted for in the mass load contaminant model (as it is described in Appendix F of the 2015 Annual Report). This means that the mass loading estimates provided in the annual reports are likely to over-estimate the actual mass loadings entering the Hokio via groundwater.

54. To better inform the likely attenuation processes acting upon the contaminants within the shallow groundwater, a more detailed modelling approach could be adopted which would need to be supported by additional monitoring wells located adjacent to the Hokio Stream.

DESCRIPTION OF THE ENVIRONMENT

55. I have, to now, discussed the conditions of consent and the recent monitoring results. It is very important to consider this information in light of the site geology and hydrogeology, which will influence how contaminants migrate from the unlined landfill to down-hydraulic gradient receptors.

56. The Levin Landfill and the underlying groundwater system has been described in previous reports, including the original application and the numerous expert reviews that have been undertaken since. I have summarised my understanding of the groundwater system based on the previous reports and investigations.

57. I will focus my discussion to the old unlined landfill area, as the lined landfill is unlikely to be discharging leachate to ground as discussed by Mr Landmark.

58. Royds (1994[7]) provided a detailed description of the geology and hydrogeological setting of the regional and local environment. I have relied largely on the information presented in Royds (1994) in forming my conceptualisation of the groundwater system. The more recent investigations which I have reviewed did not address the fundamental elements of the geology and hydrogeology to the extent that Royds (1994) did.

59. The groundwater system has been previously characterised to comprise a shallow unconfined aquifer which is within the sand/dune deposits, and an underlying semi-confined gravel aquifer.

60. The local geology comprises dune sands and coastal sand deposits underlain by alluvial gravels and sands. The sand dunes have amplitude of 20 m to 30 m in the surrounding area. Peat lenses are known to occur within the sand deposits. Bore logs reviewed Royds (1994) inferred the site geology to comprise up to 30 m of sands (including peat lenses), underlain by a 2 m layer of silt and clay, underlain by at least 30 m of gravel and sand deposits. The total thickness of the alluvial sequence is not given, but the depth of greywacke basement is known to increase towards the coast from the basement high (Poroutawhao High) located to the east of the landfill area.

61. Groundwater in the deeper semi-confined gravel aquifer is inferred to flow towards the coast. I note that there are very few wells installed in the deep gravel aquifer to confirm flow direction. However, I consider the conceptualisation of the deeper groundwater system as described initially by Royds (1994) is reasonable. An additional deep monitoring well installed on the western side of the old landfill, between wells BH2d and BHEd, could assist to confirm the deep groundwater flow direction.

62. The groundwater flow direction in the shallow aquifer is variable and affected by surface water courses and topography (MWH, 2015). A groundwater level survey completed by Royds (1994) determined a northerly groundwater flow direction in the landfill area, towards Hokio Stream. This was confirmed by MWH during subsequent monitoring events. The hydraulic gradient between the landfill site and Hokio Stream

[7] Royds (1994): Assessment of hydrogeology and impact of leachate at Levin Landfill. Royds Consulting Limited , June 1994.

was calculated to be between 0.006-0.007. However, this gradient is expected to vary seasonally. The hydraulic conductivity of the shallow aquifer at the site was initially calculated to be in the range of 10^{-5} – 10^{-6} m/sec (Royds 1994), and updated by MWH in 2012 whereby testing indicated values in the range of 2 x 10^{-5} to 6 x 10^{-6} m/s. These values are typical of fine sands.

63. It is the hydraulic gradient and hydraulic conductivity which controls the discharge rate of groundwater (i.e. Darcy's Law). The pore velocity, which is a measure of the particle transport flow rate, is also governed by the porosity. Based on the values of hydraulic conductivity, hydraulic gradient, and porosity used in the MWH (2016) mass transport model, the travel times for contaminants in groundwater equate to <0.1 m/d to 0.2 m/d (or approximately 10-80 m/yr). The seasonal variance in groundwater levels will result in a varying rate of groundwater discharge to the Hokio Stream, with the lower groundwater levels during summer months resulting in a reduction in groundwater discharge.

ADDITIONAL MITIGATION MEASURES PROPOSED BY HORIZONS AND BY HDC UNDERTAKEN BY HOROWHENUA DISTRICT COUNCIL

64. As part of this review process, Horizons proposes the imposition of additional (or amended) conditions of consent requiring HDC to take further action in respect of groundwater quality. HDC is separately proposing amendments to the conditions of consent in respect of groundwater quality.

65. In this section of my evidence I comment on the amendments to the conditions proposed by the two councils, setting out my view as to whether each proposed change is appropriate and necessary to ensure that groundwater quality is at an acceptable level. I note that the summary of changes proposed by Horizons and HDC are appended to Mr Edwards' evidence.

Additional conditions of consent or amendments to existing conditions of consent proposed by Horizons

66. Horizons propose to retain Condition 2, which states that landfill leachate shall not contaminate adjoining land. I understand that this condition was imposed during the 1998 hearing to address concerns raised by a submitter with regard to runoff of leachate and ponding on their property (Mr Jones paragraph 76 of the original decision). I consider that the wording of the condition is unclear, as it could be interpreted that groundwater contaminated with leachate cannot be discharged from the site, as this has occurred since the unlined landfill has been at the site. I am unaware of any ponding issues of leachate on neighbouring properties, notwithstanding the Tatana Drain which intercepts shallow groundwater.

67. Condition 2A as notified by Horizons sought to cease the discharge of landfill leachate to Tatana Drain. In his Section 42A report, Mr Brashford amended the position slightly, altering the condition to state that there shall be no discharge of landfill leachate from the Tatana Drain to the Hokio Stream. However, the position of Mr Brashford was not retained in the proposed conditions attached to his report.

68. I do not have a view on the status of the drain. However, I note that the drain is shallow and intercepts shallow groundwater. Mr Saidy and Mr Landmark note that the drain was intended, following the original decision, to intercept leachate to avoid ponding and the effects on Mr Jones property. As groundwater is found near the ground surface, a discharge of groundwater to the drain would be expected. Therefore, the fact that monitoring date indicates groundwater contaminated with leachate entering the drain is not surprising.

69. Methods to cease the discharge of leachate to the drain, such as installing a cut off drain, are questionable as to their likely success without further investigation. In addition, the construction of a cut-off drain may result in unintended effects on Tatana Drain, including the reduction of groundwater discharge to the drain. I am uncertain what analysis Horizons have undertaken to determine if this condition that is proposed can be achieved (or achieved in the timeframe) and what effects they are proposing to address.

70. I consider that if the Panel considers that Condition 2A as proposed by Horizons is the be inserted, that there should be adequate opportunity for HDC to undertake further investigations and monitoring to determine the likely effects of the various intervention options available. I am uncertain if the six months as proposed by Horizons will allow sufficient time to implement a robust, cost effective, and sustainable solution. Furthermore, if a solution is installed and commissioned, there will be a lag time associated with contaminated groundwater down-hydraulic gradient of a "cut off" which would continue to migrate to the drain for some period following. Therefore, I do not consider that the timeframe as proposed by Condition 2A is achievable.

71. Horizons and HDC have proposed additional monitoring locations in Tatana Drain and incorporating groundwater monitoring well G2s in Table B.

72. There is some discussion in the need to increase the frequency of surface water monitoring to monthly between November and April. However, from a groundwater perspective this is not considered necessary, as the rate of groundwater flow is relatively slow in the groundwater system as discussed above. Given the estimated rate of groundwater particle velocity ranges between less than 0.1 m/d to 0.2 m/d, monthly monitoring of groundwater is considered unnecessary.

73. I do not have a view on the proposed changes to condition 11(a) or the introduction of a new condition 11(aa). However, I note that the testing regime applied to Tatana Drain and the proposed reporting requirements (and triggers) are unlikely to be achieved without direct intervention to prevent groundwater discharging to Tatana Drain. As stated above, I have not seen any investigations undertaken by Horizons which would demonstrate that it is technically feasible to do this without totally removing flow in the drain. Ultimately, the need for condition 11(aa) depends on the Panel's findings on the proposed Condition 2(a).

Amendments to the conditions proposed by HDC

74. There are no specific amendments proposed by the HDC that affect the existing groundwater monitoring and reporting programme. However, I note that the HDC has proposed to include the existing well G2s within Table B of Condition 3.

75. Beyond the conditions that have been proposed by either Horizons or HDC, there are additional improvements that could be made to the existing groundwater monitoring network that would better enable the impacts of the old landfill on surface water to be quantified. I have referred to these throughout my evidence.

76. I consider that the down-hydraulic gradient extent of the groundwater plume would be better understood with an additional monitoring well(s) located alongside the Hokio Beach road, adjacent to the stream. This was discussed during the pre-hearing meeting in 2010 (paragraph 109, page 274 of the 2010 review decision). This would enable the extent of the impacted groundwater to be better understood where groundwater discharges to the Hokio Stream. A broad estimate of costs to install a shallow monitoring well by a drilling contractor to approximately 5 m depth would be $3,000-5,000 (ex GST) per well. I consider that two shallow wells could be installed as shown in my **Appendix A**.

77. Furthermore, I consider that a new deep groundwater monitoring well, located between E2d and E1d, could be installed to confirm the flow direction of the gravel aquifer and the quality. The cost estimate for installing a monitoring well to 30 m depth would be approximately $10,000-15,000 (ex GST).

78. In addition, as I discuss below, I consider that there is a need to move the upstream monitoring point on the Hokio Stream further upstream. This is on the basis that the groundwater flow direction is likely to be more northerly, with the wells C1 and G2 exhibiting signs of contamination from the landfill. However, any new site must take into consideration the potential for other contaminant sources.

QUESTIONS POSED VIA THE WHAKAWATEA FORUM

79. I understand that the Whakawatea Forum was set up to address issues, including broader issues beyond the scope of this hearing, in advance of the review hearing. As explained by Mr Saidy in his evidence:

    (a) the Whakawatea Forum is comprised of HDC staff, Horizons staff, and community representatives from the Neighbourhood Liaison Group ("**NLG**") set up via the conditions of consent for the Landfill; and

    (b) as part of the Whakawatea Forum process, the NLG community representatives drafted a set of questions to be addressed by the technical experts advising the parties in respect of this hearing.

80. Questions in respect of water quality were considered at expert witness caucusing. The witnesses who participated (and addressed the questions) were Dr Ausseil for HDC; Mr Brown for Horizons; and Ms McArthur for the NLG community representatives. I understand that at caucusing those experts agreed that input from specialist groundwater scientists should be sought in respect of the questions posed. I have considered the questions relevant to groundwater quality (and ignoring any

issues of scope), and set out my responses to each question in turn below to assist the Panel.

Question [1]: What are the likely sources and flow paths of leachate from the landfill (that is from all part of the landfill: the old capped area and current operating landfill)?

81. It is unlikely that leachate from the new lined landfill will enter groundwater. Monitoring wells indicate that the new landfill is performing as expected. However, leachate is being discharged from the old unlined landfill to the shallow groundwater system. I consider that there are two groundwater flow paths associated with this discharge.

82. The first is for groundwater to seep into Tatana Drain, with the surface water then discharging to Hokio Stream (as previous discussed). The second flow path is via groundwater discharging to the Hokio Stream. Given the northerly shallow groundwater flow direction and the short flow path, I consider that this it is possible Hokio Stream may be receiving low levels of contaminates from the unlined landfill.

83. This potential effect was assessed by Royds (1994) at the time the original consent was granted, with groundwater modelling undertaken (using an advection/dispersion analytical model). The conclusions reached by Royds (1994) indicated that groundwater discharge to the stream comprised less than 0.1% of the daily flow in the stream during the summer months. However, I note that the modelling did not consider the attenuation effects that occur in groundwater. Additional monitoring of shallow groundwater adjacent to the stream would assist the understanding of the attenuation processes and confirm the original modelling that was undertaken at the time the consent was granted.

84. Groundwater within the deep semi-confined aquifer is interpreted to flow towards the coast. Monitoring of groundwater quality in wells installed in the deeper gravel aquifer indicates no discernible migration of leachate into this aquifer. This was discussed during the original hearing and the 2010 review. The deeper monitoring wells on the landfill site show no signs of leachate contamination. However, I consider that an additional deep groundwater well could be installed west of the unlined landfill to enhance the understanding of the deep groundwater system.

Question [3]: Is the current landfill monitoring regime capable of detecting these constituents of concern?

85. I consider that the frequency of groundwater monitoring is appropriate. I recommend continued quarterly sampling of the wells in the shallow aquifer, the frequency of monitoring could be reduced to biannual in wells intercepting the deeper aquifer given the stability of the monitoring record over the past 15+ years.

86. However, I note that the recommendation in the Joint Witness Statement[8] (JWS) for sampling for total metals in groundwater is inconsistent with MfE (2002) guidelines. I

[8] Joint Witness Statement: Water quality Conferencing Notes, dated 25 August 2016.

consider that groundwater samples which are analysed for metals should be reported in their dissolved form (as this is the method of transport through groundwater).

87. Surface water sample are collected from Hokio Stream at three locations. Groundwater contour maps presented in MWH (2008) shows the shallow aquifer groundwater flow direction towards the north. I have reviewed groundwater quality data collected at the site, these data also supports a northerly groundwater flow direction. However, the position of the upstream monitoring site (HS1) has the potential to be impacted by shallow groundwater from the landfill area. I recommend that a new upstream sampling location be determined for the Hokio Stream. The location of the new sampling site must not be too far upstream of the site that it has the potential to be impacted by other discharges. The original upstream sampling point (HS1) should be retained to provide additional information on surface water quality in the vicinity of the landfill. I have also considered the location of HS3 (downstream sampling site). This site is unlikely to be down-hydraulic gradient of the groundwater flow path from the unlined landfill.

88. There is seasonal variation in groundwater levels relative to the elevation of the Hokio Stream. Given this variation, it is likely that rate of shallow groundwater discharge to the stream varies, with summer periods corresponding to lower groundwater levels and hence lower discharge rates to the Hokio Stream. Quarterly sampling is likely to measure water quality in the shallow groundwater over a range of water levels. However, this seasonal variation needs to be considered when analysing the water quality results.

Question [4]: What is the likely impact of Horizons RC's proposed Condition 2A?

a) What further on-site works or changes to landfill systems or infrastructure would be required to comply with the condition

89. I only have a preliminary view on this, as it is a question for a landfill engineer, in consultation with a hydrogeologist. MWH (2016a) has recently considered a range of options to address Condition 2A. However, these options have not considered the effects associated with the work on the drain or the wider groundwater system.

90. In addition, as I have mentioned earlier, the lag time following any intervention strategy would result in shallow contaminated groundwater continuing to discharge to the Tatana Drain for a period of greater than six months. The time it would take to reduce the discharge to Tatana Drain would depend on the location and type of management approach adopted, the duration it takes to construct, and the lag time thereafter.

b) What will be the environmental outcome of implementing Condition 2A?

91. I do not have sufficient information to assess the environmental outcomes of implementing condition 2A from a groundwater perspective. However, complete interception of groundwater affected by the landfill is unlikely, meaning that whilst Tatana drain discharge may be able to be addressed, the discharge of groundwater to Hokio Stream would continue. As stated previously, there is insufficient information on

the potential mass entering the Hokio Stream, as the modelling undertaken to date excludes the attenuation processes that occur in the aquifer. I have proposed that additional monitoring and modelling is undertaken to better quantify the discharge effect.

Question [5]: What monitoring or other work would be required to characterise the sources and flow paths of leachate from the landfill site (or, alternatively is there sufficient information available to do so)?

92. I have already discussed a number of options for additional groundwater monitoring, including the introduction of additional monitoring wells adjacent to Hokio Stream. This information would assist to quantify the discharge effects to the stream.

93. Furthermore, the relative water level surveys by Royds (1994) and MWH (2008 and 2015) indicate a northerly groundwater flow direction in the shallow unconfined aquifer. The date of the Royds survey is not clear. The MWH water level surveys were completed in April 2007 and July 2008, with a limited survey around the Tatana Drain area in February 2015. A comprehensive site survey, including the invert of Tatana Drain and Hokio Stream would be useful to determine options for management of the discharge.

Question [6]: What is the likely impact of deposition of drain diggings generated by the creation of Tatana Drain and the use of Tatana Drain itself on groundwater and surface water quality?

94. Until the material in the drain is tested I do not have view on this.

Question [7]: What is the interaction between groundwater beneath the landfill and the Hokio Stream (and this question should explicitly address the interaction of landfill leachate that is potentially present in the groundwater and the Hokio Stream)

95. As discussed in Question 1, shallow groundwater flow is towards the Hokio Stream. A contaminant transport model was built by Royds (1994) to model the landfill leachate in groundwater. A numerical groundwater model should be constructed (costing approximately $25,000 ex GST), taking into account the additional 20 years of monitoring data, to clarify the interaction between leachate, shallow groundwater and the Stream. However, to confirm the attenuation processes that are taken place in the shallow groundwater system, some additional monitoring wells adjacent to the stream would be required.

96. In addition, stream gauging may assist to quantify the groundwater baseflow the stream.

Question [8]: What is the interaction between groundwater beneath and immediately adjacent to the landfill and down-gradient groundwater, including down-gradient groundwater and aquifers beneath Hokio Beach residential properties that could potentially be sources of drinking water?

97. An updated groundwater model as discussed in Question 7 may help address this interaction. Royds (1994), based on the results of their groundwater model, concluded

that potential for impact on groundwater resources low due to low permeability layers in the sediment and dilution factors . Monitoring of the deeper gravel aquifer does not indicate migration of leachate into this aquifer. Therefore, based on the monitoring data collected to date there is unlikely to be a groundwater pathway for contaminants to migrate from the landfill to the drinking water wells at Hokio Beach. However, I have recommended that an additional deep groundwater well is installed on the western side of the old landfill, between wells E2d and E1d.

Question [9]: What is the potential for leachate from the landfill to enter groundwater or aquifers that are used human drinking water supply?

98. Refer to question 8.

Question [12]: What are the appropriate location for monitoring the presence of landfill leachate in:

a) The groundwater (including groundwater near the coast and coastal Hokio Beach settlement)

99. A review of the groundwater monitoring network should be undertaken taking into account the seasonal variation groundwater flow direction (as discussed in Question 5) and/or updated groundwater modelling. I consider that, with the exception of some additional shallow monitoring wells adjacent to the Hokio Stream and a new deep well discussed in Question 8, no additional groundwater monitoring is required. However, based on the existing information and the conceptual understanding of the groundwater system I consider that it is unlikely that the landfill is affecting groundwater quality west of the site in the vicinity of Hokio Beach settlement.

Question [15]: In terms of RMA section 105, how would experts characterise the sensitivity of the Hokio Stream and groundwater receiving environments?

100. Previous investigations have stated that the shallow aquifer is considered to be of poor quality and is not used for potable supply in the immediate vicinity of the landfill. Therefore, I would consider that the shallow groundwater system is not sensitive, albeit that is acts as a pathway for contaminates to discharge to surface water.

Question [16]: What are the projected leachate contaminant concentrations and volumes of leachate likely to generated from all parts of eth landfill (ie. Including the old capped landfill and the current operating landfill)?

101. The Annual Monitoring reports provide an estimate of mass transport in the groundwater system for the unlined landfill. There are not expected to be any leachate discharging from the new landfill cells as they are lined.

Question [17]: What, therefore, are the potential adverse effects on down-gradient groundwater and on the Hokio Stream?

102. The monitoring data to date indicates the unlined landfill affects the shallow groundwater system, which I have discussed earlier in my evidence. The direct effect on the Hokio Stream water quality is likely to be very minor, given the interpreted rate

of transport, mass loading rate (as described in the Annual Monitoring report) and the small groundwater flux compared to the flow in the stream.

Question [26]: Has the historical groundwater monitoring included test to determine the presence of organic toxins and agrichemicals such as dieldrin, 24D, 24T DDT, 'PCBs' and 'POPs'?

103. The January 2015 sampling round included analysis of samples from five wells for the presence of volatile organic compounds (VOC) and semi-volatile organic compounds (SVOC). The annual report presented the results of the sampling in a condensed form.

104. The following parameters were not detected above the laboratory detection limits in all five wells: benzene, chlorobenzene, chloroform. 1,4-dichlorobenzene, dichloromethane, vinyl chloride, and 1,4-dioxane. Propanone (acetone) and methylene chloride were measured at low concentrations (below DWSNZ, 2008) in the one sample analysed for these parameters (from well B3).

Question [27]: What does the historical groundwater monitoring data tell us about the presence of the above chemicals of concern?

105. As far as I am aware the January 2015 monitoring round was the only monitoring round to include analysis for VOC/SVOCs. Therefore, I cannot comment on historical monitoring or trends regarding these contaminants at the site. I agree with the JWS that annual sampling for VOC/SVOCs should be undertaken in shallow groundwater down-hydraulic gradient from the unlined landfill.

Question [28]: Tables 'A' and 'B' in Condition 3 of Discharge Permit 6010 set out the groundwater monitoring locations, parameters and frequency for deep and shallow aquifer monitoring wells: Are the locations, parameters and frequency sufficient to identify the presence of chemical of concern identified in question (a) above?

106. I have addressed this question previously in my evidence. However, to reiterate, I consider that there could be some additional wells installed to better inform our understanding of the extent of the plume in shallow groundwater.

RESPONSE TO THE OFFICER'S REPORT

107. I have read the Section 42A report of Mr Logan Brown, who addresses water quality. I consider that there is little disagreement between the position of Mr Brown and myself with respect to groundwater.

108. Mr Brown notes that groundwater which is affected by the unlined landfill is discharging to Tatana Drain. I agree. Mr Brown discusses the applicability of various water quality standards to be applied to Tatana Drain and Hokio Stream. I do not have a view on the applicable surface water quality standards, expect to note that this issue is addressed by Mr Edwards and Dr Ausseil.

109. In Paragraph 42 Mr Brown notes that the upstream monitoring site may not be independent from the groundwater flow paths from the unlined landfill. I have already

addressed this issue and agree with Mr Brown. I have recommended that a new upstream monitoring site is selected.

Stephen John Douglass

2 September 2016

APPENDIX A

Monitoring Well Location Plan

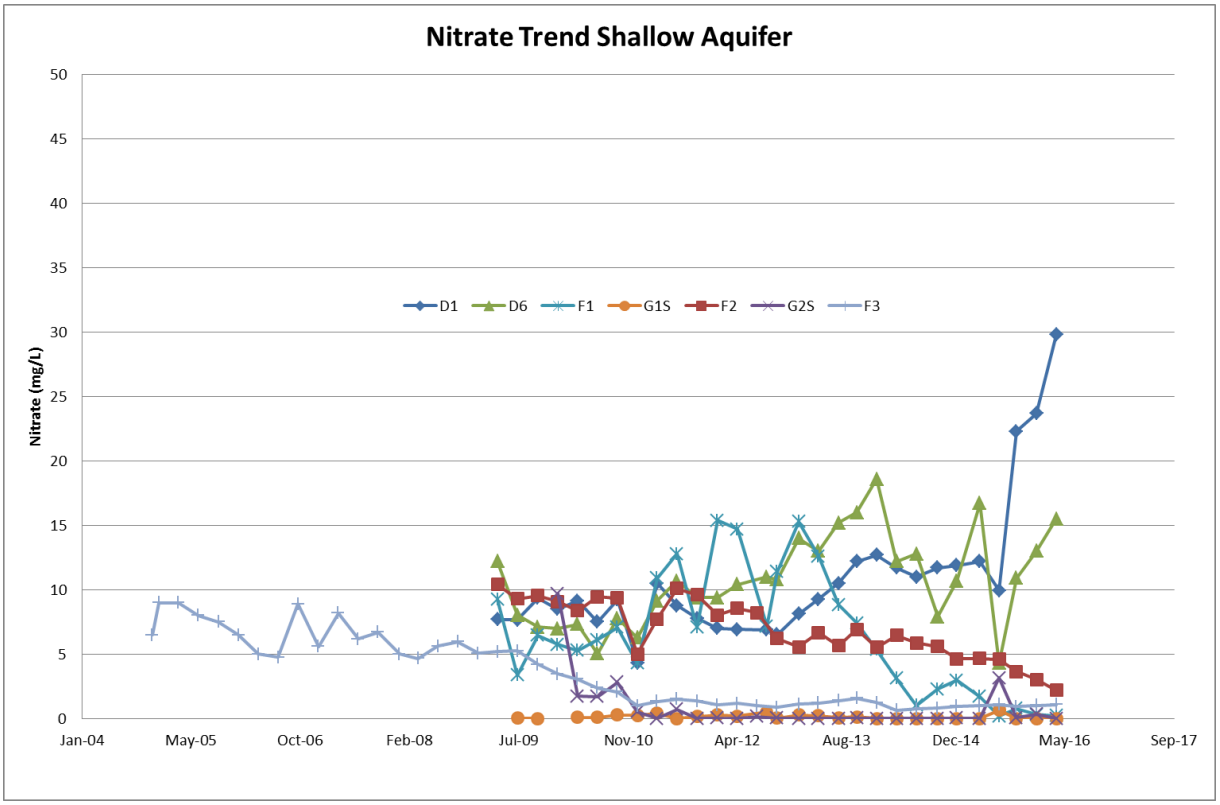
APPENDIX B

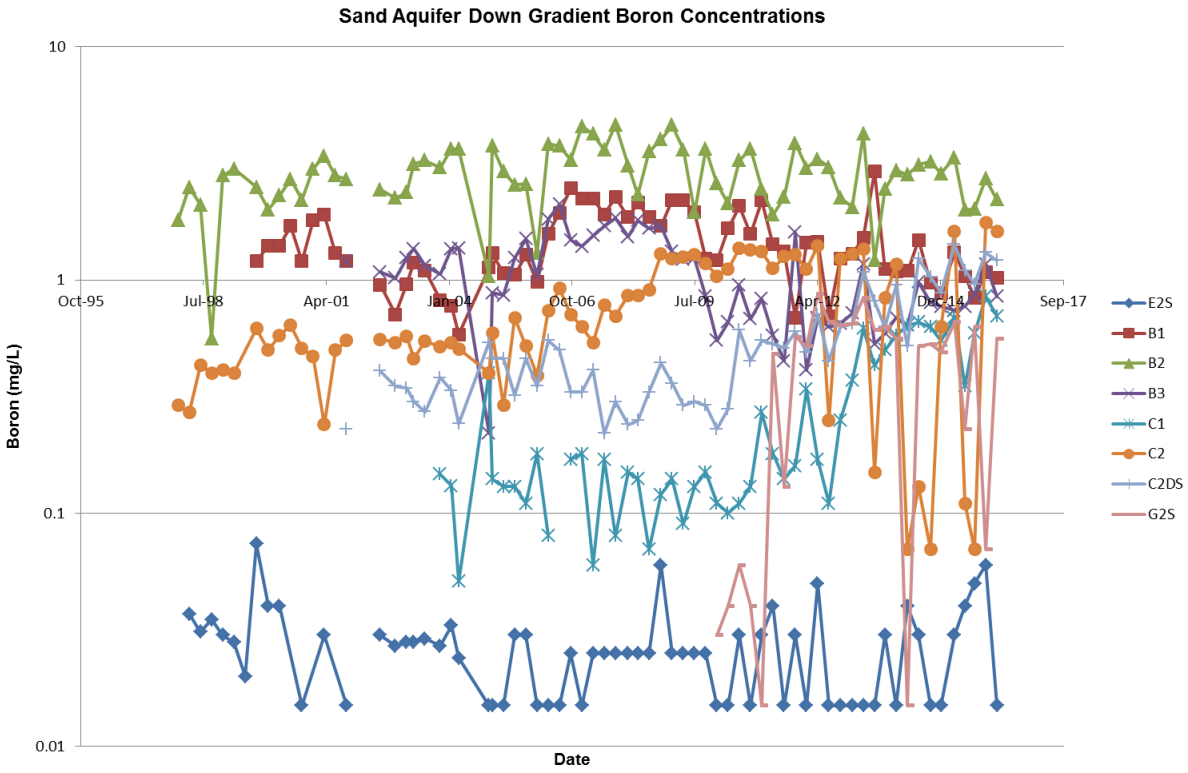
Well Depth Data

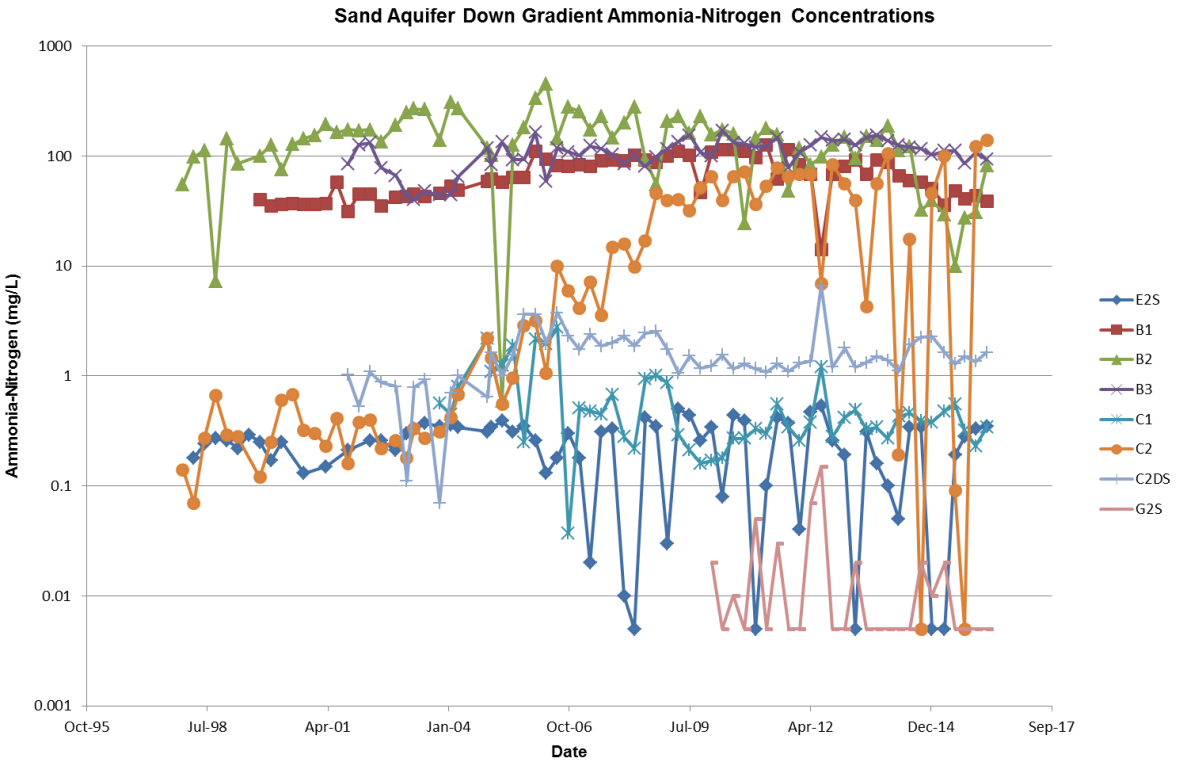
Cluster	Well	Elevation	Depth	Depth RL
Gravel Aqufier	E1D	20.91	37.8	-16.89
	C2DD	10.11	18.85	-8.74
	E2D	13.15	28.66	-15.51
	G1D	27	31.5	-4.5
Sand Aquifer Upgradient	G1S	24	15	9
	D1	27.46	23.69	3.77
	D2	32.12	29.46	2.66
	D3r	18	10	8
	D4	20.5	17	3.5
	D5	17.8	18	-0.2
	D6	26.41	16.07	10.34
	E1S	20.91	20.05	0.86
Sand Aquifer down-gradient	E2S	13.15	15.24	-2.09
	B1	9.04	4.3	4.74
	B2	9.42	3.5	5.92
	B3	7.76	2.83	4.93
	C2	7.5	2.81	4.69
	C2DS	10.13	12.88	-2.75
	G2S	8	4	4

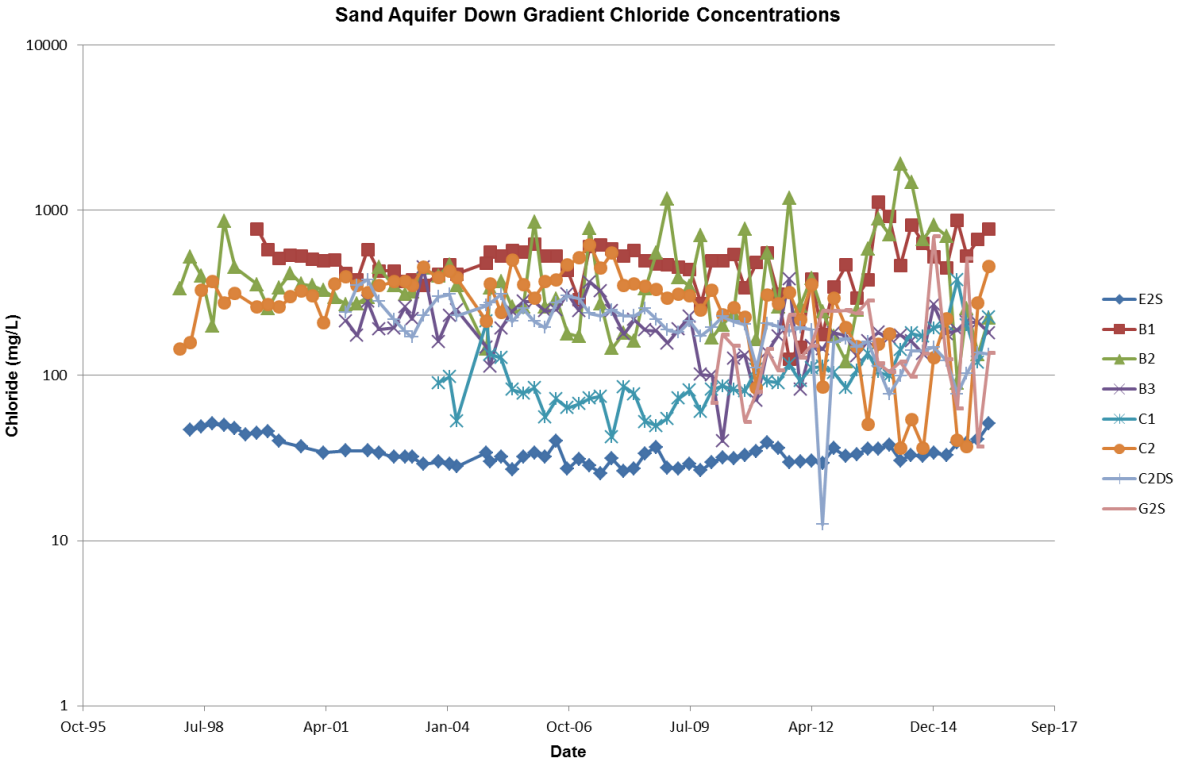
APPENDIX C

Groundwater Quality Graph






Sand Aquifer Down Gradient Ammonia-Nitrogen Concentrations
Ammonia-Nitrogen (mg/L)
1000
100
10
1
0.1
0.01
0.001
Oct-95
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Date
E2S
B1
B2
B3
C1
C2
C2DS
G2S


Sand Aquifer Down Gradient Chloride Concentrations
Chloride (mg/L)
10000
1000
100
10
1
Oct-95
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Date
E2S
B1
B2
B3
C1
C2
C2DS
G2S