Appendix K: Hydrogeology Report

REPORT

Omarunui Landfill Area B

Hydrogeological Assessment Report - For Notification

Prepared for
Hastings District Council
Prepared by
Tonkin & Taylor Ltd
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1 Introduction

Tonkin & Taylor Ltd (T+T) has been engaged by Hastings District Council (HDC) to provide engineering and planning inputs for the proposed development and operation of Area B (the site – refer Figure 1.1) of the Omarunui Landfill in Puketapu, Hawke's Bay. This report references[1] the results of the historical and recent geotechnical investigations and outlines the groundwater considerations and potential effects to be addressed during the development and operation of the proposed landfill extension.

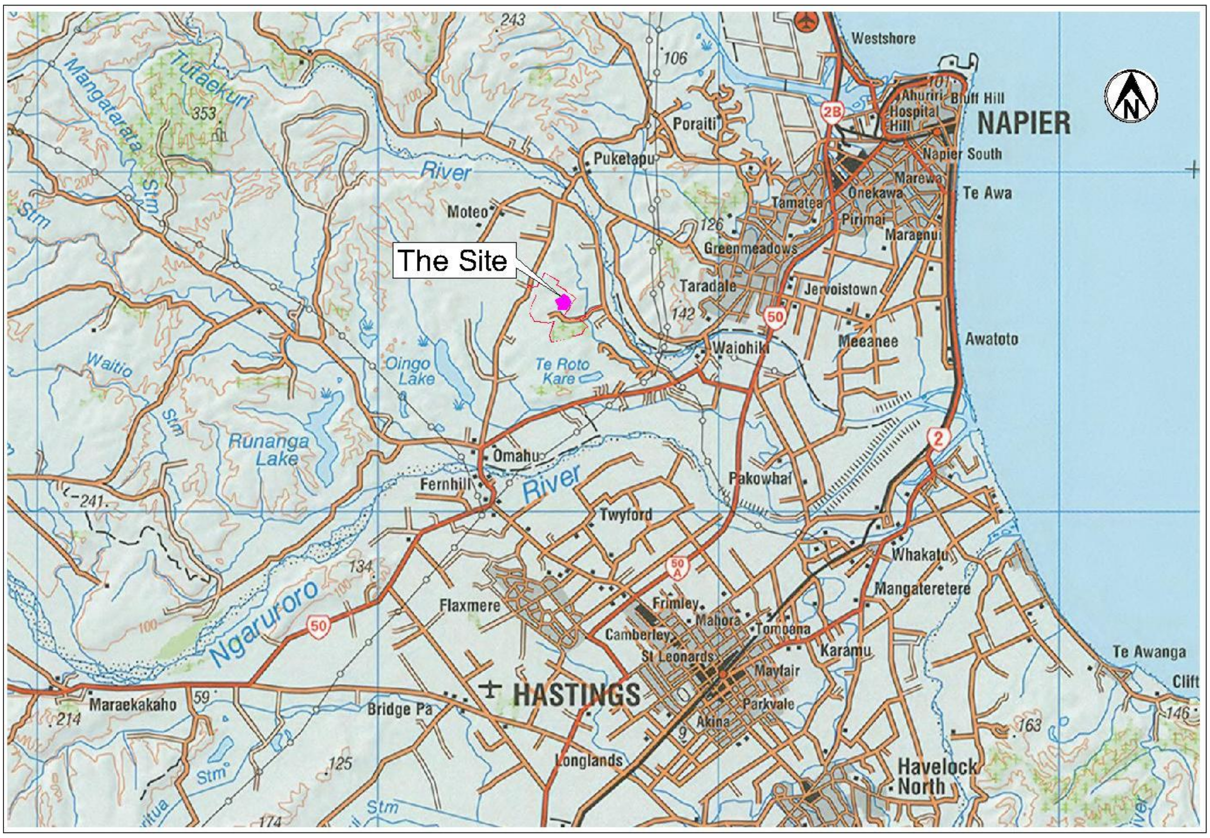

Figure 1.1: Site location in Hawkes Bay/Heretaunga Plains

T+T undertook geotechnical investigations in 2009 and 2018 to determine the geological and hydrogeological conditions of Area B at Omarunui Landfill. That work found that Area B is underlain by a sequence of shallow marine sandstones and limestones (Petane Formation) with deposits of colluvium and alluvium present on the slope margins and valley floors.

This report has been prepared to provide an assessment of potential groundwater effects that may result from the construction and operation of the landfill in Area B. This work identifies groundwater users downstream and other potential receptors, and the potential effects of the landfill on the identified receptors. This hydrogeological assessment report should be read in conjunction with the November 2018 geotechnical report.

[1] Hastings District Council, November 2018, *Omarunui Valley Landfill B – Geotechnical Report*, prepared by Tonkin & Taylor Ltd, reference 1000647.1000 v1.

The work has been undertaken in accordance with our proposal dated 16 November 2017[2] and Variation Order (VO1)[3] to support the Notice of Requirement (NoR) and resource consent applications for the development and operation of Area B.

1.1 Scope of works

The scope of works for this hydrogeological assessment includes:

- Observing the replacement of one existing well (BC7) to a location outside the proposed landfill footprint.
- Collection of continuous water level records for three months using automated level loggers. The installation and downloading of the loggers at six borehole locations was undertaken during site observations.
- Collection of two groundwater quality samples from six monitoring wells.
- Arranging a topographical survey of up to twelve wellhead elevations in Area B and the surrounding site to ensure accurate water levels can be measured.
- Brief review of HDC groundwater level and quality monitoring data from monitoring wells close to Area B.
- Obtain readily available borehole and groundwater take data from the regional council for locations within one kilometre of Area B.
- Data collation and analysis, including well details, water quality data, water level trends, rainfall data and river flow data.
- Preparation of this hydrogeological assessment report to support the Assessment of Effects on the Environment (AEE) report. This hydrogeological assessment includes:
  - A description of hydrogeological site investigations and the environmental setting,
  - A conceptual hydrogeological model for the site and immediately surrounding land,
  - A tabulation of the potentially affected downstream groundwater receptors, including existing commercial/irrigation takes and potable water supply takes,
  - High level evaluation of potential impacts to downstream receptors considering potential leachate leakage from the landfill lining system,
  - Evaluation of potential effects.

1.2 Proposed development

The proposed development of Area B will include:

- Bulk earthworks excavation[4]. Formation of the base grade will require extensive bulk excavation below existing ground levels undertaken sequentially as the early stages of the landfill in Area B are developed. Some sub-excavation of unsuitable soils will be required below the basegrade levels in some parts of the site.
- Construction of a toe bund at the northern end of the valley with a stormwater treatment pond downstream.
- Construction of a composite geosynthetic landfill lining system.
- Installation of leachate collection and pumping system and landfill gas collection system.

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[2] Tonkin & Taylor Ltd, 16 November 2017, Omarunui Landfill-Area B Consents, T+T Ref: 1000647.1000

[3] Tonkin & Taylor Ltd, 13 April, 2018. Omarunui Landfill Area B – Variation for additional geotechnical investigations and analysis, T+T Ref: 1000647.1000

[4] Tonkin & Taylor Ltd , November 2020, Omarunui Landfill Area B Engineering Report – For Notification, prepared for Hastings District Council Reference 1000647.1000.v3

- Filling in stages with refuse up to approximately RL80 m at the crest of Area B.
- Capping of the landfill with a soil capping system.

2 Regional hydrogeological overview

2.1 Introduction

The Omarunui Landfill (the landfill) is situated approximately 10 km south-west of Napier and approximately 10 km north-west of Hastings in the Hawkes Bay region. 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[5].

The area surrounding the landfill comprises the foothills at the northern edge of the Heretaunga Plains adjacent to the current course of the Tutaekuri River. The Tutaekuri River originates within the Kaweka range to the north-west and flows toward the south-east. At Puketapu the river is bounded by the foothills to the east and flows in a generally southerly direction past the landfill before bending east around the hills and continuing its flow eastward. To the west and south of Puketapu and the landfill is an infilled valley (Moteo Valley), which is believed to be a historical flow path of the Tutaekuri River. The river discharges into Hawke's Bay at the same outlet as the Clive and Ngaruroro Rivers.

2.2 Climate

The Hawke's Bay region has a generally temperate climate with approximately 2,100 to 2,200 sunshine hours annually. Mean rainfall on the Heretaunga Plains is approximately 800 mm/year with the inland mountain ranges receiving 1,600 to 2,400 mm/year[6]. Higher evaporation rates during summer results in reduced rainfall infiltration rates.

Climate data relevant to the Area B site is available from the Virtual Climate Station Network (VCSN)[7]. The VCSN data are estimates of daily rainfall, potential evapotranspiration, air and vapour pressure, maximum and minimum air temperature, soil temperature, relative humidity, solar radiation, wind speed and soil moisture on a regular (~5 km) grid covering the whole of New Zealand. The estimates are produced every day, based on the spatial interpolation of actual data observations made at climate stations located around the country.

The nearest VCSN station to the site is located at or about NZTM 1924499E 5618152N in the northern half of the Moteo Valley. The rainfall data from the station shows that the mean annual rainfall for the period 1960 – 2017 (inclusive) is 866 mm/year ranging from a minimum of 510 mm in 1994 to 1419 mm in 1971. The mean monthly rainfalls for the same period vary from 51 mm to 99 mm.

2.3 Published geology

The published regional geology[8] of the area indicates that the foothills, on which the site is located, comprise alternating mudstone, sandstone, conglomerate and limestone beds of the Petane Formation (Pmn), refer Figure 2.1 below. Subsequent erosion, faulting and infilling has resulted in

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[5] Dravid, P.N., Brown, L.J. (1997). Heretaunga Plains Groundwater study: Volume 1 Findings. Geological and Nuclear Sciences.

[6] Kerryn Pollock, 'Hawke's Bay region - Landscape and climate', Te Ara - the Encyclopedia of New Zealand, http://www.TeAra.govt.nz/en/hawkes-bay-region/page-2 (accessed 15 October 2018)

[7] https://www.niwa.co.nz/climate/our-services/virtual-climate-stations

[8] Lee, J.M; Bland, K.J; Townshend, D.B; Kamp, P.J.J. (compilers) 2001, Geology of the Hawkes Bay area, Institute of Geological and Nuclear Sciences 1:250 000 geological map 9.1 sheet +93 p. lower Hutt, New Zealand

the formation of alluvial basins and flat bottomed valleys, such as that of the Moteo Valley and the current course of the Tutaekuri River.

The Moteo Valley and Tutaekuri River flood plain is indicated to consist of gravel, sand, silt and mud deposits (Q1a). These deposits are understood to be derived from infilling by the historical and current courses of the Tutaekuri River and overlie the underlying bedrock and older sediment deposits. The way in which these deposits have been laid has resulted in a sequence of coarser and finer grained layers.

There are several large fault traces within 10km of the site. The Awanui Fault (red dashed line trending from the south-west to the north-east) is the only one indicated to be currently active and is located approximately 6 km south-east of the site.

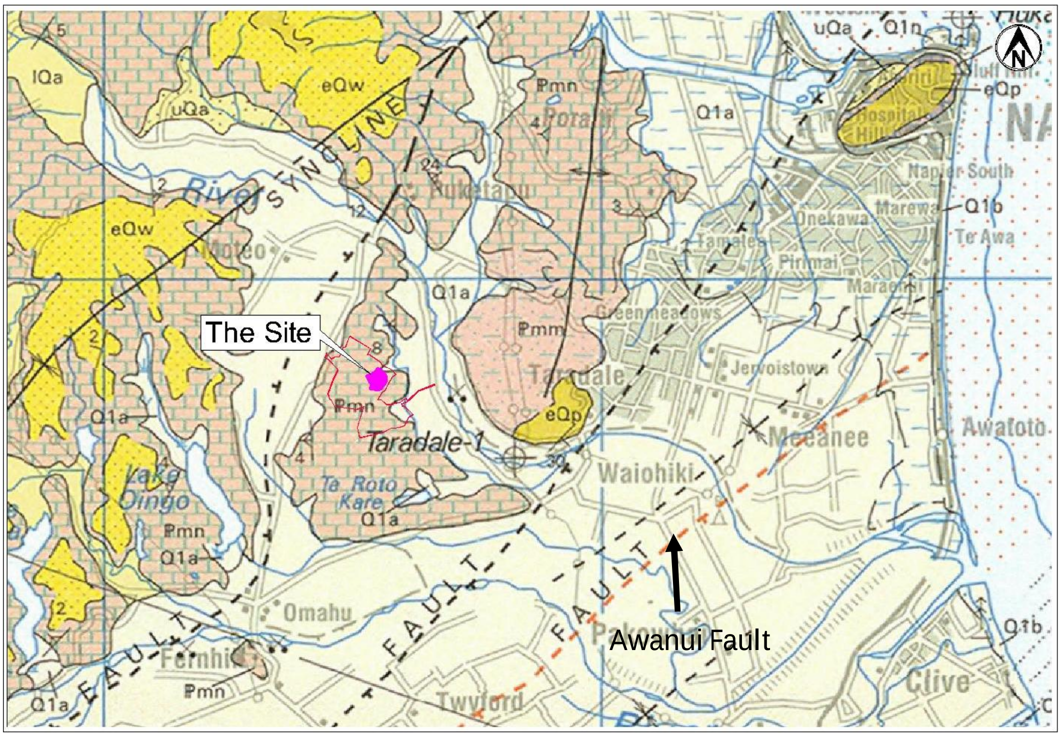

Figure 2.1: Published geological map of Omarunui Landfill site[8].

2.4 Groundwater and surface water

The layered deposition of 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 site.

Previous reporting by Hawke's Bay Regional Council (HBRC)[9] presents groundwater contours based on piezometric groundwater data for the river deposits in the Moteo Valley and Tutaekuri flood plain and is presented in Figure 2.2 below. The contours were prepared using data collected during February 1995 supplemented by data collected during December 2014. The contours were developed using a method available in ArcMap software which allows for contouring with

[9] Hawkes Bay Regional Council, 2018. Heretaunga Aquifer groundwater model: Development report. HBRC report No. RM18-14

boundaries (e.g. no contours are shown through the elevated Petane Formation bedrock on which the site is located).

The groundwater contours indicate regional groundwater flow is typically from north-west to south-east. While the presented contours are not extrapolated through the Petane Formation, the groundwater levels between the Moteo Valley and Tutaekuri gravel fan are relatively consistent. Any level and flow direction variation between the two may reflect the permeability[10] difference between the river deposits and the Petane Formation, i.e. it is possible to interpret the presented contours as showing groundwater flow through the bedrock.

The Tutaekuri River has an estimated naturalised mean annual low flow (MALF) at Puketapu of 3.9 m^3/s with a reported median flow of 8 m^3/s[11]. There are notable 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 the order of 0.82 m^3/s[12].

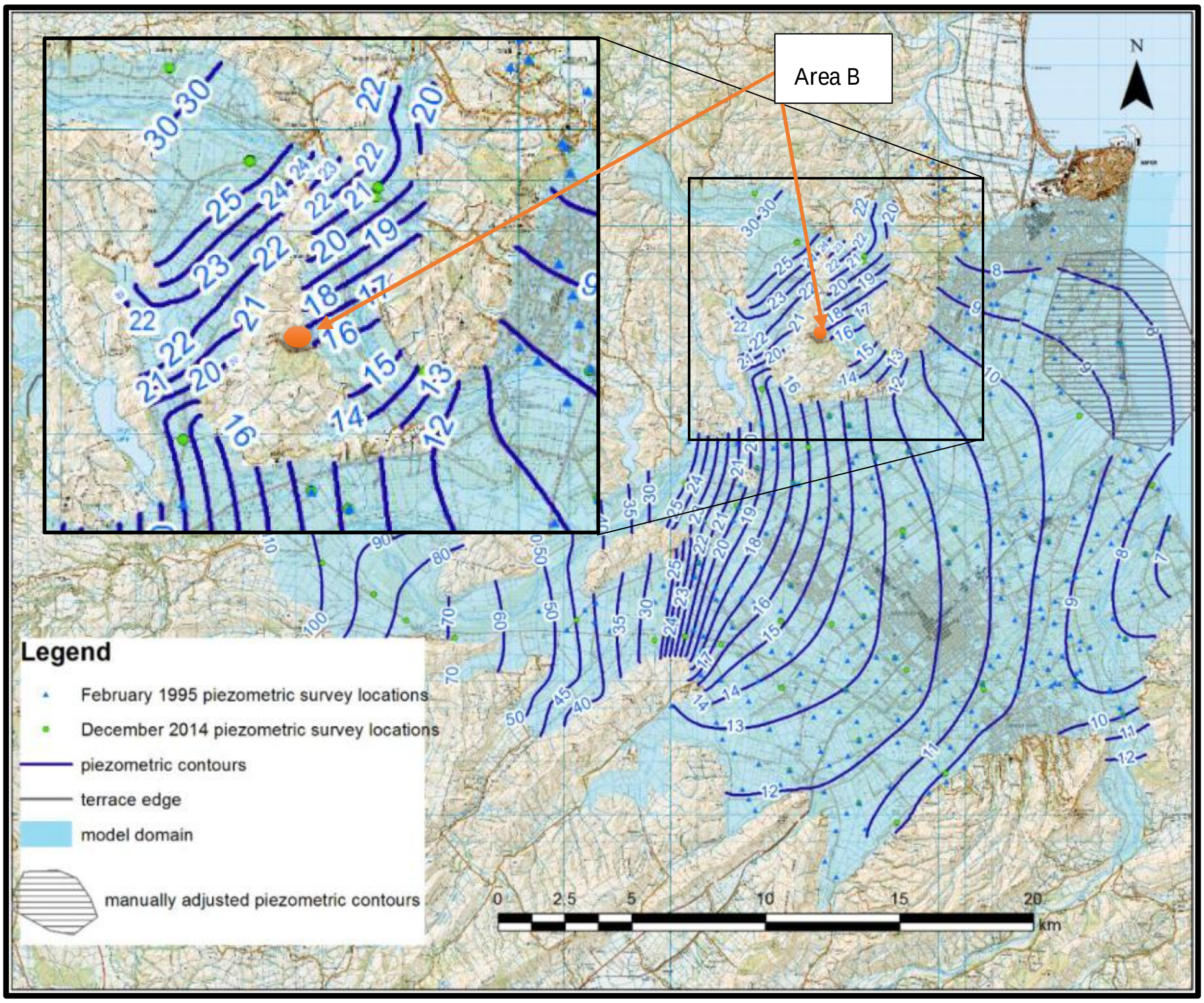

Figure 2.2: Groundwater levels across the Heretaunga Plains (HBRC, 2018), enlargement shows area of interest and relevant to this reporting.

[10] Although not technically accurate we have used the term permeability in place of the term hydraulic conductivity in general accordance with current practice throughout this report

[11] Hawkes Bay Regional Council, April 2018. Addendum to fish habitat modelling for the Ngaruroro and Tutaekuri Rivers, HBRC Report No. 4990-RM18-09.

[12] Hawkes Bay Regional Council, 2018. Heretaunga Springs: Gains and losses of stream flow to the groundwater of the Heretaunga Plains. HBRC report No. RW18-13- 4996.

2.4.1 Water use

A review of the available information related to the groundwater take consents[13] within the Moteo Valley and Tutaekuri flood plains indicates that both groundwater and surface water is extensively used. Use of groundwater and surface water is indicated to be used primarily for irrigation purposes but also for uses such as frost protection, wash down purposes and domestic water supply.

The main surface water sources comprise open drains/swales within the Moteo Valley. There is also the Upokohino Stream, which runs along the base of the hills to the east of the site, which follows a similar path to that of the Tutaekuri River and is shown on Figure 1 attached in Appendix A. The head of the stream is located to the north of the site at the base of a gully.

A review of the consented wells and consented water takes presented on the HBRC online GIS system indicates that there are 27 consented water takes within an approximate 2 km radius of the site. Consented wells are presented on Figure 2, with consented water takes presented on Figure 3, attached in Appendix A. A brief review of the well logs indicates that they vary in depths from a few metres to greater than 50 m.

The reviewed 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 also indicated to lie within the underlying bedrock aquifer.

3 Site specific overview

3.1 Topography

Area B, located within the overall Omarunui Landfill, (refer Figures 1000647.1000-03, and -04, Appendix A), comprises a series of steep narrow gullies in a larger broad valley within the north eastern portion of the landfill site. Area B comprises a valley surrounded by ridgelines on the western, southern and eastern sides of the valley. The valley opens up toward the north onto the flood plains of the Tutaekuri River.

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 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.

Several surface water ponds are observed on aerial photography within the gully floors as well as at the valley heads. The ponds in the valley heads in Area B are sediment ponds for the cut areas above. It is possible that these ponds are supporting groundwater seeps from rock exposures in elevated parts of the site. However at lower elevations we 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.

3.2 Previous investigations

A series of previous geotechnical investigation works have been undertaken across and adjacent to Area B. The extent of the previous investigations is detailed within the T+T geotechnical report for Area B[14]. Drawing No. 1000647.1000-03 presents the locations of the investigations undertaken.

In summary, the investigations comprised a series of cone penetrometer tests, test pits and machined boreholes across the extent of Area B. The purpose of the investigations was to confirm the underlying ground conditions and to assist with landfill design. A number of piezometers have

13 Hawkes Bay Regional Council, 2018. GIS viewer.
14 Tonkin & Taylor Ltd, November 2018. Omarunui Landfill Valley B – Geotechnical Report (T+T ref: 1000647.1000)

also been installed during the course of the investigations to monitor groundwater levels and assist in the development of the groundwater model for the site. In situ testing within the piezometers has also been undertaken to characterise the permeability of the materials in which they are screened to help refine the hydrogeological model.

3.3 Geology

The geology underlying Area B is explained in greater detail within the T+T geotechnical report.

In summary, the higher topography within Area B consists of rock comprising interbedded and interfingering limestone (LST), siltstone and sandstone (SST) beds. The valley floor consists of alluvium and is indicated to be up to 9 m in thickness, comprising sandy organic silts and silty sands. Near the base of the gully slopes is a layer of colluvium comprising reworked weathered sandstone and loess with minor boulder-sized limestone blocks.

The surficial geology within Area B has been mapped as part of the T+T geotechnical report, this has been attached as drawing No. 1000647.1000-04 within Appendix A.

3.4 Groundwater levels and monitoring

Groundwater levels in selected wells within Area B have been continuously monitored since 6 June 2018 to using automated unvented Leveloggers. Barometric data was also collected and used to compensate Levelogger data for atmospheric pressure fluctuations.

Manual dipping of water levels was also undertaken in August 2018 and June 2020 to calibrate the water level data collected on the Leveloggers. A summary of the manual groundwater levels are presented in Table 3.1 below. The locations at which groundwater levels have been measured are presented on drawing No. 1000647.1000-03, attached in Appendix A.

Table 3.1: Manually dipped groundwater levels.

Monitoring well	29/30 August 2018		15 June 2020	
	Water level (BTOC)	Water level (RL m)	Water level (BTOC)	Water level (RL m)
BC5	56.395	20.105	56.63	19.87
BC6	3.342	20.168	3.56	19.95
BC7A	21.826	36.824	Not located	
BC9	50.398	22.292	50.57	22.12
BC10	58.214	21.316	58.35	21.18
BH10	37.972	20.085	38.21	19.85
BC14	58.002	25.988	58.29	25.70
BH9	60.574	21.275	Not measured, as 60 m dipper ended above water level	
BH11	24.885	19.933	25.14	19.68

Note: BTOC = below top of casing

The complete details regarding time/dates of manual dips are attached in Appendix B. Continual groundwater monitoring data have been plotted to demonstrate variation in groundwater levels during the monitoring period and are attached in Appendix B.

The groundwater level monitoring data indicates that groundwater within the underlying sandstone/limestone rock is typically at elevations of between approximately 20 and 26 mRL. On the basis of these levels our assessment is that the aquifer system is unconfined or semi-confined.

The monitoring of groundwater levels within well BC7A indicates that there is potentially a perched groundwater table located within the sandstone/limestone rock at around 37 m RL. Considering that there is a steep hydraulic gradient between BC7A and other monitoring wells our assessment is that there is a perched groundwater table in the screened limestone and sandstone zone. While it is possible that this perched groundwater table is supported by rainfall recharge over the fill area in which BC7A is constructed CPT tests indicate[14] that the fill is dry and the perched water is within the rock mass. On this basis we have inferred that the nearby sediment pond (located to the east) supports the perched groundwater level.

3.5 Permeability testing

Testing within the rock underlying Area B has been undertaken in order to characterise the permeability of the materials. Testing was undertaken in May 2009 and also during 2018 comprising both packer and 'slug' testing. The testing is reported fully within the T+T geotechnical report. Although not technically accurate, we have used the term permeability in place of hydraulic conductivity in general accordance with current practice throughout this report.

The permeability testing results from the T+T geotechnical report are summarised in Table 3.2 and Table 3.3 below.

Table 3.2: Summary of slug test data

Borehole	Screened Interval (m bgl)	Lithology tested	Permeability (Hvorslev) (K) (m/s)	Permeability (Hvorslev) (K) (m/d)	Permeability (Bouwer-Rice) (K) (m/s)	Permeability (Bouwer-Rice) (K) (m/d)
BC6 (2009)	7 – 10	LST/SST	8.6×10^{-5}	7.4×10^{0}	6.6×10^{-5}	5.7×10^{0}
BC7* (2009)	37.5-43.5	SST	5.0×10^{-5}	4.3×10^{0}	5.0×10^{-5}	4.3×10^{0}
BC9 (2009)*	50-56	SST	5.0×10^{-5}	4.3×10^{0}	5.0×10^{-5}	4.3×10^{0}
BC7A (2018)**	24.8-27.8	LST/SST	-	-	3.2×10^{-8}	2.8×10^{-3}
BC9 (2018) Falling head	50-56	SST	-	-	2.66×10^{-7}	2.3×10^{-2}
BC9 (2018) Rising head	50-56	SST	-	-	6.8×10^{-7}	5.9×10^{-2}
BC10 (2018)	56-59	SST	-	-	2.66×10^{-6}	2.3×10^{-1}

Note: * Permeability inferred based on speed of recovery to static groundwater level.

** Above regional water table. Groundwater level considered to be controlled by nearby sediment pond at same level and/or by rainfall recharge through overlying fill.

Table 3.3: Summary of packer test data

Borehole	Final Depth (m)	Test Interval (m bgl)	Test Interval (m RL)	Lithology tested	Permeability (k) (m/s)
BC5 (2009)	60	5.2 - 7.0	70.4 - 72.2	5.2-6.0m LST; 6.0-7.0m SST	7.52×10^{-6}
BC8 (2009)	38.5	25.2 - 27.0	24.3 - 26.1	5.2-5.4m SST; 5.4-7.0 LST	6.54×10^{-7}

The rock permeability at the site is strongly influenced by the variably cemented and fractured limestone and sandstone. It is expected that within the sequence there is likely to be strong contrast between vertical and horizontal permeability, especially where uncemented sands and/or fractured limestone beds occur within a layered sequence of less permeable silty sandstone and/or siltstone. Furthermore, rock mass permeability can be expected to be one to two orders of magnitude higher where interconnected dissolution cavities are present within limestone units or within the uncemented sand lenses.

In summary, the permeability testing undertaken has indicated that the overall in situ rock mass permeability in the limestone units or clean sandstone ranges between 3×10^{-6} to 7×10^{-7} m/s e.g. at BC9 and BC10. We have not used the 2009 records for BC7 and BC9 because these wells are deep and were measured by hand, whereas the monitoring in 2018 was undertaken with automated data loggers. The higher permeability (reported as 8.6×10^{-5} m/s at BC6, a shallow monitoring well) may reflect the effect of the fine-grained material.

For the purposes of our assessment we have calculated the geometric mean of the Bouwer-Rice permeability reported in Table 3.2. The calculated permeability is 0.27 m/day or 3.1×10^{-6} m/s for the unconfined bedrock aquifer. However at the proposed toe of the landfill we consider that it is appropriate to use the hydraulic conductivity of 8.6×10^{-5} m/s measured at BC6 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 for further details).

3.6 Groundwater quality

3.6.1 Sampling

Groundwater quality sampling has been undertaken within the monitoring wells located around Area B. Groundwater samples were collected by a variety of methods as the sampled groundwater is so far below ground. The sampling methods involved the use of bladder pumps, bailers and proprietary sampling devices known as Hydrasleeves. Samples were collected into laboratory provided sampling bottles and transported in a chilled container to Hill Laboratories for testing. The sample locations and collection dates are summarised in Table 3.4 below.

Table 3.4: Summary of groundwater samples collected

Well Sampled	Date sampled				
	26 April 2018	27 April 2018	6 June 2018	29 August 2018	30 August 2018
BC5		✓		✓	
BC6	✓				✓
BC7A	✓			✓	
BC9		✓		✓	
BC10			✓		✓
BH10		✓		✓	
BC14			✓	✓	

3.6.2 Testing

Groundwater sample analysis was undertaken by Hill Laboratories, an IANZ accredited laboratory. The groundwater samples were tested against a suite of determinands and concentrations were evaluated against the Drinking-water Standards for New Zealand (DWSNZ)[15] as well as the ANZECC (2000) 95% guideline trigger values[16] for freshwater species.

The ANZECC (2000) 95% guideline trigger values were initially adopted based on the description provided within the guideline document Technical Guidelines for Disposal to Land[17] (referred to as the WasteMINZ Technical Guidelines) which was issued in 2018. Appendix K of the guidelines sets out a description of the guideline protection values as follows: -

"The ANZECC 2000 guidelines provide values for 80%, 90%, 95% and 99% protection levels. The level of modification of the surrounding environment will determine the protection level used. A 99% protection level is appropriate for highly pristine, unmodified ecosystems, while 80% protection level is appropriate for highly modified environments with little ecological significance or value (again not often used). The most common guideline level used is 95% protection level which is suitable for modified ecosystems". On this basis the 95% protection level was adopted. However, further assessments in this report and future groundwater quality monitoring and compliance will be assessed against the ANZG (2018)[18] guideline values.

A copy of the laboratory transcripts for each of the groundwater samples analysed is attached in Appendix C.

3.6.3 Results

Based on the results provided by Hill Laboratories, exceedances in the DWSNZ and ANZECC guideline values were observed at some of the sampled locations. The exceedances measured are presented within Table 3.5 below. We have also identified a number of unexpected organic contaminants that were detected above the laboratory limit of detection. These are summarised in Table 3.6 with a

[15] Ministry of Health, 2008. Drinking-water Standards for New Zealand 2005 (Revised 2008).
[16] 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
[17] Appendix K (Landfill Monitoring) from Technical Guidelines for Disposal to Land Appendices Waste Management Institute New Zealand (WasteMINZ), August 2018.
[18] ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia.

comment about the relevant ANZG 95% guideline value. The full tabulated results are provided with the laboratory transcripts in Appendix C.

Table 3.5: Summary of measured exceedances April – August 2018

Determinand (units shown in brackets)	Well ID/sample date	Measurement	NZDWS (2008)	ANZECC 2000 95% guideline value (freshwater species)
pH (pH units)	BC7A (April)	6.9	7.0-8.5[2]	N/A N.B. Not defined ANZG
	BC10 (June)	6.7		
	BC7A (August)	6.6		
	BC10 (August)	6.8		
Nitrate (g/m^3)	BC6 (April)	7.3	11.3[1]	7.2[3] (Refer note, now 2.4[3])
	BH10 (April)	11.7		
	BH10 (August)	11.0		
Dissolved Iron (g/m^3)	BC10 (June)	3.4	0.2[2]	0.3 N.B. Not defined ANZG
	BC10 (August)	18.7		
	BC14 (June)	1.7		
	BC14 (August)	0.3		
Dissolved Copper (g/m^3)	BC7A (April)	0.0082	2.0[1]	0.0014 N.B. Same value for ANZG
	BH10 (April)	0.0016		
	BC10 (June)	0.006		
	BC10 (August)	0.0024		
	BC14 (June)	0.008		
Dissolved Zinc (g/m^3)	BC7A (April)	0.142	1.5[2]	0.008 N.B. Same value for ANZG
	BH10 (April)	0.022		
	BC10 (June)	0.022		
	BC14 (June)	0.034		
Dissolved Manganese (g/m^3)	BC10 (June)	0.83	0.4[1]	1.9 N.B. Same value for ANZG
	BC14 (June)	0.44		
	BC10 (August)	1.93		
	BC14 (August)	0.6		
Dissolved Arsenic (g/m^3)	BC10 (June)	0.012	0.01[1]	0.013* N.B. Same value for ANZG
	BC10 (August)	0.0175		

* Value is indicative of Arsenic (AsV) guideline value, AsIII guideline value (0.024 g/m^3) not exceeded.

[1] Indicates Maximum Acceptable Value (MAV).

[2] Indicates Guideline Value (GV).

[3] Updated nitrate guideline values prepared by Chris Hickey, NIWA, 30 September 2002, Reference MFE0237. Further updated by Hickey, C. W., January 2013, *Updating nitrate toxicity effects on freshwater aquatic species*, prepared by NIWA for MBIE, which provides an ANZG 95% guideline value of 2.4 g/m^3

[4] Note that total hardness (when measured) exceedances are not reported in this table as only BC6 sample in June was below NZDWS.

Table 3.6: Summary of unexpected contaminants detected April – August 2018

Determinand exceeded	Well ID/sample date	Concentration of determinand (g/m^3))	Lowest laboratory detection limit (g/m^3)
Total Volatile Fatty Acids (VFA)	BC10 (August)	280	5.0
3 & 4-Methylphenol (m- + p-cresol)	BC10 (August)	0.04	0.001
Toluene	BC10 (August)	0.0005	0.0003
m & p-Xylene	BC10 (August)	0.0006	0.0005
Carbon disulphide	BC10 (August)	0.0016	0.0005

3.6.4 Discussion

The values of pH reported in samples from BC7A and BC10, which were below the range of NZDWS guideline values (7.0 to 8.5), may indicate the source of groundwater for these two wells is different from other monitoring wells on the site. It is possible that these lower pH values may indicate areas where the groundwater pH may be strongly influenced by direct rainfall infiltration, which has been reported as having a pH of 5.6 if saturated with CO_2[19].

Our evaluation is that the nitrate exceedances of both the NZDWS MAV and ANZECC trigger level in samples from BC6 and BH10, may result from the effects of surface infiltration (e.g. potential fertiliser use). Based on the August 2018 groundwater level contours, the locations of these wells is such that the source of groundwater may originate from the east or the west (refer Section 4.2 and Figure 4, Appendix A). We note that the BC6 nitrate exceedance above the ANZECC guideline is marginal. The groundwater from the vicinity of BC6 may require further testing before discharge as part of proposed dewatering activities.

Elevated concentrations of the metals iron, manganese, and arsenic exceed both NZDWS and ANZECC trigger values in wells BC10 and BC14 (N.B. arsenic not exceeded at BC14). These elevated concentrations may be naturally occurring as a result of natural groundwater conditions or alternatively indicating influence from nearby farming/ horticultural activities. In view of the elevated arsenic concentrations and the regional council evaluation of other similar arsenic exceedances (e.g. at nearby Breckenridge[20]) our assessment is that the arsenic exceedances are a result of natural processes.

The elevated concentrations of copper and zinc, which exceed ANZECC trigger levels at BC7A, BH10, BC10, and BC14 are well below the NZDWS MAV and GV, respectively. It's possible that these elevated concentrations may reflect naturally occurring groundwater quality.

With the exception of BC6 (August 2018) sample exceedances outside relevant trigger values (NZDWS and ANZECC 2000 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.

There were several unexpected contaminants detected in the sample from BC10. The measured levels of volatile fatty acids (VFA), methyl phenol (m+p cresol), toluene, xylene, and carbon disulphide are typically found to be from manufactured sources though it is noted that

[19] Building Research Association of New Zealand, October 1984, Atmospheric Corrosion in New Zealand, prepared by J R Duncan.
[20] Accessed 5 April 2019, https://www.hbrc.govt.nz/services/water-management/bore-security/arsenic-concentrations/?url=/services/water/bore-security/arsenic-concentrations/

methylphenol and carbon disulphide can occur naturally. The presence of these contaminants is considered unlikely to be from a single common source. Toluene and xylene can be found together as a result of petrol releases but the cresol and carbon disulphide are not. Instead, these contaminants are associated with a wider range of industrial sources. The VFA is typically associated with a biological source e.g. municipal or other wastewater.

Other potential reasons to explain the presence of the unexpected contamination include:

- Cross contamination during sampling.
- Cross contamination at the laboratory.
- Contamination as a result of discharge of leachate to groundwater from Area A.
- Contamination as a result of off-site discharges.

We have enquired with the laboratory and field sampling staff and consider that the contamination reflects the groundwater quality near this location. Our contaminated land staff consider that m+p cresol and carbon disulphide are not substances that would occur as a result of cross contamination during normal groundwater sampling procedures on a largely greenfield site. Accordingly we have excluded cross-contamination, either in the field or the laboratory, as a source of the unexpected contaminants.

Retrolens aerial photography was available for the period 1949 to 1996. Aerial photography was available for the period 2003 – 2019 in Google Earth Pro. Each aerial photo was reviewed to assess land use in the footprint of landfill Area B and surrounds. From 1949 to 1987, Area B is open grazing farmland. Farm ponds and tracks are evident within Area B and adjacent land. Land use between the Upokohino Stream and the Tutaekuri River is horticulture as it is currently. The quarrying associated with the Area B footprint is first evident in the 1994 aerial photograph. Quarrying has continued and evidence of that may be seen up to the most recent (2019) aerial photograph.

We note that quarry operations include refuelling of vehicles which if there was a release, could explain some of the contaminants encountered (i.e. toluene, m&p xylene). However, given that the quarry area has been subject to both removal of materials and placement of fill, it is also possible that e.g. waste materials have been placed and are responsible for the observed trace levels of contamination. Of note, the detected concentrations at BC10 of VFA, methylphenol, toluene, xylene, and carbon disulphide are well below the relevant ANZECC (and ANZG) trigger values and NZDWS maximum acceptable or guideline values.

The 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. These differences support our recommendation for a minimum of a year’s baseline monitoring before landfilling commences in Area B.

4 Conceptual hydrogeological model

Our conceptual hydrogeological model has been developed based on the information available within published articles as well as interpretation of the investigation and monitoring data collected within Area B.

An illustrated conceptual hydrogeological model is presented as Sketch 1 attached in Appendix A. Relevant components of the hydrogeological model are presented within the following sections.

In summary the aquifer system beneath site comprises:-

- Regional water table at about 19 to 25 m RL, and
- Perched groundwater seeps at higher elevations (e.g. at around 37 mRL at BC7A).

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

- The adjacent sediment pond.
- Rainfall on the overlying fill material.
- Rainfall on the dipping rock outcrop located at a higher level.

Where these groundwater seeps are currently observed our view is that as potential recharge sources are removed and covered by landfill liner the seeps will no longer occur. As the landfill is completed at Area B our assessment is that groundwater flow direction will depend on the effect of recharge over higher ground and the effect of the regional water table. While the regional water table is likely to exist at around 18 to 23 mRL and flowing in a south-easterly direction the effect of the higher ground east of Area B will continue to support groundwater flows to the west and northwest beneath Area B.

4.1 Geology

The investigation data generally confirms the published geology for Area B, which predominantly comprises interbedded limestone, sandstone and siltstone rock. The valley floor has been infilled by alluvium and colluvium materials which form a layer over the underlying rock.

4.2 Groundwater levels and flow direction

Groundwater surface contours have been developed from groundwater monitoring information collected for annual consent compliance monitoring[21], and the additional groundwater monitoring undertaken for Area B. Contours have been developed in ArcGIS using ordinary kriging with default variograms and a cell size of 25 m. The kriged fields have then been contoured to 0.5 m intervals.

Contour plans were prepared for July 2018, with and without compliance monitoring results. In addition to this, contours of compliance monitoring results for April 2010 and January 2020 were also prepared to confirm whether there is seasonal variation in the groundwater levels. Based on these plans, there is no unexpected change in groundwater flow direction beneath Area B. A copy of these contour plans is attached in Appendix A.

Based on the contour plans and monitoring data, the groundwater surface appears highest (20 to 21 mRL) around MW BH-8 and MW BH-9, as well as close to MW BH-11 (19.5 to 20 mRL). Groundwater is expected to flow to the southwest towards MW BH-12, which is consistently the lowest groundwater level measured in the data (~18.5 mRL). The combined compliance and Area B monitoring well contours indicate that the highest point of the groundwater surface is at BC14 (24 mRL), close to the eastern site boundary. The contours indicate that groundwater flows radially out from this point. A weak groundwater divide may be inferred approximately along a line between MW BH-11 and MW BH-9, with groundwater flowing either southwest or potentially northeast along this divide.

[21] Omarunui Landfill – Environmental Monitoring Annual Report 2019. Prepared for Hastings District Council November 2019 by Stantec.

The contours indicate that the groundwater regime is generally stable beneath the overall Omarunui landfill site, with some minor seasonal variation. The groundwater flow regime appears to be controlled by the topography of the site. The groundwater surface roughly follows the topography, with highest groundwater elevations corresponding with topographical high points and groundwater flow directions towards topographical lows, including close to MW BH-12 and the valley floor that extends west from BC6.

While groundwater levels vary seasonally and annually, e.g. just over 20 mRL at MW BH-8 in April 2010 and approximately 21.5 mRL at the same location in January 2020, the groundwater flow direction has stayed relatively constant.

Based on the monitored and measured groundwater levels the alluvium and colluvium is not considered to form an impermeable layer/low permeability infiltration barrier. Groundwater levels recorded within the alluvium during the investigations indicate groundwater levels lie at or close to the alluvium/rock interface. We have inferred that the alluvium and underlying rock form an unconfined aquifer system within Area B. Plotted groundwater contours based on 29/30 August 2018 groundwater levels are presented on Figure 4 attached in Appendix A. We provide further discussion of groundwater levels in the alluvial system associated with the Tutaekuri River to the east and west of the Omarunui landfill in section 4.3 (below).

Groundwater flow within the aquifer is generally towards the west beneath Area B. The groundwater contours also indicate a potential groundwater flow from the vicinity of BH9, beneath the existing Area A landfill, to the east toward Area B (Refer Figure 4, Appendix A). To the west of Area B the groundwater levels appear to form a plateau before rising up toward BH9. On this basis and considering the measurements taken on 29/30 August 2018, groundwater to the west of Area B (i.e. in the vicinity of BH10) is expected to flow predominantly toward the south, although it is possible that flow to the north east may also occur from the vicinity of BC5, depending on groundwater levels.

A potential weak groundwater divide was observed from the groundwater level readings in August 2018 between BH9, BC5, and BC14. Groundwater to the north of the divide is interpreted as flowing to the north west beneath Area B and then north/north east towards the Upokohino Stream after mixing with groundwater from beneath Area A, with groundwater to the south of this boundary flowing to the west beneath Area B but south/south west when considering both Area A and Area B. For the purposes of evaluating the effect of discharge of contaminants to groundwater (refer section 5) we have assumed that all of the contaminants will mix with groundwater discharging to the Upokohino Stream.

As the Area B footprint will be progressively developed it is reasonable to expect that these flow directions may change. Accordingly, ongoing groundwater level monitoring recommendations are made for monitoring (refer Section 6) later in this report.

4.3 Groundwater recharge

The main recharge to site groundwater is considered to be 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. Recharge to the regional groundwater in the vicinity of the site is indicated to be from flow losses from the Tutaekuri River into the alluvial aquifer at the head of the Moteo Valley.

4.3.1 Rainfall

Annual rainfall recharge to groundwater has been assumed as being 10%[22] of annual rainfall within the extent of Area B. We have inferred this rainfall recharge value based on a range of 1% to 30% provided by N. Merrick (2004) for clay and sand, respectively. Based on the assessed catchment area for Area B being approximately 176,000 m^2, and annual rainfall assessed as 800 mm/year, recharge within the catchment area would be approximately 14,100 m^3/year.

Following landfill construction the rainfall recharge over the filled area will be significantly reduced because the landfill lining system will prevent infiltration of rainfall into the groundwater system beneath the landfill, with all infiltration into the landfill being removed as leachate.

4.3.2 Surface water

North of the site three ponds are mapped (refer Figure 4 in Appendix A) with estimated levels of 19 m RL, 33 mRL, and 40 mRL. The August 2018 groundwater level contours indicate that two of the ponds (at 33 mRL and 40 mRL) are perched above the mapped groundwater levels. However, the pond at 19 mRL may reflect the groundwater level at that location. Surface water runoff within the site would be expected to flow toward the valley floor and percolate into the alluvium at the base of the slopes.

Surface water bodies that may pond within the base of the valley within Area B are considered to be the result of surface water runoff (based on the pond levels shown to the west and north of Area B – refer Figure 4). While the water in ponds may, in the past, have allowed infiltration to deeper groundwater our assessment is that the ponds are now present as a result of the low permeability soils in the base of the ponds which reduce the rate of vertical infiltration.

5 Environmental considerations

A description of the proposed development is summarised in Section 1.2. A full description of the engineering works is provided in the Omarunui Landfill Area B Engineering Report[4].

The potential environmental effects of the proposed landfill construction and operation including potential effects on the local hydrogeology are related to:-

- Groundwater take and divert resulting from construction of the Area B landfill extension liner.
- Groundwater take and divert effects (i.e. dewatering and discharge of pumped water) associated with installation of toe bund and shear key.
- Discharge of contaminants to groundwater i.e. potential leakage through possible lining system defects to the regional water table.
- Discharge of contaminants to subsoil drains and therefore discharge to the stormwater system.
- Cumulative effects of landfill construction and operation in Area B.

We have assessed these potential effects in terms of effects on: -

- Nearby groundwater and surface water users in terms of groundwater level and quality.
- Stream depletion.
- Saline intrusion.

[22] Brooks, T., April 2006. Heretaunga steady-state ground-water model, Environmental Management Group Technical Report, Appendix B. HBRC plan number 3765.

5.1 Groundwater take and divert

The proposed basegrade level in the floor of the valley will be constructed with a top of liner level[4] between approximately 25 and 30 mRL. Sub-excavation will be required below these levels 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 where the valley of Area B opens out onto the mouth of the valley of Area C.

Test pit and borehole logs indicate that typical ground water 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 normal conditions. However, a number of groundwater seeps were encountered during the construction of the Area D landfill and a precautionary approach should be adopted to provide a means for draining any seeps that are found. Groundwater pressures beneath the lining system prior to it being filled with waste have the potential to damage the lining system and subsoil drains will be installed where groundwater seeps are identified to relieve groundwater pressures beneath the lining system and avoid the possibility of damage. The full extent of the subsoil drainage system will be determined during construction. However, it will likely include an outlet drain from each side slope, to allow for draining seeps found as construction proceeds. The system may comprise:

- A central drain beneath Stage 1 and Stage 2 if seeps are found during Stage 1 and Stage 2 development. This could be sealed once filling in Stage 2 is complete.
- Possible additional subsoil drains on the bench above Stage 1 and Stage 2 (only if required) to collect any seeps observed during construction of Stages 3 and 4.
- Possible subsoil drain 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.

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 from this area may need to be collected in subsoil drains beneath Stage 1 and 2 or could be drained to the south of the Area B landfill footprint if these seeps are still present during development of Stage 5. The proposed subsoil drainage system will be sealed as groundwater seeps decline following construction of the landfill.

Regional groundwater levels in the vicinity of the north toe bund (at BC6) were reported as approximately 20.2 mRL during site investigations. The highest groundwater level in the proposed landfill footprint is mapped as 24.8 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 regional groundwater levels as a result of the landfill basegrade construction.

5.1.1 Dewatering effects during north toe bund construction

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 to a level of 16 m RL is expected during the proposed works.

We have assessed potential inflows to the excavation using the expected hydraulic conductivity at BC6 and assessed the radius of influence using an analytical method[23]. The parameters used are set out below and assume steady state conditions are achieved: -

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

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. Our assessment is based on the dewatering discharge being disposed of via the proposed stormwater system from the landfill toe towards the Upokohino Stream.

If the horizontal hydraulic conductivity is 10 times greater than the vertical hydraulic conductivity 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.

In both cases initial flows 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. In addition the pumped volume will be discharged to the stormwater network which discharges to the Upokohino Stream, following suitable treatment to remove entrained sediment, which means that any potential stream depletion caused by this pumping is assessed as inconsequential.

5.2 Discharge of contaminants to groundwater

Discharge of contaminants to groundwater may occur via two possible mechanisms through the base of the landfill:

- Leakage of leachate through potential lining system defects to the regional water table ultimately discharging to the Upokohino Stream.
- Leakage of leachate into perched groundwater entering the subsoil drains and therefore discharge to the stormwater system ultimately discharging to the Upokohino Stream.

The details of our assessment of these discharges are described in the following sections. In summary our evaluation is that any potential discharge of a representative range of leachate contaminants to the regional water table would reach the Upokohino Stream at concentrations below the relevant guideline value.

While subsoil drains may be installed to facilitate drainage of perched groundwater during liner installation our assessment is that these can be sealed following installation of the liner. On that basis leakage will be unable to discharge to the stormwater system.

5.2.1 Potential leakage through landfill lining system

5.2.1.1 Potential for leakage

The proposed landfill lining system is described in the Engineering Report. It will generally comprise: -

[23] Fred Marinelli and Walter L. Niccoli, March-April, 2 000, Groundwater, Vol. 38, No. 2, Simple Analytical Equations for Estimating G round Water Inflow to a Mine Pit

- 300 mm drainage aggregate leachate collection layer.
- Protection geotextile.
- 1.5 mm HDPE geomembrane.
- GCL ($k \leq 3 \times 10^{-11}$ m/s).
- Selected compacted soil layer, 600 mm thickness on base areas and 300 mm thickness on side slopes, selected to be mostly silt soils, and avoiding particularly sandy soils, but with no specified maximum permeability (k likely to be in the range of $1 \times 10^{-6} < k < 1 \times 10^{-8}$ m/s).

In addition to the above material requirements, an Electrical Leak Location (ELL) survey will be undertaken on all completed sections of lining system after placement of the drainage aggregate layer, and any leaks found from this survey will be repaired.

In addition to the above lining system, there will be an allowance for both a Type 1 or Type 2 lining system as defined in the WasteMINZ Technical Guidelines. This will allow for the possibility of locating sufficient low permeability soils on site or locating a source of suitable soils from off-site.

The various components of the composite lining system will work together to minimise the potential for leakage. For example, leakage through a pinhole in the geomembrane is expected to be blocked due to the direct contact with the underlying GCL or Type 1 clay layer. The leachate drainage system above the geomembrane enables leachate to be removed from the landfill thereby minimising the head on top of the geomembrane. A lower driving head will result in less potential leakage through any defect that may be present. The ELL will provide confidence that there are no leaks in the lining system.

Modelling has been undertaken to determine the possible rate of leakage through the lining system, conservatively assuming there are some defects present in the geomembrane (see the Engineering Report) in accordance with standard international practice. This modelling shows that for the worst case, i.e. at full development of the Area B landfill, the potential theoretical leakage from the landfill for the peak year over a 50 year modelling period is assessed as follows: -

Liner with 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
Liner using 10^{-9} m/s 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

Any leachate that may seep through imperfections in the lining system will move vertically through the unsaturated subgrade and underlying bedrock. Ultimately the leachate will enter the groundwater system within the bedrock, mixing with the groundwater flowing beneath Area B and flowing towards the valley exit beyond the toe of the landfill. The leachate and groundwater mixture will ultimately flow towards the Upokohino Stream.

Leachate quality characterisation used for our assessment has been determined from the maximum reported leachate monitoring concentrations provided by HDC from monitoring at the leachate pond in the existing landfill[24]. 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.

We set out details of our assessment below which considers nitrate-nitrogen, ammoniacal nitrogen, dissolved metals, and organic compounds. Metals contained in particulates are not considered as our assumption is that the granular nature of the bedrock aquifer and velocity of the groundwater means that particulate matter will not be entrained in the flowing groundwater.

[24] Email from Phil Doolan, 15 April 2019, DP040120Lc HDC Omarunui Landfill - Leachate Results Oct 2018.

5.2.1.2 Leachate dilution modelling

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 x 10^{-3} m/s. The calculated permeability of the unconfined bedrock aquifer is reported as 0.27 m/day or 3.1 x 10^{-6} m/s (refer Section 3.5). We have conservatively assumed that:-

- Leachate concentrations (dissolved metals) are the maximum reported by HDC between 2001 and 2018.
- Group 3 parameters are the maximum concentrations of organic compounds reported by HDC between 2004 and 2018 and which have relevant ANZG trigger values.
- 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.
- 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.

The calculated groundwater throughflow is 1800 L/d (1.8 m^3/d). Allowing for 90% of the lining system to comprise a Type 1 clay liner and the remaining 10% to include a GCL as part of the liner then the calculated dilution available during the peak year is 1400 times. The dilution is calculated as follows: -

Dilution = 0.9 *1800/1.07 + 0.1 *1800/0.39

The dilution table provided below presents the maximum and median values for leachate concentrations and the maximum leachate concentrations after 1400 times dilution as described above. This shows that there is no exceedance of the ANZG 95% guideline values for this modelled case. This assessment considers the modelled leakage rate in the peak year and the maximum recorded leachate concentration. We consider that:-

- Daily seepage in the average year is approximately 60% of the seepage in the peak year.
- Median leachate concentration is less than 60% of the maximum leachate concentration.

This means that there is an additional factor of safety in this assessment and accordingly the tabulated concentrations may be lower than predicted.

Parameter	Units	Leachate Median	Leachate Maximum	ANZG 95%	Maximum after allowing for dilution of 1400[25] times	Maximum above ANZG after dilution?	Notes
Nitrate N	g/m^3	0.03	8.00	2.4	5.7E-03	no	"Grading" guideline values[26].
Total Ammoniacal-N	g/m^3	645	1220	0.9	8.6E-01	no	
Dissolved Iron	g/m^3	2.30	4.20	NA	3.0E-03	NA	
Dissolved Manganese	g/m^3	0.81	2.97	1.9	2.1E-03	no	
Dissolved Aluminium	g/m^3	0.10	0.27	0.055	1.9E-04	no	
Dissolved Arsenic	g/m^3	0.15	0.54	0.024	3.8E-04	no	Assume As III
Dissolved Cadmium	g/m^3	0.0003	0.0010	0.0002	7.1E-07	no	
Dissolved Cobalt	g/m^3	0.04	0.07	0.0014[27]	5.0E-05	no	Refer footnote
Dissolved Chromium	g/m^3	0.37	1.11	0.0033	7.9E-04	no	Assume Cr III, does not exceed NZDWS limit of 0.05 g/m^3
Dissolved Copper	g/m^3	0.002	0.014	0.0014	9.9E-06	no	
Dissolved Mercury	g/m^3	0.00004	0.00015	0.0006	1.1E-07	no	
Dissolved Nickel	g/m^3	0.13	0.24	0.011	1.7E-04	no	
Dissolved Lead	g/m^3	0.0011	0.0050	0.0034	3.5E-06	no	
Dissolved Boron	g/m^3	4.95	11.80	0.37	8.3E-03	no	
Dissolved Selenium	g/m^3	0.005	0.010	0.011	7.1E-06	no	
Dissolved Zinc	g/m^3	0.022	0.140	0.008	9.9E-05	no	

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

The subsoil drainage system is described in section 5.1 (above) which describes 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

25 Calculated as (0.9 x (1800/1.7))+(0.1*(1800/0.39)) = 1414 where throughflow is 1800 L/day and maximum daily leachate flow through Type 1 liner is 1.7 L/day and through the GCL is 0.39 L/day.
26 Hickey, C. W., January 2013, *Updating nitrate toxicity effects on freshwater aquatic species*, prepared by NIWA for MBIE
27 Note that level of species protection listed as unknown for cobalt default guideline value (DGV)

seeps to outside the landfill footprint. It is anticipated that similar seeps will be found in Area B. It is not intended to install a comprehensive subsoil drainage system beneath Area B, but 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.

The subsoil drainage system only needs to 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.

Each drain will collect seepage from a relatively small area of liner. In the rare event that leakage were to occur above the drain the groundwater collected in the drain could become contaminated. As soon as any such contamination is detected the drain can be sealed to prevent any discharges. The potential effect of such discharges is thus not considered further.

5.3 Nearby surface and groundwater users

As previously noted in section 2.4.1 there are approximately 120 wells within approximately 2 km of the centre of Area B. Of these 120 wells identified, 35 are indicated to lie within the curtilage of the Omarunui landfill area (investigation wells), 41 are indicated to lie within the Moteo Valley, and 44 are indicated to lie within the Tutaekuri flood plain.

The wells within the Moteo Valley are indicated to be between 3.5 m and 55 m depth, with the average well depth approximately 18 m.

The wells within the Tutaekuri flood plain are indicated to be between 10 m and 49 m depth, with the average well depth approximately 19.5 m.

The wells within the two areas 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.

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 m^3/annum. A list of the relevant consent numbers considered as part of our assessment is provided within Appendix D.

The uses for groundwater in the surrounding area are predominantly for irrigation, frost protection, wash down purposes and domestic water supply. The two consented domestic water supplies are indicated to be taken from Well No. 4328, approximately 1.6 km to the north west of Area B, and Well No. 1686, approximately 1.8 km to the south east.

5.3.1 Effects on nearby surface and groundwater users

Effects on nearby groundwater and surface water users include: -

- Effects of the groundwater take and diversion at Area B on groundwater levels at nearby user sites.
- Changes in groundwater quality at the nearby surface and groundwater takes.

Based on the preceding evaluations in sections 5.1 and 5.2 there is 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 regional water table.

5.3.2 Stream depletion effects

It is proposed that the landfill basegrade be installed at least two metres above the regional 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. Review of groundwater level monitoring data[28] for BH8 and BH9 compared with BH12 and BH13 (upstream and downstream of Area D, respectively) 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

While dewatering is likely to be required during installation of the toe bund it is expected that pumped water will be discharged to the stormwater water network (i.e. ultimately discharging to the Upokohino Stream). As there is no consumptive use of the water pumped for dewatering purposes, the discharge to the downstream surface water system will be no less than any potential stream depletion effect from pumping.

5.3.3 Saline intrusion/settlement/other effects

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. Applying the Ghyben-Herzberg approximation we expect the saline interface to be greater than 500 m below mean sea level at the site.

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.

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

6 Mitigation and monitoring

The groundwater risk assessment indicates the potential adverse effects of contaminants contained in leachate which may seep into the groundwater are inconsequential. There is an existing network of observation boreholes installed as part of this investigation, which (with the exception of a replacement for BH10)is considered sufficient for continuous monitoring of groundwater levels and to provide for monitoring for the presence of leachate in groundwater at the boundary of the site. These bores are: -

- Outside the Area B footprint:
  - Upstream BH9, BC10, BC14 and BC9.
  - Downstream BC6, BC5, (for BH10 see below).
- Inside the Area B footprint:
  - BH10 (a downstream borehole), will require decommissioning and replacement/relocation to west of the Area B footprint as landfill development (of Stage 4 of Area B) proceeds.
  - BC7A.

Note that BH10 is currently monitored as part of the consent monitoring requirements for the existing landfill comprising Areas A and D (consent number DP040120Lc).

The selected parameters for, and frequency of, groundwater monitoring as specified in DP040120Lc is proposed for the new Area D landfill, in part, for ease of monitoring without the need for different

[28] Stantec, *Omarunui Landfill - Environmental Monitoring Annual Report 2018,* prepared for Hastings District Council, November 2018.

sampling intervals or parameters across the entire landfill. For the proposed monitoring boreholes BC14, BC5, BC6, BC9, BC10 and BH10 the monitoring is set out in Table 6.1 (below) and the parameters for each group are provided in Appendix E.

Table 6.1: Recommended monitoring parameters and monitoring frequency

Sampling	Analysis	Frequency
Measure and record water level in the specified bores		January, April, July, and October
Measure and record water quality in the specified bores	Group 1	January, April, July, and October
Measure and record water quality in the specified bores	Group 2	April and October
Measure and record water quality in the specified bores	Group 3	April

To further confirm the background conditions, at least one year prior to receiving the waste, monitoring should commence as follows: -

- Routine and detailed groundwater quality monitoring following the proposed monitoring scheme set out in Table 6.1 (above), and
- Routine (i.e. continuous using automated monitoring equipment) groundwater level monitoring.

7 Conclusions

Based on the available geotechnical and groundwater information relating to the site, our assessment concludes:

- 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.
- Groundwater has been measured and monitored within the underlying bedrock to be at around 19 to 20 mRL with higher levels to the east of the Area B boundary. Water levels measured within BC7A indicate a water level at around 36 mRL. We have inferred that the nearby sediment pond (located to the east) supports the perched groundwater level.
- Groundwater flow beneath Area B generally flows from east to west. To the west of Area B, groundwater is inferred to potentially flow both south and north and may be controlled by a groundwater divide situated along a line between BH9, BC5 and BC14.
- Recharge of the groundwater is inferred to occur through rainfall infiltration with groundwater levels also supported by the regional groundwater table beyond the site area. Recharge to the regional groundwater level is indicated to occur from losses from the Tutaekuri River to the north west of the site at the head of the Moteo Valley.
- Permeability of the underlying bedrock has been measured to be in the range of 1×10^{-4} to 3×10^{-8} m/s. For the purposes of our assessment we have calculated the geometric mean of the permeability reported in Table 3.2. The calculated permeability is 0.27 m/day or 3.1×10^{-6} m/s for the unconfined bedrock aquifer.
- With the exception of BC6 (August 2018) sample exceedances outside relevant trigger values (NZDWS and ANZECC 2000 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.

- The 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.
- Of note, the detected concentrations at BC10 of VFA, methylphenol, toluene, xylene, and carbon disulphide are well below the relevant ANZECC (and ANZG) trigger values and NZDWS maximum acceptable or guideline values.
- Potential leachate leakage from Area B has been modelled as having a theoretical average annual daily rate of 3.2 L/day and an average day rate of 6 L/day in the peak year.
- Based on our assumed mixing model, should leakage occur at the modelled rate, leachate concentrations are generally expected 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.
- 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.
- The effects on the closest nearby water users of groundwater take and diversion are assessed as being immeasurable. Therefore, it is considered that no water user within the 2 km assessed area will have water quality adversely effected as a result of the Area B extension to the landfill.
- 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.
- 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.

8 Applicability

This report has been prepared for the exclusive use of our client Hastings District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:

....

Ryan Tutbury

Engineering Geologist

Tony Reynolds

....

Tony Reynolds

Hydrogeologist

Authorised for Tonkin & Taylor Ltd by:

....

Tony Bryce

Project Director

rwot/tir
p:\1000647\1000647.1001\issueddocuments\aee\hydrogeology\20201217 landfill.s92 updated.docx

Appendix A: Figures

HASTINGS DISTRICT COUNCIL

Omarunui Landfill - Area B

Figure 1 - Nearby surface water bodies

DATA SOURCE Cadastral information derived from the Land Information New Zealand Core Record System (CRS) CROWN COPYRIGHT RESERVED

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DISCLAIMER The Hastings District Council cannot guarantee that the data shown on this map is 100% accurate.

Map Produced Using Intramaps

6/09/2018

1:6000 on A3

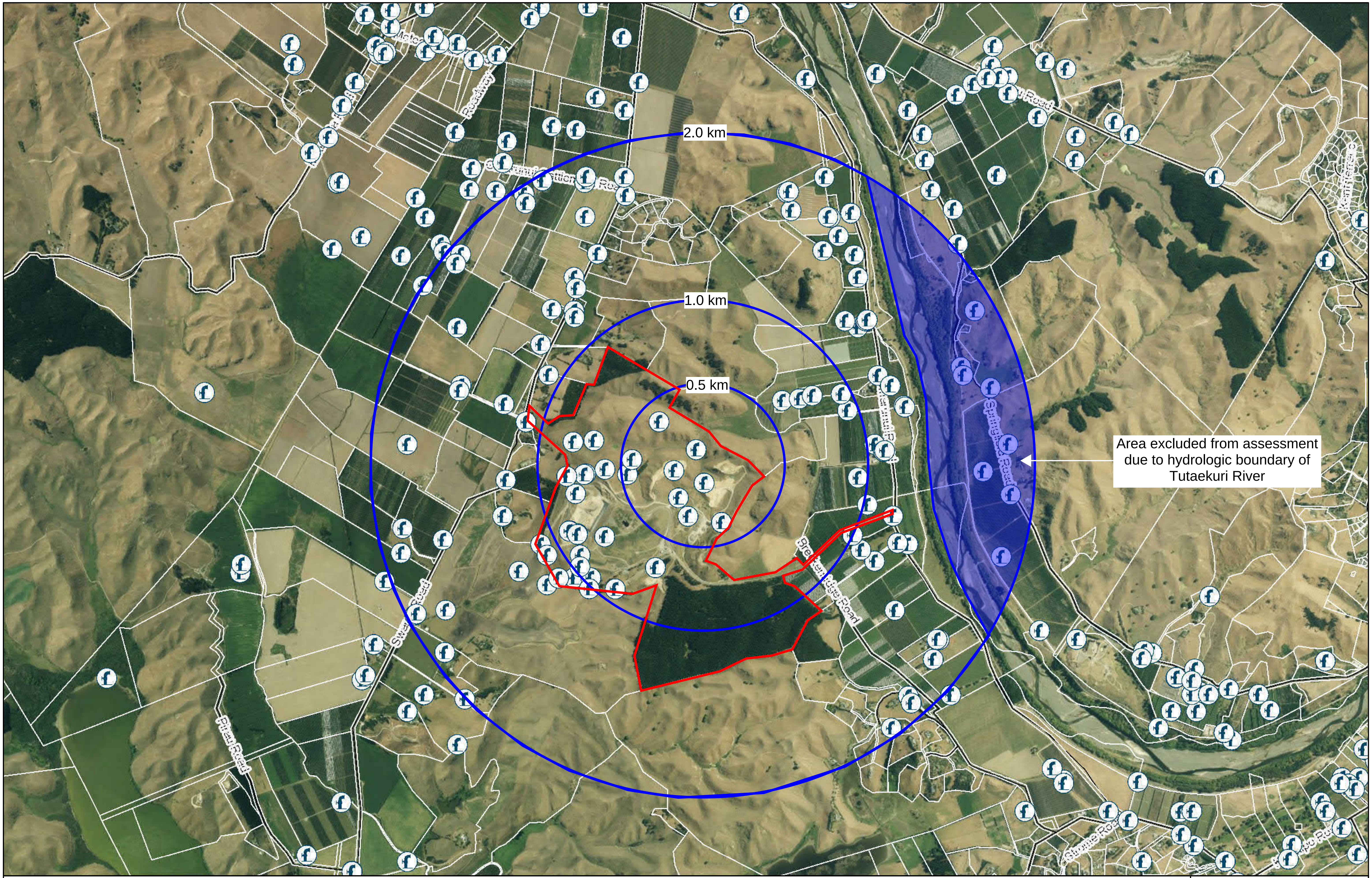

Figure 2
Nearby consented groundwater wells

LocalMaps Print

The information displayed is schematic only and serves as a guide.
It has been compile from Hawke's Bay Regional Council records and is made available in good faith but its accuracy or completeness is not guaranteed.
Cadastral information has been derived from Land Information New Zealands (LINZ) Core Record System Database (CRS).

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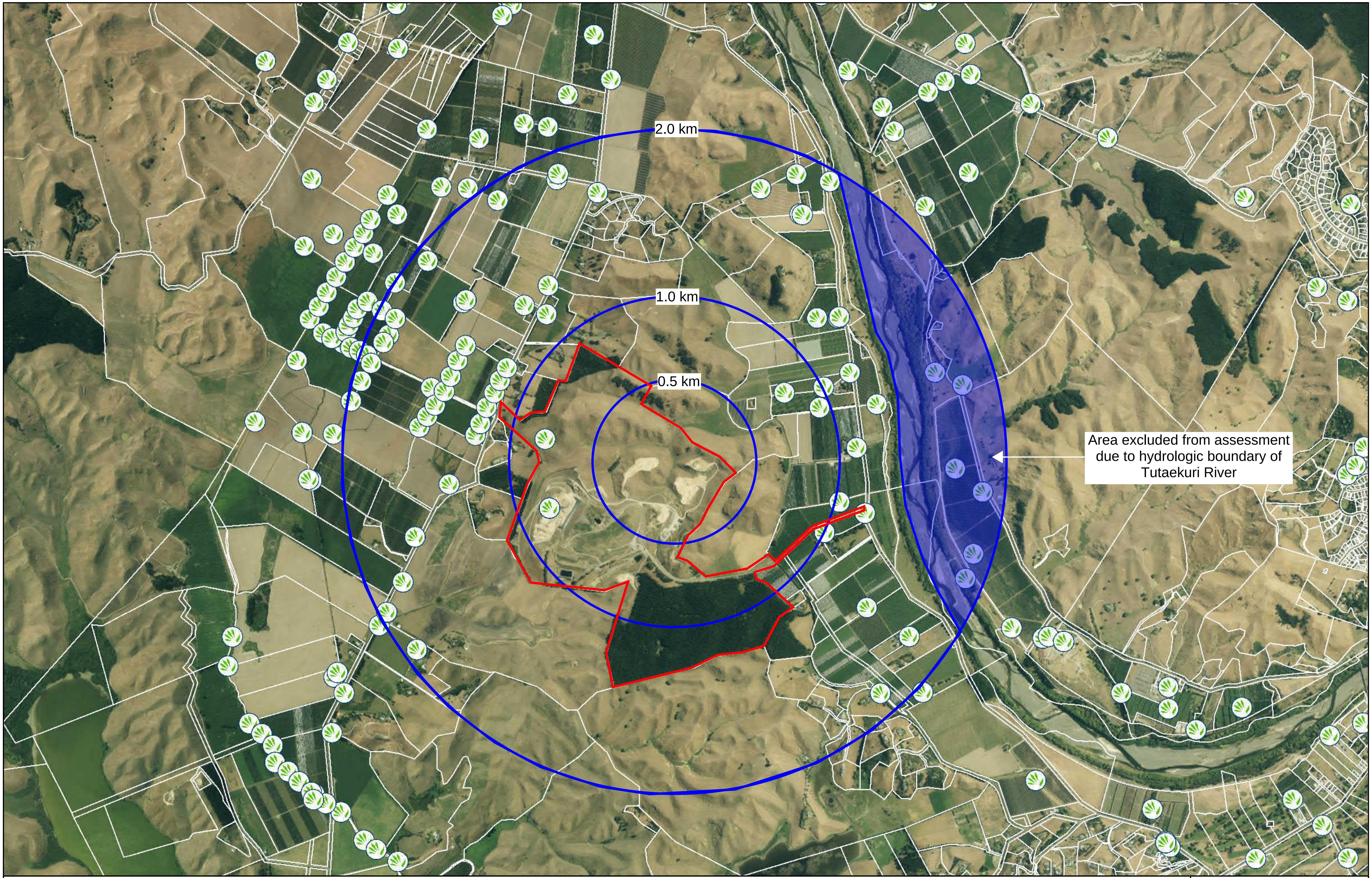
Scale: 1:20,000
Tuesday, August 28, 2018

Original Sheet Size 210x297mm



HAWKE'S BAY REGIONAL COUNCIL

Figure 3
Consent locations

LocalMaps Print

The information displayed is schematic only and serves as a guide.
It has been compile from Hawke's Bay Regional Council records and is made available in good faith but its accuracy or completeness is not guaranteed.
Cadastral information has been derived from Land Information New Zealands (LINZ) Core Record System Database (CRS).

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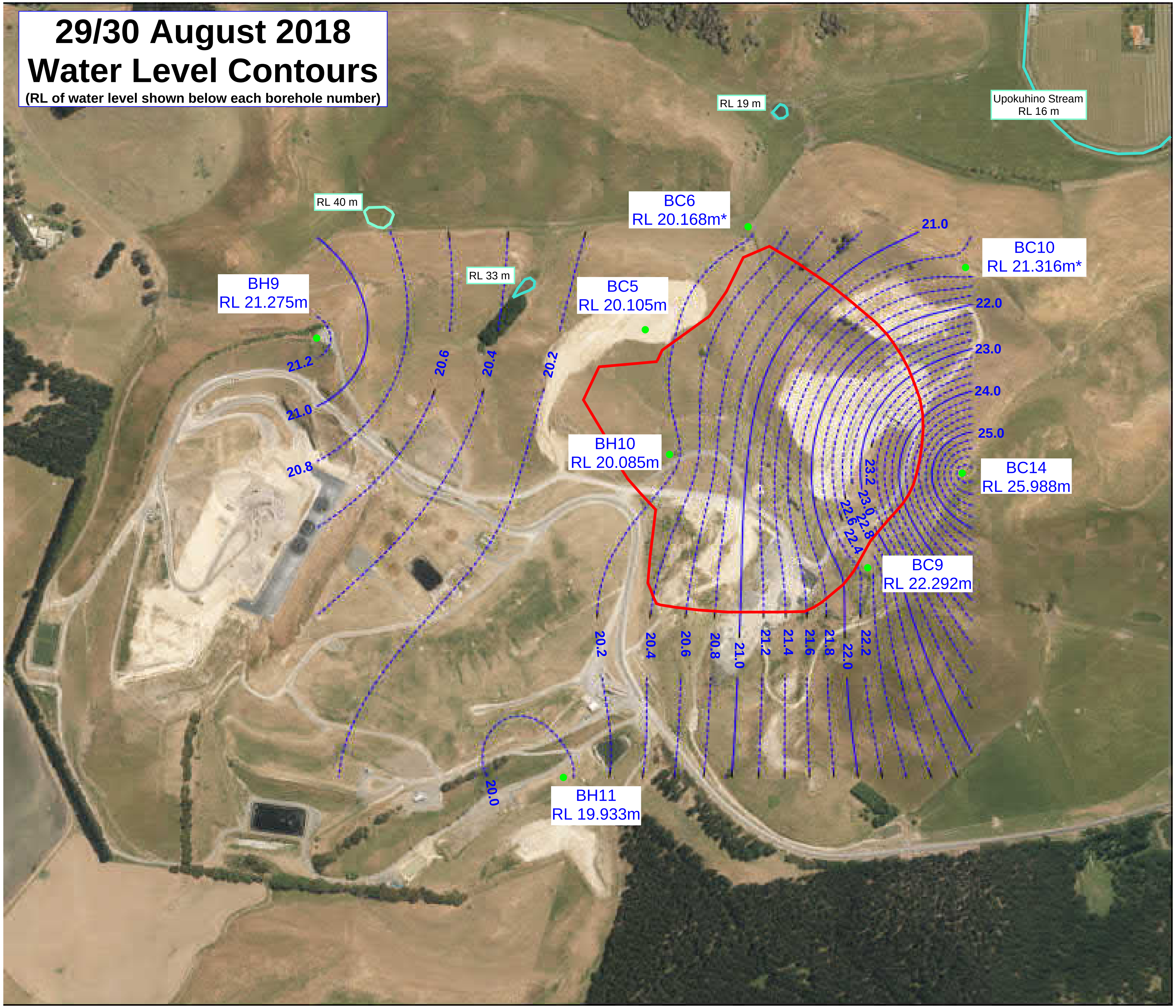
N

Scale: 1:0
Thursday, September 6, 2018

Original Sheet Size 210x297mm



LEGEND

- Inferred water level contour line (1.0m interval)
- Inferred water level contour line (0.2m interval)
- Topographic surface water levels
- Approximate Landfill extent
- Monitored well and measured water level on 29 August 2018. (*denotes measurement taken on 30 August 2018)

A3 SCALE: 1:5,000

0 50 100 150 200 250 (m)

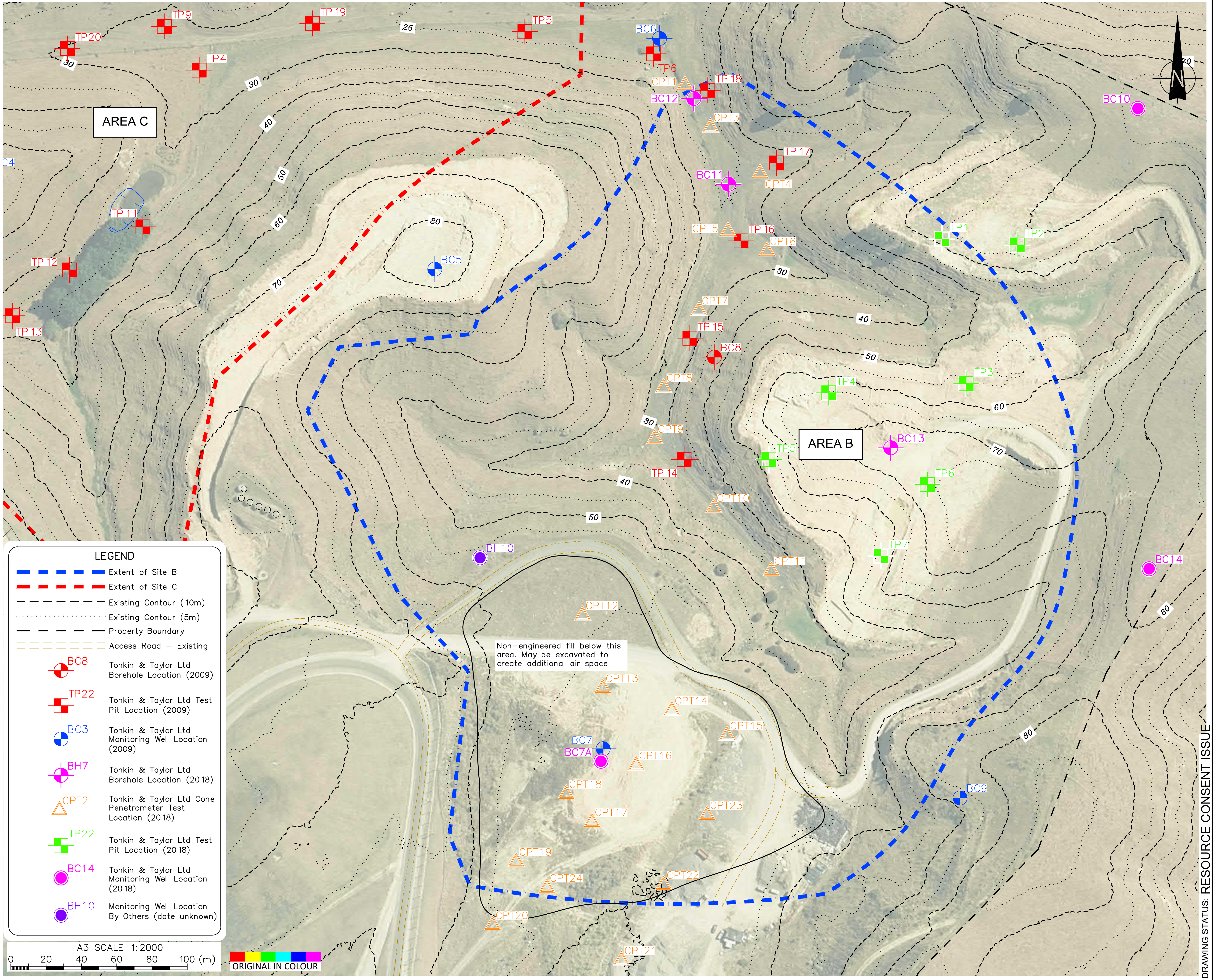
N

1. World Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
2. Contours produced in Surfer software based on measured water levels and topographic contours

Created On:	17/08/2018
Created By:	RTutbury
Approved By:	
TT Proj Ref:	
TT Map Ref: TTMAPREF1433463001.902	

Tonkin+Taylor
105 Carlton Gore Road, Newmarket, Auckland
www.tonkintaylor.co.nz

FIGURE No.
Figure 2



NOTES :
1. All dimensions are in millimetres unless noted otherwise.
2. Lidar information supplied by Hastings District Council, February 2008.
3. Additional survey supplied by Hastings District Council, August 2008.
4. Coordinate Datum: NZ Geodetic 1949 Hawkes Bay Circuit Origin: 700,000 mN 300,000 mE
5. Aerial image sourced from LINZ Data Service, flown 2014–2015 <https://data.linz.govt.nz/layer/53401-hawkes-bay-03m-rural-aerial-photos-2014-2015>.

REVISION	DESCRIPTION	BY	DATE
1	Resource Consent Issue		

DESIGNED :	JWY	Sep. 18
DRAWN :	JELO	Sep. 18
DESIGN CHECKED :		
DRAFTING CHECKED :		
REFERENCE :		

CADFILE : \\1000647.1000-03.dwg

APPROVED : NOT FOR CONSTRUCTION

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HASTINGS DISTRICT COUNCIL

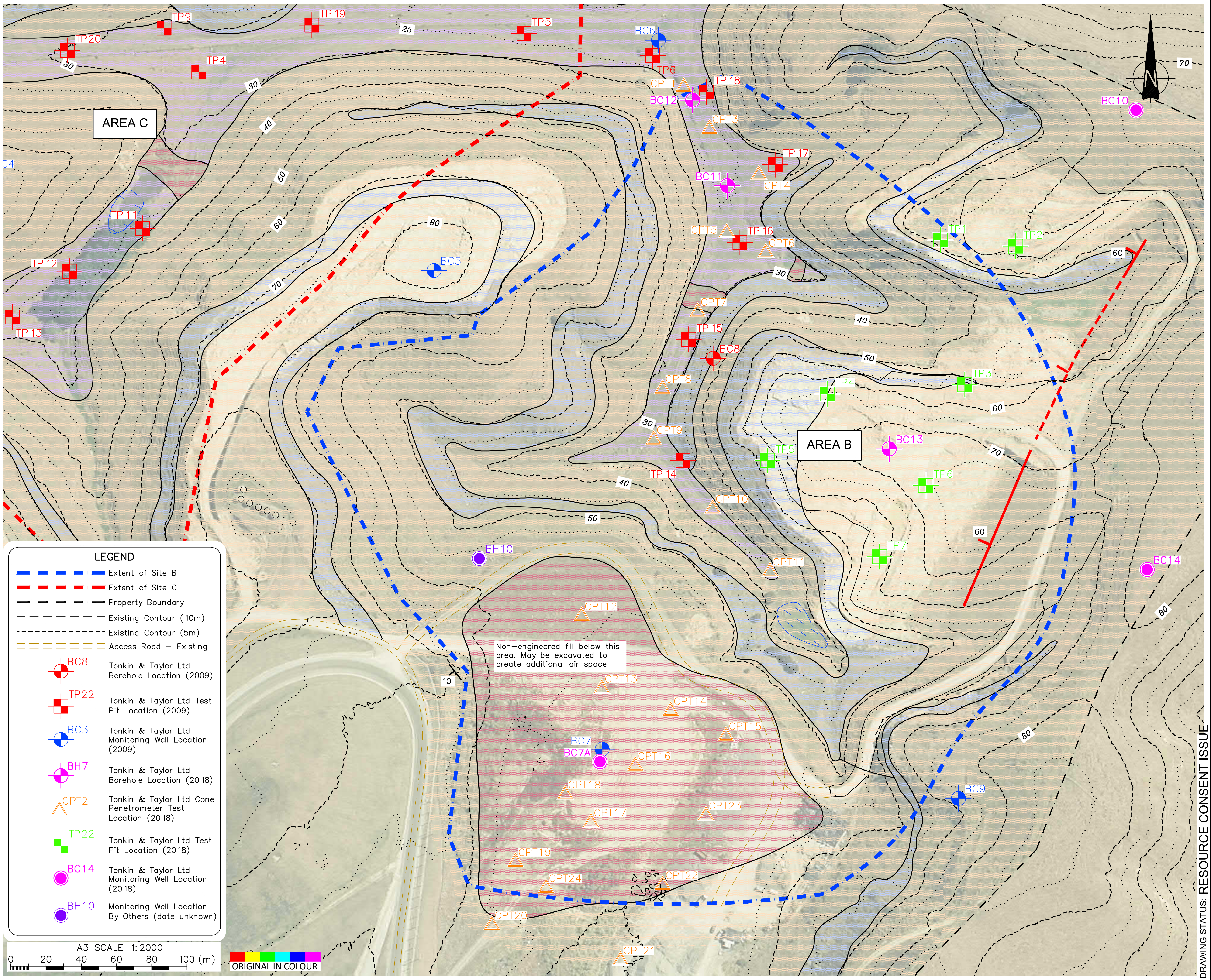
OMARUNUI LANDFILL

AREA B DELEVOPMENT Site Investigation Plan

DRAWING STATUS: RESOURCE CONSENT ISSUE

SCALES (AT A3 SIZE) 1:2000

DWG. No. 1000647.1000–03 REV. 1



DRAWING STATUS: RESOURCE CONSENT ISSUE

NOTES :

1. All dimensions are in millimetres unless noted otherwise.
2. Lidar information supplied by Hastings District Council, February 2008.
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5. Aerial image sourced from LINZ Data Service, flown 2014–2015 <https://data.linz.govt.nz/layer/53401-hawkes-bay-03m-rural-aerial-photos-2014-2015>.

GEOLOGICAL LEGEND:

- Sandstone, Limestone, Siltstone – Petane Group (Pleistocene)
- Alluvium
- Fill
- Dam/pond
- 60 (dip and dip direction) Fault (observed)
- Fault (inferred)
- Strata dip (dip in degrees)

REVISION	DESCRIPTION	BY	DATE
1	Resource Consent Issue		

DESIGNED :	JWY	Sep. 18
DRAWN :	JELO	Aug. 18
DESIGN CHECKED :		
DRAFTING CHECKED :		
REFERENCE :		

CADFILE : \\1000647.1000-04.dwg

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HASTINGS DISTRICT COUNCIL

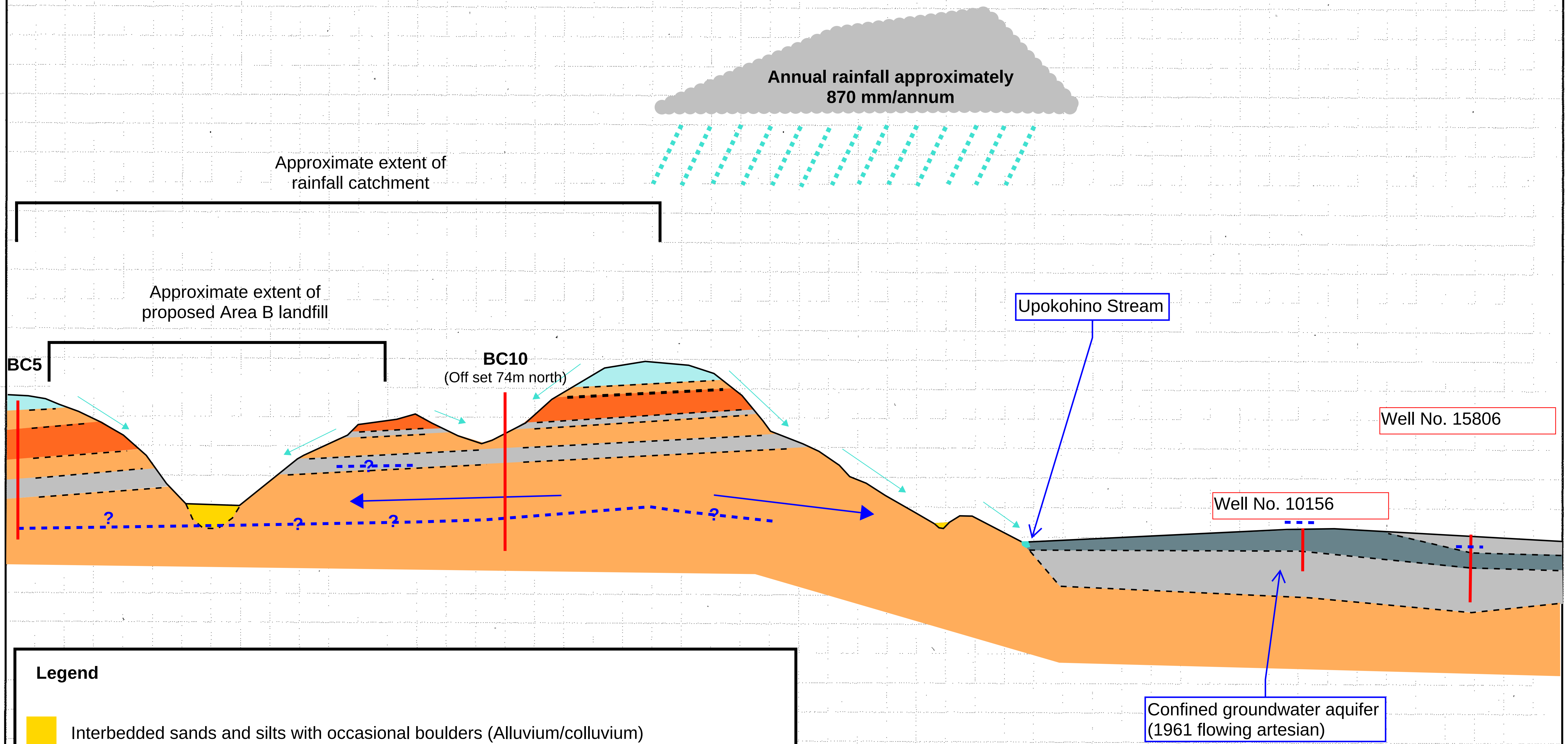
OMARUNUI LANDFILL

AREA B DELEVOPMENT
Gelogical Site Plan

SCALES (AT A3 SIZE) 1:2000

DWG. No. 1000647.1000-04 | REV. 1

Sketch 1: Conceptual hydrogeological model



Legend

- Interbedded sands and silts with occasional boulders (Alluvium/colluvium)
- Interbedded sands, gravels and clays (Alluvium)
- Siltstone (Petane Formation)
- Sandstone (Un-cemeted) (Petane Formation)
- Sandstone (Cemented) (Petane Formation)
- Limestone (Petane Formation)
- Inferred surface water flow direction
- Inferred groundwater flow direction
- Inferred groundwater levels

Notes:
Sketch not drawn to scale.
Groundwater levels and geological profiles have been inferred.
Gully plan area is approximately 176,000m². Annual volumetric rainfall is approximately 140,800m³/annum within gully catchment.
Recharge to groundwater is estimated to be 10% of rainfall (subject to further review of rainfall and groundwater levels).
Estimated groundwater recharge in catchment 14,100m³/annum.

Tonkin+Taylor

Description: Conceptual hydrogeological model

Project: Omarunui Landfill - Area B

Computed: RWOT	18/07/2018	Office:	Hamilton
Checked:	20	Job No:	1000647.1000
Revised:	20	File:	
Checked:	20	Sheet No.	1 of 1

Plotted groundwater contours from annual groundwater level variations

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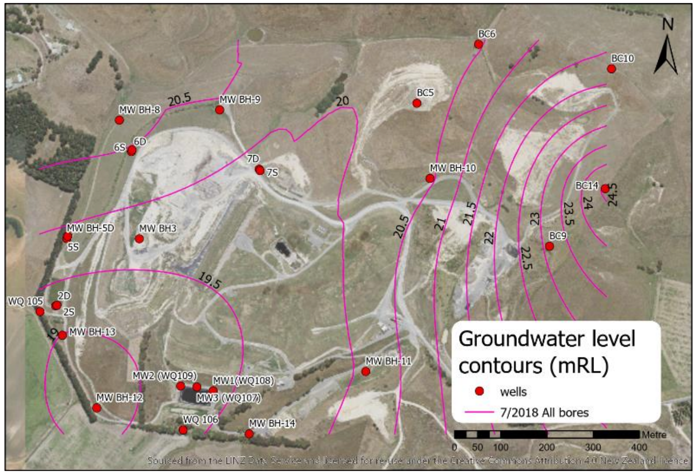
<td>
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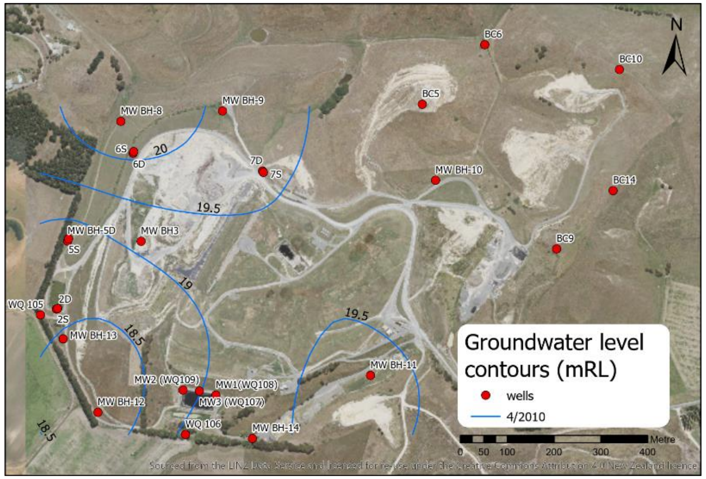
<td>
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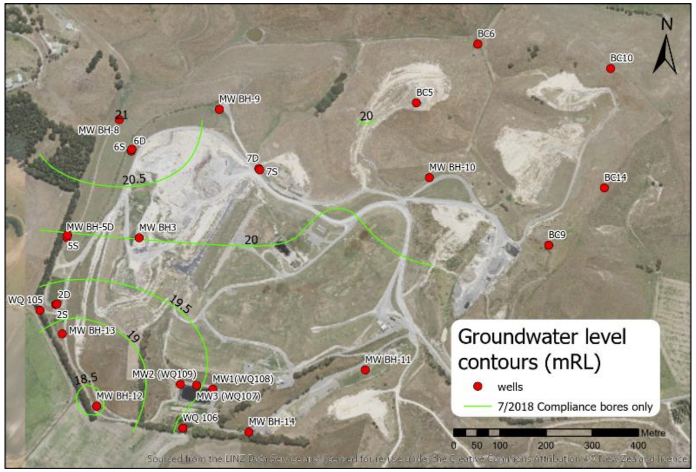
<td>
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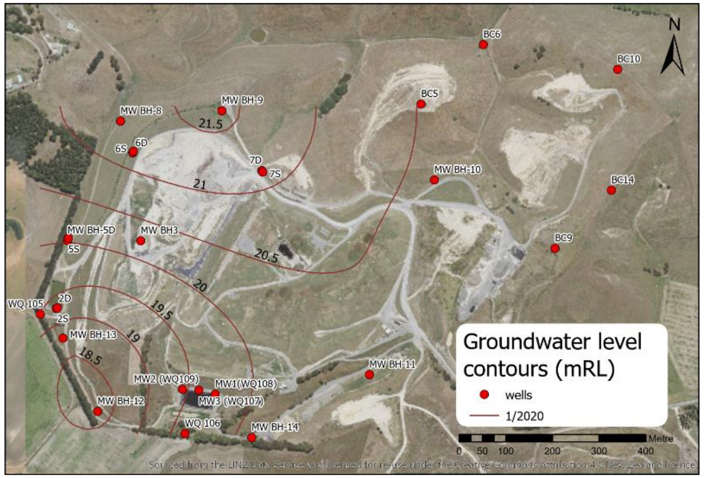
<td>
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<td>January 2020 – compliance wells contour plan</td>
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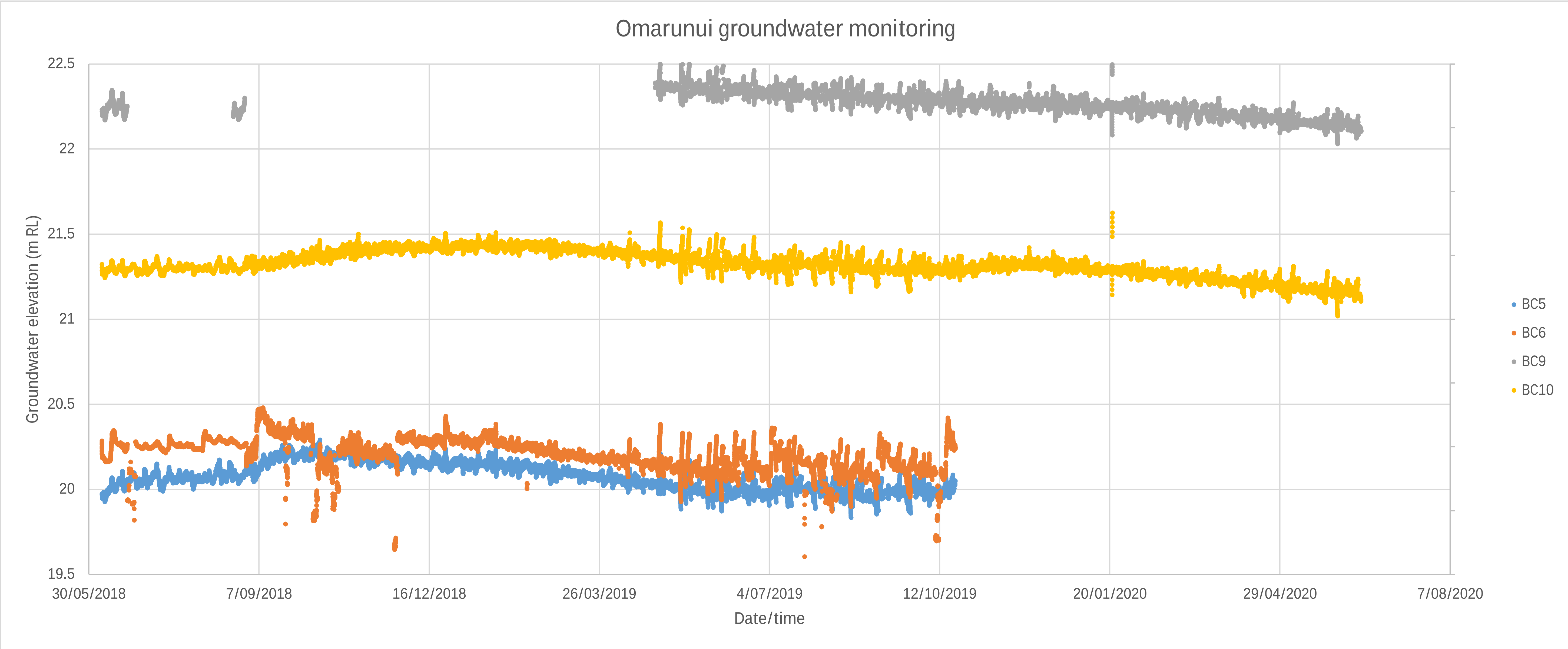
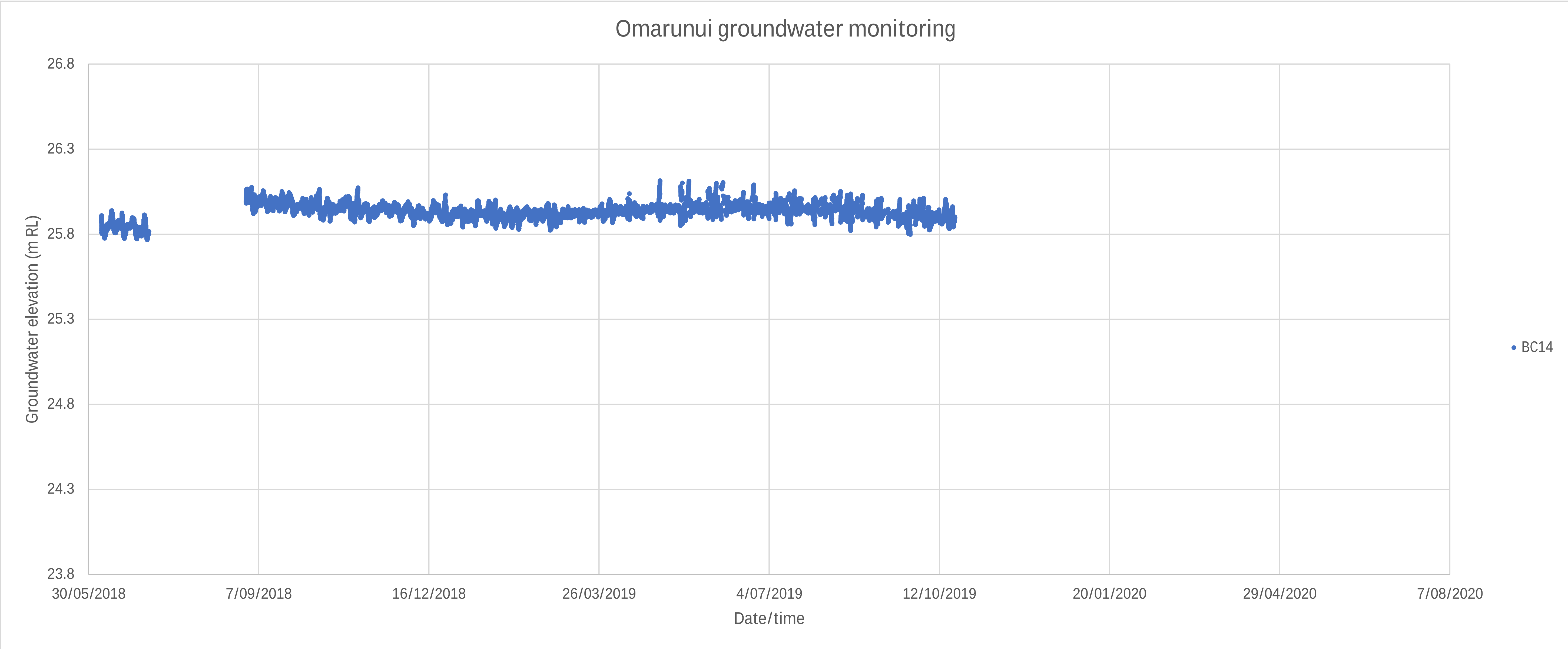
Seasonal variation in groundwater levels beneath the Omarunui site. Contours showing groundwater flow directions and level variation

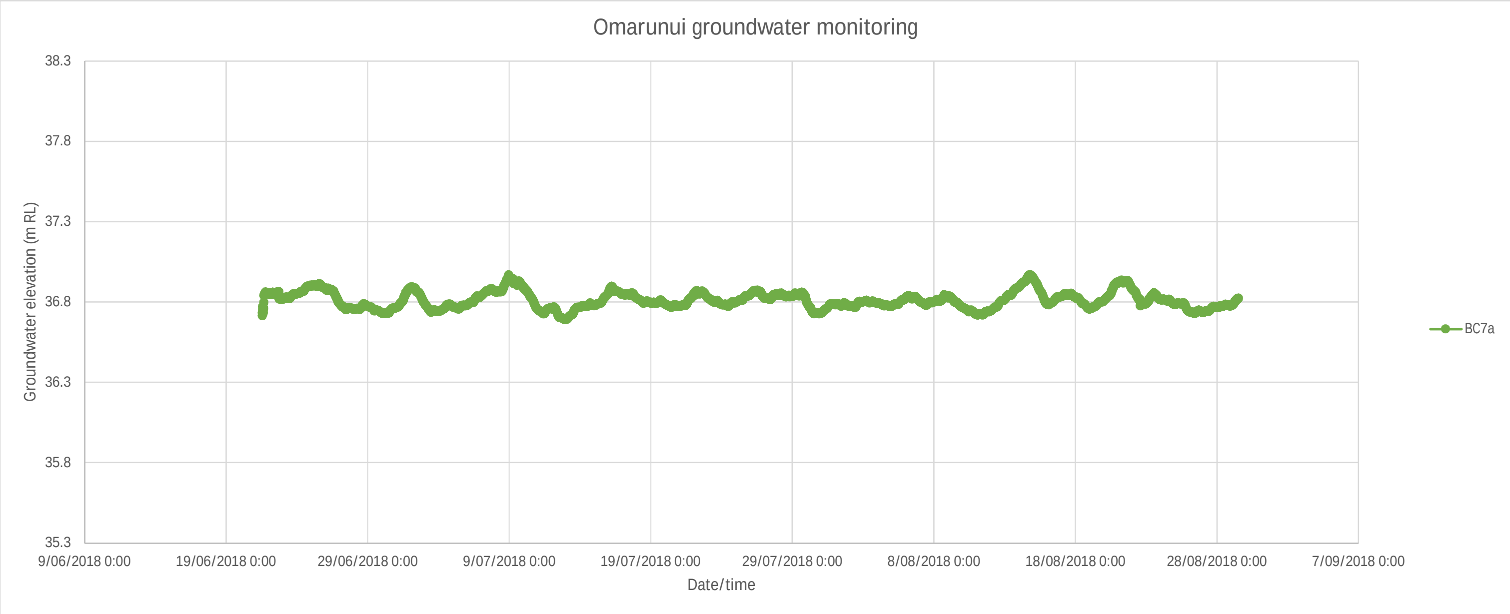
Appendix B: Groundwater monitoring

Measured static groundwater levels, August 2018 and June 2020

Monitoring well	Monitoring date/time	Water level below top of casing (BTOC)	Water level (RL m)	Monitoring date/time	Water level (BTOC)	Water level (RL m)
BC5	29/08/2018 12:00	56.395	**20.105**	15/06/2020 15:00	56.63	**19.87**
BC6	30/08/2018 11:25	3.342	**20.168**	15/06/2020 15:27	3.56	**19.95**
BC7A	29/08/2018 12:58	21.826	**36.824**	Not located, may have been destroyed by site works		
BC9	29/08/2018 13:40	50.398	**22.292**	15/06/2020 14:25	50.57	**22.12**
BC10	30/08/2018 07:58	58.214	**21.316**	15/06/2020 13:13	58.35	**21.18**
BH10	29/08/2018 10:46	37.972	**20.085**	15/06/2020 12:50	38.21	**19.85**
BC14	29/08/2018 14:20	58.002	**25.988**	15/06/2020 14:06	58.29	**25.70**
BH9	29/08/2018 10:29	60.574	**21.275**	Not measured, as 60 m dipper ended above water level		
BH11	29/08/2018 09:47	24.885	**19.933**	15/06/2020 15:57	25.14	**19.68**


Omarunui groundwater monitoring
Groundwater elevation (m RL)
22.5
22
21.5
21
20.5
20
19.5
30/05/2018
7/09/2018
16/12/2018
26/03/2019
4/07/2019
12/10/2019
20/01/2020
29/04/2020
7/08/2020
Date/time
BC5
BC6
BC9
BC10


Omarunui groundwater monitoring
Groundwater elevation (m RL)
26.8
26.3
25.8
25.3
24.8
24.3
23.8
30/05/2018
7/09/2018
16/12/2018
26/03/2019
4/07/2019
12/10/2019
20/01/2020
29/04/2020
7/08/2020
Date/time
BC14



Omarunui groundwater monitoring
Groundwater elevation (m RL)
38.3
37.8
37.3
36.8
36.3
35.8
35.3
9/06/2018 0:00
19/06/2018 0:00
29/06/2018 0:00
9/07/2018 0:00
19/07/2018 0:00
29/07/2018 0:00
8/08/2018 0:00
18/08/2018 0:00
28/08/2018 0:00
7/09/2018 0:00
Date/time
BC7a

Appendix C: Laboratory transcripts

Sample Name Reference Number Sample Round Date	NZDWS (2005)	ANZECC 95% Freshwater Guidelines	BC5 1971386.4 27-Apr-18	BC6 1971386.1 26-Apr-18	BC7A 1971386.2 26-Apr-18	BC9 1971386.3 27-Apr-18	BH10 1971386.5 27-Apr-18	BC14 1996580.1 6-Jun-18	BC10 1996580.2 6-Jun-18	BC5 2040634.1 29-Aug-18	BC6 2040634.2 30-Aug-18	BC7A 2040634.3 29-Aug-18	BC9 2040634.4 29-Aug-18	BC10 2040634.5 30-Aug-18	BH10 2040634.6 29-Aug-18	BC14 2040634.7 29-Aug-18
pH	7.0 – 8.5[2]	-	7.4	7.5	**6.9**	7.5	7.4	7.4	**6.7**	7.3	7.4	**6.6**	7.5	**6.8**	7.4	7.3
Electrical Conductivity	-	-	83.9	62	156	83.4	78.9	58.8	69	84.3	46.8	155.4	58.4	93.2	75.9	64.3
Total Alkalinity	-	-	930	260	1010	1110	300	310	480 [#6]	730	210	880	330	620	270	300
Bicarbonate	-	-	1130	310	1230	1350	370	380	590	890	250	1070	400	750	330	370
Dissolved Calcium	See hardness[2]	-	116	102	270	109	120	93	116	118	69	-	91	182	-	98
Dissolved Magnesium	See hardness[2]	-	11.5	7.6	22	11.2	5.8	7.9	14.8	10.5	5.4	-	2.9	15.8	-	7.1
Total Hardness	200 [2]	-	**340**	**290**	**760**	**320**	**320**	**260**	**350**	**340**	194	-	**240**	**520**	-	**270**
Dissolved Sodium	200 [2]	-	63	17.4	77	64	34	28	39	67	16.9	-	32	45	-	37
Dissolved Potassium	-	-	1.45	6.3	2.9	1.43	6.3	2.8	2.1	1.51	12.3	1.88	3.5	1.8	3.4	1.95
Nitrate-N + Nitrite-N	-	-	0.159	7.3	0.38	0.13	11.7	0.169	3.2	0.25	0.054	0.013	3	0.003	11	0.056
Nitrate-N	11.3 [1]	7.2[3,4]	0.155	7.3	0.37	0.126	**11.7**	0.01	2.8	0.25	0.041	0.013	3	< 0.002	11	0.056
Nitrite-N	0.9 [1]	-	0.004	0.005	0.006	0.004	< 0.002	0.158	0.44	< 0.002	0.013	< 0.002	< 0.002	0.002	< 0.002	< 0.002
Chloride	250 [2]	-	40	23	47	40	53	26	33	39	19.9	50	41	33	52	30
Sulphate	250 [2]	-	15.8	9.8	8.3	15.7	11	7.2	6.8	16.7	7.8	-	19	< 0.5	-	11.5
Dissolved Boron	1.4 [1]	0.37	0.039	0.024	0.039	0.038	0.029	< 0.05	< 0.05	0.038	0.026	-	0.015	0.032	-	0.02
Dissolved Iron	0.2 [2]	0.3	< 0.02	< 0.02	0.03	< 0.02	< 0.02	**1.7**	**3.4**	< 0.02	0.05	-	< 0.02	**18.7**	-	**0.3**
Dissolved Manganese	0.4 [1]	1.9	0.0011	0.0018	0.168	0.0015	0.0031	**0.44**	**0.83**	0.024	0.3	-	0.0064	**1.93**	-	**0.6**
Dissolved Arsenic	0.01 [1]	0.024 (III), 0.013 (V)	< 0.0010	0.0017	0.0014	< 0.0010	0.004	< 0.010	**0.012**	< 0.0010	0.0011	-	0.0027	0.0175	-	0.0063
Dissolved Cadmium	0.004 [1]	0.0002	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.0005	< 0.0005	< 0.00005	< 0.00005	-	< 0.00005	< 0.00005	-	< 0.00005
Dissolved Chromium	0.05 [1]	0.0033	0.0007	0.0008	0.0012	0.0005	0.0015	< 0.005	< 0.005	< 0.0005	< 0.0005	-	< 0.0005	0.0026	-	< 0.0005
Dissolved Copper	2.0 [1]	0.0014	0.0006	0.001	0.0082	< 0.0005	0.0016	0.008	0.006	< 0.0005	0.0005	-	< 0.0005	0.0024	-	< 0.0005
Dissolved Nickel	0.02 [1]	0.011	< 0.0005	< 0.0005	0.0098	0.0005	0.0017	0.009	0.009	0.001	0.0009	-	< 0.0005	0.0054	-	0.0014
Dissolved Lead	0.01 [1]	0.0034	< 0.00010	< 0.00010	0.0004	< 0.00010	0.0005	< 0.0010	< 0.0010	< 0.00010	< 0.00010	-	< 0.00010	0.00064	-	0.00017
Dissolved Zinc	1.5 [2]	0.008	0.0048	0.0013	0.142	0.0071	0.022	0.034	0.022	0.0049	0.0023	-	< 0.0010	0.0058	-	0.0025
Dissolved Aluminium	-	0.055	0.011	0.003	0.022	0.014	0.01	0.03	0.05	< 0.003	0.004	-	< 0.003	0.013	-	0.008
Dissolved Cobalt	-	-	< 0.0002	0.0005	0.0016	< 0.0002	< 0.0002	0.002	0.003	0.0014	0.0022	-	0.0003	0.0031	-	0.0002
Dissolved Mercury	0.007 [1]	0.0006 (inorganic)	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	-	< 0.00008	< 0.00008	-	< 0.00008
Dissolved Selenium	0.01 [1]	0.011 (total)	< 0.0010	< 0.0010	0.0015	< 0.0010	0.0014	< 0.010	< 0.010	< 0.0010	< 0.0010	-	0.0024	< 0.0010	-	< 0.0010
Total Ammoniacal-N	-	-	< 0.010	< 0.010	< 0.10 [#1]	< 0.010	< 0.010	< 0.010	0.04	< 0.010	0.46	< 0.10 #1	< 0.010	0.01	< 0.010	< 0.010
Total Kjeldahl Nitrogen (TKN)	-	-	0.97	0.63	0.74	0.92	1.09	13.1	25	1.33	2.8	-	0.46	56	-	2.3
Dissolved Reactive Phosphorus	-	-	0.008	0.21	0.011	0.006	0.024	< 0.004	0.019	< 0.004	0.43	-	0.022	0.013	-	< 0.004
Total Phosphorus	-	-	1.9	0.24	0.19	2.1	0.23	0.132	0.57	0.79	0.8	-	0.26	0.26	-	0.176
Total Sulphide	-	-	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.22	0.13	< 0.004	< 0.002	-	< 0.002	< 0.004	-	< 0.002
Carbonaceous Biochemical Oxygen Demand (CBOD5)	-	-	3	< 2 [#2]	< 2 [#2]	< 2 [#2]	3	29 [#3]	2,000 [#4]	< 2	6	-	< 2	750	-	8
Chemical Oxygen Demand (COD)	-	-	26	8	6	< 6	47	220	750 [#5]	44	80	37	66	1640	18	36
Total Organic Carbon (TOC)	-	-	< 0.5	< 0.5	< 5	8	1.1	82	770	17	14.3	< 5	1	840	8.4	16.8
Total Phenols	-	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	< 0.02	0.02	-	< 0.02

Note

All data are recorded as g/m^3 except electrical conductivity (mS/m) and pH.

Numbers in bold show sample results that exceed NZDWS maximum acceptable value

Numbers in shaded cells show sample results that exceed ANZECC (2000) 95% guidelines

[1] Indicates Maximum Acceptable Value.

[2] Indicates Guideline Value.

[3] Indicates a value revised from Table 3.4.1 of ANZECC (2000) guidelines.

[4] Hickey, C 2002: Nitrate guideline values in ANZECC 2000. Memorandum to James Court, Ministry for the Environment, September 2002.

[#1] Severe matrix interferences required that a dilution be performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NH4N analysis.

[#2] Due to an instrument error in the laboratory during the original analysis of carbonaceous Biochemical Oxygen Demand (cBOD5) on the sample. The cBOD5 was repeated using the frozen sample.

[#3] During the original analysis of carbonaceous Biochemical Oxygen Demand (cBOD5) the results obtained for the Quality Control standards were outside our acceptance limits and so the analysis of cBOD5 was repeated from the frozen sample. The result for carbonaceous Biochemical Oxygen Demand (cBOD5) is an indication only. During analysis the sample seemed to exhibit inhibitive properties.

[#4] During the original analysis of carbonaceous Biochemical Oxygen Demand (cBOD5) the results obtained for the Quality Control standards were outside our acceptance limits and so the analysis of cBOD5 was repeated from the frozen sample.

[#5] It has been noted that the result for Carbonaceous Biochemical Oxygen Demand (CBOD5), was greater than that for Chemical Oxygen Demand (COD), and outside the analytical variation of these methods. Both results have been confirmed by re-analysis.

[#6] It was observed that the results for 'Sum of Anions' and 'Sum of Cations' were not in good agreement. This was largely attributed to the sediment contained in the sample. The anions and cations analysed, were determined on the filtered sample, with the exception of Alkalinity. The Alkalinity was determined in accordance with APHA 'Standard Methods for the Examination of Water and Wastewater, 21st Edition, 2005', which states; 'Do not filter, dilute, concentrate or alter the sample.' The sediment present in the sample may have contributed to the result obtained for Alkalinity and therefore added to the result for 'Sum of Anions'.

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Certificate of Analysis

SPv1

Client:	Tonkin & Taylor	**Lab No:**	1971386
Contact:	Sami Hutchings	**Date Received:**	28-Apr-2018
	C/- Tonkin & Taylor	**Date Reported:**	14-May-2018
	PO Box 5271	**Quote No:**	91828
	Auckland 1141	**Order No:**	1000647
		Client Reference:	1000647
		Submitted By:	Sami Hutchings

Sample Type: Aqueous

Sample Name:		BC6 26-Apr-2018 1:30 pm	BC7A 26-Apr-2018 12:00 pm	BC9 27-Apr-2018 10:30 am	BC5 27-Apr-2018 12:00 pm	BH10 27-Apr-2018 2:40 pm
Lab Number:		1971386.1	1971386.2	1971386.3	1971386.4	1971386.5
Individual Tests						
Sum of Anions	meq/L	6.5	22	24 #3	20 #3	8.6
Sum of Cations	meq/L	6.6	18.6	9.2	9.5	8.1
pH	pH Units	7.5	6.9	7.5	7.4	7.4
Total Alkalinity	g/m^3 as $CaCO_3$	260	1,010	1,110	930	300
Bicarbonate	g/m^3 at 25°C	310	1,230	1,350	1,130	370
Total Hardness	g/m^3 as $CaCO_3$	290	760	320	340	320
Electrical Conductivity (EC)	mS/m	62.0	156.0	83.4	83.9	78.9
Dissolved Aluminium	g/m^3	0.003	0.022	0.014	0.011	0.010
Dissolved Boron	g/m^3	0.024	0.039	0.038	0.039	0.029
Dissolved Calcium	g/m^3	102	270	109	116	120
Dissolved Cobalt	g/m^3	0.0005	0.0016	< 0.0002	< 0.0002	< 0.0002
Dissolved Iron	g/m^3	< 0.02	0.03	< 0.02	< 0.02	< 0.02
Dissolved Magnesium	g/m^3	7.6	22	11.2	11.5	5.8
Dissolved Manganese	g/m^3	0.0018	0.168	0.0015	0.0011	0.0031
Dissolved Mercury	g/m^3	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008
Dissolved Potassium	g/m^3	6.3	2.9	1.43	1.45	6.3
Dissolved Selenium	g/m^3	< 0.0010	0.0015	< 0.0010	< 0.0010	0.0014
Dissolved Sodium	g/m^3	17.4	77	64	63	34
Chloride	g/m^3	23	47	40	40	53
Total Ammoniacal-N	g/m^3	< 0.010	< 0.10 #2	< 0.010	< 0.010	< 0.010
Nitrite-N	g/m^3	0.005	0.006	0.004	0.004	< 0.002
Nitrate-N	g/m^3	7.3	0.37	0.126	0.155	11.7
Nitrate-N + Nitrite-N	g/m^3	7.3	0.38	0.130	0.159	11.7
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.63	0.74	0.92	0.97	1.09
Dissolved Reactive Phosphorus	g/m^3	0.21	0.011	0.006	0.008	0.024
Total Phosphorus	g/m^3	0.24	0.19	2.1	1.9	0.23
Total Sulphide	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Sulphate	g/m^3	9.8	8.3	15.7	15.8	11.0
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m^3	< 2 #1	< 2 #1	< 2 #1	3	3
Chemical Oxygen Demand (COD)	g O_2/m^3	8	6	< 6	26	47
Total Organic Carbon (TOC)	g/m^3	< 0.5	< 5	8	< 0.5	1.1
Total Phenols	g/m^3	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

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The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Aqueous						
Sample Name:		BC6 26-Apr-2018 1:30 pm	BC7A 26-Apr-2018 12:00 pm	BC9 27-Apr-2018 10:30 am	BC5 27-Apr-2018 12:00 pm	BH10 27-Apr-2018 2:40 pm
Lab Number:		1971386.1	1971386.2	1971386.3	1971386.4	1971386.5
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	0.0017	0.0014	< 0.0010	< 0.0010	0.0040
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Chromium	g/m^3	0.0008	0.0012	0.0005	0.0007	0.0015
Dissolved Copper	g/m^3	0.0010	0.0082	< 0.0005	0.0006	0.0016
Dissolved Lead	g/m^3	< 0.00010	0.00040	< 0.00010	< 0.00010	0.00050
Dissolved Nickel	g/m^3	< 0.0005	0.0098	0.0005	< 0.0005	0.0017
Dissolved Zinc	g/m^3	0.0013	0.142	0.0071	0.0048	0.022

Analyst's Comments

#1 Due to an instrument error in the laboratory during the original analysis of carbonaceous Biochemical Oxygen Demand (cBOD5) on the sample. The cBOD5 was repeated using the frozen sample.

#2 Severe matrix interferences required that a dilution be performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NH4N analysis.

#3 It was observed that the results for 'Sum of Anions' and 'Sum of Cations' were not in good agreement. This was largely attributed to the high level of sediment contained in the sample. The anions and cations analysed, were determined on the filtered sample, with the exception of Alkalinity. The Alkalinity was determined in accordance with APHA 'Standard Methods for the Examination of Water and Wastewater, 21st Edition, 2005', which states; 'Do not filter, dilute, concentrate or alter the sample.' The sediment present in the sample may have contributed to the result obtained for Alkalinity and therefore added to the result for 'Sum of Anions'.

Samples 3, 5 Comment:
Please note that the level of Uncertainty of Measurement (UOM) for the TOC result is significantly greater than that usually reported for this analyte (>300% at the 95% confidence level).

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00005 - 0.0010 g/m^3	1-5
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-5
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1-5
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1-5
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-5
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m^3 at 25°C	1-5
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-5
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.003 g/m^3	1-5

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m^3	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5
Dissolved Cobalt	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0002 g/m^3	1-5
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1-5
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5
Dissolved Selenium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1-5
Total Ammoniacal-N	Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 22nd ed. 2012.	0.010 g/m^3	1-5
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-5
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-Norg D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-5
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified). 22nd ed. 2012.	0.004 g/m^3	1-5
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NAWASCO, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-5
Sulphide Distillation	Acid distillation of sample into alkaline trapping solution using Simple Distillation system. APHA 4500-S^{2-} I 22nd ed. 2012.	-	1-5
Total Sulphide	Sulphide distillation. Automated methylene blue colorimetry, discrete analyser. APHA 4500-S^{2-} I (modified) 22nd ed. 2012.	0.002 g/m^3	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1-5
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, dilutions, seeded. APHA 5210 B (modified) 22nd ed. 2012.	2 g O_2/m^3	1-5
Chemical Oxygen Demand (COD), trace level	Dichromate/sulphuric acid digestion in Hach tubes, colorimetry. Trace Level method. APHA 5220 D 22nd ed. 2012.	6 g O_2/m^3	1-3
Chemical Oxygen Demand (COD), screen level	Dichromate/sulphuric acid digestion, colorimetry. Screen Level method.	25 g O_2/m^3	4-5
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC.The uncertainty of the calculated result is a combination of the uncertainties of the two analytical determinands in the subtraction calculation. Where both determinands are similar in magnitude, the calculated result has a significantly higher uncertainty than would normally be achieved if one of the results was significantly less than the other. In such cases, the elevated uncertainty should be kept in mind when interpreting the data. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-5
Total Phenols	In-line distillation, segmented flow colorimetry. NB: Does not detect 4-methylphenol. Skalar Method I497-001 (modified). APHA 5530 B & D (modified) 22nd ed. 2012.	0.02 g/m^3	1-5

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental

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Certificate of Analysis

Client:	Tonkin & Taylor	**Lab No:**	1996580	SPv2
Contact:	Sami Hutchings	**Date Received:**	08-Jun-2018	
	C/- Tonkin & Taylor	**Date Reported:**	21-Jun-2018	
	PO Box 5271	**Quote No:**	91828	
	Auckland 1141	**Order No:**	Sami Hutchings	
		Client Reference:		
		Submitted By:	Sami Hutchings	

Sample Type: Aqueous

Sample Name:		BC14 06-Jun-2018 1:22 pm	BC10 06-Jun-2018 3:35 pm			
Lab Number:		1996580.1	1996580.2			
Individual Tests						
Sum of Anions	meq/L	7.1	11.0 #4	-	-	-
Sum of Cations	meq/L	6.6	8.9	-	-	-
pH	pH Units	7.4	6.7	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$	310	480	-	-	-
Bicarbonate	g/m³ at 25°C	380	590	-	-	-
Total Hardness	g/m³ as $CaCO_3$	260	350	-	-	-
Electrical Conductivity (EC)	mS/m	58.8	69.0	-	-	-
Dissolved Aluminium	g/m³	0.03	0.05	-	-	-
Dissolved Boron	g/m³	< 0.05	< 0.05	-	-	-
Dissolved Calcium	g/m³	93	116	-	-	-
Dissolved Cobalt	g/m³	0.002	0.003	-	-	-
Dissolved Iron	g/m³	1.7	3.4	-	-	-
Dissolved Magnesium	g/m³	7.9	14.8	-	-	-
Dissolved Manganese	g/m³	0.44	0.83	-	-	-
Dissolved Mercury	g/m³	< 0.00008	< 0.00008	-	-	-
Dissolved Potassium	g/m³	2.8	2.1	-	-	-
Dissolved Selenium	g/m³	< 0.010	< 0.010	-	-	-
Dissolved Sodium	g/m³	28	39	-	-	-
Chloride	g/m³	26	33	-	-	-
Total Ammoniacal-N	g/m³	< 0.010	0.04	-	-	-
Nitrite-N	g/m³	0.158	0.44	-	-	-
Nitrate-N	g/m³	0.010	2.8	-	-	-
Nitrate-N + Nitrite-N	g/m³	0.169	3.2	-	-	-
Total Kjeldahl Nitrogen (TKN)	g/m³	13.1	25	-	-	-
Dissolved Reactive Phosphorus	g/m³	< 0.004	0.019	-	-	-
Total Phosphorus	g/m³	0.132	0.57	-	-	-
Total Sulphide	g/m³	0.22	0.13	-	-	-
Sulphate	g/m³	7.2	6.8	-	-	-
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m³	29 #1	2,000 #2	-	-	-
Chemical Oxygen Demand (COD)	g O_2/m³	220	750 #3	-	-	-
Total Organic Carbon (TOC)	g/m³	82	770	-	-	-
Total Phenols	g/m³	< 0.02	< 0.02	-	-	-

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Sample Type: Aqueous						
Sample Name:		BC14 06-Jun-2018 1:22 pm	BC10 06-Jun-2018 3:35 pm			
Lab Number:		1996580.1	1996580.2			
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	< 0.010	0.012	-	-	-
Dissolved Cadmium	g/m^3	< 0.0005	< 0.0005	-	-	-
Dissolved Chromium	g/m^3	< 0.005	< 0.005	-	-	-
Dissolved Copper	g/m^3	0.008	0.006	-	-	-
Dissolved Lead	g/m^3	< 0.0010	< 0.0010	-	-	-
Dissolved Nickel	g/m^3	0.009	0.009	-	-	-
Dissolved Zinc	g/m^3	0.034	0.022	-	-	-

Analyst's Comments

#1 During the original analysis of carbonaceous Biochemical Oxygen Demand (cBOD5) the results obtained for the Quality Control standards were outside our acceptance limits and so the analysis of cBOD5 was repeated from the frozen sample.

The result for carbonaceous Biochemical Oxygen Demand (cBOD5) is an indication only. During analysis the sample seemed to exhibit inhibitive properties.

#2 During the original analysis of carbonaceous Biochemical Oxygen Demand (cBOD5) the results obtained for the Quality Control standards were outside our acceptance limits and so the analysis of cBOD5 was repeated from the frozen sample.

#3 It has been noted that the result for Carbonaceous Biochemical Oxygen Demand (CBOD5), was greater than that for Chemical Oxygen Demand (COD), and outside the analytical variation of these methods. Both results have been confirmed by re-analysis.

#4 It was observed that the results for 'Sum of Anions' and 'Sum of Cations' were not in good agreement. This was largely attributed to the sediment contained in the sample. The anions and cations analysed, were determined on the filtered sample, with the exception of Alkalinity. The Alkalinity was determined in accordance with APHA 'Standard Methods for the Examination of Water and Wastewater, 21st Edition, 2005', which states; 'Do not filter, dilute, concentrate or alter the sample.' The sediment present in the sample may have contributed to the result obtained for Alkalinity and therefore added to the result for 'Sum of Anions'.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00005 - 0.0010 g/m^3	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1-2
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1-2
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m^3 at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-2
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-2

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.003 g/m^3	1-2
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m^3	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Cobalt	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0002 g/m^3	1-2
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1-2
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Selenium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1-2
Total Ammoniacal-N	Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 22nd ed. 2012.	0.010 g/m^3	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-Norg D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified). 22nd ed. 2012.	0.004 g/m^3	1-2
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NAWASCO, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-2
Sulphide Distillation	Acid distillation of sample into alkaline trapping solution using Simple Distillation system. APHA 4500-S^{2-} I 22nd ed. 2012.	-	1-2
Total Sulphide	Sulphide distillation. Automated methylene blue colorimetry, discrete analyser. APHA 4500-S^{2-} I (modified) 22nd ed. 2012.	0.002 g/m^3	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1-2
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, dilutions, seeded. APHA 5210 B (modified) 22nd ed. 2012.	2 g O_2/m^3	1-2
Chemical Oxygen Demand (COD), screen level	Dichromate/sulphuric acid digestion, colorimetry. Screen Level method.	25 g O_2/m^3	1-2
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC.The uncertainty of the calculated result is a combination of the uncertainties of the two analytical determinands in the subtraction calculation. Where both determinands are similar in magnitude, the calculated result has a significantly higher uncertainty than would normally be achieved if one of the results was significantly less than the other. In such cases, the elevated uncertainty should be kept in mind when interpreting the data. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-2
Total Phenols	In-line distillation, segmented flow colorimetry. NB: Does not detect 4-methylphenol. Skalar Method I497-001 (modified). APHA 5530 B & D (modified) 22nd ed. 2012.	0.02 g/m^3	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental

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Certificate of Analysis

Client:	Tonkin & Taylor	**Lab No:**	2040634	SPv2
Contact:	T Reynolds	**Date Received:**	31-Aug-2018	
	C/- Tonkin & Taylor	**Date Reported:**	12-Sep-2018	
	PO Box 5271	**Quote No:**	94459	
	Auckland 1141	**Order No:**	1000647.1000	
		Client Reference:	1000647.1000	
		Submitted By:	T Reynolds	

Sample Type: Aqueous

Sample Name:		BC 5 29-Aug-2018 12:00 pm	BC6 30-Aug-2018 11:50 am	BC 7A 29-Aug-2018 12:58 pm	BC 9 29-Aug-2018 1:40 pm	BC10 30-Aug-2018 7:58 am
Lab Number:		2040634.1	2040634.2	2040634.3	2040634.4	2040634.5
Individual Tests						
pH	pH Units	7.3	7.4	6.6	7.5	6.8
Total Alkalinity	g/m^3 as $CaCO_3$	730	210	880	330	620
Electrical Conductivity (EC)	mS/m	84.3	46.8	155.4	58.4	93.2
Dissolved Aluminium	g/m^3	< 0.003	0.004	-	< 0.003	0.013
Dissolved Boron	g/m^3	0.038	0.026	-	0.015	0.032
Dissolved Calcium	g/m^3	118	69	-	91	182
Dissolved Cobalt	g/m^3	0.0014	0.0022	-	0.0003	0.0031
Dissolved Iron	g/m^3	< 0.02	0.05	-	< 0.02	18.7
Dissolved Magnesium	g/m^3	10.5	5.4	-	2.9	15.8
Dissolved Manganese	g/m^3	0.024	0.30	-	0.0064	1.93
Dissolved Mercury	g/m^3	< 0.00008	< 0.00008	-	< 0.00008	< 0.00008
Dissolved Potassium	g/m^3	1.51	12.3	1.88	3.5	1.80
Dissolved Selenium	g/m^3	< 0.0010	< 0.0010	-	0.0024	< 0.0010
Dissolved Sodium	g/m^3	67	16.9	-	32	45
Total Cyanide	g/m^3	< 0.002	< 0.002	-	< 0.002	< 0.002
Chloride	g/m^3	39	19.9	50	41	33
Total Ammoniacal-N	g/m^3	< 0.010	0.46	< 0.10 #1	< 0.010	0.010
Nitrite-N	g/m^3	< 0.002	0.013	< 0.002	< 0.002	0.002
Nitrate-N	g/m^3	0.25	0.041	0.013	3.0	< 0.002
Nitrate-N + Nitrite-N	g/m^3	0.25	0.054	0.013	3.0	0.003
Total Kjeldahl Nitrogen (TKN)	g/m^3	1.33	2.8	-	0.46	56
Dissolved Reactive Phosphorus	g/m^3	< 0.004	0.43	-	0.022	0.013
Total Phosphorus	g/m^3	0.79	0.80	-	0.26	0.26
Total Sulphide	g/m^3	< 0.004	< 0.002	-	< 0.002	< 0.004
Sulphate	g/m^3	16.7	7.8	-	19.0	< 0.5
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m^3	< 2	6	-	< 2	750
Chemical Oxygen Demand (COD)	g O_2/m^3	44	80	37	66	1,640
Total Organic Carbon (TOC)	g/m^3	17	14.3	< 5	1.0	840
Total Phenols	g/m^3	< 0.02	< 0.02	-	< 0.02	0.02
Volatile Fatty Acids (VFA), Total	g/m^3 as acetic acid	< 5	< 5	< 5	< 5	280
Absorbance at 254 nm	AU cm^{-1}	0.029	0.152	0.078	0.030	1.496

ilac-MRA IANZ ACCREDITED LABORATORY

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Aqueous						
Sample Name:		BC 5 29-Aug-2018 12:00 pm	BC6 30-Aug-2018 11:50 am	BC 7A 29-Aug-2018 12:58 pm	BC 9 29-Aug-2018 1:40 pm	BC10 30-Aug-2018 7:58 am
Lab Number:		2040634.1	2040634.2	2040634.3	2040634.4	2040634.5
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	< 0.0010	0.0011	-	0.0027	0.0175
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	-	< 0.00005	< 0.00005
Dissolved Chromium	g/m^3	< 0.0005	< 0.0005	-	< 0.0005	0.0026
Dissolved Copper	g/m^3	< 0.0005	0.0005	-	< 0.0005	0.0024
Dissolved Lead	g/m^3	< 0.00010	< 0.00010	-	< 0.00010	0.00064
Dissolved Nickel	g/m^3	0.0010	0.0009	-	< 0.0005	0.0054
Dissolved Zinc	g/m^3	0.0049	0.0023	-	< 0.0010	0.0058
Haloethers Trace in SVOC Water Samples by GC-MS						
Bis(2-chloroethoxy) methane	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
Bis(2-chloroethyl)ether	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
Bis(2-chloroisopropyl)ether	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
4-Bromophenyl phenyl ether	g/m^3	< 0.0003	-	-	< 0.0003	< 0.003
4-Chlorophenyl phenyl ether	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
Nitrogen containing compounds Trace in SVOC Water Samples, GC-MS						
2,4-Dinitrotoluene	g/m^3	< 0.0010	-	-	< 0.0010	< 0.005
2,6-Dinitrotoluene	g/m^3	< 0.0010	-	-	< 0.0010	< 0.005
Nitrobenzene	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
N-Nitrosodi-n-propylamine	g/m^3	< 0.0010	-	-	< 0.0010	< 0.005
N-Nitrosodiphenylamine + Diphenylamine	g/m3	< 0.0010	-	-	< 0.0010	< 0.005
Organochlorine Pesticides Trace in SVOC Water Samples by GC-MS						
Aldrin	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
alpha-BHC	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
beta-BHC	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
delta-BHC	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
gamma-BHC (Lindane)	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
4,4'-DDD	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
4,4'-DDE	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
4,4'-DDT	g/m^3	< 0.0010	-	-	< 0.0010	< 0.005
Dieldrin	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
Endosulfan I	g/m^3	< 0.0010	-	-	< 0.0010	< 0.005
Endosulfan II	g/m^3	< 0.0010	-	-	< 0.0010	< 0.005
Endosulfan sulfate	g/m^3	< 0.0010	-	-	< 0.0010	< 0.005
Endrin	g/m^3	< 0.0005	-	-	< 0.0005	< 0.005
Endrin ketone	g/m^3	< 0.0010	-	-	< 0.0010	< 0.005
Heptachlor	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
Heptachlor epoxide	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
Hexachlorobenzene	g/m^3	< 0.0005	-	-	< 0.0005	< 0.003
Polycyclic Aromatic Hydrocarbons Trace in SVOC Water Samples						
Acenaphthene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.0013
Acenaphthylene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.0013
Anthracene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.0013
Benzo[a]anthracene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.0013
Benzo[a]pyrene (BAP)	g/m^3	< 0.0003	-	-	< 0.0003	< 0.003
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.003
Benzo[g,h,i]perylene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.003
Benzo[k]fluoranthene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.003
1&2-Chloronaphthalene	g/m^3	< 0.0006	-	-	< 0.0006	< 0.006
Chrysene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.0013
Dibenzo[a,h]anthracene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.003
Fluoranthene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.0013
Fluorene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.0013
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.003
2-Methylnaphthalene	g/m^3	< 0.0003	-	-	< 0.0003	< 0.0013

Sample Type: Aqueous						
Sample Name:		BC 5 29-Aug-2018 12:00 pm	BC6 30-Aug-2018 11:50 am	BC 7A 29-Aug-2018 12:58 pm	BC 9 29-Aug-2018 1:40 pm	BC10 30-Aug-2018 7:58 am
Lab Number:		2040634.1	2040634.2	2040634.3	2040634.4	2040634.5
Polycyclic Aromatic Hydrocarbons Trace in SVOC Water Samples						
Naphthalene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0013
Phenanthrene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0013
Pyrene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0013
Phenols Trace (drinkingwater) in SVOC Water Samples by GC-MS						
2-Chlorophenol	g/m³	< 0.0005	-	-	< 0.0005	< 0.003
2,4-Dichlorophenol	g/m³	< 0.0005	-	-	< 0.0005	< 0.003
2,4,6-Trichlorophenol	g/m³	< 0.0010	-	-	< 0.0010	< 0.005
Phenols Trace (non-drinkingwater) in SVOC Water Samples by GC-MS						
4-Chloro-3-methylphenol	g/m³	< 0.0010	-	-	< 0.0010	< 0.005
2,4-Dimethylphenol	g/m³	< 0.0005	-	-	< 0.0005	< 0.003
3 & 4-Methylphenol (m- + p-cresol)	g/m³	< 0.0010	-	-	< 0.0010	0.040
2-Methylphenol (o-Cresol)	g/m³	< 0.0005	-	-	< 0.0005	< 0.003
2-Nitrophenol	g/m³	< 0.0010	-	-	< 0.0010	< 0.005
Pentachlorophenol (PCP)	g/m³	< 0.010	-	-	< 0.010	< 0.05
Phenol	g/m³	< 0.0010	-	-	< 0.0010	< 0.005
2,4,5-Trichlorophenol	g/m³	< 0.0010	-	-	< 0.0010	< 0.005
Plasticisers Trace (non-drinkingwater) in SVOC Water by GCMS						
Butylbenzylphthalate	g/m³	< 0.0010	-	-	< 0.0010	< 0.005
Diethylphthalate	g/m³	< 0.0010	-	-	< 0.0010	< 0.005
Dimethylphthalate	g/m³	< 0.0010	-	-	< 0.0010	< 0.005
Di-n-butylphthalate	g/m³	< 0.0010	-	-	< 0.0010	< 0.005
Di-n-octylphthalate	g/m³	< 0.0010	-	-	< 0.0010	< 0.005
Plasticisers Trace (drinkingwater) in SVOC Water Samples by GCMS						
Bis(2-ethylhexyl)phthalate	g/m³	< 0.003	-	-	< 0.003	< 0.010
Di(2-ethylhexyl)adipate	g/m³	< 0.0010	-	-	< 0.0010	< 0.003
Other Halogenated compounds Trace (drinkingwater) in SVOC Water						
1,2-Dichlorobenzene	g/m³	< 0.0005	-	-	< 0.0005	< 0.005
1,3-Dichlorobenzene	g/m³	< 0.0005	-	-	< 0.0005	< 0.005
1,4-Dichlorobenzene	g/m³	< 0.0005	-	-	< 0.0005	< 0.005
Other Halogenated compounds Trace (non-drinkingwater) in SVOC						
Hexachlorobutadiene	g/m³	< 0.0005	-	-	< 0.0005	< 0.005
Hexachloroethane	g/m³	< 0.0005	-	-	< 0.0005	< 0.005
1,2,4-Trichlorobenzene	g/m³	< 0.0005	-	-	< 0.0005	< 0.003
Other SVOC Trace in SVOC Water Samples by GC-MS						
Benzyl alcohol	g/m³	< 0.005	-	-	< 0.005	< 0.03
Carbazole	g/m³	< 0.0005	-	-	< 0.0005	< 0.003
Dibenzofuran	g/m³	< 0.0005	-	-	< 0.0005	< 0.003
Isophorone	g/m³	< 0.0005	-	-	< 0.0005	< 0.003
BTEX in VOC Water by Headspace GC-MS						
Benzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Ethylbenzene	g/m³	< 0.0005	-	-	< 0.0005	< 0.0005
Toluene	g/m³	< 0.0003	-	-	< 0.0003	0.0005
m&p-Xylene	g/m³	< 0.0005	-	-	< 0.0005	0.0006
o-Xylene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Halogenated Aliphatics in VOC Water by Headspace GC-MS						
Bromomethane (Methyl Bromide)	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Carbon tetrachloride	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Chloroethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Chloromethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,2-Dibromo-3-chloropropane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,2-Dibromoethane (ethylene dibromide, EDB)	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Dibromomethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003

Sample Type: Aqueous						
Sample Name:		BC 5 29-Aug-2018 12:00 pm	BC6 30-Aug-2018 11:50 am	BC 7A 29-Aug-2018 12:58 pm	BC 9 29-Aug-2018 1:40 pm	BC10 30-Aug-2018 7:58 am
Lab Number:		2040634.1	2040634.2	2040634.3	2040634.4	2040634.5
Halogenated Aliphatics in VOC Water by Headspace GC-MS						
Dichlorodifluoromethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,1-Dichloroethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,2-Dichloroethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,1-Dichloroethene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
cis-1,2-Dichloroethene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
trans-1,2-Dichloroethene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Dichloromethane (methylene chloride)	g/m³	< 0.010	-	-	< 0.010	< 0.010
1,2-Dichloropropane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,3-Dichloropropane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,1-Dichloropropene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
cis-1,3-Dichloropropene	g/m³	< 0.0005	-	-	< 0.0005	< 0.0005
trans-1,3-Dichloropropene	g/m³	< 0.0005	-	-	< 0.0005	< 0.0005
Hexachlorobutadiene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,1,1,2-Tetrachloroethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,1,2,2-Tetrachloroethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Tetrachloroethene (tetrachloroethylene)	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,1,1-Trichloroethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,1,2-Trichloroethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Trichloroethene (trichloroethylene)	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Trichlorofluoromethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,2,3-Trichloropropane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,1,2-Trichlorotrifluoroethane (Freon 113)	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Vinyl chloride	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Halogenated Aromatics in VOC Water by Headspace GC-MS						
Chlorobenzene (monochlorobenzene)	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,2-Dichlorobenzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,3-Dichlorobenzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,4-Dichlorobenzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,2,3-Trichlorobenzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,2,4-Trichlorobenzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,3,5-Trichlorobenzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Bromobenzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
2-Chlorotoluene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
4-Chlorotoluene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Monoaromatic Hydrocarbons in VOC Water by Headspace GC-MS						
n-Butylbenzene	g/m³	< 0.0005	-	-	< 0.0005	< 0.0005
tert-Butylbenzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
4-Isopropyltoluene (p-Cymene)	g/m³	< 0.0005	-	-	< 0.0005	< 0.0005
Isopropylbenzene (Cumene)	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
n-Propylbenzene	g/m³	< 0.0005	-	-	< 0.0005	< 0.0005
sec-Butylbenzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Styrene	g/m³	< 0.0005	-	-	< 0.0005	< 0.0005
1,2,4-Trimethylbenzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
1,3,5-Trimethylbenzene	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Ketones in VOC Water by Headspace GC-MS						
Acetone	g/m³	< 0.05	-	-	< 0.05	< 0.05
2-Butanone (MEK)	g/m³	< 0.05	-	-	< 0.05	< 0.05
Methyl tert-butylether (MTBE)	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
4-Methylpentan-2-one (MIBK)	g/m³	< 0.010	-	-	< 0.010	< 0.010
Trihalomethanes in VOC Water by Headspace GC-MS						
Bromodichloromethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Bromoform (tribromomethane)	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Chloroform (Trichloromethane)	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003
Dibromochloromethane	g/m³	< 0.0003	-	-	< 0.0003	< 0.0003

Sample Type: Aqueous						
Sample Name:		BC 5 29-Aug-2018 12:00 pm	BC6 30-Aug-2018 11:50 am	BC 7A 29-Aug-2018 12:58 pm	BC 9 29-Aug-2018 1:40 pm	BC10 30-Aug-2018 7:58 am
Lab Number:		2040634.1	2040634.2	2040634.3	2040634.4	2040634.5
Other VOC in Water by Headspace GC-MS						
Carbon disulphide	g/m³	< 0.0005	-	-	< 0.0005	0.0016
Naphthalene	g/m³	< 0.0005	-	-	< 0.0005	< 0.0005

Sample Name:		BH10 29-Aug-2018 10:46 am	BC14 29-Aug-2018 2:20 pm			
Lab Number:		2040634.6	2040634.7			
Individual Tests						
pH	pH Units	7.4	7.3	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$	270	300	-	-	-
Electrical Conductivity (EC)	mS/m	75.9	64.3	-	-	-
Dissolved Aluminium	g/m³	-	0.008	-	-	-
Dissolved Boron	g/m³	-	0.020	-	-	-
Dissolved Calcium	g/m³	-	98	-	-	-
Dissolved Cobalt	g/m³	-	0.0002	-	-	-
Dissolved Iron	g/m³	-	0.30	-	-	-
Dissolved Magnesium	g/m³	-	7.1	-	-	-
Dissolved Manganese	g/m³	-	0.60	-	-	-
Dissolved Mercury	g/m³	-	< 0.00008	-	-	-
Dissolved Potassium	g/m³	3.4	1.95	-	-	-
Dissolved Selenium	g/m³	-	< 0.0010	-	-	-
Dissolved Sodium	g/m³	-	37	-	-	-
Total Cyanide	g/m³	-	< 0.002	-	-	-
Chloride	g/m³	52	30	-	-	-
Total Ammoniacal-N	g/m³	< 0.010	< 0.010	-	-	-
Nitrite-N	g/m³	< 0.002	< 0.002	-	-	-
Nitrate-N	g/m³	11.0	0.056	-	-	-
Nitrate-N + Nitrite-N	g/m³	11.0	0.056	-	-	-
Total Kjeldahl Nitrogen (TKN)	g/m³	-	2.3	-	-	-
Dissolved Reactive Phosphorus	g/m³	-	< 0.004	-	-	-
Total Phosphorus	g/m³	-	0.176	-	-	-
Total Sulphide	g/m³	-	< 0.002	-	-	-
Sulphate	g/m³	-	11.5	-	-	-
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m³	-	8	-	-	-
Chemical Oxygen Demand (COD)	g O_2/m³	18	36	-	-	-
Total Organic Carbon (TOC)	g/m³	8.4	16.8	-	-	-
Total Phenols	g/m³	-	< 0.02	-	-	-
Volatile Fatty Acids (VFA), Total	g/m³ as acetic acid	< 5	< 5	-	-	-
Absorbance at 254 nm	AU cm⁻¹	0.014	0.066	-	-	-
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m³	-	0.0063	-	-	-
Dissolved Cadmium	g/m³	-	< 0.00005	-	-	-
Dissolved Chromium	g/m³	-	< 0.0005	-	-	-
Dissolved Copper	g/m³	-	< 0.0005	-	-	-
Dissolved Lead	g/m³	-	0.00017	-	-	-
Dissolved Nickel	g/m³	-	0.0014	-	-	-
Dissolved Zinc	g/m³	-	0.0025	-	-	-

Analyst's Comments
[#1] Severe matrix interferences required that a dilution be performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NH4N analysis.

Sample 1 Comment:
Please note that the level of Uncertainty of Measurement (UOM) for the TOC result is significantly greater than that usually reported for this analyte (up to 200-300% at the 95% confidence level).

Sample 4 Comment:
Please note that the level of Uncertainty of Measurement (UOM) for the TOC result is significantly greater than that usually reported for this analyte (>300% at the 95% confidence level).

Samples 6-7 Comment:
Please note that the level of Uncertainty of Measurement (UOM) for the TOC result is significantly greater than that usually reported for this analyte (up to 100-200% at the 95% confidence level).

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00005 - 0.0010 g/m^3	1-2, 4-5, 7
Semivolatile Organic Compounds Trace in Water by GC-MS	Liquid/Liquid extraction, GPC cleanup (if required), GC-MS FS analysis	-	1, 4-5
Volatile Organic Compounds Trace in Water by Headspace GC-MS	Headspace, GC-MS SIM analysis [KBIs:37857,37921]	0.0003 - 0.05 g/m^3	1, 4-5
Filtration, Glass Fibre	Sample filtration through glass fibre filter.	-	1-7
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-7
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-7
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-7
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-7
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-7
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.003 g/m^3	1-2, 4-5, 7
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m^3	1-2, 4-5, 7
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2, 4-5, 7
Dissolved Cobalt	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0002 g/m^3	1-2, 4-5, 7
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2, 4-5, 7
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2, 4-5, 7
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1-2, 4-5, 7
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-2, 4-5, 7
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-7
Dissolved Selenium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-2, 4-5, 7
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2, 4-5, 7
Total Cyanide Trace	On-line distillation, colorimetry, trace level. ISO 14403:2012(E) (modified).	0.002 g/m^3	1-2, 4-5, 7
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1-7

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Ammoniacal-N	Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 22nd ed. 2012.	0.010 g/m^3	1-7
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-7
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-7
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-7
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-Norg D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2, 4-5, 7
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified). 22nd ed. 2012.	0.004 g/m^3	1-2, 4-5, 7
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NAWASCO, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-2, 4-5, 7
Total Sulphide Trace	In-line distillation, segmented flow colorimetry. APHA 4500-S2-E (modified) 22nd ed. 2012.	0.002 g/m^3	1-2, 4-5, 7
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1-2, 4-5, 7
Carbonaceous Biochemical Oxygen Demand (cBOD$_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, dilutions, seeded. APHA 5210 B (modified) 22nd ed. 2012.	2 g O_2/m^3	1-2, 4-5, 7
Chemical Oxygen Demand (COD), trace level	Dichromate/sulphuric acid digestion in Hach tubes, colorimetry. Trace Level method. APHA 5220 D 22nd ed. 2012.	6 g O_2/m^3	6
Chemical Oxygen Demand (COD), screen level	Dichromate/sulphuric acid digestion, colorimetry. Screen Level method.	25 g O_2/m^3	1-5, 7
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC.The uncertainty of the calculated result is a combination of the uncertainties of the two analytical determinands in the subtraction calculation. Where both determinands are similar in magnitude, the calculated result has a significantly higher uncertainty than would normally be achieved if one of the results was significantly less than the other. In such cases, the elevated uncertainty should be kept in mind when interpreting the data. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-7
Total Phenols	In-line distillation, segmented flow colorimetry. NB: Does not detect 4-methylphenol. Skalar Method I497-001 (modified). APHA 5530 B & D (modified) 22nd ed. 2012.	0.02 g/m^3	1-2, 4-5, 7
Volatile Fatty Acids (VFA), Total	Ion Chromatography. Sum of Formic, Acetic, Propionic and Butyric acids only, expressed as acetic acid.	5 g/m^3 as acetic acid	1-7
Formic Acid	Ion Chromatography.	0.5 g/m^3	1-7
Acetic Acid	Ion Chromatography.	0.5 g/m^3	1-7
Propionic Acid	Ion Chromatography.	0.5 g/m^3	1-7
Butyric Acid	Ion Chromatography.	0.5 g/m^3	1-7
Absorbance at 254 nm	Filtered sample. Spectrophotometry, 1cm cell. APHA 5910 B 22nd ed. 2012.	0.002 AU cm^{-1}	1-7

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Appendix D: Nearby groundwater users and consents

5616335

Area	Easting	Northing	Well Numb	Well Depth	Well Diame	Drill Date	Top Screen	Bottom Screen	DrillerName	ValuationId	Location	LocationMethod	WQSite	Address
Motoe Valley	1924428	5617971	9	20.42	100	16/10/1970			Baylis Brothers Limited	957016500	0051 OMARUNUI SETT RD	HASTINGS		
Motoe Valley	1923728	5616469	162	15.85	100	28/10/1972			Baylis Brothers Limited	957015800	0459 SWAMP RD	HASTINGS		111
Motoe Valley	1924729	5617470	232	10.97	75	13/01/1973			Baylis Brothers Limited	957016302	0 SWAMP RD	HASTINGS		1204
Tutaekuri Grave	1926731	5615869	280	16.15	100	27/01/1973			Baylis Brothers Limited	957007700	297 OMARUNUI RD	HASTINGS		
Tutaekuri Grave	1926531	5616470	331	13.72	100	29/10/1973	10.98	13.72	Baylis Brothers Limited	957007500	367 OMARUNUI RD	HASTINGS		127
Motoe Valley	1924729	5617270	459	11.89	75	16/09/1974			Baylis Brothers Limited	957016102	606 SWAMP RD	HASTINGS		1206
Tutaekuri Grave	1926919	5615297	569	16.15	100	29/11/1975			Baylis Brothers Limited	957007703	251 OMARUNUI RD	HASTINGS	Hand-held GPS	126
Tutaekuri Grave	1926988	5614966	570	23.01	100	19/12/1975	21.33	23.01	Baylis Brothers Limited	957007704	207 OMARUNUI RD	HASTINGS	Hand-held GPS	2399
Tutaekuri Grave	1926430	5617471	590	10.67	75	26/03/1976	9.15	10.67	Baylis Brothers Limited	957007201	489 OMARUNUI RD	HASTINGS		113
Tutaekuri Grave	1926030	5617871	802	20.27	100	26/03/1979	18.75	20.27	Baylis Brothers Limited	957007100	0515 OMARUNUI RD	HASTINGS		
Tutaekuri Grave	1926431	5617171	865	17.3	150	27/07/1979	11.3	17.3	Boag & Hill Ltd	957007300	0451 OMARUNUI RD	HASTINGS		1167
Tutaekuri Grave	1926369	5616672	922	13.11	150	17/11/1979	10.06	13.11	Baylis Brothers Limited	957007404	395 OMARUNUI RD	HASTINGS	Hand-held GPS	
Motoe Valley	1924576	5616886	975	8.2	75	5/08/1980			Boag & Hill Ltd	957016100	0574 SWAMP RD	HASTINGS	Differential GPS	110
Motoe Valley	1924259	5617988	1577	15.24	100	30/10/1983	9.14	15.24	Baylis Brothers Limited	957016501	87 OMARUNUI SETT RD	HASTINGS	Hand-held GPS	1226
Tutaekuri Grave	1926585	5616428	1628	21.03	150	21/01/1984	15.03	21.03	Baylis Brothers Limited	957007500	367 OMARUNUI RD	HASTINGS	Hand-held GPS	
Tutaekuri Grave	1926652	5615473	1660	22.25	200	3/04/1984	18.25	22.25	Baylis Brothers Limited	957007700	297 OMARUNUI RD	HASTINGS	Hand-held GPS	2771
Tutaekuri Grave	1926632	5614768	1685	48.76	100	4/07/1984			Baylis Brothers Limited	957007717	191 BRECKENRIDGE LANE	HASTINGS		
Tutaekuri Grave	1926734	5614960	1686	18.89	250	9/07/1984	12.89	18.89	Baylis Brothers Limited			Hand-held GPS		OMARUNU
Tutaekuri Grave	1926551	5616882	1803	29.42	200	15/01/1985	29.42	35.42	Hill Well Drillers Ltd	957007402	417 OMARUNUI RD	HASTINGS	Hand-held GPS	
Tutaekuri Grave	1926388	5617856	1972	25	200	27/09/1985	19	25	Hill Well Drillers Ltd	957007101	0517 OMARUNUI RD	HASTINGS	Hand-held GPS	
Motoe Valley	1924795	5617835	2179	3.6	200	18/12/1986	3.6	9.6	Hill Well Drillers Ltd	957016402	0 SWAMP RD	HASTINGS		SWAMP RI
Tutaekuri Grave	1926480	5617210	2238	21.3	300	8/06/1987	15.3	21.3	Baylis Brothers Limited	957007300	0451 OMARUNUI RD	HASTINGS	Hand-held GPS	OMARUNU
Tutaekuri Grave	1926487	5617216	2239	22.2	300	8/06/1987	16.2	22.2	Baylis Brothers Limited	957007300	0451 OMARUNUI RD	HASTINGS	Hand-held GPS	
Motoe Valley	1923954	5615221	2301	13.7	100	26/11/1987	10.97	12.5	Honnor Drilling Limited	957015301	0362 SWAMP RD	HASTINGS	Hand-held GPS	SWAMP RC
Motoe Valley	1924438	5617916	2320	20	200	2/11/1987	13.1	20	Hill Well Drillers Ltd	957016500	0051 OMARUNUI SETT RD	HASTINGS	Differential GPS	1698
Omarunui LF	1924529	5615869	2353	27		17/02/1988			Hill Well Drillers Ltd	0957007600A	329 OMARUNUI RD	HASTINGS		SWAMP RC
Omarunui LF	1924723	5616483	2354	50	200	26/01/1988			Hill Well Drillers Ltd	0957007600A	329 OMARUNUI RD	HASTINGS		SWAMP RC
Motoe Valley	1924529	5617070	2394	12.8	100	21/06/1988	10.8	12.8	Baylis Brothers Limited	957016202	0 SWAMP RD	HASTINGS		SWAMP RC
Motoe Valley	1924742	5617404	2441	18.14	150	25/10/1988	12.14	18.14	Baylis Brothers Limited	957016302	0 SWAMP RD	HASTINGS	Hand-held GPS	
Motoe Valley	1923928	5617670	2469	16.13	100	23/01/1989	14.13	16.13	Hill Well Drillers Ltd	957016700	89 OMARUNUI SETT RD	HASTINGS		OMARANU
Motoe Valley	1923701	5615964	2554	15.2	150	9/06/1989	11.37	14.3	Honnor Drilling Limited	957015700	421 SWAMP RD	HASTINGS	2775	421 SWAM
Omarunui LF	1924729	5615669	2555			8/03/1995			Hill Well Drillers Ltd	0957007600A	329 OMARUNUI RD	HASTINGS		SWAMP RC
Omarunui LF	1924729	5615669	2556						Unknown	0957007600A	329 OMARUNUI RD	HASTINGS		SWAMP RC
Motoe Valley	1924793	5618040	2597	20.5	200	5/10/1989	14.5	20.5	Hill Well Drillers Ltd	957016402	0 SWAMP RD	HASTINGS	Hand-held GPS	
Omarunui LF	1924729	5615669	2934		100				Unknown	0957007600A	329 OMARUNUI RD	HASTINGS		OMARANU
Omarunui LF	1924729	5615669	2935		100				Unknown	0957007600A	329 OMARUNUI RD	HASTINGS		OMARANU
Omarunui LF	1924830	5615669	2936		100				Unknown	0957007600A	329 OMARUNUI RD	HASTINGS		OMARANU
Tutaekuri Grave	1926265	5617830	2969		150				Unknown	957007100	0515 OMARUNUI RD	HASTINGS	Hand-held GPS	OMARANU
Tutaekuri Grave	1926626	5616820	2974	19.2	150	19/09/1991	13.2	19.2	Baylis Brothers Limited	957007403	394 OMARUNUI RD	HASTINGS		OMARANU
Motoe Valley	1924050	5616822	3021	32.91	200	27/11/1991	23.61	32.91	Honnor Drilling Limited	957016001	535 SWAMP RD	HASTINGS	Hand-held GPS	
Tutaekuri Grave	1926531	5615769	3047	11.4	100	20/01/1992	9.4	11.4	Hill Well Drillers Ltd	957007700	297 OMARUNUI RD	HASTINGS		OMARANU
Motoe Valley	1924309	5616709	3088	14.2	100	20/03/1992	12.2	14.2	Hill Well Drillers Ltd	957015904	0 SWAMP RD	HASTINGS		SWAMP RC
Motoe Valley	1923948	5617623	3096	16.1	100	27/04/1992	14.1	16.1	Hill Well Drillers Ltd	957016601	0085 OMARUNUI SETT RD	HASTINGS	2776	85 OMARA
Tutaekuri Grave	1926220	5617631	3105	10.36	100	18/05/1992	4.36	10.36	Baylis Brothers Limited	957007200	469 OMARUNUI RD	HASTINGS		PUKETAPU
Tutaekuri Grave	1926883	5615180	3126						Baylis Brothers Limited	957007707	229 OMARUNUI RD	HASTINGS	Hand-held GPS	
Tutaekuri Grave	1926488	5616106	3365	18	150	5/11/1993	15	18	Hill Well Drillers Ltd	957007601	339 OMARUNUI RD	HASTINGS	Hand-held GPS	OMARUNU
Motoe Valley	1924320	5616256	3384	36.57	100	27/11/1993	19.5	36.57	Baylis Brothers Limited					SWAMP RC
Motoe Valley	1923691	5615817	3489	18.29	150	11/07/1994	14.54	18.29	Baylis Brothers Limited			Differential GPS		SWAMP RC
Motoe Valley	1924039	5616790	3681	12.5	150	7/08/1995	10.5	12.5	Baylis Brothers Limited	957015904	0 SWAMP RD	HASTINGS	Differential GPS	
Motoe Valley	1923943	5615896	3682	14.34	100	25/08/1995	12.57	14.34	Baylis Brothers Limited	957015702	435 SWAMP ROAD	HASTINGS	Differential GPS	
Motoe Valley	1924539	5618051	3725	19.5	80	6/11/1995	14	15.4	Honnor Drilling Limited	957016502	49 OMARUNUI SETT RD	HASTINGS	Differential GPS	51 OMARU
Motoe Valley	1924441	5616603	3896	54.86	100	29/11/1996	13.08	54.86	Baylis Brothers Limited	957015900	534 SWAMP RD	HASTINGS	Differential GPS	SWAMP RC
Motoe Valley	1924869	5617611	4048	19.7	100	19/06/1997	3	19.7	Hill Well Drillers Ltd	957016300	0652 SWAMP RD	HASTINGS	Differential GPS	652 SWAM
Motoe Valley	1924074	5614942	4203	33	100	12/08/1999	12.7	30	Honnor Drilling Limited	957015302	364 SWAMP RD	HASTINGS	Differential GPS	362 SWAM
Motoe Valley	1925037	5617962	4328	20.01	250	11/10/1999	16	20	Baylis Brothers Limited	957016417	684/17 SWAMP RD	HASTINGS	Differential GPS	SWAMP RC
Omarunui LF	1924702	5615951	4463	19.2	50	3/07/2000	16	19	WEBSTER DRILLING LTD	0957007600A	329 OMARUNUI RD	HASTINGS	Map estimate	
Omarunui LF	1924738	5616173	4464	13.7	50	13/07/2000	7.5	13.5	WEBSTER DRILLING LTD	0957007600A	329 OMARUNUI RD	HASTINGS	Map estimate	
Omarunui LF	1924798	5616293	4465	29.2	50	14/07/2000	26	29	WEBSTER DRILLING LTD	0957007600A	329 OMARUNUI RD	HASTINGS	Map estimate	
Omarunui LF	1925051	5616293	4466	51.1	50	26/06/2000	42.1	51.1	WEBSTER DRILLING LTD	0957007600A	329 OMARUNUI RD	HASTINGS	Map estimate	
Omarunui LF	1924750	5615933	4467	18.9	50	2/07/2000	12.3	18.3	WEBSTER DRILLING LTD	0957007600A	329 OMARUNUI RD	HASTINGS	Map estimate	

Omarunui LF	1924913	5615915	4468	9.2	50	29/06/2000	6	9	WEBSTER DRILLING LTD	0957007600A	329 OMARUNUI RD	HASTINGS	Map estimate	
Motoe Valley	1924732	5617232	4498	18	100	6/09/2000	16	18	Baylis Brothers Limited	957016200	606 SWAMP RD	HASTINGS	Differential GPS	2778
Tutaekuri Grave	1925977	5616731	4527	17.55	100	6/11/2000	16.25	17.55	Baylis Brothers Limited	957007400	0 OMARUNUI RD	HASTINGS	Differential GPS	419 OMAR
Tutaekuri Grave	1926706	5616700	4541	14.58	100	22/11/2000	12.58	14.58	Baylis Brothers Limited	957007403	394 OMARUNUI RD	HASTINGS	Differential GPS	OMARANU
Motoe Valley	1923823	5617421	4745	18	150	18/01/2002	12	18	Baylis Brothers Limited	957016601	0085 OMARUNUI SETT RD	HASTINGS	Hand-held GPS	85 OMARU
Omarunui LF	1924821	5615604	4786	21.1	150	19/04/2002	16.3	21.1	Honnor Drilling Limited	0957007600A	329 OMARUNUI RD	HASTINGS	Differential GPS	2713
Motoe Valley	1924301	5616038	5133	6	150	13/03/2004			Baylis Brothers Limited	957015801	500 SWAMP RD	HASTINGS	Differential GPS	SWAMP R
Tutaekuri Grave	1926079	5616742	5178	16.5	100	15/05/2004	14.79	16.49	Baylis Brothers Limited	957007400	0 OMARUNUI RD	HASTINGS	Hand-held GPS	419 OMAR
Omarunui LF	1924699	5615949	5248	9	50	4/07/2000	6	9	WEBSTER DRILLING LTD	0957007600A	329 OMARUNUI RD	HASTINGS	Map estimate	
Omarunui LF	1924789	5616289	5249	19.5	50	14/07/2000	16.5	19.5	WEBSTER DRILLING LTD	0957007600A	329 OMARUNUI RD	HASTINGS	Map estimate	
Omarunui LF	1925050	5616289	5250	24.9	50	28/06/2000	21.9	24.9	WEBSTER DRILLING LTD	0957007600A	329 OMARUNUI RD	HASTINGS	Map estimate	
Omarunui LF	1924749	5615929	5251	10	50	3/07/2000	1	10	WEBSTER DRILLING LTD	0957007600A	329 OMARUNUI RD	HASTINGS	Map estimate	
Tutaekuri Grave	1926906	5615299	5338	21	200	15/02/2005	19.35	20.85	Baylis Brothers Limited	957007703	251 OMARUNUI RD	HASTINGS	Hand-held GPS	251 OMAR
Omarunui LF	1924685	5616278	5406	45	150	29/08/2005	39	45	Honnor Drilling Limited	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Omarunui LF	1924914	5616320	5407	78	150	31/08/2005	72	78	Honnor Drilling Limited	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Omarunui LF	1925355	5616148	5408	45	150	2/09/2005	39	45	Honnor Drilling Limited	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	OMARANU
Omarunui LF	1925217	5615730	5409	30.5	150	26/08/2005	24	30.5	Honnor Drilling Limited	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Motoe Valley	1923774	5615445	5690	14.7	100	20/06/2007	13.46	14.66	Baylis Brothers Limited	957015401	384 SWAMP ROAD	HASTINGS	Hand-held GPS	384 SWAM
Omarunui LF	1924567	5615805	5702	18.4	50	24/06/2007	6.4	18.4	Baylis Brothers Limited	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Motoe Valley	1924567	5615627	5703	18.6	50	27/06/2007	12.6	18.6	Baylis Brothers Limited	957015401	384 SWAMP ROAD	HASTINGS	Hand-held GPS	OMARANU
Tutaekuri Grave	1926712	5616692	5758	15.7	150	3/10/2007	13.7	15.7	Baylis Brothers Limited	957007500	367 OMARUNUI RD	HASTINGS	Hand-held GPS	
Omarunui LF	1924848	5616492	5940			6/03/2009			Boart Longyear (NZ) Ltd	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Omarunui LF	1925239	5616605	5942	50	50	14/03/2009	47	50	Boart Longyear (NZ) Ltd	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Omarunui LF	1925077	5616378	5943	41	50	3/03/2009	35	41	Boart Longyear (NZ) Ltd	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Omarunui LF	1925328	5616312	5944	60	50	3/03/2009	57	60	Boart Longyear (NZ) Ltd	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Omarunui LF	1925461	5616438	5945	10	50	10/03/2009	7	10	Boart Longyear (NZ) Ltd	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Omarunui LF	1925412	5616037	5946	43.5	50	28/02/2009	37.5	43.5	Boart Longyear (NZ) Ltd	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Omarunui LF	1925509	5616237	5947			16/03/2009			Boag & Hill Ltd	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Omarunui LF	1925613	5616000	5948	56	50	3/03/2009	50	56	Boart Longyear (NZ) Ltd	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	
Tutaekuri Grave	1926331	5616770	6504	15.85	100	1/10/1970	15.85	0	Baylis Brothers Limited	957007404	395 OMARUNUI RD	HASTINGS		
Tutaekuri Grave	1926157	5616761	8483	21.34	100	1/10/1970	21.34	0	Baylis Brothers Limited	957007404	395 OMARUNUI RD	HASTINGS	Hand-held GPS	
Motoe Valley	1924801	5618074	8542	6.52	75	15/04/1980	6.52		Hill Well Drillers Ltd	957017100	705 SWAMP RD	HASTINGS	Hand-held GPS	
Motoe Valley	1924028	5617170	10136	16.2	50	29/10/1962	15.2	16.2	Baylis Brothers Limited	957016602	89 OMARUNUI SETT RD	HASTINGS		
Tutaekuri Grave	1926431	5616270	10156	18.3	100	29/11/1961	16.5	18.2	Baylis Brothers Limited	957007500	367 OMARUNUI RD	HASTINGS		
Motoe Valley	1925029	5618071	10189	7.6	75	18/12/1961	6.4	7.6	Baylis Brothers Limited	957017100	705 SWAMP RD	HASTINGS		
Tutaekuri Grave	1926230	5618071	10261	10.1	100	22/01/1965	0	0	Boag & Hill Ltd	957007100	0515 OMARUNUI RD	HASTINGS		OMARANU
Tutaekuri Grave	1926314	5617719	15141		100				Unknown	957007201	489 OMARUNUI RD	HASTINGS	Hand-held GPS	OMARANU
Tutaekuri Grave	1926449	5615835	15145		100				Unknown	957007702	321 OMARUNUI RD	HASTINGS	Hand-held GPS	OMARANU
Motoe Valley	1924595	5617278	15146		75				Unknown	957016202	0 SWAMP RD	HASTINGS	Hand-held GPS	SWAMP R
Tutaekuri Grave	1926399	5615923	15265		50					957007601	339 OMARUNUI RD	HASTINGS	Hand-held GPS	339 OMAR
Motoe Valley	1924049	5617609	15338		100					957016501	87 OMARUNUI SETT RD	HASTINGS	Hand-held GPS	87 OMARA
Tutaekuri Grave	1926641	5616039	15440	27.36	300	10/02/2009	18.36	27.36	Baylis Brothers Limited	957007601	339 OMARUNUI RD	HASTINGS	Hand-held GPS	OMARANU
Tutaekuri Grave	1926004	5617980	15654	11.5	100	13/04/2010	9.85	10.85	Baylis Brothers Limited	957007001	549 OMARUNUI RD	HASTINGS	Hand-held GPS	
Tutaekuri Grave	1926668	5615877	15779	23.82	250	3/07/2018	20.82	23.82	Baylis Brothers Limited	957007700	297 OMARUNUI RD	HASTINGS	Hand-held GPS	305 Omaru
Tutaekuri Grave	1926016	5617985	15793		100					957007001	549 OMARUNUI RD	HASTINGS	Hand-held GPS	
Tutaekuri Grave	1926591	5616432	15806	29.3	250	10/12/2010	21.8	29.3	Honnor Drilling Limited	957007500	367 OMARUNUI RD	HASTINGS	Hand-held GPS	
Omarunui LF	1924636	5615668	15929	10	25	19/12/2011	0.8	10	Baylis Brothers Limited	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	Omarunui
Omarunui LF	1924765	5615805	15930	10.5	25	15/12/2011	1.2	10.5	Baylis Brothers Limited	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	Omarunui
Omarunui LF	1924764	5615736	15931	9	25	13/12/2011	0.7	9	Baylis Brothers Limited	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	Omarunui
Motoe Valley	1923592	5615648	15943	15.6		20/02/2012	15.6	16.9	Baylis Brothers Limited	957015500	385 SWAMP RD	HASTINGS	Hand-held GPS	
Motoe Valley	1924019	5617551	15983	13	125	19/06/2012	11.65	13	Baylis Brothers Limited	957016602	89 OMARUNUI SETT RD	HASTINGS	Hand-held GPS	Omarunui
Tutaekuri Grave	1926751	5614918	16168	14.58	100	28/02/2014	14.58	15.94	Baylis Brothers Limited				Hand-held GPS	165 Brecke
Omarunui LF	1924976	5615603	16310	11.3	100	27/11/2014	11.3	18	Honnor Drilling Limited	0957007600A	329 OMARUNUI RD	HASTINGS	Hand-held GPS	329 Omaru
Motoe Valley	1924398	5615707	16462	15	100	2/03/2017	12	15	Honnor Drilling Limited	957015401	384 SWAMP ROAD	HASTINGS	Hand-held GPS	384 Swam
Motoe Valley	1923959	5615475	16464	35.5	100	7/03/2017			Honnor Drilling Limited	957015401	384 SWAMP ROAD	HASTINGS	Hand-held GPS	384 Swam
Motoe Valley	1923784	5615452	16576	14.71	200	21/02/2017	11.61	14.71	Baylis Brothers Limited	957015401	384 SWAMP ROAD	HASTINGS	Hand-held GPS	384 Swam
Tutaekuri Grave	1926353	5617210	16640	31	300	3/08/2017	23.5	30	Honnor Drilling Limited	957007300	0451 OMARUNUI RD	HASTINGS	Hand-held GPS	451 Omaru
Tutaekuri Grave	1926408	5617605	16689	12	100	11/09/2017	10.6	12	Baylis Brothers Limited	957007201	489 OMARUNUI RD	HASTINGS	Hand-held GPS	489 Omaru
Tutaekuri Grave	1926668	5615877	16779	23.82	250	3/07/2018	20.82	23.82	Baylis Brothers Limited	957007700	297 OMARUNUI RD	HASTINGS	Hand-held GPS	305 Omaru
Tutaekuri Grave	1926251	5617834	16801							957007100	0515 OMARUNUI RD	HASTINGS	Hand-held GPS	515 Omaru

CasingDiameter	WaterLevelAccess	BoreDepth	OpenHoleTop	OpenHoleBottom	AquiferLithology	AquiferCondition	InitalWaterLevel	InitalWaterLevelDateText	BoreNo
OMARUNUI SETTLEMENT RD	100	Unknown			Gravels	Confined			9
SWAMP RD	100	Unknown			Unknown	Flowing confined	-0.76		162
SWAMP RD	75	Unknown			Gravels	Confined	0.5		232
OMARUNUI RD	100	Unknown			Unknown	Unknown	-0.3		280
OMARUNUI RD	100	Unknown			Gravels	Confined			331
SWAMP RD	75	Unknown			Gravels	Flowing confined	-2.62		459
OMARUNUI RD	100	Unknown			Unknown	Confined	0.4		569
OMARUNUI RD	100	Unknown			Gravels	Flowing confined	-3.05		570
OMARUNUI RD	75	Unknown			Gravels	Confined	0		590
OMARUNUI RD PUKETAPU	100	Unknown			Gravels	Confined	-3.05		802
OMARUNUI RD (L/C)	150	Unknown			Gravels	Confined	-0.91		865
OMARUNUI RD PUKETAPU (L/C)	150	No			Gravels	Confined	-3.9		922
SWAMP RD	75	Unknown			Gravels	Confined	-3.63		975
OMARUNUI SETTLEMENT RD MOTEO	100	No			Gravels	Confined	-1.7		1577
OMARUNUI RD (L/C)	150	Unknown			Gravels	Unknown	-1.28		1628
297 OMARUNUI RD WAIOHIKI (L/C)	200	Unknown			Gravels	Confined			1660
OMARUNUI RD WAIOHIKI (L/C)	100	Unknown			Unknown	Unknown	-3.65		1685
250	Yes				Gravels	Confined			1686
OMARUNUI RD NAPIER (L/C)	200	Unknown			Gravels	Unknown	-0.38		1803
OMARUNUI RD/PUKETAPU (L/C)	200	No			Gravels	Flowing confined			1972
MOTEO (L/C)	200	Unknown			Gravels	Confined	4.25		2179
KOROKIPO	300	Unknown			Gravels	Unknown	-0.9		2238
OMARANUI RD	300	Unknown			Gravels	Unknown			2239
FERNHILL	100	Unknown			Gravels	Confined			2301
OMARANUI SETTLEMENT ROAD (L/C)	200	Unknown			Gravels	Unconfined	-2.56		2320
MOTEO		Unknown			Unknown	Unknown	-1.9		2353
MOTEO (L/C)	200	Unknown	10	50	Unknown	Unknown			2354
PUKETAPU	100	Unknown			Gravels	Unknown	-2.12		2394
SWAMP RD MOTEO (L/C)	150	Unknown			Gravels	Confined			2441
MOTEO	100	Unknown			Gravels	Confined	-0.6		2469
FERNHILL	150	Unknown			Gravels	Confined	-0.05		2554
OMARANUI ROAD		Unknown			Unknown	Unknown	-1.1		2555
OMARANUI ROAD		Unknown			Unknown	Unknown			2556
OMARANUI SETTLEMENT ROAD (L/C)	200	Unknown			Gravels	Confined			2597
OMARANUI	100	Unknown			Unknown	Unknown	-0.9		2934
OMARANUI	100	Unknown			Unknown	Unknown			2935
OMARANUI	100	Unknown			Unknown	Unknown			2936
TARADALE	150	Yes			Unknown	Unknown			2969
TARADALE (L/C)	150	Unknown			Gravels	Confined			2974
SWAMP ROAD (L/C)	200	Unknown			Gravels	Flowing confined	-3.4		3021
NAPIER	100	Unknown			Gravels	Confined	0.3		3047
FERNHILL	100	Unknown			Gravels	Unknown	-4.7		3088
TARADALE	100	Unknown			Gravels	Unknown			3096
Napier)	100	Unknown			Other	Confined			3105
OMARANUI ROAD		Unknown			Unknown	Unknown	-2		3126
TARADALE	150	Unknown			Gravels	Confined			3365
MOTEO PA	100	Unknown			Limestone	Confined	-4		3384
MOTEO PA	150	Unknown				Flowing confined	-3.4		3489
BOX 7140 TARADALE	150	Unknown					0.5		3681
BOX 7140 TARADALE NAPIER	100	Unknown					-0.5		3682
PUKETAPU	80	Unknown							3725
MOTEO.	100	Unknown							3896
HASTINGS.	100	Unknown				Flowing confined	-1.85		4048
FERNHILL	100	Unknown				Unknown	0.3		4203
MOTEO	250	Yes				Confined	-5.4		4328
REGIONAL REFUSE DISPOSAL SITE	50	Unknown	38.7				-1.25		4463
REGIONAL REFUSE DISPOSAL SITE	50	Unknown	17.5		Sandstone		-6.7	11/07/2000	4464
REGIONAL REFUSE DISPOSAL SITE	50	Unknown	49.1		Sandstone		-7.95	12/07/2000	4465
REGIONAL REFUSE DISPOSAL SITE	50	Unknown	51.1				-10.49	12/07/2000	4466
REGIONAL REFUSE DISPOSAL SITE	50	Unknown	23.1				45.97	1/07/2000	4467

REGIONAL REFUSE DISPOSAL SITE	50	Unknown	17.6		Limestone		-1	11/07/2000	4468
606 SWAMP ROAD	100	No				Unconfined	-6.3	2/07/2000	-0.45
TARADALE	100	Unknown				Unconfined			4527
TARADALE	100	Unknown				Unconfined	-2.95		4541
NAPIER	150	Unknown	18				-3.8		4745
REFUSE DUMP	150	Unknown				Unknown			-5.98
MOTEO	150	No	24			Unknown			5133
MOTEO	100	Unknown	16.5		Gravels		0		5178
REGIONAL REFUSE DISPOSAL SITE	50	Unknown	9		Gravels		-3.45	15/05/2004	5248
REGIONAL REFUSE DISPOSAL SITE	50	Unknown	21.5		Sand		-7.28	11/06/2000	5249
REGIONAL REFUSE DISPOSAL SITE	50	Unknown	25						5250
REGIONAL REFUSE DISPOSAL SITE	50	Unknown	10				-24.12	1/07/2000	5251
TARADALE	200	Yes	21		Gravels	Confined	-0.97	11/07/2000	5338
OMARANUI RD LANDFILL	150	Unknown	45				-4.23	15/02/2005	5406
OMARANUI RD LANDFILL	150	Unknown	78				-25	29/08/2005	5407
LANDFILL	150	Unknown	45				-60.8	31/08/2005	5408
OMARANUI RD LANDFILL	150	Unknown	30.5				-38	2/09/2005	5409
PUKETAPU.	100	Unknown	14.7		Gravels	Flowing confined	-25	26/08/2005	5690
OMARANUI LANDFILL	50	Unknown	22		Limestone	Confined			5702
PUKETAPU	50	Unknown	30		Limestone	Unconfined	-3.2	24/06/2007	5703
394 OMAUNUI ROAD PUKETAPU	150	Unknown	15.7		Gravels	Confined	-11.3	27/06/2007	5758
329 OMARUNUI ROAD		Unknown	36				-3.3	3/10/2007	5940
329 OMARANUI ROAD	50	Unknown	50		Limestone	Confined			5942
329 OMARUNUI ROAD	50	Unknown	41		Sandstone	Confined	-46.85	20/03/2009	5943
329 OMARUNUI ROAD	50	Unknown	60		Sandstone	Confined	-36.2	20/03/2009	5944
329 OMARUNUI ROAD	50	Unknown	10		Sandstone	Confined	-57.9	20/03/2009	5945
329 OMARUNUI ROAD	50	Unknown	43.5		Sandstone	Confined	-3.4	20/03/2009	5946
329 OMARUNUI ROAD		Unknown	38.5				-40.5	20/03/2009	5947
329 OMARUNUI ROAD	50	Unknown	56		Sandstone	Confined			5948
OMARUNUI RD	100	Yes				Confined	-50.6	20/03/2009	6504
OMARUNUI RD	100	Unknown				Confined	0		8483
SWAMP RD	75	No				Confined	0		8542
TARADALE	50	Unknown				Confined	-0.3		10136
MOTEO	100	Unknown				Flowing confined	-0.8		10156
MOTEO	75	Unknown				Unconfined	3		10189
MOTEO	100	Unknown					-1.5		10261
NAPIER	100	No			Unknown	Unknown	0		15141
TARADALE	100	No			Unknown	Unknown			15145
MOTEO	75	Unknown			Unknown	Unknown			15146
OMARANUI	50	No							15265
MOTEO	100	Unknown							15338
TARADALE	300	Unknown	27.36		Gravels	Confined			15440
549 OMARUNUI ROAD PUKETAPU	100	Unknown	10.85	11.5	Gravels		-4.03	6/10/2009	15654
Napier	250	Unknown	23.82				-2.37	6/04/2010	15779
	100	Unknown					-4.6	3/07/2018	15793
367 OMARANUI RD	250	Unknown	29.3		Gravels	Unconfined			15806
Taradale	25	Unknown	14				-4.22	10/12/2010	15929
Taradale	25	Unknown	10.5						15930
Taradale	25	Unknown	9				-8.8	15/12/2011	15931
Omahu		Unknown	16.9		Gravels	Flowing confined	-2.8	13/12/2011	15943
Puketapu	125	Unknown	13		Gravels	Unknown			15983
Taradale	100	Unknown	15.94	16.1			-0.4	20/11/2012	16168
Puketapu	100	Unknown	18				-1.35	28/02/2014	
Fernhill	100	Unknown	18				11.02	27/11/2014	
Fernhill	100	Unknown	36				0.5	2/03/2017	
Napier	200	Unknown	14.71				2	7/03/2017	16576
Puketapu	300	Unknown	31				1.5	21/02/2017	16640
Napier	100	Unknown	12				-3.6	3/08/2017	16689
Napier	250	Unknown	23.82				-4.19	11/09/2017	16779
Omarunui		Unknown					-4.6	3/07/2018	16801

Easting	Northing	Consent Number	Site Address			Status	Type	Sub Type	Use	Use Detail
1923728	5615365	DP030219W	384 Swamp Road		Napier	Current	Discharge Permit	Discharge into water	Pastoral Farming	Stormwater - Pumped Subsurface Drainage
1923871	5615627	DP030219W	384 Swamp Road		Napier	Current	Discharge Permit	Discharge into water	Pastoral Farming	Stormwater - Pumped Subsurface Drainage
1926430	5618027	DP030449L	Various Sites Around Napier & Hastings within the Heretaunga Plains			Current	Discharge onto land	Private Landfill	Solid Waste - Organic	to discharge contaminants (drain cleanings) onto lan
1924749	5616069	DP040120Lc	329 Omarunui Road		Omarunui	Current	Discharge Permit	Discharge onto land	Municipal Landfill	Leachate
1924749	5616069	DP040121Wb	329 Omarunui Road		Omarunui	Current	Discharge Permit	Discharge into water	Municipal Landfill	Stormwater - Polluted
1924749	5616069	DP040122Ab	329 Omarunui Road		Omarunui	Current	Discharge Permit	Discharge into air	Municipal Landfill	Air - Odour
1924749	5616069	DP160044L	329 Omarunui Road		Omarunui	Current	Discharge Permit	Discharge onto land	Government	Leachate
1924723	5616483	WP040123T	329 Omarunui Road		Omarunui	Current	Water Permit	Take underground water	Municipal Landfill	Water
1923954	5615221	WP050519T	362 Swamp Road		Fernhill	Current	Water Permit	Stream depleting undertak	Cropping	Irrigation
1926988	5614966	WP050572Tb	207 Omarunui Road		Omarunui	Current	Water Permit	Stream depleting undertak	Orchard	Irrigation & other use
1923452	5617713	WP060043Tb	265 Moteo Pa Road		Moteo	Current	Water Permit	Stream depleting undertak	Orchard	Irrigation & Frost
1926734	5614960	WP060050T	305 Omaranui Road		Taradale	Current	Water Permit	Take underground water	Residential - Single property	Potable Supply
1924742	5617404	WP060053T	624 Swamp Road		Moteo	Current	Water Permit	Stream depleting undertak	Cropping	Irrigation
1926652	5615473	WP060059Ta	297 Omarunui Road		Omarunui	Current	Water Permit	Stream depleting undertak	Orchard	Irrigation & Frost
1924732	5617232	WP060063T	586 Swamp Road		Omarunui	Current	Water Permit	Stream depleting undertak	Cropping	Irrigation
1926906	5615299	WP060067T	251 Omarunui Road		Omarunui	Current	Water Permit	Stream depleting undertak	Orchard	Irrigation
1926399	5615923	WP060068Ta	339 Omarunui Road		Omarunui	Current	Water Permit	Stream depleting undertak	Orchard	Irrigation & Frost
1924231	5617302	WP060138T	601 Swamp Road		Omarunui	Current	Water Permit	Stream depleting undertak	Cropping	Irrigation
1924801	5618074	WP060149T	705 Swamp Road		Moteo	Current	Water Permit	Take underground water	Orchard	Irrigation
1923779	5617947	WP060151T	Moteo Road		Moteo	Current	Water Permit	Stream depleting undertak	Cropping	Irrigation
1926353	5617210	WP060180Tb	451 Omarunui Road		Omarunui	Current	Water Permit	Stream depleting undertak	Cropping	Irrigation & Frost
1923785	5617109	WP060227T	Swamp Road		Moteo	Current	Water Permit	Take surface water	Cropping	Irrigation
1925037	5617962	WP060266T	CWS - Swamp Road		Moteo	Current	Water Permit	Take underground water	Residential - Single property	Potable Supply
1923235	5616955	WP060567Tc	459 Swamp Road and 266 Moteo Pa Road		Napier	Current	Water Permit	Take surface water	Cropping	Irrigation
1923266	5616523	WP060568Tc	459 Swamp Road		Napier	Current	Water Permit	Take surface water	Pastoral Farming	Irrigation
1924019	5617551	WP060587Ta	87 Omarunui Settlement Road		Moteo	Current	Water Permit	Stream depleting undertak	Orchard	Irrigation
1923311	5617203	WP120343Ta	89 Omarunui Settlement Road	535 Swam	Fernhill	Current	Water Permit	Stream depleting undertak	Orchard	Irrigation & Frost
1924148	5616213	WP140193T	459 Swamp Road		Hastings	Current	Water Permit	Take surface water	Pastoral Farming	Irrigation
1926016	5617985	WP140479T	551 Omarunui Road	Puketapu	Napier	Current	Water Permit	Take underground water	Orchard	Irrigation
1923774	5615445	WP160115T	384 Swamp Road	Fernhill	Hastings	Current	Water Permit	Stream depleting undertak	Pastoral Farming	Irrigation
1923943	5615896	WP160130T	435 Swamp Road	Moteo	Hastings	Current	Water Permit	Take underground water	Orchard	Irrigation
1926551	5616882	WP170369T	395 Omarunui Road		Omarunui	Current	Water Permit	Stream depleting undertak	Vineyard	Irrigation & Frost
1926230	5618071	WP170445T	515 Omarunui Road		Omarunui	Current	Water Permit	Stream depleting undertak	Orchard	Irrigation & Frost
1926712	5616692	WP170516T	394 Omarunui Road		Omarunui	Current	Water Permit	Stream depleting undertak	Vineyard	Irrigation & Frost

Appendix E: Proposed groundwater monitoring parameters

ATTACHMENT 3 MONITORING SCHEDULE

GROUP ONE

Determinand	**Units**	**Detection limit**
Dissolved Oxygen	g/m^3	on site
pH (field and laboratory)		0.2
Conductivity (field and laboratory)	mS/m	0.1
Absorbance	AU	0.002
Chloride	g/m^3	0.5
Potassium	g/m^3	0.05
Total Organic Carbon	g/m^3	0.5
Ammoniacal Nitrogen	g/m^3	0.01
Nitrate-Nitrogen	g/m^3	0.002
Volatile fatty acids (total)	g/m^3	0.5
Chemical Oxygen Demand (COD)	g/m^3	6.0
Alkalinity (as $CaCO_3$)	g/m^3	1

GROUP TWO

Determinand	**Units**	**Detection limit**
Biochemical Oxygen Demand - Total (BOD_5)	g/m^3	1.0
Sodium	g/m^3	0.02
Calcium	g/m^3	0.05
Magnesium	g/m^3	0.02
Sulphate	g/m^3	0.5
Sulphide	g/m^3	0.002
Total Kjeldahl Nitrogen	g/m^3	0.1
Dissolved Reactive Phosphorus	g/m^3	0.004
Total Phosphorus	g/m^3	0.004
Total Phenols	g/m^3	0.002
Total CN	g/m^3	0.001
Al (See Footnote for method)[a]	g/m^3	0.003
As (See Footnote for method)[a]	g/m^3	0.001
B (See Footnote for method)[a]	g/m^3	0.005
Cd (See Footnote for method)[a]	g/m^3	0.00005
Co (See Footnote for method)[a]	g/m^3	0.0002
Cr (See Footnote for method)[a]	g/m^3	0.0005
Cu (See Footnote for method)[a]	g/m^3	0.0005
Fe (See Footnote for method)[a]	g/m^3	0.02
Mn (See Footnote for method) [a]	g/m^3	0.0005
Ni (See Footnote for method) [a]	g/m^3	0.0005
Pb (See Footnote for method) [a]	g/m^3	0.0001
Hg (See Footnote for method) [a]	g/m^3	0.00008
Se (See Footnote for method) [a]	g/m^3	0.001
Zn (See Footnote for method) [a]	g/m^3	0.001

GROUP THREE

Volatile Organic Compounds (VOC)	g/m^3	0.003 – 0.02[b]
Semi Volatile Organic Compounds (SVOC)	g/m^3	0.003 – 0.02[b]
Pentachlorophenol (PCP) (leachate only) [c]	g/m^3	0.0003
Polychlorinated biphenyls (PCB) (leachate only)[c]	g/m^3	0.0001
Organonitrogen & Organophosphorus (ONOP) pesticides (leachate only) [c]	g/m^3	varies

[a] Soluble Only for Groundwater – Both Total and Soluble for Leachate Samples
[b] Method Detection Limit (MDL) range (variable per compound)
[c] Test only required for Leachate Samples

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Appendix L: Ecology Report

REPORT

Assessment of Ecological Effects: Omarunui Landfill Area B

Prepared for
Hastings District Council

Prepared by
Tonkin & Taylor Ltd

Date
October 2020

Job Number
1000647.1000.v3

Exceptional thinking together

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Document Control

Title: Assessment of Ecological Effects: Omarunui Landfill Area B					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
20.12.19	1	Final report for lodgement	T Shell	D Miller	T Bryce
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Hastings District Council	1
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Table of contents

Executive summary

Hastings District Council is seeking to develop a new area (Area B) at the Omarunui Landfill. Treated stormwater from Area B will be discharged into the Upokohino Stream. This report presents an assessment of ecological effects for the proposed stormwater discharge.

The Upokohino Stream is a tributary of the Tutaekuri River and runs through agricultural land to the east of the Omarunui Landfill. It is proposed that stormwater from Area B will pass through a treatment pond and a wetland before it is discharged at the boundary of the landfill site to an unnamed farm drain and then to the Upokohino Stream. The farm drain system comprises a combination of 100 mm diameter sub-soil pipe sections and open drain. The open drain terminates around 50 m upstream of the Upokohino Stream with another 100 mm diameter section leading to Upokohino Stream. The discharge point to the Upokohino Stream is approximately 4 km upstream from its confluence with the Tutaekuri River.

A site visit and ecological assessment by a Tonkin & Taylor Ltd (T+T) ecologist has found the Upokohino Stream to be characterised by poor water and habitat quality and this was reflected in the low diversity macroinvertebrate and fish populations encountered.

Our assessment shows that Upokohino Stream is of low ecological value and has low sensitivity as a receiving environment in its current condition. Without mitigation (good practice stormwater management) the proposed stormwater discharge would have the potential to cause a further decline in water quality in the stream, especially over the summer period when flow conditions in the stream are naturally low. However, provided the proposed stormwater management measures (erosion control and stormwater treatment pond and wetland) are well installed and maintained then the magnitude of the effect of the stormwater discharge on the health of the Upokohino Stream should be ‘negligible’ and the overall level of effect will be ‘very low’.

We understand all rain falling on exposed refuse is to be treated as leachate and will be discharged to the leachate system. Only stormwater which has not come into contact with refuse will be diverted to the stormwater treatment system. Without effective stormwater and leachate management the magnitude of the effect of other contaminants from the landfill operation on the health of the Upokohino Stream is likely to be “moderate” and the overall level of effect would be “low”. However, with appropriate and well-maintained stormwater and leachate management systems the likelihood of other contaminants from the landfill operation entering the Upokohino Stream is low. Therefore, with mitigation and with reference to the Ecological Impact Assessment guidelines (EcIA) guidelines the magnitude of effects on stream health is expected to be “negligible” and the overall effect “very low”. However, monitoring water quality of the discharge and in the Upokohino Stream is recommended and will enable detection of any accidental contamination from the landfill operation to allow appropriate corrective action to be taken.

1 Introduction

Hastings District Council (HDC) is planning for future development of the Omarunui Landfill. A new area of the landfill is required to be operational by approximately 2026, with approximately three years required for design and construction of the next stage. An area in a valley to the north-east of the operational filling area is now being assessed as the preferred option for future landfill development. The proposed future area is known as Area B.

Area B comprises a series of steep narrow gullies amongst a larger broad valley within the north eastern portion of the Omarunui Landfill site. Land use comprises mostly grazed pasture but with some level plateaus, that have been heavily modified by borrow and fill activities as part of the ongoing landfill operation. Area B does not support any permanent watercourse habitat or any terrestrial habitat of ecological value.

Area B drains to the north and then north-east to the Upokohino Stream via an unnamed farm drain/swale and subsoil drainage system on the neighbouring property. The unnamed farm drain system and the Upokohino Stream will receive stormwater runoff from the Area B development.

Runoff from the southern portion of Area B currently discharges through a rock drain running south-east and then eastwards beside the landfill access road. This is treated in a sediment pond and then discharges via a grassed swale to the Upokohino Stream where it crosses the landfill access road. Discharge at this location will continue.

Tonkin & Taylor Ltd (T+T) has been engaged to prepare an Assessment of Environmental Effects (AEE) to accompany resource consent applications for the new site development. This report covers the potential effects of the proposed stormwater discharge from the new landfill site (Area B) on the ecology of the Upokohino Stream receiving environment.

This report has been prepared in accordance with our letter of engagement dated 16 November 2017.

2 Methods

2.1 Site visit

A site visit was undertaken by a T+T ecologist on 26 February 2018. The farm drain system was dry at the time of the site visit and the Upokohino Stream appeared to be in low flow condition with shallow water depths and a dry area of streambed downstream. No rain had fallen in the general area in the two weeks prior to sampling (data obtained from Hawkes Bay Regional Council Moteo rainfall site).

During the site visit, water quality, sediment, macroinvertebrates and stream habitat quality were assessed at three sites on the Upokohino Stream. Site locations are described in Table 2.1 and shown on Figure 2.1. Figure 2.1 also shows the location where Upokohino Stream was dry at the time of the site visit.

Table 2.1: Stream assessment site locations

Site name	Location description	Coordinates (NZTM)
Upstream Landfill	Upokohino Stream approximately 170 m upstream of the confluence with the unnamed farm drain on the property boundary	5616970 1925916
Downstream Mixing Zone	Upokohino Stream approximately 480 m downstream of the confluence with the unnamed farm drain on the property boundary.	5616594 1926051
Downstream 2	Upokohino Stream approximately 1km downstream of the confluence with the unnamed farm drain on the property boundary and immediately upstream of the landfill access road.	5616021 1926151

Figure 2.1: Aerial image of the Omarunui Landfill showing the three sampling sites visited on 26 February 2018 and the location of the dry area of stream bed ('stream dry') further downstream (Source: Google Earth).

Macroinvertebrate sampling was undertaken using a 0.3 mm mesh kick-net following the Ministry for the Environment standard protocols for semi-quantitative sampling in soft-bottomed streams (Protocol C2) and processed using protocol P2 (Stark et al. 2001[1]). Samples were preserved in 70 % ethanol and sent to Stark Environmental for processing.

Water quality and sediment samples were collected from each of the three sample sites and sent to Hill Laboratories in Hamilton for analysis. Water quality was tested using the following calibrated water quality meters; YSI ProDO, Bluelab pH Pen, and a PC Tester 34. Water samples were tested for a range of ecological water quality parameters, dissolved ions, dissolved nutrients, biological oxygen demand and metals (refer to the results section for details). Sediment samples were tested for heavy metals.

2.2 Information review

The following information has been used in the assessment of ecological effects of the proposed landfill stormwater discharge on the Upokohino stream:

- New Zealand freshwater fish database records.
- Relevant monitoring reports from Hawke's Bay Regional Council.

2.3 Assessment of ecological effects

Our assessment of ecological effects follows Ecological Impact Assessment guidelines (EcIA) produced by the Environment Institute of Australia and New Zealand (EIANZ, 2018)[2]. The aim of using a standard framework and matrix approach is to provide a consistent and transparent assessment of effects. This framework provides structure but does not replace the need for sound ecological judgement. The steps involved in undertaking this EcIA are outlined in the following sections.

2.3.1 Step 1: Assessment of ecological values

Ecological values were assigned on a scale of 'Low' to 'Very High' based on assessing the values of species, communities, and habitats against criteria in the EcIA guidelines (see Table 2.2).

Unlike for terrestrial ecosystems, there is no defined set of attributes used to assign value to freshwater systems. Matters that may be considered when assigning ecological value to freshwater systems include representatives, rarity/distinctiveness, diversity and the ecological context.

Table 2.2: Assignment of values within the Project footprint to species and habitats (adapted from EIANZ, 2018)

Value	Species value requirements
Very High	Important for Nationally Threatened species, either permanently or occasionally
High	Important for Nationally At-Risk species and may provide less suitable habitat for Nationally Threatened species, locally rare or distinctive ecosystem.
Moderate	No Nationally Threatened species, no or very poor habitat for At-Risk species, but habitat for locally uncommon or rare species. High MCI and good water quality.

[1] Stark JD, Boothroyd IKG, Harding JS, Maxted JR, Scarsbrook MR 2001. Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103. 57 p.

[2] Environment Institute of Australia and New Zealand (EIANZ). (2018). Ecological Impact Assessment Guidelines for New Zealand 2nd Edition. EIANZ. Melbourne, Australia.

Value	Species value requirements
Low	No Nationally Threatened, At-Risk or locally uncommon or rare species. Low MCI and low water quality.

2.3.2 Step 2: Assessment of the magnitude of effects

The magnitude of effect is a measure of the extent or scale of the effect and the degree of change that the activity will cause. For our assessment, effects were assessed in terms of intensity, spatial scale, duration, reversibility, and timing. Risk/uncertainty and confidence in predictions were also considered. The magnitude of the effect was scored on a scale of 'No Effect' to 'Very High' (Table 2.3).

Table 2.3: Summary of the criteria for describing the magnitude of effect (EIANZ, 2018).

Magnitude of effect	Description
Very High	Total loss or alteration of the existing baseline conditions; Loss of high proportion of the known population or range.
High	Major loss or alteration of existing baseline conditions; Loss of high proportion of the known population or range.
Moderate	Moderate loss or alteration to existing baseline conditions; Loss of a moderate proportion of the known population or range.
Low	Minor shift away from existing baseline conditions; Minor effect on the known population or range.
Negligible	Very slight change from the existing baseline conditions; Negligible effect on the known population or range.

2.3.3 Step 3: Level of effects assessment

An overall level of effect was determined using a matrix approach that combine the 'ecological values' and the 'magnitude of effects' on these values. The matrix describes a level of ecological effect on a scale ranging from 'Very Low' to 'Very High' (Table 2.4).

The overall level of effect can be used as a guide to determine whether effects management is required. Effects assessed as being 'Moderate' or greater in Table 2.4 warrant efforts to avoid, remedy or mitigate.

Table 2.4: Criteria for describing overall levels of ecological effects (modified from EIANZ, 2018)

	Ecological Value			
Magnitude of effect	**Very High**	**High**	**Moderate**	**Low**
Very High	Very High	Very High	High	Moderate
High	Very High	High	Moderate	Low
Moderate	High	High	Moderate	Low
Low	Moderate	Low	Low	Very Low
Negligible	Low	Very Low	Very Low	Very Low

3 Description of proposed activity

For a detailed description of the project, refer the Engineering Concept Design Report. A brief summary of the relevant parts of the activity are described below.

3.1 Landfill construction

The Area B landfill will be constructed over five stages. Each stage will be developed over an area of three to four hectares. This allows the bulk earthworks of a single stage to be completed in one earthworks season (1 October to 30 April), managing the risk by reducing the likelihood of earthworks being required during winter. The exception to this is Stage 1 which is 9 hectares in extent and which will have to be completed over a number of construction seasons.

3.2 Stormwater management

3.2.1 Overview

Landfill operations require ongoing movement of soils for placement of daily and intermediate cover and, in addition, regular construction projects are required to form new stages of the landfill or to provide access or other works essential for the operation of the landfill. All of these activities have the potential to generate sediment erosion during wet weather conditions. Good stormwater management is required throughout all of these activities to keep all areas operational, to minimise erosion of soils from the site and to control the potential transport of sediments off the site.

All water falling on exposed refuse at the working face of the landfill will be discharged to the leachate system, and no water that has been exposed to waste will be discharged to the stormwater system. Stormwater treatment at a landfill site is therefore aimed at removing sediment and is not intended to provide treatment for other contaminants.

Landfill activities will generally be confined to the Area B footprint, other than for the stockpiling and winning of soils for ongoing operation and construction. For the Area B development at Omarunui the stormwater management system will comprise:

- A main stormwater drain around the perimeter of each stage, and ultimately around the perimeter of Area B. This drain will intercept runoff from upstream portions of the catchment (clean water) and water diverted from earthworks and waste fill surfaces covered with intermediate or final cover.
- Temporary stormwater drains as required to divert stormwater to the main diversion drains.
- Erosion control measures throughout the site to minimise the transport of sediment as far as practicable from exposed earth surfaces.
- Construction of a new Area B treatment pond beyond the main landfill toe bund to remove sediment in stormwater runoff from Area B.
- Diversion of the run-off from the Area C site (refer to Figure 4.1) around the stormwater sedimentation pond. Where possible, clean water diverted from the Area B site will be diverted to this by-pass.

All short-term stormwater drains will be designed for a 10 year ARI event. All permanent drains will be designed for a 100 year ARI event.

3.2.2 Stormwater treatment

All stormwater discharged from Area B will be treated for sediment removal. Treatment systems will be designed to meet or exceed the requirements of "Hawke's Bay Waterway Guidelines – Erosion and Sediment Control" (Hawkes Bay Regional Council, 2009; hereafter "the guidelines").

The southern portion of Area B currently drains to a sediment pond located beside the main landfill access road, which discharges through an on-site drain to the Upokohino Stream. In order to keep the catchment discharging to the new Area B treatment pond as small as practicable it is proposed that areas to the south of Area B currently draining to this system will continue to do so. Without this diversion the catchment area would be 23 ha. By the time this southern portion of the site is incorporated into the landfill there will be areas along the western side of Area B that will be fully vegetated and can be diverted into the Area C clean water by-pass.

For the development of Area B, stormwater will flow to the outlet of the Area B valley where it will be treated through a new sediment treatment pond and a polishing wetland. The sediment treatment pond will be sized to treat runoff from the estimated area of exposed/disturbed land during construction and operation of Area B.

To meet the requirements of the guidelines a pond size based on 3% of the catchment area will be provided. This requires a volume of 5,200 m^3. At a maximum depth of 2 m, the average pond area would be 2,600 m^2.

The key features of the pond are:

- The pond will have a length to width ratio of between 4:1 and 5:1.
- A forebay will be provided for coarse sediment removal.
- It will be designed to have 30% of its volume as dead storage (70% as live storage).
- T-bar decants will be provided at the outlet to decant from the surface of the pond. The decants will discharge to a wetland for further treatment prior to discharge.
- A high flow spillway will be provided at the end of the pond to discharge to a channel along the property boundary and by-pass the wetland.

The ponds will be designed to meet the overall treatment requirements for sediment removal. A wetland will be provided to further treat the decant flow from the pond system. This will not be sized to meet any specific design requirement but will fit into the area of land available, providing some further polishing of stormwater discharges. The wetland will discharge to a drain along the property boundary, with a discharge to the farm drain on the neighbouring property where flows from Area B and Area C currently discharge. This farm drain joins the Upokohino Stream around 300 m downstream of the Area B site.

The pond will block the outlet from the Area C Valley. A pipeline will be installed within the pond bund to carry flow from Area C to by-pass the treatment pond and discharge to the drain downstream of the pond.

3.3 Leachate management

A leachate collection system (LCS) will be installed at the landfill so that leachate can be removed for treatment and disposal, and to minimise the head of leachate above the lining system. The LCS will be located directly above the composite lining system and will consist of perforated leachate collection pipes within a layer of drainage aggregate covered by a filter geotextile. The leachate drainage aggregate will be 300 mm thick along the side slopes, benches and floor of the landfill. Leachate will be collected at a sump at the toe of Area B and transferred to a lined leachate pond for temporary storage prior to discharge to on-site treatment and disposal.

All water falling on exposed refuse at the working face of the landfill will be discharged to the leachate system, and no water that has been exposed to waste will be discharged to the stormwater system.

Following consideration of these options, HDC has elected to dispose of leachate by spray irrigation to areas of the landfill cap, with sufficient balancing storage and irrigation to suit the expansion into Area B.

4 Receiving environment description

Area B and C are un-developed landfill areas that both drain towards the north eastern corner of the landfill site, and then to the Upokohino Stream (Figure 4.1). For both areas, surface drainage and groundwater flows generally to the north east. Surface water from Areas B and C flow via a farm drain and subsoil drainage system to the Upokohino Stream which subsequently enters the Tutaekuri River approximately 4 km downstream from the discharge point to the Upokohino Stream.

Runoff from Area B and C discharges to an existing pond on the neighbouring property downstream and subsequently to the Upokohino Stream (Figure 4.1 and Photograph 4.1). The proposed stormwater treatment pond and wetland for Area B would be in the vicinity of the existing pond as described in Section 3.2.2.

A layout sketch and accompanying photographs of the farm drain system is provided in Appendix A. In summary, the farm drain system comprises a combination of 100 mm diameter sub-soil pipe sections and open drain. The open drain terminates around 50 m upstream of the Upokohino Stream with another 100 mm diameter section leading to Upokohino Stream. The system conveys flows from the whole of the valley (which includes the Area B). During dry weather there is unlikely to be flow or water consistently present in the open section of the Farm Drain. During rain events some catchment runoff (including the discharge) will discharge to the Upokohino Stream via the two sub-soil pipes and some via overland flow. Given this discharge scenario we consider that Upokohino Stream is more relevant to consider as the receiving environment.

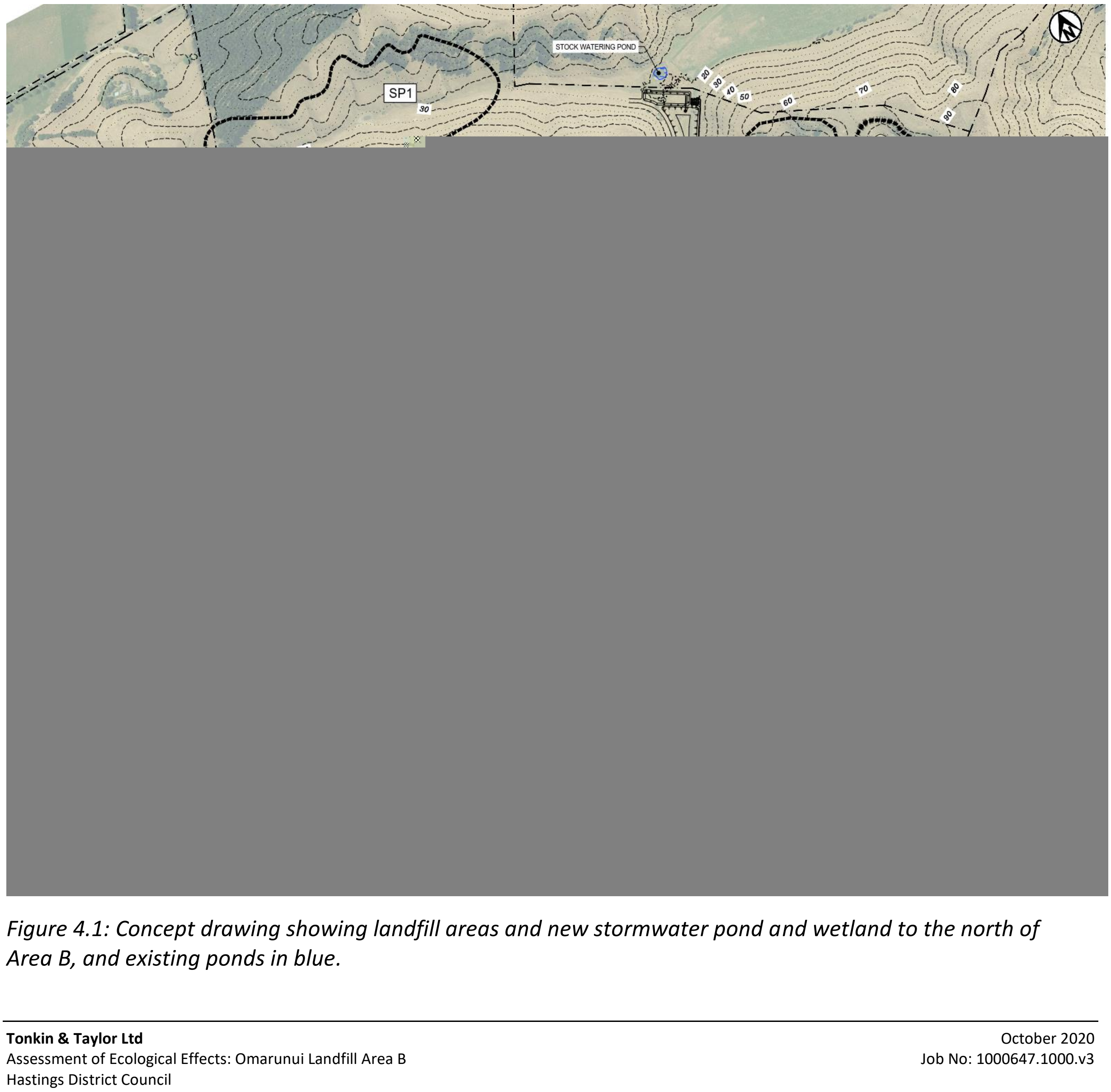

Figure 4.1: Concept drawing showing landfill areas and new stormwater pond and wetland to the north of Area B, and existing ponds in blue.

Photograph 4.1: From left to right: the existing pond at the downstream end of Area C, and the unnamed farm drain leading to Upokohino Stream (looking upstream towards pond).

The Upokohino Stream then flows through agricultural and horticultural land until it meets the Tutaekuri River.

The average flow from the Upokohino Stream is unknown, although landfill operations staff have described it as having a stable flow most of the year with little fluctuation. The flow observed during the February site visit was low, with no observable flow velocity. The stream was observed to be dry immediately upstream from the landfill access road, suggesting the stream is intermittent in the lower reaches.

We understand that the Upokohino Stream can flow into Lake Te Rotokare via the lake's outflow/ inflow drain[3] approximately 4.3 km downstream of the proposed landfill stormwater discharge point. We understand that this can occur when flows are high in the Upokohino Stream and Lake Te Rotokare water levels are low[3]. HBRC 2005 LiDAR data found the lake water level to be at 12.4 m elevation and the Upokohino Stream water at 12.6 m elevation at the time of the survey. However, as mentioned previously, the Upokohino Stream appears to be intermittent in the lower reaches and therefore any stream flows into the lake would be infrequent.

There is limited information on the lake ecology, however aerial images suggest the lake is shallow with patches of vegetation (likely raupo-*Typha orientalis*) but otherwise algal dominated.

Hawke's Bay Regional Council (HBRC) monitors ecological health and water quality at seven State of the Environment sites in the Tutaekuri River catchment. Nutrient levels in the Tutaekuri River increase generally from upstream to downstream although nitrogen stays at moderate levels, while dissolved phosphorus increases significantly. The macroinvertebrate community index (MCI) indicates excellent water quality conditions in the upper catchment, good conditions at most other sites in the middle Tutaekuri River and fair in the lower Tutaekuri main stem. Nuisance levels of

[3] Thomas Wilding HBRC pers. Comm.

periphyton develop during extended low flows in the Tutaekuri River, likely associated with high dissolved nitrogen and phosphorous contributed from the Mangatutu and Mangaone catchments[4].

Seven native fish species with populations which are classified as 'At Risk – Declining' or 'Nationally Vulnerable' are found in the Tutaekuri River and it is an important catchment for lamprey and koaro (Table 4.1). The catchment supports a significant brown and rainbow trout fishery with good angling opportunities in the Tutaekuri main stem. The lower section of the Tutaekuri River is fenced to exclude cattle and to support the high recreational value of the river.

No records were found on the NZ Freshwater Fish Database for the Upokohino Stream. However, some species that are more tolerant of reduced habitat and water quality conditions such as eels, may move into suitable habitats in the Upokohino Stream (Table 4.1) if there are no fish passage barriers. Dry sections of stream and several culverts exist downstream of the landfill site and may impede passage for some fish species.

Table 4.1: NZ Freshwater Fish Database records of fish species present in the Tutaekuri River.

Species	Scientific name	Threat Classification
Longfin eel	*Anguilla dieffenbachii*	At Risk – Declining
Shortfin eel	*Anguilla australis*	Not Threatened
Common bully	*Gobiomorphus cotidianus*	Not Threatened
Torrentfish	*Cheimarrichthys fosteri*	At Risk – Declining
Redfin bully	*Gobiomorphus huttoni*	Not Threatened
Inanga	*Galaxias maculatus*	At Risk – Declining
Crans bully	*Gobiomorphus basalis*	Not Threatened
Common smelt	*Retropinna*	Not Threatened
Koaro	*Galaxias brevipinnis*	At Risk – Declining
Giant bully	*Gobiomorphus gobioides*	Not Threatened
Bluegill bully	*Gobiomorphus hubbsi*	At Risk – Declining
Lamprey	*Geotria australis*	Nationally Vulnerable
Koura	*Paranephrops planifrons*	-

[4] Haidekker, S., Uytendaal, A., Hicks, A., Wade, O., Wade, H., Lyon, V., Madarasz-Smith, A. (2016). Ngaruroro, Tutaekuri, Karamu River and Ahuriri Estuary Catchments State and Trends of River Water Quality and Ecology. HBRC Report No. RM 16-08. Plan Number 4787.

5 Site investigation results

5.1 Upokohino Stream environment

A site visit was completed on 26 February 2018 during fine weather conditions. Three sites were assessed on the Upokohino Stream: one upstream of the landfill, one downstream of the likely mixing zone for the proposed stormwater discharge and one downstream of the landfill site (Figure 2.1)

5.1.1 General stream habitat description

The Upokohino Stream along the study reach was incised and had a wetted width of less than 1.3 m and depth below 0.2 m. The stream had no flow velocity and downstream of the landfill site, at the landfill access road, the stream bed was dry. The stream bed material comprised a deep layer of mud and decomposing macrophytes (likely *Lemna minor)*. The stream is fenced on both sides and had a riparian margin of grass and tall weeds that provide limited shade. A number of plastic bags were observed at the Downstream 2 site.

5.1.2 Upstream landfill

The Upstream Landfill site is located approximately 350 m upstream of the stormwater discharge point (Photograph 5.2). The stream bed comprised a thick layer of mud and decomposing aquatic weeds, and the stream was choked with a dense growth of macrophytes (likely *Lemna minor*). An eel was disturbed at this site. The average stream depth was approximately 0.15 m.

5.1.3 Downstream mixing zone

The Downstream Mixing Zone site is approximately 320 m downstream of the proposed stormwater discharge point (Photograph 5.2). Stormwater discharge from the Area C valley also enters at this discharge point. The stream bed comprised a thick layer of mud, and there was very little growth of macrophytes (likely *Lemna minor).* There were patches small of cyanobacteria mats on the sediments. The average stream depth was approximately 0.1 m.

5.1.4 Downstream 2

This site is downstream of the Downstream Mixing Zone site, approximately 970 m downstream the proposed stormwater discharge point (Photograph 5.3). Two dead eels were observed at the sample site, and two live eels (< 300 mm) were observed swimming up and down a short section of stream. The average stream depth was approximately 0.1 m.

Photograph 5.2: From left to right: Omarunui Upstream Landfill sample site (looking upstream) and Downstream Mixing Zone sample site (looking upstream).

Photograph 5.3: From left to right Omarunui Downstream 2 sample site (looking downstream) and dead eel (circled) at the Downstream 2 site.

5.2 Water quality

Spot water quality measurements were collected around and after mid-day (Table 5.1). The spot water quality measurements are indicative only of conditions at the time of sampling and would vary diurnally. Spot measurements showed dissolved oxygen saturation was below the Hawkes Bay Regional Resource Management Plan (HBR RMP) and the National Policy Statement for Freshwater

Management (NPSFM 2014[5]) National Bottom Line at the Downstream 2 site and the Upstream Landfill site.

Dissolved oxygen saturation was above HBR RMP guidelines at the Downstream Mixing Zone site. The cause of the high level of dissolved oxygen measured at the Downstream Mixing Zone likely reflects the high levels of macrophyte biomass and associated photosynthesis (and oxygen release) upstream of the site and that spot measurements were collected during the day.

Temperature at the Downstream Mixing Zone and Downstream 2 site exceeded the guideline threshold (<20°C) for sensitive taxa[6], due to shallow water depth and lack of shade. The pH was within the Australia New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2018[7]) at all except the Downstream Mixing Zone site (pH 8.92), which could also be linked to macrophyte photosynthesis.

Table 5.1: Spot water quality measurements collected from the three landfill sample sites on 26 February 2018 (Shaded cells refer to values over guidelines).

Parameter	Upstream Landfill	Downstream Mixing Zone	Downstream 2	Guideline
Time measured	13.10	12.25	11.46	
Temperature (°C)	17.2	24.8	19.2	<20 *
Dissolved oxygen % saturation	23.1	225.1	8.9	>80% ⁺
Dissolved oxygen mg/L	2.21	18.80	0.86	Band D : <4 mg/L#
pH	7.50	8.92	7.62	7.2 20th percentile DVG≡ 7.8 80th percentile DVG≡

*Olsen (2012)

⁺ Hawkes Bay Regional Resource Management Plan (HBR RMP)

≡ Australia New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2018)

NPS FM-1 November to 30 April, mg/L = g/m³

Water quality sampling data are summarised in Table 5.2 and laboratory transcripts are provided in Appendix B. Water quality sampling results show the stream has high water hardness, likely due to the areas of underlying limestone geology. Total ammoniacal-nitrogen was well above the HBR RMP standard at the Downstream 2 site, where concentrations start causing acute impacts on aquatic life. Further sampling and testing may be needed to confirm if this is a reoccurring issue and to assess the likely cause, as the other sites were below the laboratory detection limit. Nitrate nitrogen was slightly above the ANZECC (2018) stressor guideline at the Upstream Landfill site but below at the Downstream Mixing Zone and Downstream 2 site. All sites were under the nitrate toxicity limit outlined in Hickey (2013).

Dissolved reactive phosphorus increased from upstream to downstream and exceeded the ANZECC (2018) guideline at all three monitoring sites. Dissolved reactive phosphorus also exceeded the HBR RMP guideline for all sites except the Upstream Landfill site. The elevated nutrient results likely reflect the effect of agricultural and horticultural land use within the upper Upokohino Stream catchment.

[5] National Policy Statement for Freshwater Management. 2014.

[6] Olsen, D.A., Tremblay, L., Clapcott, J., Holmes, R. 2012. Water temperature criteria for native biota. Aucklalnd Council Technical Report 2012/036.

[7] Australia New Zealand Guidelines for Fresh and Marine Water Quality. 2018.https://www.waterquality.gov.au/anz-guidelines.

Table 5.2: Water quality results collected on 26 February 2018 from the three landfill sampling sites (shaded cells refer to values over guidelines).

Parameter (g/m^3)	Upstream Landfill	Downstream Mixing Zone	Downstream 2	Guideline
Total alkalinity (g/m^3 as CaCO3)	430	280	400	-
Total hardness (g/m^3 as $CaCO_3$)	450	260	320	-
Electrical conductivity (EC) mS/cm	99.4	66.8	99.3	
Dissolved calcium	150	89	105	
Total iron	2.1	2.6	5.6	
Dissolved magnesium	18.3	10.1	14.5	
Total manganese	0.75	1.06	1.41	3.6 *
Dissolved potassium	6.9	6.9	14.7	
Dissolved sodium	44	44	66	
Chloride	38	47	76	
Total ammoniacal-N	< 0.010	< 0.010	11.6	0.01+
Nitrite-N	< 0.10	< 0.10	< 0.10	
Nitrate-N	0.21	< 0.10	< 0.10	0.195* 6.3#
Nitrate-N + nitrite-N	0.27	< 0.10	< 0.10	
Dissolved reactive phosphorus	0.011	0.188	0.7	0.007 * <0.015 +
Sulphate	67	8.2	9.2	
cBOD5 (g O2/m^3)	7	7	8	

* ANZECC (2018) - 80th percentile default value guideline for physical and chemical stressors for and 80% level of species protection for toxicants

+ HBR RMP standard

Hickey,C.W. (2013). Updating nitrate toxicity effects on freshwater aquatic species. NIWA Client Report No:HAM13-009.

Heavy metal results for water quality samples are presented in Table 5.3 (laboratory transcripts in Appendix B). Heavy metals were below the ANZECC (2018) guideline value (GV) or hardness modified guideline value (HMGV) at all sites except for copper at the Downstream 2 site. Copper increased from Upstream Landfill to the Downstream 2 site, and further testing may be needed to confirm if this is a reoccurring issue and assess the likely cause.

Table 5.3: Heavy metal concentrations from 2018 stream water quality sampling and ANZECC (2018) guidelines values (GV) or hardness modified guideline values (HMGV).

Heavy metals (Mg/L)	Upstream Landfill	GV or HMGV	Downstream Mixing Zone	GV or HMGV	Downstream 2	GV or HMGV
Total Arsenic	0.0104	0.36	0.0145	0.36	0.026	0.36
Total Cadmium	< 0.000053	0.0089	< 0.000053	0.0055	< 0.000053	0.0066
Total Chromium	0.0010	0.0304	0.0011	0.0194	0.0025	0.0230
Total Nickel	0.0018	0.1699	0.0015	0.1066	0.0031	0.1271
Total Zinc	0.0058	0.3098	0.0047	0.1943	0.0178	0.2318

Heavy metals (Mg/L)	Upstream Landfill	GV or HMGV	Downstream Mixing Zone	GV or HMGV	Downstream 2	GV or HMGV
Total Lead	0.0007	0.2929	0.0008	0.1459	0.0018	0.1900
Total Copper	0.0009	0.0025	0.0013	0.0025	0.0059	0.0025

ANZECC 80% level of species protection used for toxicants.

+Toxicity value for chromium (III)

The results of sediment quality testing are presented in Table 5.4 and laboratory transcripts are in an Appendix B. Heavy metals in sediment samples were below the ANZECC (2018) default guideline value (DGV).

Table 5.4: Heavy metal concentrations from 2018 stream sediment sampling and ANZECC (2018) sediment quality guidelines.

Heavy metals sediment (mg/kg dry wt)	Upstream Landfill	Downstream Mixing Zone	Downstream 2	DGV
Total Recoverable Arsenic	10	4	7	20
Total Recoverable Cadmium	0.12	0.14	0.18	1.5
Total Recoverable Chromium	21	19	20	80
Total Recoverable Copper	12	13	44	65
Total Recoverable Lead	15.4	11.9	12.4	50
Total Recoverable Nickel	17	13	14	21
Total Recoverable Zinc	73	65	109	200

5.3 Macroinvertebrates

Macroinvertebrate communities were characterised by low diversity at all three sample sites on the Upokohino Stream (Table 5.5 and Appendix C). Samples were dominated by species that are tolerant to reduced water and habitat quality conditions. The lowest MCI score was recorded at the Downstream 2 site. These scores represent probable severe pollution and/or reduced habitat quality conditions at all sites.

Table 5.5: MCI-sb and QMCI-sb scores from the Omarunui landfill macroinvertebrate sampling on 26 February 2018. (Quality class and description from Stark & Maxted 2007[8], Stark 1998[9]).

Metric	Upstream Landfill	Downstream Mixing Zone	Downstream 2	Description
MCI-sb	69	67	45	Poor Probable severe pollution
QMCI-sb	3.61	2.75	0.62	

[8] Stark, J. D., and J. R. Maxted. 2007. A user guide for the Macroinvertebrate Community Index. Cawthron Report No.1166, Report prepared by the Cawthron Institute for the Ministry for the Environment.

[9] Stark JD 1998. SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. New Zealand Journal of Marine and Freshwater Research 32:55-66.

5.4 Fish

Two eels were seen in the downstream site, along with two dead eels, and one eel was disturbed at the Upstream site. Schools of small unidentified fish, likely tadpoles, were present at all sites.

6 Assessment of ecological effects

This section presents an assessment of ecological effects for the proposed Area B landfill. There are no ecological values within the Area B footprint, and therefore our assessment focusses on proposed landfill discharges.

As described in Section 3.3 leachate from Area B operation will be managed by a leachate collection system (LCS) and disposed of by spray irrigation to areas of the landfill cap. All water falling on exposed refuse at the working face of the landfill will be discharged to the leachate system, and no water that has been exposed to waste is expected to be discharged to the stormwater system. However, water quality monitoring is recommended to enable detection of any accidental discharge of other contaminants from the landfill operation into the Upokohino Stream (see section 6.2).

The following assessment focusses on stormwater discharges only and specifically on discharges of sediment to the Upokohino Stream. This includes sediment discharges during construction and operation and water quality effects associated with the placement and operation of the proposed pond and wetland. Other contaminants are briefly assessed.

6.1 Fine sediment

As set out in Section 4 the receiving environment for the proposed discharge is considered to be the Upokohino Stream.

An assessment of potential sediment loads due to the proposed discharge has been undertaken as part of the Landfill Engineering Report. In summary, a USLE assessment suggests a conservative (worst case and unlikely to occur) increase of 4 tonnes/year of sediment due to the discharge and relative to the existing situation. This estimate is after treatment in the proposed pond and wetland system (expected treatment efficiency when the Area B pond and wetland operate in series is stated to be 95%).

During stormwater discharge events the Area B treated stormwater discharge would mix with other catchment flows and enter the Upokohino Stream via the drainage arrangement described in Section 4. Some attenuation of sediment would likely occur within the open drain (which is vegetated with weeds) and on land. For context, the catchment area draining to the proposed pond and wetland system is around 19.49 hectares, which is around 7.1 % of the Upokohino Stream catchment upstream of the Landfill Access Road culvert (274 hectares).

There are no flow (discharge) data and limited water quality data available for the Upokohino Stream. Therefore, there are insufficient data to prepare meaningful mass load or mass balance calculations to assess potential receiving environment sediment effects. Upokohino Stream is soft bottomed stream with bottom substrates comprising a thick layer of mud. It is therefore likely that Upokohino Stream is characterised by elevated suspended sediment concentrations during storm flow conditions.

Our assessment shows that Upokohino Stream is of low ecological value and has low sensitivity as a receiving environment in its current condition. However, without proper sediment controls and a well-maintained stormwater treatment system, stormwater runoff containing fine sediment from construction and operation of Area B could potentially enter the Upokohino Stream and cause a further decline in water quality and associated negative effects on fish and macroinvertebrate communities. High levels of suspended sediment can reduce visibility for fish, damage fish gills and the filter feeding apparatus of invertebrates, smother invertebrate habitat (if deposited on the stream bed) and carry nutrients and other contaminants into the stream.

Given the treatment system proposed and mixing with wider valley runoff it is unlikely the proposed discharge would elevate suspended sediment concentrations in Upokohino Stream to a level or for a duration where adverse ecological effects on stream fauna would occur. Eels are the only native fish likely to be present in the Upokohino Stream and are tolerant of short-term elevations in suspended sediment (Cavanagh et al. 2014)[10]. It is also unlikely that the discharge will result in levels of deposited sediment that would have adverse effects on the ecology of Upokohino Stream.

Considering the low sensitivity of the receiving environment, and the proposed stormwater management measures the stormwater discharge is likely to result in only negligible effects on the Upokohino Stream. The potential for adverse effects is also likely to be partially mitigated by the likely additional dilution available during stormwater discharge events when the stream flows would also likely be elevated. Our conclusion is on the basis that the stormwater treatment system and erosion and sediment controls are appropriately designed and well maintained during landfill construction and operation. Any effects are not expected to extend past the mixing zone within the Upokohino Stream and very unlikely to extend to the Tutaekuri River.

With reference to the EcIA guidelines (see Section 2.2), the ecological value of the Upokohino Stream is “low” due to poor macroinvertebrate communities (low metric scores) and poor water quality. Without specific mitigation the magnitude of the effect of deposited and suspended sediment on the health of the Upokohino Stream could potentially be “moderate” (Table 2.3). This is on the basis that an increase in sediment inputs to the stream could cause further decline in water quality and aquatic life. The overall level of effect without effective stormwater treatment will likely be “low” (Table 2.4). However, with erosion and sediment controls during earthworks, and with an appropriate and a well-maintained stormwater treatment pond, the magnitude of effects on the Upokohino Stream will likely be “negligible” and the overall effect will be “very low”.

In order to confirm that the level of effects of construction and operation discharges are low we recommend a before/after and control / impact (BACI) programme of monitoring:

- Baseline water quality monitoring of the Upokohino Stream prior to construction commencing. Monitoring sites should include a control site upstream of where the discharge enters Upokohino Stream. A downstream site located around 50 m downstream of the discharge point which is the zone of reasonable mixing as set out in the Hawke's Bay Regional Resource Management Plan and a second site further downstream. We recommend that monitoring comprise of three sampling rounds during wet weather and three in dry weather with samples analysed for TSS and turbidity.
- Monitoring for the construction phase is undertaken as part of the erosion and sediment control plan prepared for the works. This should comprise water quality monitoring at the three sites sampled in the baseline monitoring programme , as well as from the outlet of the stormwater treatment wetland with samples analysed for TSS and turbidity. Monitoring should be completed at approximately quarterly intervals when a discharge is occurring from the stormwater treatment system.
- Operational monitoring comprising water quality sampling at quarterly intervals when a discharge is occurring from the stormwater treatment system. Monitoring should be undertaken at the three sites sampled in the baseline monitoring programme, as well as from the outlet of the stormwater treatment wetland with samples analysed for TSS and turbidity. Instream sediment quality and macroinvertebrate monitoring is recommended on an annual basis. Monitoring will ensure the stormwater pond and wetland are operating as intended (data collected as part of this investigation can serve as baseline sediment quality and macroinvertebrate data).

[10] Cavanagh, J.E.; Hogsden, K.L.; Harding, J.S. 2014. Effects of suspended sediment on freshwater fish. Report prepared by Landcare Research for West Coast Regional Council.

6.2 Stormwater and wetland effects

There is potential for cyanobacteria blooms to occur in the stormwater pond and associated effects on downstream water quality any wildlife that use the stormwater pond. The potential for these effects is low and will be addressed by monitoring in conjunction with routine inspections. Response actions will be developed as part of the stormwater monitoring and management/response plan if these issues arise.

6.3 Other contaminants

Potential sources of other contaminants include accidental discharge from refuse or leachate entering the stormwater system from the operation of Area B. We understand leachate from Area B will be disposed of by spray irrigation to areas of the landfill cap, with sufficient balancing storage and irrigation to suit the expansion into Area B. Controls for spray irrigation drift and runoff are detailed in the Engineering Concept Design report.

We understand all rain falling on exposed refuse is to be treated as leachate and will be discharged to the leachate system. Only stormwater which has not come into contact with refuse will be diverted to the stormwater treatment system.

Should contaminants from refuse or leachate enter stormwater due to unforeseen circumstances then the associated effects on aquatic life could comprise:

- Ammonia: In sufficient concentrations, ammonia can cause both chronic (long-term exposure) and acute (short term exposure) toxic effects on aquatic life. The toxicity of ammonia increases with water pH and temperature. We detected elevated ammoniacal nitrogen at the Downstream 2 site.
- Metals: Various metals (zinc, copper, lead, etc.) or metalloids (arsenic) can cause both chronic and acute toxic effects on aquatic life.
- Ammoniacal-nitrogen: is a macro-nutrient directly available to plant growth. Under stable flow conditions, it can promote excessive growth of algae and macrophytes in waterways. High levels of macrophyte and algal growth can deplete oxygen levels in waterways overnight as the plants respire (use oxygen).
- Organic contaminants and nutrients: can increase the biological oxygen demand and lower dissolved oxygen levels in the stream. The decomposition of plant matter can also increase the biological oxygen demand consequently reduce dissolved oxygen in waterways.

With reference to the EcIA guidelines (see Section 2.2), the ecological value of the Upokohino Stream is “low” due to poor macroinvertebrate communities (low metric scores), poor water quality and stressed fish populations. Without an effective stormwater and leachate treatment the magnitude of the effect of other contaminants from the landfill operation on the health of the Upokohino Stream is likely to be “moderate” (Table 2.3) and the overall level of effect would be “low” (Table 2.4). This assessment is on the basis that any increase in contaminants could cause further decline in the already poor health of the stream.

However, with an appropriate and well-maintained stormwater and leachate management systems the likelihood of other contaminants from the landfill operation entering the Upokohino Stream is low. Therefore, with mitigation and with reference to the EcIA guidelines the magnitude of effects on stream health is expected to be “negligible” and the overall effect “very low”. However, monitoring water quality in the Upokohino Stream is recommended and will enable detection of any accidental contamination from the landfill operation.

Monitoring of the Upokohino Stream should comprise:

- Baseline water quality sampling and testing for leachate contamination indicators including, ammoniacal nitrogen, heavy metals and biological oxygen demand and to be confirmed in the stormwater monitoring and management/response plan.
- Water quality monitoring undertaken at approximately quarterly intervals when discharge is occurring from the sediment pond. Monitoring should be undertaken at the three sites described in the baseline monitoring programme in Section 6.1 and the outlet of the stormwater treatment system. Samples should be analysed to enable detection of accidental leachate contamination, including, ammoniacal nitrogen, heavy metals and biological oxygen demand.
- Macroinvertebrate and sediment quality monitoring completed on an annual basis as recommended in Section 6.1.

6.4 Lake Te Rotokare

Information from HBRC and historic records[3] have indicated when flows are high in the Upokohino Stream water can flow into Lake Te Rotokare. The Upokohino Stream enters Lake Te Rotokare approximately 4.3 km downstream from the proposed landfill stormwater discharge point. The Upokohino Stream was dry at the landfill access road on the day of the site visit (26 February 2018) and is likely intermittent in the lower reaches. Due to the intermittent nature of the Upokohino Stream in the lower reaches and the distance of the landfill stormwater discharge from Lake Te Rotokare, we consider that there would be a low probability for the landfill stormwater discharge to have a measurable adverse effect the water quality of the lake.

With reference to the EcIA guidelines (see Section 2.2), we have assumed that the ecological value of Lake Rotokare is “high” as the lake could support nationally threatened flora and fauna. This is precautionary due to a lack of data for the lake. Due to the distance of the lake form the landfill discharge and the low frequency of Upokohino Stream flows into the Lake, the effect of stormwater inflow on the health of the lake is likely to be “negligible” and the overall effect would be “very low”.

However, should the receiving environment monitoring proposed above identify sediment issues due to the discharge then the effect of the discharge on other downstream environments can be investigated as part of an adaptive management response and management actions developed accordingly.

7 Recommendations

We recommend the following measures to protect the health of the Upokohino Stream:

- Baseline water quality monitoring of the Upokohino Stream prior to construction commencing. We recommend that monitoring comprised of three sampling rounds during wet weather and three in dry weather with samples analysed for TSS and turbidity.
- Construction phase monitoring of the Upokohino Stream comprising turbidity based water quality sampling. Samples should be analysed for TSS and turbidity at quarterly intervals when discharge occurs from the stormwater treatment system.
- Operational monitoring of the Upokohino Stream comprising water quality monitoring at approximately quarterly intervals when discharge is occurs from the stormwater treatment system. Samples analysed for TSS, turbidity and parameters to detect accidental leachate contamination. Instream sediment quality and macroinvertebrate monitoring undertaken annually, to ensure the stormwater pond and wetland are operating as intended and to detect any accidental contamination of stormwater from leachate or refuse.
- Control of wind-blown litter by screening to prevent debris from the landfill (such as plastic bags) from entering the stream.

8 Applicability

This report has been prepared for the exclusive use of our client Hastings District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
PP	....
Toni Shell	Tony Bryce
Ecologist	Project Director

Report reviewed by Dean Miller, Principal Ecologist

DCM
p:\1000647\1000647.1001\issueddocuments\aee\ecology\20200715 ecology assessment.v3.docx

Appendix A: Farm drain system layout sketch and photographs

- **Sketch and photographs provided to T+T by Hastings District Council**

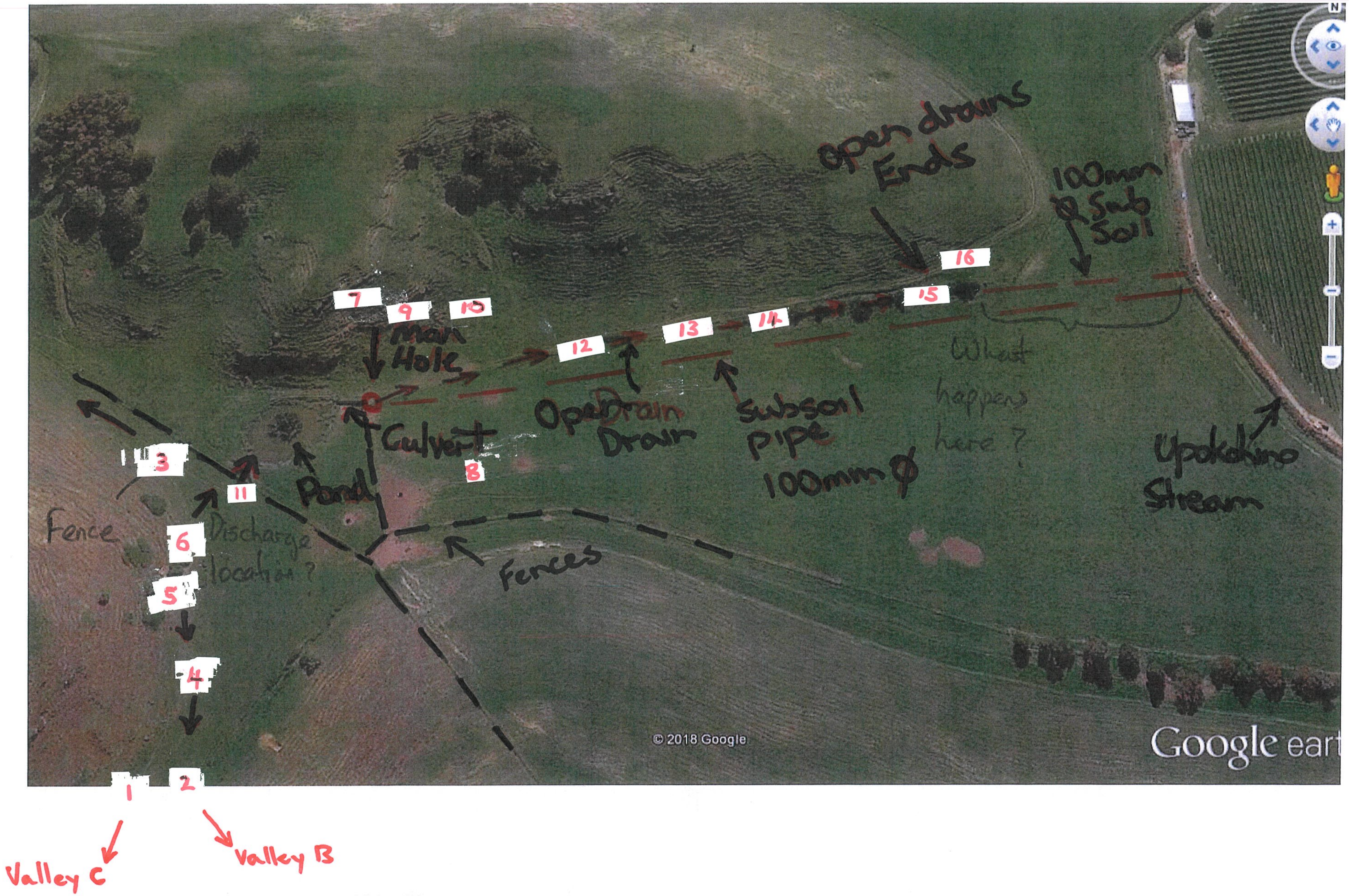
Open drains Ends
100mm ø Sub Soil
16
15
14
13
12
7
9
10
Man Hole
Open Drain
Subsoil pipe 100mm ø
What happens here?
Upokohino Stream
Culvert
8
Pond
3
11
Fence
6
Discharge location?
5
4
Fences
© 2018 Google
Google eart
1
2
Valley C
Valley B

Photo 1 looking up valley C

Photo 2   looking up valley C

Photo 3

Photo 4 Back towards Valley B,C entrances

Photo 5 Back towards Valley B,C entrances

Photo 6 towards the pond / wetland

Photo 7   900 mm dia Manhole culvert and runs to the Upokohino Stream.

Photo 9 Looking at Manhole back towards Valley B, C the and runs to Upokohino Stream.

Photo 8 Small steel helicoil culvert between Pond / wetland and the small pond which feed the Manhole

Photo 10 Wetland, Culvert and small pond which feeds Man hole.

Photo 11 looking north at wetland

Photo 12 Looking south back up valley this is the small open ditch which runs down the valley

Photo 13 Looking south back up valley this is the small open ditch which runs down the valley

Photo 14 Looking south back up valley this is the small open ditch which runs down the valley

Photo 15 Looking south back up valley this is the small open ditch which runs down the valley

And into a small vegetated area

Photo 16 this is the end of the open drain next to photo 15 water then runs into a 100 mm Dia there is no over land drain from here this is were

the water runs through to the Upokohino Stream

Appendix B: Water and sediment quality laboratory transcripts

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

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T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

SPv1

Client:	Tonkin & Taylor	**Lab No:**	1932208
Contact:	Toni Shell	**Date Received:**	27-Feb-2018
	C/- Tonkin & Taylor	**Date Reported:**	06-Mar-2018
	PO Box 9544	**Quote No:**	90510
	Hamilton 3240	**Order No:**	1000647.1000
		Client Reference:	Landfill Stormwater Discharge
		Submitted By:	Toni Shell

Sample Type: Sediment

Sample Name:		Omarunui d/s Landfill 26-Feb-2016 11:46 am	Omarunui d/s/ Mixing Zone 26-Feb-2016 12:25 pm	Omarunui u/s Landfill 26-Feb-2016 1:10 pm		
Lab Number:		1932208.4	1932208.5	1932208.6		
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	7	4	10	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.18	0.14	0.12	-	-
Total Recoverable Chromium	mg/kg dry wt	20	19	21	-	-
Total Recoverable Copper	mg/kg dry wt	44	13	12	-	-
Total Recoverable Lead	mg/kg dry wt	12.4	11.9	15.4	-	-
Total Recoverable Nickel	mg/kg dry wt	14	13	17	-	-
Total Recoverable Zinc	mg/kg dry wt	109	65	73	-	-

Sample Type: Aqueous

Sample Name:		Omarunui d/s Landfill 26-Feb-2016 11:46 am	Omarunui d/s/ Mixing Zone 26-Feb-2016 12:25 pm	Omarunui u/s Landfill 26-Feb-2016 1:10 pm		
Lab Number:		1932208.1	1932208.2	1932208.3		
Individual Tests						
Total Alkalinity	g/m^3 as $CaCO_3$	400	280	430	-	-
Total Hardness	g/m^3 as $CaCO_3$	320	260	450	-	-
Electrical Conductivity (EC)	mS/m	99.3	66.8	99.4	-	-
Dissolved Calcium	g/m^3	105	89	150	-	-
Total Iron	g/m^3	5.6	2.6	2.1	-	-
Dissolved Magnesium	g/m^3	14.5	10.1	18.3	-	-
Total Manganese	g/m^3	1.41	1.06	0.75	-	-
Dissolved Potassium	g/m^3	14.7	6.9	6.9	-	-
Dissolved Sodium	g/m^3	66	44	44	-	-
Chloride	g/m^3	76	47	38	-	-
Total Ammoniacal-N	g/m^3	11.6	< 0.010	< 0.010	-	-
Nitrite-N	g/m^3	< 0.10	< 0.10	< 0.10	-	-
Nitrate-N	g/m^3	< 0.10	< 0.10	0.21	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.10	< 0.10	0.27	-	-
Dissolved Reactive Phosphorus	g/m^3	0.7	0.188	0.011	-	-
Sulphate	g/m^3	9.2	8.2	67	-	-
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m^3	8	7	7	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	0.026	0.0145	0.0104	-	-
Total Cadmium	g/m^3	< 0.000053	< 0.000053	< 0.000053	-	-
Total Chromium	g/m^3	0.0025	0.00112	0.00101	-	-
Total Copper	g/m^3	0.0059	0.00126	0.00090	-	-

ilac-MRA IANZ ACCREDITED LABORATORY

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Aqueous						
Sample Name:		Omarunui d/s Landfill 26-Feb-2016 11:46 am	Omarunui d/s/ Mixing Zone 26-Feb-2016 12:25 pm	Omarunui u/s Landfill 26-Feb-2016 1:10 pm		
Lab Number:		1932208.1	1932208.2	1932208.3		
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Lead	g/m^3	0.00179	0.00076	0.00070	-	-
Total Nickel	g/m^3	0.0031	0.00149	0.00175	-	-
Total Zinc	g/m^3	0.0178	0.0047	0.0058	-	-

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	4-6
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	0.10 - 4 mg/kg dry wt	4-6
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	4-6

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8	0.000053 - 0.0011 g/m^3	1-3
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-3
Total Digestion	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-3
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-3
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-3
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-3
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-3
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-3
Total Iron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.021 g/m^3	1-3
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-3
Total Manganese	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8.	0.00053 g/m^3	1-3
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-3
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-3
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1-3
Total Ammoniacal-N	Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 22nd ed. 2012.	0.010 g/m^3	1-3
Nitrite-N Screen	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.10 g/m^3	1-3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-3
Nitrate-N + Nitrite-N Screen	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.10 g/m^3	1-3
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified). 22nd ed. 2012.	0.004 g/m^3	1-3
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1-3
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, dilutions, seeded. APHA 5210 B (modified) 22nd ed. 2012.	2 g O_2/m^3	1-3

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental

Appendix C: Macroinvertebrate results

200FC with scan for rare taxa	MCI	MCI-sb	Omarunui	Omarunui	Omarunui
	score	score	Downstream Landfill	Downstream Mixing Zone	Upstream Landfill
Beetles					
Antiporus	5	3.5	-	-	2
Enochrus	5	2.6	-	2	15
Hydrophilidae	5	8	-	1	-
Liodessus	5	4.9	2	4	34
Staphylinidae	5	6.2	-	1	1
Water Bugs					
Microvelia	5	4.6	-	1	-
Sigara	5	2.4	-	1	1
Damselflies & Dragonflies					
Xanthocnemis	5	1.2	1	9	1
True Flies					
Ceratopogonidae	3	6.2	-	1	-
Chironomus	1	3.4	-	72	5
Orthocladiinae	2	3.2	-	-	2
Stratiomyidae	5	4.2	-	1	7
Tanytarsus	3	4.5	-	-	4
Caddisflies					
Triplectides	5	5.7	-	1	-
Crustacea					
Ostracoda	3	1.9	1	14	-
Mites	5	5.2	-	-	1
Worms	1	3.8	9	24	20
Flatworms	3	0.9	17	1	-
Leeches					
Placobdelloides	3	1.2	-	6	12
Snails					
Austropeplea	3	1.2	-	1	-
Physa	3	0.1	184	26	-
Potamopyrgus	4	2.1	33	6	4
Sphaeriidae	3	2.9	-	3	-
Round worms	3	3.1	1	35	7
Total number of taxa			**8**	**20**	**15**

200FC with scan for rare taxa	MCI	MCI-sb	Omarunui	Omarunui	Omarunui
	score	score	Downstream Landfill	Downstream Mixing Zone	Upstream Landfill
Number of rare taxa			3	5	0
Number of individuals			248	210	116
Percentage Counted			10	30	100
MCI			67.5	75	76
QMCI			3.084677	2.314286	3.655172
MCI-sb			45	66.6	68.66667
QMCI-sb			0.617742	2.748571	3.611207
%EPTtaxa (excl. Hydroptilidae)			0	5	0
%EPTabundance (excl. Hydroptilidae)			0	0.47619	0

Appendix M: Air Quality Report

REPORT

Tonkin+Taylor

Omarunui Landfill Area B

Air Quality Impact Assessment

Prepared for
Hastings District Council

Prepared by
Tonkin & Taylor Ltd

Date
December 2019

Job Number
1000647

Exceptional thinking together

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Document Control

Title: Omarunui Landfill Area B					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
20/12/19	1	Final for lodgement	J Pene	J Simpson	T Bryce
14/12/19	2	Update to incorporate information responses	J Pene	J Simpson	T Bryce

Distribution:

Hastings District Council — 1 electronic copy

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Table of contents

1 Introduction

1.1 Background

Hastings District Council (HDC) operates the Omarunui Landfill, at 329 Omarunui Road approximately 12 km to the northwest of Hastings.

Omarunui Landfill is jointly owned by HDC and Napier City Council (NCC) and receives residual solid waste collected from Napier City and Hastings District.

The Omarunui landfill site comprises four designated fill areas (Areas A, B, C and D) located in four adjacent valleys. Area D is the currently active landfill area on the site. Area D commenced operation in 2006, following closure of Area A. Areas B and C are currently un-developed.

The current expected closure date for Area D is between 2025 and 2026, although recent increases in waste volumes delivered to the landfill suggest Area D may reach its capacity earlier than these predictions.

HDC and NCC are therefore seeking resource consents for the construction and operation of Area B, including resource consent for discharges to air.

HDC also proposes to alter the designation for the landfill in the Hastings District Plan through a Notice of Requirement to be lodged with HDC simultaneously with the resource consent application.

Tonkin & Taylor Ltd (T+T) has been commissioned to prepare this assessment of air quality impacts of the discharges to air from the construction and operation of Area B. This report should be read in conjunction with the Assessment of Environmental Effects (AEE) for the applications for resource consent.

This report has been updated since lodgement of the application to include detail provided in the following responses by T+T on behalf of HDC to Hawkes Bay Regional Council (HBRC) requests for further information under section 92 of the Resource Management Act 1991 (RMA):

- "Omarunui Landfill (consent ref: APP-125003) - Response to request for further information under section 92 of the Resource Management Act 1991", dated 25 June 2020 ("s92 response of June 2020");
- "Omarunui Landfill (consent ref: APP-125003) - Response to further discussion on the request for further information under section 92", dated 21 September 2020 ("s92 response of September 2020"); and
- "Omarunui Landfill - Consent ref: APP-125003", dated 3 December 2020 ("s92 response of December 2020").

1.2 Statutory context of assessment

The scope of this assessment is limited to discharges to air that require consent under Section 15 of the RMA and rules of the relevant operative and proposed regional plans. In this case this is the Hawkes Bay Regional Resource Management Plan (HBRRMP).

Under Rule 28 of the HBRRMP, discharges to air from waste disposal activities not specifically regulated by other rules of the plan is considered a discretionary activity (and therefore require resource consent).

Discharges to air from the flaring and combustion of landfill gas (LFG) at the site are not specifically provided for under the rules of the HBRRMP but have been considered to be ancillary to the overarching waste disposal activity (and therefore also governed under Rule 28).

HDC and NCC currently hold a resource consent (DP040122Aa) for the discharge of contaminants to air from Areas A and D. The authorised contaminant discharges are for (i) odour and LFG derived from the decomposition of refuse, (ii) dust, and (iii) the products of controlled combustion of LFG.

As LFG from Area B will be collected and reticulated to the same flare and LFG to energy facility used for Areas A and D, it makes sense for these discharges to be authorised by the same consent and subject to the same conditions. As such, the applicant is seeking to obtain a new consent for the discharge of the products of controlled combustion of landfill gas from Areas A, D, and B.

Consequently, an application is also being made to change the conditions of existing resource consent DP040122Aa to exclude discharges from landfill gas combustion, should consent be granted for the combined discharges from Areas A, D and B.

Consent is also being sought for discharges to air from waste disposal in Area B, including odour, LFG and dust.

This assessment therefore encompasses the effects of the following discharges to air to be authorised from the two new resource consents:

- Odour, LFG and dust generated from Area B waste disposal activities; and
- Combustion contaminants derived from controlled combustion of LFG collected from Areas A, D and B.

1.3 Purpose and scope

The purpose of this report is to detail the methods, results and findings of the assessment of potential effects of discharges to air from Area B landfilling activities to inform the AEE for the consent application. In particular this report includes:

- A summary of the proposed site activities as they relate to discharges of contaminants to air;
- A description of the nature of the proposed discharges to air;
- A description of the environmental setting of the discharges in terms of sensitivity to the discharged contaminants, and potential meteorological and topographical influences on the dispersion of emissions to air from the site;
- An assessment of the actual and potential effects of the discharges to air on local air quality; and
- A summary of conclusions and findings of the assessment.

2 Description of the site and activities

2.1 Site description

The Omarunui Landfill has been in operation since 1988. The landfill site is located at Omarunui between Swamp Road to the west and Omarunui Road to the east. The site occupies 178.73 ha and encompasses a series of ridgelines and reasonably steep-sided gullies draining west towards the Moteo Valley and east towards the Upokohino Stream and Tutaekuri River.

As illustrated in Figure 2.1, the landfill comprises four identified fill areas, which are intended to be sequentially constructed and filled. Area A, the initial and southernmost fill area commenced operation in 1987 and was completed in 2006. Area D, adjacent to Area A to the west is the current fill area and is currently anticipated to be completed between 2025 and 2026 (dependent on the volumes of waste received for disposal).

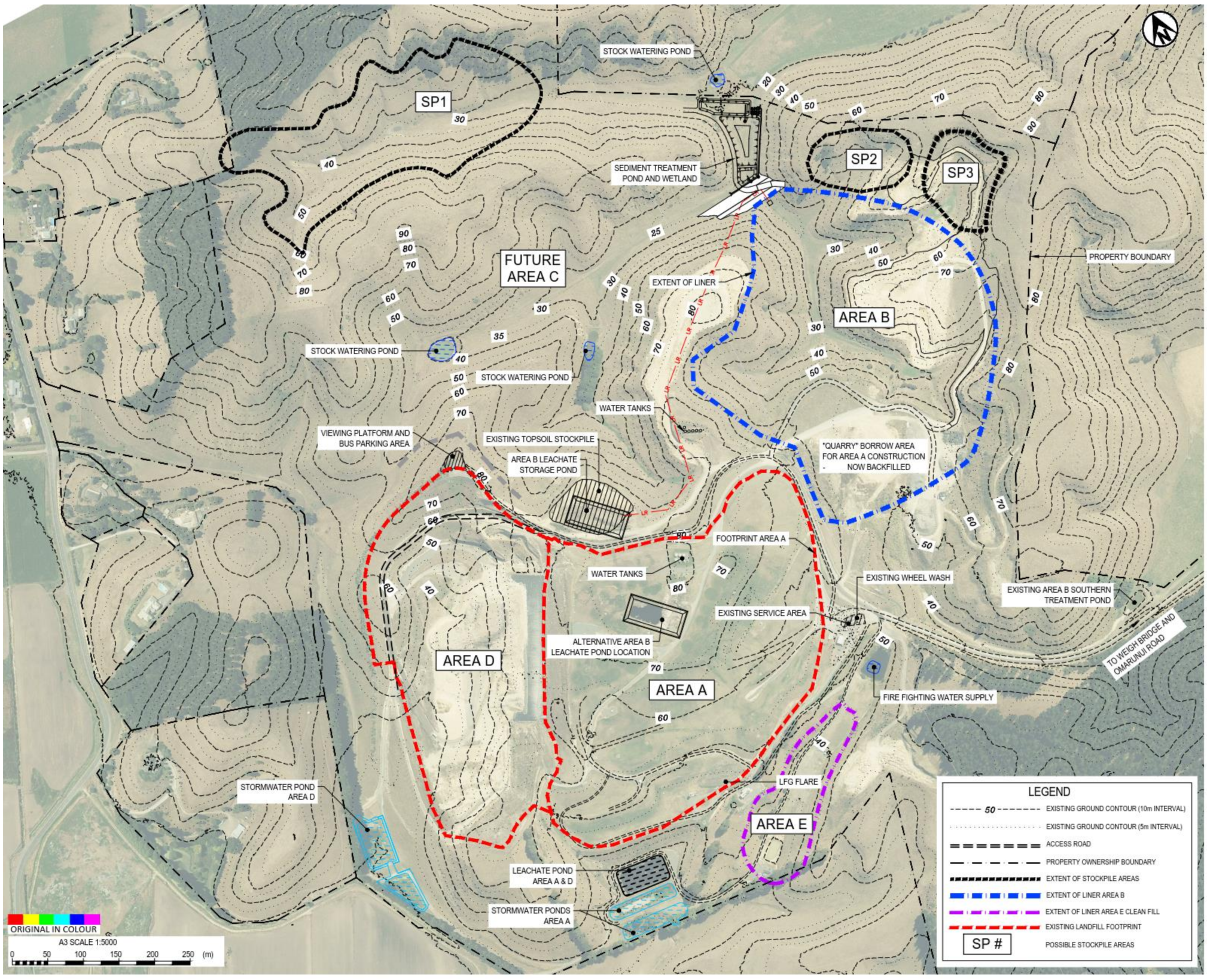


Figure 2.1: Omarunui landfill site layout illustrating the extent of completed Area A, operational Area D and future Areas B and C.

Filling of Area B is proposed to commence on completion of Area D, subject to new consents. Area C is a potential future fill area and is not within the scope of this assessment.

Areas A and D are located in valleys that drain to the south and west, towards the Moteo Valley. Conversely, the valleys in which Area B and future Area C are located drain towards the Tutaekuri River to the east.

2.2 Summary of current site activities

The Omarunui Landfill receives waste from both Hasting District and Napier City Council areas. Refuse is delivered to the site from the following sources:

- Kerbside waste collection of both Councils;
- Refuse transfer stations located at Flaxmere, Haumoana and Redclyffe; and
- Commercial and Industrial (C&I) waste delivered directly to the site.

Refuse delivery is therefore by truck only and direct delivery of waste is not available to the public. All refuse access is from the site access road connecting to Omarunui Road to the east of the site.

The landfill currently accepts waste from 8:00 am until 4:30 pm Monday to Friday and machines continue to operate until 5:00 pm to finish processing the waste. The landfill is closed on weekends, except at Christmas when it is open on Saturday for a half day due to increased demand.

Area D has been progressively filled in stages since the completion of Area A in 2006. Delivery trucks tip waste at the tipping face. Waste is spread over the active working face with an excavator and front end loader and is compacted with a purpose built waste compactor. Daily cover is spread over the active working face at the end of each working day. Intermediate cover is applied to areas that will not receive additional lifts of waste or final capping within a three month period.

Landfill gas (LFG) is currently extracted from vertical and horizontal wells penetrating Areas A and D and reticulated to the site energy centre located to the south of Area A (at the location denoted as "LFG Flare" in Figure 2.1). A Waukesha generator utilises a portion of the LFG to generate up to 0.9 MW of electricity. Residual LFG is combusted in an enclosed flare with a capacity to combust LFG at a rate of up to 2,000 m^3/h.

Leachate from Areas A and D is collected and stored in a leachate pond at the toe of Area A adjacent to the southern site boundary. Additional storage is provided in a pit on the upper surface of Area A. Leachate is spray irrigated over the completed areas of Area A cap.

The current operation of the landfill is described in detail in the Omarunui Landfill Operations and Maintenance Manual (Landfill Manual).

2.3 Summary of proposed Area B activities

The concept design and construction of Area B is described in the Omarunui Landfill Area B Engineering Report. Filling and landfill management activities are proposed to continue in accordance with that described in the Landfill Manual.

The following activities are relevant to potential discharges to air from Area B:

- Preparatory construction works for Area B will occur in a staged manner by excavating below existing ground levels to form the design liner levels for Area B. Excavated material will be stockpiled on site for future use for cover and capping material. Any surplus material not required on site (material not used as cover, capping or fill material on-site) may be trucked off-site via the main site access route as construction fill material;
- The majority of soil excavated from the Area B footprint is suitable for use as daily cover. Alternatives described in the Area B Engineering Report, that may be implemented where suitable soil is not available and where the alternative provides equivalent or better control, may include:
  - Foam products;
  - Geosynthetic fabric or panel products (blankets); and
  - Spray-applied cement.

- Intermediate capping of areas where no further filling will occur for at least 3 months or more will be of compacted clean soil at least 300 mm thickness. Areas where fill has reached the final fill height will be capped with an intermediate cap of at least 500 mm thickness, which will ultimately form part of the final cap;
- LFG collected from Area B will be reticulated to the existing energy centre (to the south of Area A) for combustion. Where required, LFG collection will occur initially via horizontal wells to improve collection during initial filling phases. Vertical gas wells will be constructed as fill height increases and will provide long term gas extraction; and
- Leachate from Area B will be collected and stored in a pond, situated either on the Area A cap or adjacent to the upper surface of Area A. Leachate is proposed to be recirculated over the completed fill areas of Area A and D and eventually Area B by spray irrigation onto final or intermediate capped areas.

The measures proposed to manage odour emissions from Area B are described in further detail in section 6.4.

3 Nature of the discharges to air

3.1 Overview of discharges to air

The discharges to air from the existing and proposed landfilling comprise the following:

- LFG derived from degradation of filled waste, including odorous, hazardous and combustible components;
- Odour from a range of sources associated with waste filling activities;
- Combustion by-products derived from the combustion of LFG; and
- Dust from handling of soil and other materials and disturbance of exposed soil surfaces.

3.2 Landfill gas

3.2.1 Landfill gas composition

The generation of LFG in the landfill varies in terms of volume and composition as the fill material ages.

Bacterial degradation of waste occurs in four phases as illustrated in Figure 3.1. The rate of progress through the degradation phases will be dependent on landfill/environmental conditions.

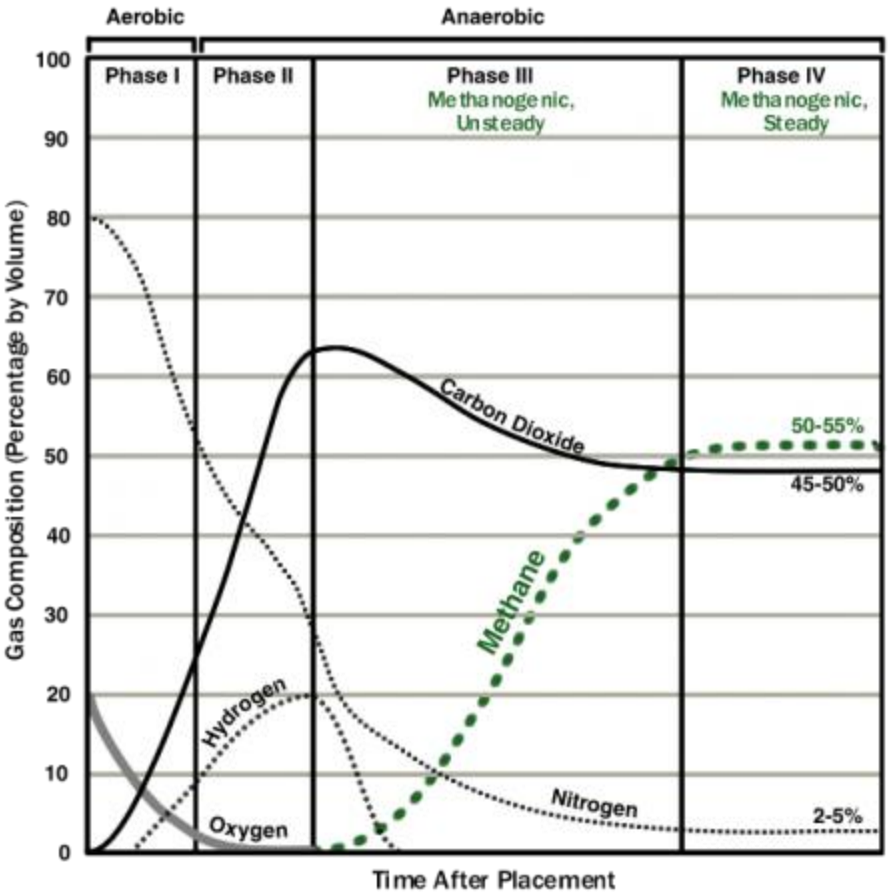


Figure 3.1: Typical LFG generation phases after placement of fill *Source: US EPA*[1]

[1] US EPA. 2016. "LFG Energy Project Development Handbook".

Typical LFG composition, as described by the US Agency for Toxic Substances and Disease Registry (US ATSDR), 2001[2] is detailed in Table 3.1.

Table 3.1: Typical chemical composition of LFG

Component	Composition range (by volume)
Methane	45% - 60%
Carbon dioxide	40% - 60%
Nitrogen	2% - 5%
Oxygen	0.1% - 1%
Ammonia	0.1% - 1%
Reduced sulphur compounds	0% - 1%
NMOCs (non-methane organic compounds)	0.01% - 0.6%
Hydrogen	0% - 0.2%
Carbon monoxide	0% - 0.2%

Source: US ATSDR

Although the majority of components of LFG are non-odorous, a number of components present in trace quantities have odorous characteristics including reduced sulphur compounds (such as hydrogen sulphide and mercaptans), ammonia and certain non-methane organic compounds (NMOC, such as volatile fatty acids). Odorous compounds are primarily generated from anaerobic fermentation and sulphur reduction processes that occur during phase II of the degradation process (early anaerobic degradation). Odour emissions from the site are described further in section 3.3.

Certain non-methane organic compounds that can be present in LFG in trace quantities have hazardous characteristics and can potentially cause adverse health effects where people are exposed in sufficient quantities.

LFG typically contains a substantial component of combustible gases (including methane, hydrogen and organic compounds) that allows LFG to be combusted, oxidising odorous components into non-odorous compounds (e.g. sulphur, nitrogen and carbon oxides).

3.2.2 Landfill gas generation

The rate at which LFG is generated at a landfill is related to waste acceptance rates, the composition of the waste (in particular the organic fraction of waste) and factors that influence how quickly the waste decomposes.

The degradation of the waste (and consequently the rate of LFG generation) is influenced by the following factors:

- Landfill construction and site operation procedures, particularly cover practices;
- Waste type/composition, density and age;
- Physical and chemical conditions within the landfill – particularly moisture content, temperature and pH; and
- Climate.

[2] US ATSDR. 2001. "Landfill Gas Primer".

Under optimum conditions, the readily biodegradable organic content of a modern landfill is likely to be largely degraded within 10 years or less. However, paper and other less biodegradable material may continue to break down for 30 years or more. This means that LFG continues to be generated, at a diminishing rate, for a number of years after the closure of Area B (as LFG continues to be generated from the completed Area A).

Rates of LFG generation from the existing and completed Areas A and D and anticipated to be generated from Area B have been estimated in the Omarunui Landfill Area B Engineering Report.

A peak total LFG generation rate from the existing and completed Areas A and D of 1,961 m^3/h has been estimated to occur in 2027. The rate of LFG generation from the site once Area B is constructed will vary depending on filling rates and the organic composition of waste occurring in future. A total upper bound estimate of LFG generation from Areas A, D and B of 2,286 m^3/h is estimated to occur in 2059. However, if the organic component of waste received is reduced by 30% LFG generation rates are likely to be lower than presently occurring (with a corresponding total site generation rate of 1,443 m^3/h in 2059).

3.2.3 Landfill gas collection

LFG will be collected for combustion as Area B is progressively filled (as LFG is currently collected from Area D). LFG will be continued to be collected from Area B upon completion (as LFG is currently collected from the completed Area A).

The rate at which LFG is collected is a function of the LFG generation rate and the efficiency of the LFG collection system. As the design of cover and collection systems have improved over time, the overall efficiency of LFG collection from Area B is likely to be improved from Areas A and D (Area A in particular).

The LFG collection system will be installed progressively as the waste is placed in Area B. This will involve placement of horizontal wells and progressive construction of vertical wells as the height of filling rises in each section of Area B. The suction on the collection system must be kept relatively low in the early stages of filling to avoid drawing air into the landfill and collection system, and creating a potentially explosive atmosphere. After a year of waste placement in Area B, the efficiency of LFG collection from the area is likely to be in the order of 50% of the LFG generated.

The collection efficiency will progressively increase as the depth of waste increases and the extent of cover, wells and reticulation infrastructure is expanded. The ultimate collection efficiency of LFG from Area B, once the final cap has been placed, is expected to be of the order of 95 %.

The balance of the uncollected LFG will generally permeate through the landfill cap and is bioremediated by bacteria and natural processes within the cap layer. Regular surface methane emission measurements in completed areas of the landfill have typically shown no detectable methane at the surface of the final cap (in the absence of cracks or defects in the capping layer).

3.2.4 Hazardous components of LFG

LFG typically contains organic components from the decomposition or volatilisation of waste. The primary organic component generated in LFG is methane (typically comprising 45% to 60% of LFG), which is not toxic. However, LFG contains small quantities of other organic components (referred to as non-methane organic compounds, NMOCs).

Certain NMOCs have been identified to cause or potentially cause adverse effects on human health (with exposure to sufficient doses) and are classified as hazardous air pollutants (HAPs).

Potential peak emissions of specific NMOCs, for which the Ministry for the Environment (MfE) has published health-based Ambient Air Quality Guidelines (AAQG)[3], have been estimated based on default concentrations for LFG constituents published by the US EPA (in the absence of site specific measurements). The estimates have been based on an estimated combined rate of LFG release from the three fill areas when LFG generation is predicted to peak in 2059[4].

Mercury may be volatilised, and be present in LFG, if mercury-containing wastes are deposited in the landfill. Emissions of elemental mercury have been estimated via the same method as the NMOC.

Table 3.2: Estimated peak emissions of HAPs in LFG emissions from the site (including Areas A, D and B)

Contaminant	**Peak emission rate (g/s)**
Total NMOCs* (as hexane)	0.25
• Benzene	6.46×10^{-4}
• Formaldehyde	1.21×10^{-6}
• Acetaldehyde	1.18×10^{-5}
• 1,3-Butadiene	3.10×10^{-5}
Mercury (elemental)	5.33×10^{-8}

* Non-methane organic compounds

The emissions of hazardous VOCs and mercury are relatively small in scale.

3.3 Odour emissions

Odour generation at the landfill is primarily associated with the anaerobic degradation of putrescible waste and also the release/volatilisation of other inherently odorous waste types.

Potential odour sources at the landfill site include the following:

- The active filling/tip face where waste is unloaded, spread over the active fill area and covered at the end of the working day;
- Odour neutralising sprays used in the vicinity of filling activities, which are typically scented;
- Excavation into older waste (for burial of odorous loads or installation of LFG collection or other infrastructure);
- LFG collection, reticulation and combustion systems;
- Leachate collection, storage ponds and irrigation system (over final cover areas), although experience on site demonstrates that these activities are not odorous; and
- On-site access routes (while odorous loads are in transit).

The character of odour may vary by source to some degree but in general odour derived from anaerobic degradation processes is likely to have an unpleasant character (strongly negative hedonic tone). Odour derived from volatilisation of inherently odorous waste will vary in terms of character and hedonic tone, depending on the material involved. The scent used in odour neutralising sprays is designed to have a generally pleasant character (positive hedonic tone).

[3] MfE. 2002. "*Ambient Air Quality Guidelines: 2002 Update*"

[4] The estimated LFG release rate has been based on the peak upper bound generation estimate in 2059 of 2,286 m^3/h described in section 3.2.2 and collection efficiencies at that time of 60% for Area A, 75% for Area D and 90% for Area B)

The mechanisms for odour release and the potential frequency, duration and intensity of odour emissions from each type of odour source on-site are described in Table 3.3.

Table 3.3: Summary of odour sources and potential frequency, duration and intensity of emissions

Odour emission source	Emission mechanism	Potential frequency/duration of emissions	Potential scale of emissions
Active filling/tip face	Filling and handling of received waste	On-going through operating hours	Variable, dependent on nature of loads received and extent of working face/filling activity
	Passive venting of LFG and odour through daily cover	Potentially on-going outside of operating hours	Generally low, mitigated by effective cover
	Spraying of scented odour neutraliser sprays	Occasional, dictated by filling activity odour levels	Generally low (the character of this odour is less offensive than anaerobic landfill odour types)
Intermediate cover and final cover(completed fill) areas	Passive venting of LFG and odour through intermediate and final cover areas	Potentially on-going	Generally low and mitigated by LFG extraction (increased if extraction is not in operation)
	Release of odour from irrigation of leachate over final cover areas (via pod spray)	Intermittent, as leachate irrigation to final cover areas occurs	Typically low or negligible but dependent on state of irrigated leachate.
	Excavation into older waste for burial of odorous waste or for installation or maintenance of linear infrastructure (e.g. LFG wells and pipes)	Occasional, dictated by receipt of odorous waste	Potentially high, dependent on state of excavated waste
	Leakage from LFG collection/reticulation system	Rare	Potentially high, dependent on extent of leakage
LFG combustion devices (flare/engine)	Residual release of odour in combustion exhaust	On-going during LFG extraction and combustion	Very low – combustion typically provides efficient destruction of odorants
	Venting through extinguished flare	Rare	Likely to be high
Leachate storage ponds	Release of odour from stored leachate	Potentially on-going	Dependent on state of stored leachate but typically low or negligible
On-site access routes	Delivery of odorous loads (still in truck)	Occasional. Duration is minimised by odorous load procedures but can be increased if load is not identified in advance of delivery	Potentially high, dependent on nature of load

3.4 Combustion emissions

3.4.1 Flare combustion

Estimates of emission rates from the flare of nitrogen oxides (NO_x), sulphur dioxide (SO_2), fine particulate matter (including PM_{10} and $PM_{2.5}$), carbon monoxide (CO) and non-methane VOCs are shown in Table 3.4. Emissions have been estimated using emission factors developed for the flaring of combined LFG and anaerobic digester biogas to be located in California[5] at an assumed peak LFG combustion rate of 1,982 Nm^3/h[6].

SO_2 emissions have been derived from an assumed H_2S concentration[7] of 310 mg/m^3 (which equates to a SO_2 concentration of 522 mg/m^3 assuming full stoichiometric conversion) and an assumed upper LFG collection rate of 1,982 m^3/h.

Table 3.4: Estimation of peak combustion by-product emissions from the proposed flaring of LFG from Areas A, D and B

Contaminant	Peak emission rate (g/s)
Nitrogen oxides	0.36
PM_{10} particulate	0.073
$PM_{2.5}$ particulate	0.073
Carbon monoxide	1.98
Non-methane organic compounds	0.34
Sulphur dioxide	0.32

3.4.2 Generator combustion

Emission rates from an individual Waukesha generator (as currently utilised) of NO_x, CO and NMVOCs have been estimated in the following table using the manufacturer's emission specifications for the engine model operating at full load (LFG combustion rate of 600 m^3/h). SO_2 emissions have been based on full stoichiometric conversion of H_2S as described in section 3.4.1.

Table 3.5: Estimation of peak combustion by-product emissions from the existing LFG fired generator

Contaminant	Emission rate (g/s)
Nitrogen oxides	0.67
Carbon monoxide	0.57
Non-methane organic compounds	0.13
Sulphur dioxide	0.096

[5] TSS Consultants. 2012. "UC Davis Anaerobic Digester Emissions"

[6] The assumed peak LFG combustion rate has been based on the peak upper bound generation estimate in 2059 of 2,286 m^3/h described in section 3.2.2 and collection efficiencies at that time of 60% for Area A, 75% for Area D and 90% for Area B)

[7] The average of H2S measured at Auckland's Redvale landfill, between 2007 and 2015 is 307 mg/m^3

3.4.3 Landfill fire combustion by-products

The occurrence of fires at landfills is unintentional. Fires can be considered in two categories: surface fires and fires that can occur within the waste mass.

Surface fires can occur when incompatible materials are mixed at the working face, or when objects capable of creating an ignition source are disposed. A specific example of this is when lithium ion batteries are disposed in household waste, which can create an ignition source at the working face if they are crushed. Surface fires typically occur during working hours and are therefore readily identified at the working face and can typically be managed by covering with inert materials to "suffocate" the fire or by using a fire extinguisher. The use of adequate daily cover material is typically sufficient to prevent exposure of disposed waste to oxygen in the air. Surface fires outside of operating hours are rare at landfill with adequate cover practices. Emissions to air from small surface fires are minimal and of short duration.

Combustion can occur within the waste mass at landfills that do not have adequate cover combined with active landfill gas extraction. Conditions inside the waste mass are typically anaerobic (oxygen deprived) and therefore combustion cannot be sustained. However, if there is inadequate cover, the active landfill gas extraction system can draw air into the waste mass. The risk of landfill fires within the waste mass is minimised through good cover practices and regular monitoring of landfill gas to detect air ingress. The emissions to air that might occur from a fire within the waste mass are difficult to characterise and quantify. However, emissions would include particulate matter, oxidised combustion contaminants (which are likely to include hazardous air pollutants) as well as the more common combustion contaminants described in sections 3.4.1 and 3.4.2. Given the controls in place at Omarunui Landfill, the risk of a fire within the waste mass is considered very low.

3.5 Dust emissions

During both the construction and filling phases of proposed Area B, dust may result from handling of soil and other materials and disturbance of exposed soil surfaces. Disturbance of dust from exposed surfaces may be through mechanical disturbance (e.g. vehicle movements) or through wind erosion.

Dust generated through these activities will generally be comprised of coarse particles that will generally gravitate and deposit on ground surfaces within 100 m of the source.

Weather conditions will influence both the generation (likely to be increased in dry conditions) and transport (likely to be increased in string winds) of dust.

Construction phase activities with a potential to generate dust include:

- Excavation and handling of material removed to create fill areas;
- Stockpiling of cut and fill material; and
- Haulage truck and vehicle movements over unsealed roads and exposed soil surfaces.

Landfilling activities with the potential to generate dust include:

- Stockpiling and handling of soil stored as cover material;
- Refuse truck and vehicle movements over unsealed roads and exposed soil surfaces;
- Placement of dusty loads of waste at the working face under windy conditions; and
- Placement of daily, intermediate and final cover.

4 Environmental setting

4.1 Adjacent activities

The landfill site is rurally located, which is reflected in the nature of activities in the area. Hill properties to the north and south of the landfill site generally feature pastoral farming and plantation forestry.

The valley terraces to the east and west of the site primarily feature horticulture and pastoral farming. The properties in which these activities are located generally exhibit a low sensitivity due to the low density and frequency of human occupation, though sensitivity may increase during labour intensive phases of the activities (e.g. harvesting of horticultural produce).

A number of rural lifestyle properties are also located in the vicinity of the site to the west of the site in the Moteo Valley along Swamp Road and to the southeast along Breckenridge Road. Each of these properties typically features a single dwelling, the location of which is illustrated in Figure 4.1.

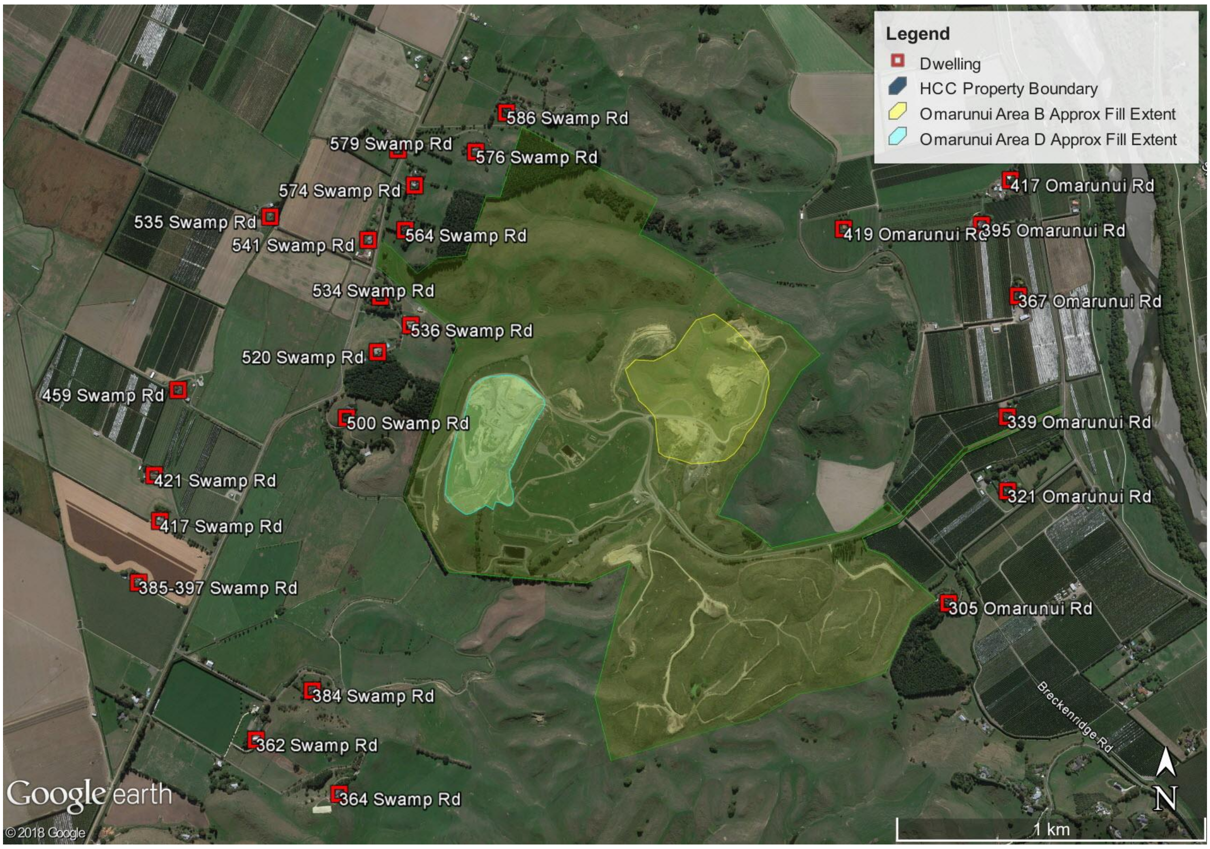


Figure 4.1: Site locality and dwellings located within 1km of Area B (proposed) and Area D (existing)

Land surrounding the site is zoned Rural (to the immediate north and south) and Plains Production (to the east and west). There is an area of Rural Residential to the north of the site accessed off Swamp Road.

The nearest urban zoned land is located at Taradale approximately 3.5 km from the landfill boundary to the east.

In general, due to both low population density and the background of rural odours that may be expected from the agricultural activities in the area, the surrounding rural area is relatively insensitive to odour and other air pollutants emitted from the proposed activities. However, sensitivity to odour will be elevated at the rural dwellings, where consistent human occupation is likely and expectations of amenity will be higher. Expectation of amenity may also be high in garden and yard areas within the immediate curtilage of the dwelling.

4.2 Topography

The topography of an area can influence wind and air flow and therefore the dispersion of emitted contaminants. The topography of the site and locality is illustrated in Figure 4.2.

As noted in section 2.1, the landfill site is located within a range of hills between the Moteo Valley to the west and the Tutaekuri River to the east.

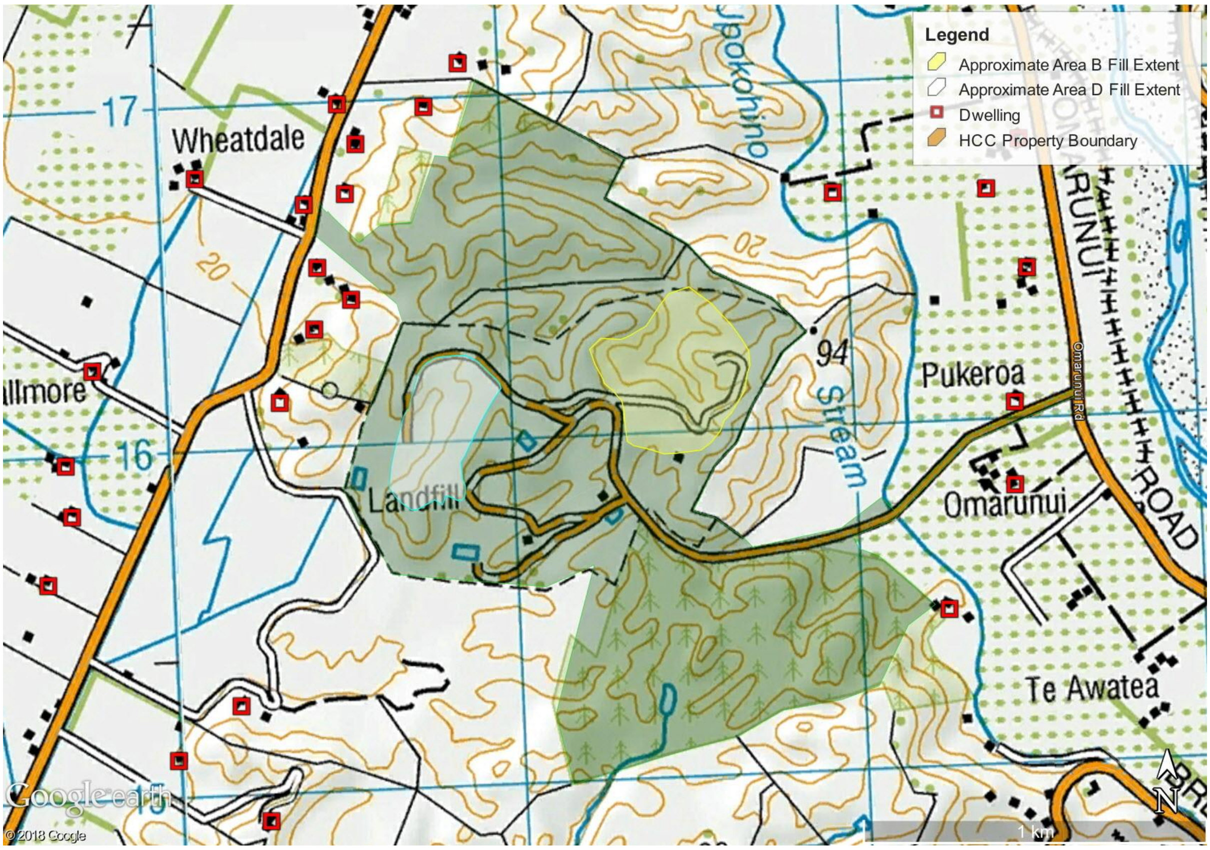


Figure 4.2: Topography of landfill site and surrounds *Source: LINZ Topo50*

4.3 Meteorology

The topography of an area may influence wind and air flow and therefore the dispersion of emitted contaminants. Local terrain at raised elevations in relation to an emission source may lead to impingement of emission plumes at those locations and a potential for higher contaminant concentrations than at lower elevations.

Influences on the dispersion of contaminants emitted from the site resulting from local topography are likely to include:

- The elevated nature of the landfill site on the range between two valleys is likely to result in exposure to relatively high frequencies of strong winds compared to valley locations, which will tend to promote dispersion of emissions of odour and other airborne contaminants; and
- In overnight temperature inversion conditions when calm stable conditions may promote the accumulation of odour and contaminants around emission sources at the site, katabatic drainage air flows will tend to propagate accumulated contaminants down-gradient towards lower elevations. The currently operated Area D drains towards Swamp Road and the Moteo

Valley to the west. The new Area B will drain towards Omarunui Road and the Tutaekuri River to the east.

A wind rose analysis of the wind speed and wind direction measured at the weather station operated by NIWA at Whakatū approximately 12 km to the southeast of the site from 2011 to 2015 is illustrated in Figure 4.3.

The Whakatū weather station is situated on the Heretaunga Plains and does not feature the topographical variation present in the area of the landfill. However, though Whakatū observations will not illustrate localised weather conditions at the landfill site, they are illustrative of regional wind patterns in the area.

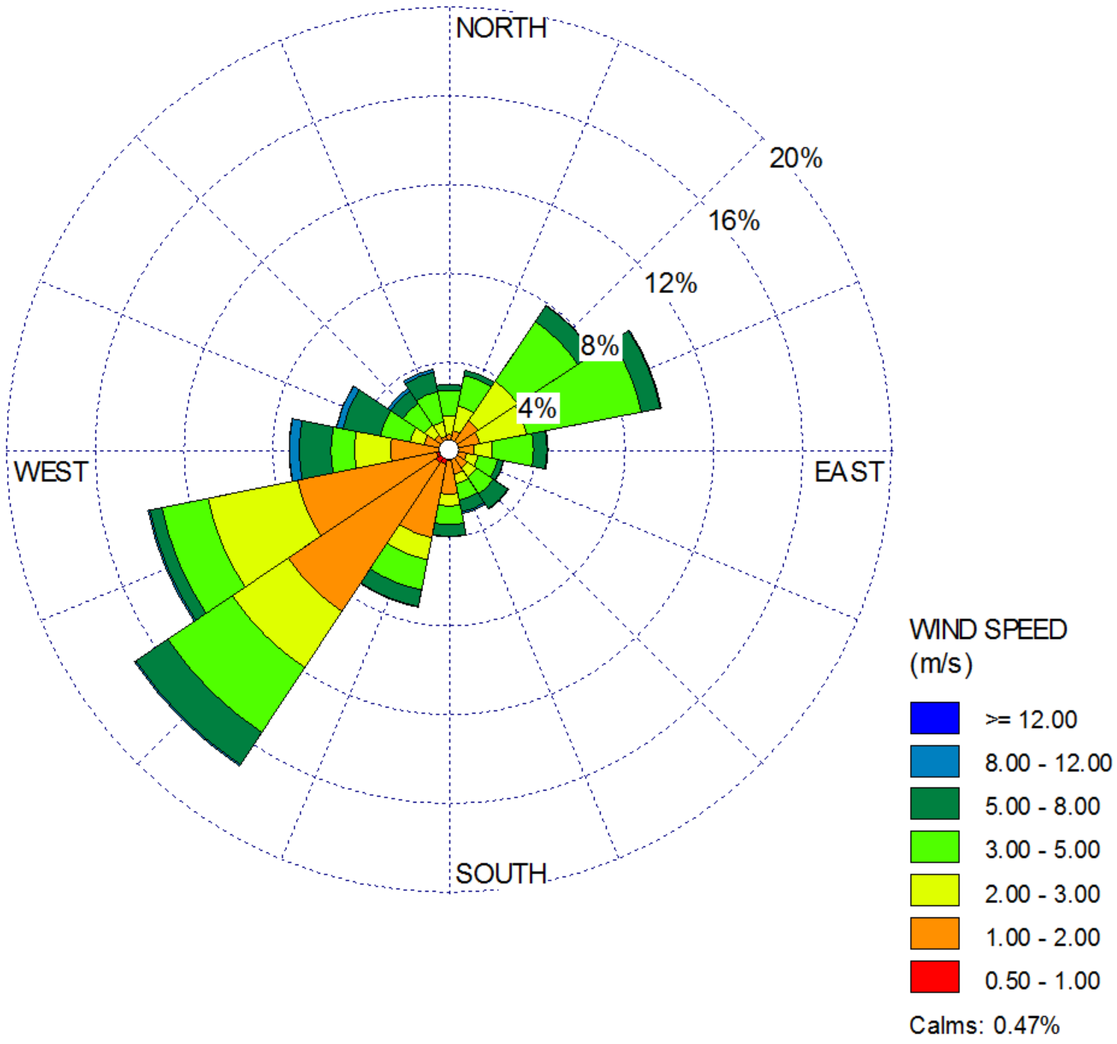


Figure 4.3: Frequency of wind speeds and directions measured at Whakatū 2011-2015 (1-hour average data)

There is a reasonably strong prevalence for winds from the southwest at Whakatū with a secondary prevalence of winds from the northeast. Similar wind patterns are likely at the site though local topography is likely to modify wind directions close to ground level in low wind speed conditions.

5 Assessment of effects methodology

5.1 Odour effects assessment method

Appendix 2 of the Good Practice Guide for Assessing and Managing Odour (GPG Odour) published by MfE provides guidance on the selection of odour assessment tools/techniques for the assessment of existing and proposed activities. Table 5.1 presents information which may be used to assess the activity against both the overall existing landfilling activity and the proposal to develop Area B at the site.

Table 5.1: Consideration of MFE guidance on selection of odour assessment tools

Assessment tool	Relevance in relation to this assessment
Community consultation	Community feedback in relation to odour detailed in complaints received at the landfill and by the HBRC has been reviewed in section 6.2. No further community feedback has been taken into account.
Complaints record	Discussed in section 6.2
Industry/council experience	Experience of odour impacts and odour management at other landfills in New Zealand have been considered in the review of odour management measures at section 6.4. Experience at similar sites has also been taken into account via a consideration of geographical separation from sensitive activities with the recommendations of Australian regulatory authorities based on similar landfilling activities (refer section 6.1).
Meteorology and terrain assessment	Discussed in section 4
Odour diaries	An odour diary programme has not been implemented in the area.
Olfactometric Quantification of Source Odour Emissions & Modelling	Dispersion of odour modelling of odour emissions could provide an indication of odour concentrations that may be experienced in the area and, in particular, the potential change in spatial changes in odour resulting from the transfer of filling activities from Area D to Area B. However, odour emissions from the variety of diffuse emission sources on-site are difficult to accurately quantify on an on-going basis, which will diminish the reliability of predictions. For instance, working face emissions are likely to be one of the more significant sources of odour but the scale of emissions will vary depending on the nature of refuse received at the time. Emissions from completed cells are likely to be negligible compared to emissions from pasture but may increase if LFG extraction is compromised. As such dispersion modelling has not been used to assess odour impacts in this instance.
Review of Proposed Process Emission Control System(s) Hardware, Design Standards, Odour Management Plan & Contingency Procedures	Discussed in section 6.4.

5.2 Health effects assessment method

As described in section 3 the proposed hazardous combustion and LFG emissions is relatively small in scale. The potential health effects of these emissions have therefore been assessed in a semi-quantitative manner through comparison of emissions concentrations and health effects assessment criteria for ambient contaminant concentrations and a qualitative consideration of the dilution of emissions likely to be achieved over the relatively large separation distances that exist between source and receptor locations in this case.

5.3 Dust effects assessment method

The potential for dust effects has been assessed through a qualitative consideration of the likely degree of deposition and removal of dust occurring over the relatively large separation distances that exist between source and receptor locations in this case.

6 Assessment of the potential effects of odour emissions

6.1 Separation distances

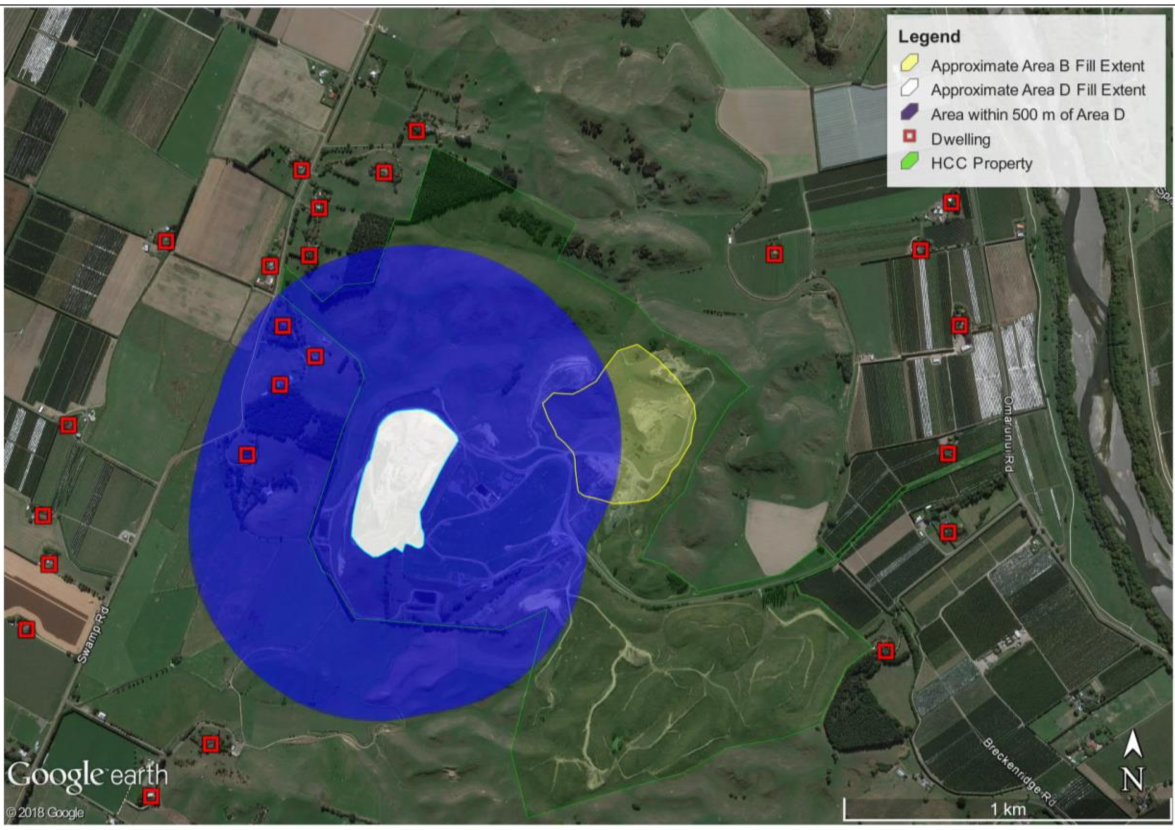
The degree of dispersion of odour or dust discharged from a particular emission source will be dependent on a range of factors that include the degree of geographical separation between the source and receptor/observation location.

Comparison of the separation distances that exist between the proposed landfilling activities and local sensitive activities with distances recommended in relevant separation distance guidance documents may therefore be used to provide a broad indication of resulting odour and dust levels and the potential for odour and dust nuisance.

Relevant separation distance guidance recommendations are published by various state Environmental Protection Authorities (EPAs) in Australia, the majority of which recommend that site specific assessments be undertaken for landfilling activities. Guidance published by EPA South Australia[8] conversely recommends a separation distance (referred to as an “evaluation distance”) between landfills and sensitive activities of 500 m.

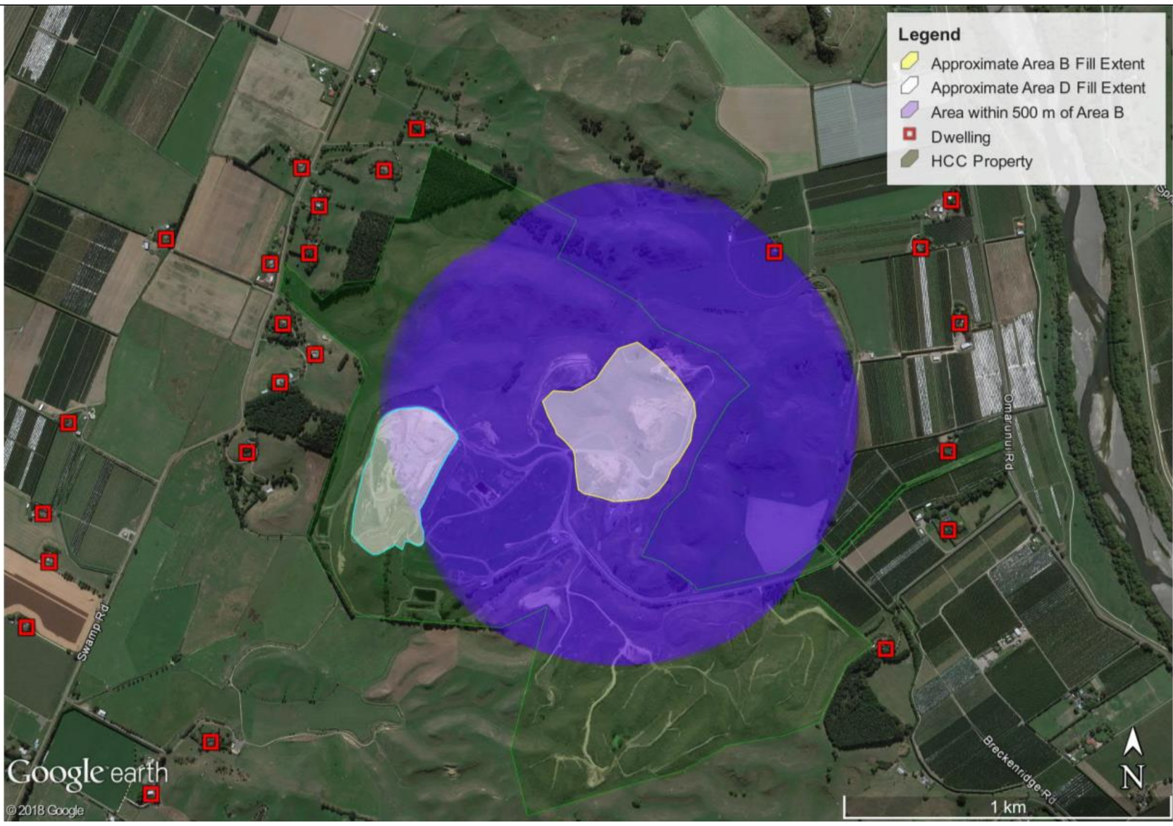
The description of the evaluation distance refers to both odour and dust emissions but given the potential for odour impacts from landfilling activities is wider, it is likely to have been based primarily on odour.

A comparison of the area and dwellings located within 500 m of the fill extent of existing Area D and proposed Area B is illustrated in Figure 6.1.



Area within 500 m of the fill extent of existing Area D

[8] EPA South Australia. 2016. “Evaluation distances for effective air quality and noise management”.



Area within 500 m of the fill extent of proposed Area B

Figure 6.1: Comparison of area within 500 m of fill extents of Existing Area D and Proposed Area B

The completion of filling at Area D and commencement of Area B will shift landfilling activities (and associated odour and dust sources) away from the Moteo Valley/Swamp Road area and towards Omarunui Road to the east.

There are a number of dwellings located along Swamp Road in the area of Area D. Specifically, four dwellings are located within 500 m of the fill extent of Area D.

To the east there are fewer dwellings within this radius of the proposed fill extent of Area B. Only the dwelling at 419 Omarunui Road lies within 500 m of the Area B fill extent. This dwelling lies at the base of the valley in which Area B is located and is just within the 500 m distance. Katabatic drainage air flows occurring in calm, stable overnight wind conditions (e.g. during temperature inversions) are likely to gently direct air from the landfill towards this dwelling.

This comparative analysis indicates in general terms, the proposed filling of Area B (at the cessation of filling of Area D) will reduce the potential exposure of occupants of neighbouring dwellings in the surrounding area to odour and dust from landfilling activities but that robust odour management measures are likely to be required to avoid odour nuisance effects at the dwelling at 419 Omarunui Road.

6.2 Review of odour complaints

While odour complaints (or a lack thereof) are not conclusive indicators of odour nuisance effects or an absence of those effects, the record of odour complaints and confirmed incidences of offensive or objectionable odour can provide a broad indication of odour nuisance experienced in the vicinity of the existing operations.

The record of complaints received by HBRC in relation to odour and other discharges to air from the site from 2003 to 2019 and the site's register of complaints received since 2013 were reviewed. The

HBRC record contained details of each complaints and investigation (if undertaken) but did not record exact date or time details for the complaints and no analysis of diurnal or seasonal patterns was able to be conducted.

The frequency of odour complaints received since 2003 is illustrated in Figure 6.2.

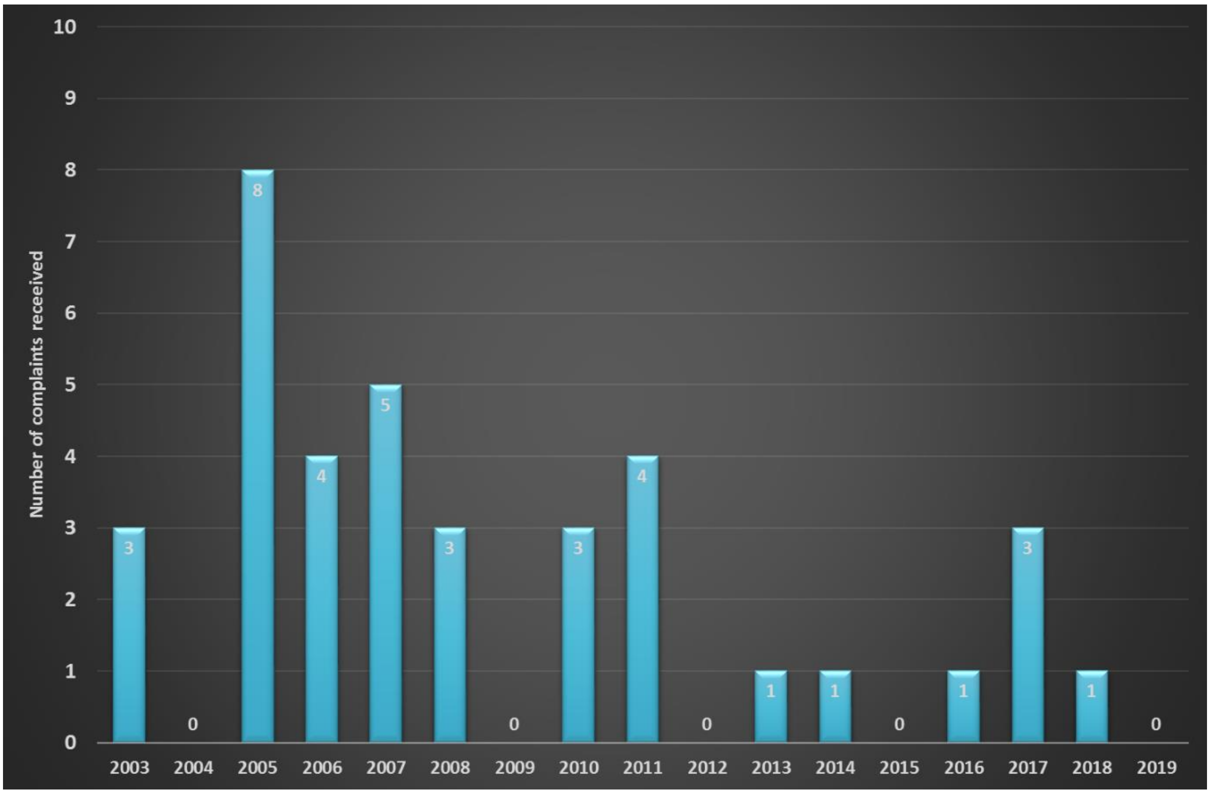


Figure 6.2: Frequency of complaints received by the HBRC and at the landfill, 2003-2019

As illustrated in Figure 6.2, complaints relating to odour from the site have been received relatively infrequently since 2012.

The frequency of complaints was higher prior to 2012 compared to more recent years. The reasons for this reduction in frequency is likely due to HDC's improvements in odour management, which have included:

- Introduction of odour sprays around the landfill operations;
- Introduction of odour sprays around the liquid waste pit operating at that time, and procedures implemented to ensure operation at the time of any liquid waste delivery. Liquid waste is no longer accepted at the site;
- Identification and sealing of areas where concentrated emissions of LFG were observed, in particular at the top of the leachate drainage blanket beside Stage 2 of Area B;
- Progressive installation of a LFG collection at Area D, comprising the final vertical wells and supplemented with horizontal collectors where coverage of the vertical wells was not adequate; and
- Greater control of the tipping face.

Although complaint details provided by the HBRC did not include location details, landfill staff have anecdotally indicated that the bulk of the complaints in recent years have been received from the nearest dwellings along Swamp Road.

In relation to complaints received since 2012:

- The most recent complaint in 2018 related to fumes/vapour that appeared to have been generated from the disturbance of volatile waste placed in the landfill;
- The three complaints received in 2017 related to penetration and trenching of completed fill areas for the installation of LFG lines;
- The complaint in 2016 related to receipt of an odorous load;
- The complaint in 2014 also related to trenching for LFG lines. HBRC notes appear to indicate that investigation of this complaint confirmed the presence of offensive or objectionable odour beyond the boundary; and
- The complaint in 2013 was received during a period when the flare and LFG collection system was down for maintenance and was not in operation.

Overall the relatively low incidence of complaints is consistent with a potential for odour nuisance that is low at most times. When complaints have been received they have tended to correspond with occasional or infrequent odorous activities. The record therefore highlights the importance of managing this type of occasional or infrequent activity to avoid odour nuisance including:

- Managing penetrations of completed landfill areas either for the burial of special waste or odorous loads or the installation of LFG lines or other infrastructure within the landfill;
- Minimising outages of the LFG extraction and combustion system; and
- Early identification and rapid burial of odorous waste.

6.3 Observations of odour from existing Area D filling activities

6.3.1 Overview of observations

Field-based odour observations were conducted by T+T staff on 2 March 2018 and 10 October 2018.

Observations conducted over two days were not intended to provide an exhaustive representation of odour or likely to encompass all operational and environmental conditions likely to be encountered at the site. However, the “snapshot” of odour levels provided by observations on the two days can provide an indication of odour levels in the conditions on the two days.

6.3.2 Observations of 2 May 2018

Blustery winds from the south and south-southwest were occurring at the time that observations at elevated locations at the landfill site. Wind speeds were lower at valley locations on-site and in valleys at the time the observations were made between 10:20 am and 1:00 pm on 2 May 2018. Overhead conditions were overcast with occasional light rain.

Tipping and filling were occurring towards the north end of Area D at the time. The working face area in operation at the time appeared to be in excess of 600 m^2. A reasonably large population of seagulls was circling above the active landfill area. No LFG extraction to the energy centre was occurring due to maintenance on the generator and ventilation system.

On-site initial observations were made at the lookout point on the crest of the hill overlooking Area D, approximately 80 m to the north-northeast of the nearest part of the active working area. Despite the strong gusting winds (which would tend to disperse odour effectively within a relatively short distance of the source) distinct odour was observed in wafts at this location. In more stable atmospheric conditions with lower wind speeds odour intensities would be expected to be higher at this location.

No further odour was observed at locations on-site and off-site along Omarunui Road to the east and northeast and Swamp Road to the north and west of the site.

6.3.3 Observations of 10 October 2018

Conditions were fine overhead and generally calm with occasional light winds from the south and southwest when observations were made between 9:00 am and 11:00 am on 10 October 2018.

Filling was occurring towards the north end of Area D at the time. Filling was well confined and occupying a substantially smaller area than during the previous May 2018 observations. The LFG extraction system had been extended with installation of further wells in the previous month and was in operation, directing LFG to the flare at the time.

No odour was observed at the lookout point to the north-northeast of the active working area (where odour had been observed in the previous May 2018 visit in conditions that were less conducive to odour propagation towards this location).

Weak to distinct odour was detected intermittently on the site access road adjacent to the active filling area.

No further odour was observed at locations on-site and off-site along Omarunui Road to the east and northeast and Swamp Road to the north and west of the site.

6.3.4 Summary of odour observations

Odour levels at approximately the same downwind lookout location were substantially higher on 2 May 2018 than levels later observed on 10 October 2018, despite weather conditions being more conducive to consistent odour propagation during the latter observations.

This would indicate that odour emissions were higher during the May observations, the cause of which is likely to have included the following:

- The absence of LFG extraction during the May 2018 observations (down for maintenance), which would have allowed fugitive release of LFG from the completed fill areas of both Areas A and D, though fugitive odour release was likely to be most prevalent from the cells of Area D in which the early stages of anaerobic degradation was occurring (those filled within the preceding two years or so); and
- The smaller active working face area in operation during the October 2018 observations was likely to have provided for improved odour management and allowed the potential for odour emissions to be minimised.

The observations highlight the importance of an effective and operational LFG extraction system and appropriate waste management measures for minimising odour from the active and completed fill areas. Although the observations only provide two brief snapshots of odour impacts, they indicate that with appropriate measures in place, odour emissions are able to be managed to avoid off-site odour nuisance.

6.4 Review of odour management measures

The measures proposed to be employed at Area B to manage odour emissions from the sources described in section 3.3 and mitigate the potential for odour nuisance effects (as described in The Landfill Manual and the Area B Engineering Report) is reviewed in Table 6.1.

Table 6.1: Review of proposed odour management measures

Odour source	Available management mechanism	Management measures proposed	Consideration of measures
Active filling/tip face	Restriction on the scale/duration of filling activities	Minimisation of working face area (the Landfill Manual specifies that "*the working face of the landfill should be minimized in line with the size of the operation*" and "*that as a general guide it should be no more than 600 m^2*" It is proposed that this area be increased to 1200 m^2.	Restriction of the working face area provides a mechanism for restricting the scale of potential working face emissions (actual emissions will be dependent on the composition of waste being tipped and handled at the time). The specified general guide for working face area of 600 m^2 is relatively small and confined and may be difficult to achieve "*in line with the size of the operation*". A larger working face area threshold (of up to twice the current 600 m^2 general guide) would be more likely to be workable and should still provide a high level of control of working face emissions.
		Restricted hours of waste acceptance (to weekday working hours).	The restriction of filling to weekday working hours will restrict the potential duration of odour emissions from the working face.
	Containment of fill material	Application of daily cover to the working face at end of daily operation. Daily cover will be primarily a 150 mm layer of soil or alternatives as described in section 2.3 .	Rigorous application of daily cover proposed should provide effective protection against the release of odour from the working face outside of working hours.
		An intermediate cover layer of at least 300 mm of compacted soil will be applied to fill areas that will be undisturbed for 30 days or more. Intermediate cover at areas at the final fill height is to be 500 mm in depth prior to installation of the final capping system.	A compacted soil cover layer of the prescribed depth should provide appropriate containment of odour from these areas that will remain unused for a period of time.

Odour source	Available management mechanism	Management measures proposed	Consideration of measures
	Exclusion of odorous waste from tip face	Customer notification of odorous loads prior to arrival on-site and implementation of odorous waste procedures (penetration of completed fill areas, burial of material and rapid recapping).	Exclusion of odorous waste from the tip face and burial in completed fill areas is appropriate provided that waste identification is effective and burial duration is minimised.
	Odour treatment/masking	Use of odour neutraliser sprays between fill area and site boundary.	Effective neutralisation of odorants would typically require confined exposure of odorants to the neutralising agents, which is not achievable with open spraying. As a result, this type of spray effectively acts as a masking agent and can supplement the other active face mitigation measures if applied in accordance with the manufacturer's specifications.
On site access routes (waste in transit on delivery)	Controls on receipt of odorous loads	Customer notification of odorous loads prior to arrival on-site (timely delivery encouraged) Odorous loads covered in transit Implementation of odorous waste procedures on delivery (penetration of completed fill areas, burial of material and rapid recapping).	The potential for odour emissions from loads in transit can be minimised through effective pre-identification procedures and ensuring these loads are covered and odorous waste procedures are implemented without delay.
Penetration of cap/excavation of fill in intermediate cover areas for burial of odorous waste or for installation or maintenance of linear infrastructure (e.g. LFG well and lines)	Restriction on scale/duration of penetration and excavation activities	Burial of waste in accordance with odorous waste procedure, including minimisation of penetration duration and immediate covering	Burial of odorous waste away from the active tip face in accordance with a prescribed procedure can provide an effective management of this potential odour source provided burial duration works are minimised and cover is rapidly reinstated.
			Scheduled penetrations (e.g. for infrastructure installation) should be planned in order to minimise the penetration works duration.
	Odour treatment/masking	Application of odour neutraliser/masking spray during planned works where odour is detected.	Odour neutralisers may be more effective when applied directly to odorous material and should be applied in accordance with the manufacturer's specifications.

Odour source	Available management mechanism	Management measures proposed	Consideration of measures
Passive venting through intermediate and final cover areas	Application and maintenance of cover	Application of intermediate cover of at least 300 mm of compacted soil (500 mm where final contour is reached). Final cap is to be installed when significant areas have been filled to final level.	Application of appropriate final capping layers will provide containment of LFG and allow the LFG extraction to draw LFG from the fill. The composite cap has been designed in accordance with WasteMINZ guidance[9].
	Extraction of LFG/maintenance of negative pressure conditions in fill	LFG is to be extracted via horizontal and vertical wells and reticulated to the existing energy centre.	LFG extraction coupled with appropriate cover can provide effective minimisation of fugitive LFG release from completed fill areas. The complaint record and observations highlight the importance of an effective and available LFG extraction system. System maintenance should be planned in advance to minimise downtime.
	Monitoring of LFG releases from completed cover surfaces	Measurement of methane concentrations (as an indicator of LFG) are currently measured at locations on the surface of completed cover areas on a quarterly basis. This practice will continue for Area B.	Daily surface walkovers will provide regular on-going feedback on the state of containment provided by cover surfaces. This feedback will be supplemented with quantitative feedback from methane measurements on a quarterly basis, with responses to methane trigger level exceedances. This should provide effective monitoring of LFG containment and minimisation of the potential for passive LFG venting.
	Regular observation of cover condition and odour over completed cover surfaces	Daily walkover of completed cover surfaces to check surface condition and identify odour releases.	
LFG combustion devices (flare/engine)	Combustion/thermal oxidation of odorous and hazardous components of LFG	LFG collected via the LFG extraction system is combusted at the energy centre in a generator engine or in an enclosed flare. HDC proposes to install a backup candlestick flare to provide further combustion redundancy before Area B is operational. Additional engines may be installed as	Both the current engine and flare provide enclosed combustion conditions that should provide efficient oxidation of the LFG contaminants, provided a residence time of at least 0.5 s at a temperature of at least 750°C is maintained[10]. HDC is currently investigating solutions to issues occasionally arising

[9] Waste Management Institute New Zealand. 2018. "Technical Guidelines for Disposal to Land"
[10] As required under Regulation 27 of the Resource Management (National Environmental Standards for Air Quality) Regulations 2004

Odour source	Available management mechanism	Management measures proposed	Consideration of measures
		LFG collection increases to provide further energy utilisation (up to three engines may be able to be sustained depending on LFG generation).	from reduced flare flame temperature during simultaneous operation of the engine and flare.
	Maintenance of flame, cessation of LFG flow	LFG flow and composition and flare operation are continuously monitored via the HDC SCADA system with results recorded manually on a daily basis. The flare features auto flame re-ignition and automated flow cut-off.	The flame out detection and response measures identify and cease any unintentional loss of LFG and odour via the flare.
Leachate collection, storage and irrigation system	Provision of leachate storage to operate as a flow balancing pond on a fill/draw basis.	No management proposed	No odour is associated with the current leachate pond. Aeration of the proposed leachate pond for Area B coupled with dissolved oxygen measurement and automated aeration control could be considered should odorous anaerobic pond conditions develop.

In summary of the review of odour management measures:

- As noted in section 3.3, there are a range of potential emission sources on site. These include on-going or regular emission sources and sources where emissions are occasional or can result from abnormal or unintended operation;
- The complaint record and odour observations described in sections 6.2 and 6.3 indicate that of the on-going odour emission sources, the active tipping and working face presents the highest risk of causing odour nuisance. This potential can be well managed through measures proposed to be employed at the working face described in in Table 6.1, including controlling the working face area;
- The general guide restriction on working face area of 600 m^2 currently specified in the Landfill Manual is too restrictive and may not be able to be achieved on a consistent basis. A larger general guide restriction of 1,200 m^2 should provide for effective control of working face emissions and be practicably workable;
- Odour emissions from completed fill areas are also potentially on-going and are mitigated through application of cover material and extraction of LFG for combustion. The potential for increased odour emissions from completed cells should be managed through progressive installation of LFG extraction infrastructure as Area B is filled. Destruction of odorous compounds in LFG in the flares and generator should be effective provided LFG combustion temperatures and residence times are maintained; and
- The complaint record and odour observations indicate that occasional or abnormal activities such as receipt of odorous loads, excavation of previously filled areas for installation of infrastructure or burial of odorous loads and temporary cessation of LFG extraction for maintenance purposes present a risk of increased odour emissions and potential for odour nuisance. It is recommended that this risk is managed through:
  - Rigorous implementation of odorous load identification and burial procedures;
  - Minimisation of the duration of penetration of completed fill areas for infrastructure installation, and planning for odour control prior to commencing these works; and
  - Minimisation of downtime of the LFG extraction system for maintenance purposes.

Overall the odour management regime proposed for Area B (implemented as recommended in the bullet point summary above) should appropriately mitigate the potential for odour nuisance beyond the site boundary and is considered appropriate.

6.5 Consideration of FIDOL factors and summary of odour nuisance effects

The potential for odour nuisance, and the potential for objectionable or offensive effects in particular may be assessed by considering what are termed the FIDOL factors (frequency, intensity, duration, offensiveness/character and location) of locations where odour may be observed.

These factors are considered in relation to the potential for odour nuisance beyond the site in the following table.

Table 6.2: Consideration of FIDOL factors

Factor	Consideration
Location	As noted in section 4.1, the site is located in a rural area on a ridge of hills separating two valleys featuring rural residential development. In general, the forestry, pastoral and horticultural activities that form the majority of the receiving environment have a low sensitivity to odour given the

Factor	Consideration
	infrequent and transient human occupation of these areas and potential for background agricultural type odour. However, sensitivity will be elevated at rural dwellings due to prolonged human occupation and high expectation of amenity. Local dwellings are generally well separated from Area B (the degree of separation will be greater than corresponding distances between Area D and adjacent dwellings). The existing dwelling at 419 Omarunui Road lies approximately 475 m from the proposed fill extent of Area B and no other dwellings lie within 500 m.
Offensiveness/Character	Odour from landfilling activities is primarily generated from anaerobic degradation of waste. The character of odour may vary by source to some degree but in general is likely to have an unpleasant character (strongly negative hedonic tone).
Frequency/duration	The frequency and duration of odour experienced at off-site locations will be dictated by the frequency of emissions from the plant and by wind conditions. The frequency and duration of emissions will depend on the operation of odour sources (e.g. filling activities) at the site. As noted in section 4.3, based on wind observations at Whakatū to the west of the site, wind will be most frequently from the southwest quadrant and will tend to push odour toward the northeast. Katabatic drainage flows that may occur in overnight calm conditions will also tend to push odour from the valley in which Area B is located toward the northeast (toward the nearest dwelling at 419 Omarunui Road).
Intensity	The intensity of odour experienced at off-site locations will be dictated by the intensity of emissions from the site and the degree of dispersion that occurs prior the emissions reaching receptor locations. The intensity of odour emissions from filling activities will vary depending on operating hours and receipt of odorous load but the complaint record and brief odour observations indicate that odour intensity should generally be able to be mitigated through implementation of the measures described in section 6.4. The complaint record and odour observations indicate that occasional or abnormal activities, such as excavation of previously filled areas, cessation of LFG extraction for maintenance purposes and receipt of odorous loads, can result in increases in the intensity of odour emissions and associated off-site odour levels. These records highlight the need to provide effective management of these activities to minimise the potential for off-site odour nuisance. The degree of dispersion of odour will be influenced by weather conditions (described in section 4.3) and the degree of geographical separation between emission source and receptor location (described in section 6.1 and below in this table). In general, the transfer of filling activities from Area D to Area B will increase separation distances from the more populated areas to the east and reduce separation distances to the west. One dwelling is located within 500 m of Area B (whereas four dwelling are located within this distance of Area D). This dwelling is located downwind in prevailing wind conditions.

In summary, the rural nature of the locality results in a generally low sensitivity to odour in the receiving environment, except at rural dwellings. The sensitive dwelling locations are generally well separated from Area B filling activities (the degree of separation will be greater than exists between the currently operating Area D and adjacent dwellings). The nearest dwelling to Area B is located at 419 Omarunui Road approximately 475 m from the proposed fill extent and although separated by a ridgeline is likely to be downwind of Area B in both prevailing winds and katabatic drainage flows (if and when they occur).

Overall, the assessment indicates that frequency, duration and intensity of odour emitted from Area B is typically able to be managed to avoid nuisance in the rural environmental context. However, the assessment also highlights the increased risk of odour nuisance effects presented by occasional or abnormal activities at the site including excavation of previously filled areas, cessation of LFG extraction for maintenance purposes and receipt of odorous loads.

Particular attention should be paid to the management of this type of activity to minimise the potential for nuisance effects, including:

- Minimisation of working face area (generally within an area of 1,200 m^2);
- Rigorous implementation of odorous load identification and burial procedures;
- Minimisation of the duration of penetration of completed fill areas for infrastructure installation;
- Installation of LFG collection as early as practicable as filling progresses at Area B; and
- Minimisation of downtime of the LFG extraction system for maintenance purposes.

Provided these measures are implemented the potential adverse effects of odour emissions on the environment are assessed as being minor and offensive or objectionable odour is unlikely.

7 Assessment of potential health effects of emissions

7.1 Potential health effects of combustion emissions

The scale of exposure of members of the public at off-site receptor locations to combustion emissions from the site will be dictated by the magnitude of the emissions and the degree of dispersion that occurs prior the emissions reaching receptor locations. The degree of dispersion will be dependent on weather conditions and the degree of geographical separation between emission source and receptor location.

As described in section 3.4 the scale of contaminant emissions from the flare and LFG generator is relatively low. The combustion appliances (located to the south of Area A) are well separated from local dwellings illustrated in Figure 4.1 where members of the public are likely to be present on a consistent basis). The nearest dwelling at 500 Swamp Road to the northwest is located more than 700 m from the nearest combustion device (the flare in this case). Dispersion of emissions will be extensive over such distances.

The nominal instantaneous concentrations of combustion contaminants on discharge from the flare are compared with corresponding MfE Ambient Air Quality Guidelines (AAQG) that are applicable to ambient air in the receiving environment where people may be exposed in Table 7.1. The dilution ratio that would need to be achieved over the intervening distance between source and receptor in order for contaminant concentrations to be reduced below the AAQG is also identified in the table.

Table 7.1: Consideration of the flare contaminant emission concentrations and the degree of dilution/dispersion required for emitted concentrations to be reduced below MfE AAQG levels

Contaminant	Nominal LFG concentration on release (mg/m3)	MfE AAQG		Required dilution
		Guideline concentration (µg/m3)	Averaging period	
NOx	18.6	200	1 hour	1/93
PM10	3.7	50	24 hour	1/75
PM2.5	3.7	25	24 hour	1/150
CO	101	30,000	1 hour	1/3
SO2	16.2	350	1 hour	1/46

Although dispersion modelling has not been conducted to provide site specific predictions, the relatively small required rates of dilution described in Table 7.1 should be able to be achieved within relatively close proximity of the flare (well within the site boundary).

Overall, as a result the small scale of emissions and the relatively large separation distances between the combustion appliances and sensitive off-site locations, discharges from the combustion appliances are unlikely to result in adverse health or other environmental effects.

7.2 Potential health effects of LFG emissions

A similar dilution analysis to that presented for combustion emissions in Table 7.1 has been conducted in relation to the emissions of hazardous LFG contaminants in Table 7.2.

Table 7.2: Consideration of the proposed LFG HAP emissions and the degree of dilution/dispersion required for emitted concentrations to be reduced below MfE AAQG levels

Contaminant	Nominal LFG concentration on release (mg/m^3)	MfE AAQG		Required dilution
		Guideline concentration (µg/m^3)	Averaging period	
Benzene	7.7	3.6	Annual	1/2130
Formaldehyde	0.014	100	30 minute	-*
Acetaldehyde	0.14	30	Annual	1/5
1,3-Butadiene	0.37	2.4	Annual	1/153
Mercury (elemental)	6.3×10^{-4}	0.33	Annual	1/2

* No dilution required

The scale of LFG HAP emissions, as described in section 3.2.4, is relatively small. The separation distance between the proposed Area B fill extent and the nearest dwelling is also relatively large (approximately 475 m between the nearest fill and nearest dwelling). Area B is also segregated from dwellings along Omarunui Road by a ridge.

The required degree of dilution for benzene released in LFG is higher than for any of the combustion contaminants described in Table 7.1. However, the required dilution ratio should still be achieved within the site boundary, given the terrain.

Overall, as a result the relatively small scale of emissions and degree of geographical separation between Area B and sensitive locations to the east, HAP emissions in LFG released from Area B are unlikely to result in adverse health or other environmental effects.

7.3 Potential health effects of emissions from landfill fires

The potential for adverse effects on human health or other aspects of the environment from emissions from landfill fires is managed through measures intended to avoid the occurrence of fires, particularly fires within the waste mass. As stated in the s92 response of June 2020, the following key measures are to be implemented to mitigate the risk of landfill fires or to control fires in the instance they occur:

- Observation by landfill staff at the tipping face of loads being deposited for any sign of a fire hazard;
- The availability of six 30,000 litre water tanks on the surface of Area A, automatically topped up from a bore supply, installed specifically to provide fire fighting water storage, with connections for the Fire Service fire-fighting hoses. This water supply supplements the six older tanks still operational and located on the knob between Area C and Area B, to the north of Area A. Both if these water storage installations are relatively close to Area B;
- Water cart with a high pressure hose system available on site;
- Fire extinguishers in buildings, vehicles and plant on site;
- Fire Service to be called for any fire emergency. Fire Service maintain familiarity with the site;
- Large machinery and experienced operators available on site for assisting with fire fighting operations;

- Stockpiles of soils suitable for smothering purposes kept at various locations around the site; and
- Training of staff on appropriate response to a fire emergency.

Overall, the risk of landfill fires and associated emissions to air, should be appropriately minimised with the measures above in place. ~~fire emissions are unlikely to result in adverse health or other environmental effects beyond the landfill site.~~

8 Assessment of the potential effects of dust emissions

As noted in section 3.4.3, the nature of dust generated from earthworks and filling activities associated with proposed Area B is such that the majority of dust will deposit within 100 m of the source.

Dust sources associated with the Area B are all located at much larger distances from dwellings and other dust sensitive activities beyond the site boundary.

As a result, dust emissions from the proposed construction and filling of Area B are unlikely to cause adverse nuisance or property effects in the surrounding area. The low potential for dust nuisance is reflected in the lack of dust complaints relating to historical filling activities at the site in the complaint records referred to in section 6.2.

9 Conclusions

This assessment has considered the potential environmental effects of discharges to air from the Area B that HDC proposes to develop at the Omarunui Landfill. The following conclusions are drawn from this assessment:

- The landfill is situated on a ridge of hills at Omarunui between the Moteo Valley and the Tutaekuri River. Area B will be the third fill area to be constructed of a total of four fill areas designated for the landfill site, which has been in operation since 1987. The topography of the completed Area A and currently operating Area D drains to the west towards the Moteo Valley. The topography of Area B conversely drains to the east towards the Omarunui River;
- The discharges to air include odour from filling activities, landfill gas (including odorous and hazardous components) generated from filled waste, by-products from the combustion of landfill gas and dust from material handling and disturbance activities;
- The local area is rural and adjacent activities predominantly comprise forestry, horticultural and pastoral land uses, interspersed with rural dwellings. Sensitivity to odour and other contaminants emitted from landfilling activities in the receiving environment is generally low, except at the rural dwellings;
- Area B is the easternmost of the four designated fill areas and local meteorology and topography will tend to push emissions to air towards the Tutaekuri River valley to the northeast. Area B is generally well separated from rural dwellings, the nearest of which is approximately 475 m from the extent of Area B and no other dwellings are located within 500 m of the proposed filling activities;
- A range of assessment techniques have been used to assess the potential impacts of odour emissions from Area B activities. This assessment concludes that the frequency, duration and intensity of odour emitted from Area B should typically be able to be managed to avoid nuisance in the rural environmental setting;
- The assessment also concludes that particular attention to the management of occasional or abnormal odorous activities is likely to be required to minimise the potential for odour nuisance and that this should include:
  - Minimisation of working face area;
  - Rigorous implementation of odorous load identification and burial procedures;
  - Minimisation of the duration of penetration of completed fill areas for infrastructure installation;
  - Installation of LFG collection as early as practicable as filling progresses at Area B; and
  - Minimisation of downtime of the LFG extraction system for maintenance purposes.
- The assessment concludes that provided these measures are implemented the potential adverse effects of odour emissions on the environment are minor, and offensive or objectionable odour is unlikely;
- Landfill gas and combustion emissions have been assessed as being unlikely to cause adverse health effects on the basis of the small scale of emissions and large separation distances from sensitive dwelling locations;
- Similarly, dust emissions are assessed has being unlikely to cause adverse nuisance or property effects, provided dust management measures are implemented, in light of the distances separating dust generating activities at Area B from local dust sensitive activities; and

- Overall, provided odour emissions from occasional or abnormal odorous activities are managed as recommended above, the potential effects of the proposed discharges to air from Area B on the environment are considered to be minor.

10 Applicability

This report has been prepared for the exclusive use of our client Hastings District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Jason Pene	Tony Bryce
Senior Environmental Engineer	Project Director

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Appendix N: Landscape Report

LANDSCAPE ASSESSMENT
OMARUNUI LANDFILL
AREA B Proposed Landfill Site

Contents

1. Introduction

Evergreen Landscapes were engaged by Hastings District Council to provide a Landscape Assessment for Area B which is the preferred option for the next stage of development of the of the Omarunui Landfill. This Landscape Assessment is to support the alteration to designation in the Proposed Hastings District Plan to authorise placement of waste in Area B. This assessment considers the location of Area B in relation to existing properties, potential future development and surrounding roads and public land. It also considers existing vegetation and if any additional planting is required to mitigate any visual effects of the proposed development of Area B on the surrounding environment.

2. Background

The Omanunui Landfill site of 178.7 ha was purchased in the early 1980s and receives solid waste collected from Hastings District Council and Napier City Council. The landfill site is identified by the designation as suitable for landfill purposes. The landfill comprises four areas (A, B, C, D) in separate valleys.
Area A was the first area used for the landfill and was completed and capped in 2006. Area D is the present landfill operation and is expected to be completed around 2025. Area E is a separate valley authorised for clean fill. Area B is the preferred next landfill area that HDC hopes to be operational and accepting refuse in approximately six years' time. The conditions of the designation only permit certain areas to be used for waste disposal. At present waste disposal is provided for Area A, Area D, and part of Area C. A landscape assessment is required to support the alteration to designation to authorise the use of Area B for waste disposal.
Refer Figure 1 : OL 1 Omarunui Landfill Surrounding Area and Photo Locations (scale 1:10,000).

3. Site Description

3.1 Surrounding Site

The Omarunui Landfill site is located at Omarunui close to the Tutaekuri River between Taradale, Puketapu and Omahu. Omarunui is a series of ridges and valleys contained by Swamp Road to the west and Omarunui Road to the east and alluvial plains west of Swamp Road and east of Omarunui Road. Many of the landholdings around the landfill site have existing dwellings. The hilly land is used primarily for grazing with some small pine plantations. The plains on the east of the site near the Tutaekuri River are predominantly Pipfruit orchards with some Kiwifruit under cover, grapes adjacent to the river bed and some pasture/cropping blocks. The plains to the west of the site are a mix of Pipfruit orchards and pasture/cropping blocks. There is a mixture of typical shelter belt planting around the horticultural crops such as Casuarina, Alder and Poplars.

3.2 Area B Site

Area B is located within the eastern area of the Omarunui Landfill site. It is located in a completely separate valley to Areas A and D, discharging groundwater and surface water to a different catchment, flowing to the north east. Area B is separated from Area A and Area C by ridgelines at approx. RL 80m – RL 30m level (based on Tonkin & Taylor contour data). There is a distinctive narrow saddle where three ridgelines from Area B and Area C converge (approx. RL 25m). Area B has been used as a working zone and has significant excavation in certain areas to obtain liner and cover materials for the construction and operation of Area D. There are construction roadways and some service prefabricated buildings. Area B is not visible from Swamp Road or Omarunui Road due to existing ridgelines and mature vegetation. Refer to Figure 4 : OL 11 Photos 1 and 2, Figure 5 : OL 12 Photos 3 and 4, Figure 6 OL 13 Photos 5 and 6 and Figure 2 : OL 2 Viewpoints from surrounding properties (scale 1:5,000).

4. Area B Development

The final concept design for the landfill is described in the Assessment of Effects on the Environment (AEE) report that this report accompanies. The site will be filled from a level of approx. RL 25m to a finished elevation of approx. RL 80m. The saddle (approx. RL 25m) between the north ridge of Area C and the north ridge of Area B will be retained. The existing ridgelines to the north and east of Area B have high points of approx. RL 90m which is above the finished level (approx. RL 80m) of the proposed landfill site.

5. Potential Visual Effects of Area B Development

5.1 Existing Properties

None of the existing dwellings along Swamp Road are affected by the development of Area B as the views into the landfill site are of the completed Area A which is contoured and grassed and partially screened with mature shelter belt plantings. Some properties along Swamp Road can also view parts of Area D which is the active landfill site. These properties have no views into Area B, due to ridgelines between the properties and Area B valley. Existing ridgelines prevent any views into Area B from dwellings on Swamp Road. Refer to Figure 4 : OL 11 Photos 1 and 2. Similarly the views from the existing dwellings on the flats along Omarunui Road to the east of the landfill site are not affected by the development of Area B as they are screened by existing ridgelines to the east and north of Area B and existing mature vegetation as shown in Figure 5 : OL 12 Photo 3.

5.2 Potential Future Development

A privately owned parcel of land of 24.65 Ha (Lot 1 DP 15421, Title HBH1/1351) (367 Omarunui Road) borders the north east boundary of the landfill site for approx. 700m. The site is accessed from Omarunui Road and consists of a flat valley with a north facing slope on the south boundary (part of a series of east ridges of Area B) and an east facing ridge at RL 60m in the west area of the property. It is within the Plains Production Zone and one dwelling is able to be built on this site as a permitted activity in the Proposed Hastings District Plan (subject to compliance with the applicable standards and it meeting the definition of a 'site'). There are a number of possible house sites ranging from valley floor to top of ridge. If a dwelling is built on the valley floor there will be no effects from the development of Area B as the north ridge will screen Area B. Alternatively if a dwelling was built on the top of the east facing ridge in the west area of the property (RL 60m), then there could be potential views into Area B when looking through the existing saddle that is being retained. Refer Figure 6 : OL 13 Photos 5 and 6.

Another property (Section 25 Blk Heretaunga SD, Title HBG3/1163) (44.55 Ha) (367 Omarunui Road) is the other property that borders the north boundary of the landfill site for approx. 200m. This property (zoned Rural) could have two dwellings built as a permitted activity in the Proposed Hastings District Plan (subject to compliance with the applicable standards and it meeting the definition of a 'site'). This property comprises flat margins to the east and a series of ridges and valleys on the remainder of the property. If the dwellings were built on the valley floor there would be no effects from the development of Area B as any views will be blocked by existing ridgelines. Alternatively, if the dwellings were built on the top of the two east facing ridges in the south area of the property (RL 95m and RL 85m), then there could be potential views into the north face of Area B when viewed through the existing saddle. Refer Figure 6: OL 13 Photos 5 and 6.

If the dwellings in the two properties above were built on top of the ridges as discussed, then a potential way to mitigate some of the visual effects would be to plant a mixed exotic shelter belt on the north ridge of Area B and part of the north ridge in Area C, including planting in the base of the saddle. A mixed exotic shelter belt would be preferred as this matches the existing shelter and forestry planting around the site. Suggested species are Cupressus macracarpa (Macracarpa, Monterey Cypress) and Acacia melanoxylon (Black Wattle). These trees grow to 25m and 20m respectively when mature (Southern Woods Nursery Catalogue). These exotics are preferred over natives as they are traditional fast growing shelter belt species and also potential timber that can be harvested at a later date when Area B is complete and capped if required. With this shelter belt reaching maturity, there will still be some partial views to the landfill site when viewed through the existing saddle as this is the lowest point at approx. RL 25. Therefore, the shelter trees at maturity would block the views of the landfill site up to approx. RL 50.

Other surrounding properties may also have future development, but this would require consent so do not need to be considered as part of the existing environment.

5.3 Surrounding Road and Public Land

Two roads run past the landfill site. Swamp Road is to the west of the landfill site and runs north to south. When travelling north along Swamp Road there are views to the east of Area A of the landfill site which is the capped landfill site that is contoured and grassed and partially screened with mature shelter belt plantings along the western boundary. There are also views to Area D (active landfill site) from Swamp Road. Once Area B is operational Area D will be capped, contoured and grassed and look similar to Area A. Area B will not be visible from Swamp Road.

Omarunui Road is to the east of the landfill site and runs north to south. When travelling along this road there are no views into the landfill site as it is fully screened by a series of ridges to the west and shelter belt plantings along the horticultural properties that border onto the road.

The main public land nearby is the Tutaekuri River and visitors to this public land will have no views of the landfill site as it is screened by a series of ridges to the west and the shelter belt plantings along the horticultural properties that border onto the road. There are also dense erosion control plantings such as willows and poplars in the catchment of the Tutaekuri River that will also screen views towards the landfill site.

Litter fences are used around the perimeter of active landfill sites to capture any wind-blown litter. These comprise vertical timber posts approx. 6m high with wire mesh. They are presently located around Area D. These litter fences are visible from Swamp Road as they are located on top of the ridgeline around Area D. These fences can be viewed in the distance as a series of vertical posts that match the character of the surrounding rural structures (post and batten wire fences) and vegetation (shelter belts) in the foreground. Refer Figure 7 OL 13 Photo 7.

Trying to screen the litter fence with tree planting would make them more visible and create further problems with the trees having to be maintained at a height below the litter fence to reduce litter getting trapped in the trees and planting along the line of the litter fence may not be the best location for a shelter belt. If feasible, a possible option could be to place the litter fence just below the top of the ridgeline, so it is not visible yet still functions as intended.

6. Proposed Landscape Plan for Area B

The Landfill Management Plan (LMP) in the Proposed Hastings District Council Plan (Operative in Part) requires a final landscape plan to be prepared and approved for each waste area.

The proposed landscape plan is a shelter belt planting 20m wide of two rows of Cupressus macracarpa (Macracarpa, Monterey Cypress) and two rows of Acacia melanoxylon (Blackwood) at 4m spacings located on the north ridges of Area B and Area C and in the adjoining saddle. These trees will grow to approximately 25m and 20m high respectively at maturity and can be harvested at a later date when Area B is complete and capped, contoured and grassed. Once Area B is complete and shelter belt harvested then Area B will resemble the surrounding hills.

As discussed earlier the only potential views into Area B are from the properties to the north of the site and only if the permitted dwellings are built on top on the ridge. At present the existing dwellings to the north of Area B have no views into the site. Therefore, the proposed landscape planting is dependent on the permitted dwellings being built in these locations and if the planting goes ahead it will help to screen any views into area B. Some of Area B will still be visible due to the lower level of the saddle between the two ridges. The view of the landfill will be less dominant with the proposed planting. Refer Figure 8 OL 4 Proposed Landscape Plan.

7. Summary

The following points have been noted in the discussion:

- Area B is located in a separate valley and separated from Area A and Area C by ridgelines.
- Area B is not visible from Swamp Road and Omarunui Road due to the screening by exiting ridgelines and vegetation.
- Area B will be filled in stages between the existing ridgelines to RL 80.
- Area B will be capped, contoured and grassed at the completion of the filling and will visually integrate with the surrounding rural landforms.
- There are no existing dwellings with views of Area B.
- There are three potential dwellings permitted on two properties to the north of the landfill boundary. If these dwellings were constructed on the top of the nearest ridges there could be potential views into Area B.
- To reduce any potential visual effects of these permitted dwellings on the north ridgelines it is proposed that a mixed shelter belt planting approx. 800m long x 20m wide of Cupressus macracarpa (Macracarpa, Monterey Cypress) and Acacia melanoxylon (Blackwood) will be planted on top of the north ridgelines and the saddle of Area B and Area C.
- To match this shelter belt on the north ridgelines it is proposed that a mixed shelter belt planting approx. 600m long x 20m wide of Cupressus macracarpa (Macracarpa, Monterey Cypress) and Acacia melanoxylon (Blackwood) will be planted on top of the east ridgeline.
- The proposed shelter belt plantings to the north and east ridgelines will be completed no matter what the outcome of the consent application.

- Litter fences around Area B could be located below the ridge lines.

Having considered all the matters associated with the landscape and visual effects of the development of Area B and given the summary points above, it is my opinion that any potential visual impacts to do with the development of Area B will be negligible, such that the landscape and visual effects of the development will be low.

Philip Henderson
Evergreen Landscapes Ltd
Registered Landscape Architect
ANZILA

HASTINGS DISTRICT COUNCIL

Tonkin+Taylor

north

Date: 01.03.2019

Scale: 1:5000 @ A3

Job Name:

OMARUNUI LANDFILL AREA B
Omarunui Road, Omarunui

Figure 8:
Proposed Landscape Plan

Issue: CONCEPT

Sheet No: OL 4

Appendix O: Noise and Vibration Report

REPORT

Tonkin+Taylor

Development and operation of Area B, Omarunui Landfill

Assessment of Noise Effects

Prepared for
Hastings District Council

Prepared by
Tonkin & Taylor Ltd

Date
December 2019

Job Number
1000647.1000

Exceptional thinking together

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Document Control

Title: Development and operation of Area B, Omarunui Landfill					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
20/12/2019	1	Final report for lodgement	K Leemeyer	M Bevington	Tony Bryce

Distribution:

Hastings District Council	1 copy
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Table of contents

1 Introduction

Tonkin + Taylor Ltd (T+T) has been engaged by Hastings District Council to prepare resource consent applications for the proposed extension of Omarunui Landfill into Area B of the landfill site.

This assessment provides an assessment of construction and operational noise effects for the Area B development at Omarunui Landfill (the site) and has been undertaken to support the Notice of Requirement (NoR) for the development and operation of Area B.

This report has been prepared in accordance with our letter of engagement, dated 16 November 2017[1]. The assessment sets out the relevant standards and predicted levels for operational noise from the landfill, together with identifying the nearest receivers and mitigation measures, based on information provided by Hastings District Council.

2 Site and project description

The site is currently operated as the Omarunui Landfill and is jointly owned by Hastings District Council (HDC) and Napier City Council (NCC). The landfill receives residual solid waste collected from Napier City and the Hastings District. The currently consented area for landfilling (Area D) is expected to be at capacity by around 2025. HDC has prepared a NoR to operate another area of the site for continued landfilling.

The Omarunui landfill was established in 1987 and has four areas identified for landfilling – Areas A, B, C, and D, and one area identified for cleanfilling – Area E (see Figure 1 below). Area A has already been filled, Area D is currently operational and Area B is the area where consent is being sought and is a valley not currently used for landfilling. Area B will not be operational until Area D is closed, although construction of the first stage of the Area B landfill will be undertaken while Area D is still operational. Area E (cleanfill) will continue to be available to receive cleanfill and is over 400 m from Area B.

The Omarunui Landfill site covers an area of approximately 178 ha. The landfill is accessed off Omarunui Road, with the weighbridge approximately 130 m from the road. All trucks entering and exiting the site stop on the weighbridge.

The site is zoned *Rural* and is designated as the *Omarunui Regional Landfill Site (D123)* in the Proposed Hastings District Plan (HDP). It also falls within the *Rural Landscape Character Area* for Tutaekuri Valley and Korokipo Road Hills. The surrounding land is a mix of land zoned *Rural* and *Plains Production,* and land use is predominantly rural or horticultural.

A full description of the site and project is provided in the Assessment of Effects on the Environment (AEE).

[1] T+T Letter of Engagement (16 November 2017) *Omarunui Landfill – Area B Consents.* Ref 1000647.1000

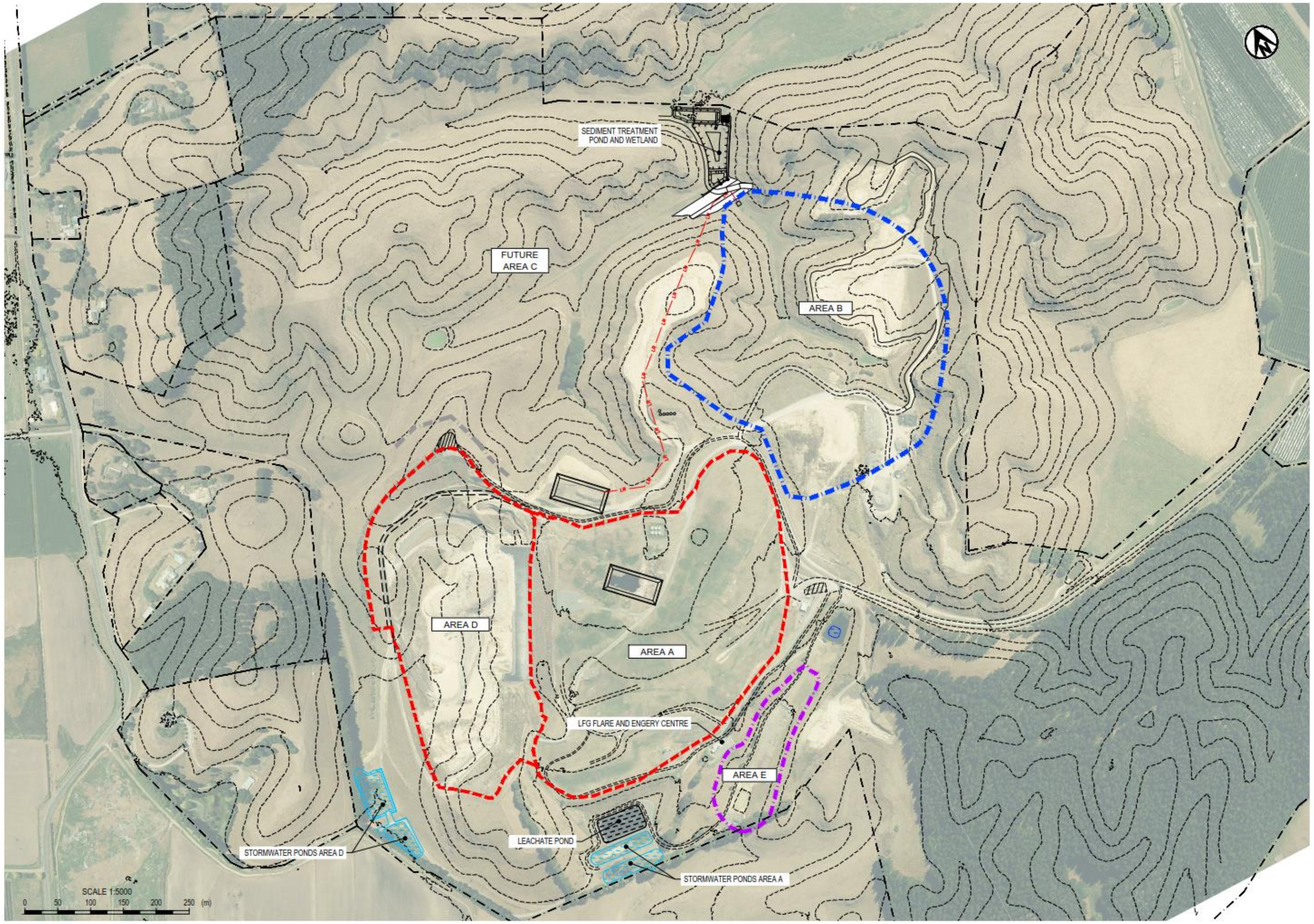

Figure 2.1: Omarunui Landfull site location and landfilling areas

3 Landfill Operation

Omarunui landfill is open to commercial operators / contractors only; it is not open to the public. Currently, around 60 trucks take rubbish to the landfill each day. Once the trucks have emptied the rubbish at the tipping face a Zaxis 20 T excavator and a CAT 37 T compactor spread the rubbish and compact it. A CAT 924 wheel loader also operates at the tip face where trucks are tipping.

The landfill currently accepts waste from 8:00 am until 4:30 pm Monday to Friday and has machines operating until 5:00 pm to finish processing the rubbish[2]. The landfill is closed on weekends, except at Christmas when it is open on Saturday for a half day due to increased demand.

The proposed hours of operation for Area B will not change. Further detail on the construction and operation of Area B is provided in the AEE.

4 Construction works

Preparatory works for Area B of the landfill will comprise the construction of Stage 1 which will take 2 to 3 construction seasons during the period from approximately October until May each year and will require a total excavation of approximately 570,000m^3.

Further stages will be constructed sequentially as required during the operation of the landfill. Based on the current staging plan, construction of further stages will comprise the following:

- Stage 2: 240,000m^3 of earthworks.
- Stage 3: approximately 30,000 m^3 of earthworks.
- Stage 4: Minor earthworks, with construction of liner on surfaces previously formed.
- Stage 5: Minor earthworks, with construction of liner on surfaces previously formed.

The total excavation volume over the life of the landfill is thus likely to be in the order of 800,000 m^3. However, some material is being taken off the site at present so the total volume of earthworks during the construction and operation period for Area B is likely to be less than this calculated amount.

Surplus excavated material will be stockpiled on site and used as required for the operation of the landfill including for daily and intermediate cover, progressive placement of the final cap and for general earthworks as required from time to time around the site for the landfill operation.

Once filling in Area B is completed the landfill surplus excavated material will be used for capping any portions of the landfill remaining uncapped.

[2] The Omarunui Landfill Management Plan in the Proposed Hastings District Plan allows for operation from 7am to 5pm Monday to Saturday.

5 Nosie standards

5.1 Proposed Hastings District Plan

The relevant noise criteria for the site are set out in Rule 25.1.6 as follows:

> *<u>25.1.6A Measurement</u>*
>
> *Unless stated by a Rule or Standard elsewhere in this Plan, noise shall be measured in accordance with New Zealand Standard 6801:2008 Acoustics – Measurement of Environmental Sound and assessed in accordance with New Zealand Standard 6802:2008 Acoustics – Environmental Noise.*
>
> *<u>25.1.6D Rural Zones</u>*
>
> *The following noise conditions shall apply to all land uses within all Rural Zones, other than exempted in Rule 25.1.6B and 25.1.7E (Wind Farm Noise):*
>
> *a. The following noise limits shall not be exceeded at any point within the notional boundary of any noise sensitive activity on any other site within a Rural Zone, or at any point within the boundary of any site, in any Zone other than an Industrial Zone:*

Control hours	*Noise Level*
0700 to 1900 hours	*55 dB L_{Aeq} (15 min)*
1900 to 2200 hours	*50 dB L_{Aeq} (15 min)*
2200 to 0700 hours the following day	*45 dB L_{Aeq} (15 min)*
2200 to 0700 hours the following day	*75 dB L_{AFmax}*

> *<u>25.1.6I Construction Noise</u>*
>
> *(a) Any noise arising from construction, maintenance and demolition work in any Zone shall comply with NZS 6803:1999 Acoustics – Construction Noise.*
>
> *(b) Construction noise shall be measured and assessed in accordance with NZS 6803:1999 Acoustics – Construction Noise.*
>
> *(c) To avoid doubt, Standards 25.1.6C – 25.1.6H above shall not apply to construction noise.*

Under Designation 123 there is a *Joint Landfill Management Plan* which states:

> *The Joint Landfill at Omarunui was established as a specific scheduled site with its own Permitted Activities and Rules, including a Management Plan for its management and operation. The Plan includes this work as a designation, but the use and development of the land for any purpose including for landfill purposes is subject to the controls and restrictions set out in Appendix 24 which includes the provisions of the Management Plan.*

Under the Omarunui Landfill – Management Plan the following sections are relevant to the control of noise:

> *<u>3.1 Times of Opening</u>*
>
> *The hours of operations, other than in emergencies, will not be in excess of 7 am to 5 pm Mondays to Saturdays inclusive.*
>
> *The landfill will not be open without an attendant being on duty. The attendant shall be positioned where vehicles may be inspected prior to entering the area where active landfill operations are taking place.*

3.8 Noise Control

All equipment used on site will be fitted with effective mufflers to keep noise to a minimum.

5.2 NZS 6803:1999

Construction noise from the site is subject to compliance with NZS 6803:1999 *Acoustics – Construction Noise.*

The construction works for Stage 1 are expected to take 2 to 3 years to complete prior to the landfill becoming operational; works are therefore subject to compliance with the "long-term duration" noise limits for construction works at any one location with a duration exceeding 20 weeks.

The noise limits from NZS 6803:1999 are set out below in Table 5.1.

Table 5.1: Table 2 of NZS 6803:1999 – Recommended upper limits for construction noise received in residential zones and dwellings in rural areas.

Time of week	Time Period	Duration of work					
		Typical duration (dBA)		Short-term duration (dBA)		Long-term duration (dBA)	
		L_{eq}	L_{max}	L_{eq}	L_{max}	L_{eq}	L_{max}
Weekdays	0630 – 0730	60	75	65	75	55	75
	0730 – 1800	75	90	80	95	70	85
	1800 – 2000	70	85	75	90	65	80
	2000 - 0630	45	75	45	75	45	75
Saturdays	0630 – 0730	45	75	45	75	45	75
	0730 – 1800	75	90	80	95	70	85
	1800 – 2000	45	75	45	75	45	75
	2000 - 0630	45	75	45	75	45	75
Sundays and public holidays	0630 – 0730	45	75	45	75	45	75
	0730 – 1800	55	85	55	85	55	85
	1800 – 2000	45	75	45	75	45	75
	2000 - 0630	45	75	45	75	45	75

6 Assessment of noise effects

6.1 Existing environment

The site is located at 329 Omarunui Road in a rural environment with Swamp Road to the west of the site and Omarunui Road and Breckenridge Road to the east.

6.1.1 Noise receivers

Omarunui Landfill Area B is located in the north-eastern area of the site. The nearest receivers to the works are listed in Table 6.1.

Table 6.1: Nearest noise receivers to site

Location in relation to Area B	Receiver address	Nearest distance to Area B	Nearest distance to entrance road
East	419 Omarunui Road	540 m	N/A
	395 Omarunui Road	900 m	N/A
	417 Omarunui Road	1060 m	N/A
	367 Omarunui Road	980 m	N/A
South east	339 Omarunui Road	830 m	42 m
	321 Omarunui Road	900 m	130 m
	305 Omarunui Road	950 m	270 m
West	574 Swamp Road	950 m	N/A
	564 Swamp Road	890 m	N/A
	536 Swamp Road	750 m	N/A
	534 Swamp Road	880 m	N/A
	520 Swamp Road	840 m	N/A
	500 Swamp Road	960 m	N/A

Landfill gas (LFG) is currently collected from Area A and D and used to generate electricity. The electricity generator is located at the base of Area A and is at least 600 m from any receivers.

Other receivers are further away and will receive lower noise levels, given the attenuation due to additional distance and the topography.

6.2 Noise Measurements

T+T visited the site and took noise measurements of the existing landfill operation on 2 May 2018. Measurements were undertaken of the current operation of the landfill approximately 10 m from the tipping face during which the excavator and compactor were operating and spreading / compacting rubbish at distances ranging approximately 10 to 100 m from the measurement location.

Noise measurements were undertaken using a Casella CEL 63X sound level meter. At the time the measurements were taken the weather was overcast with wind gusts of < 5 m/s. The dominant source of noise throughout the measurements was the machinery operating and seagulls.

Noise measurements were taken between 11:50 am to 12:40 pm on 02 May 2018; noise levels ranged between $L_{Aeq(15\ min)}$ 69 to 71 dB. These are summarised in Figure 6.1 and Table 6.2.

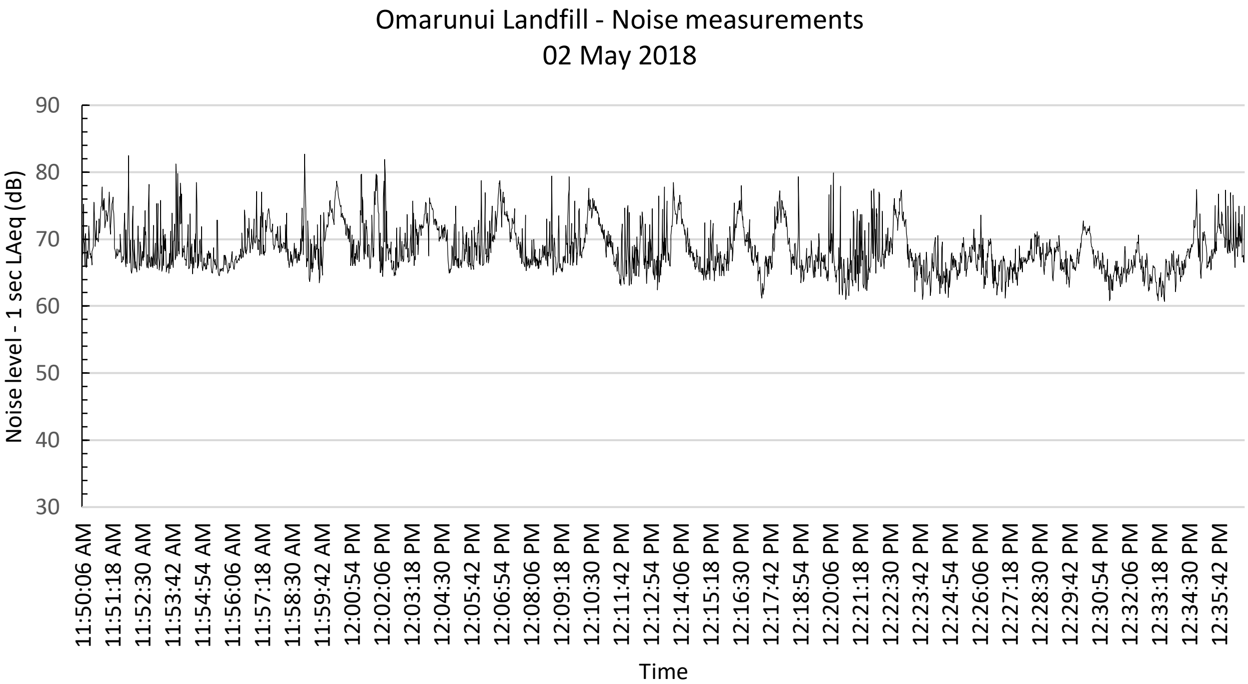

Figure 6.1: Noise levels on site at Omarunui Landfill, 02 May 2018.

Table 6.2: Summary of noise measurements at Omarunui Landfill, 02 May 2018.

Time period	Noise Level (L_{Aeq} 15 min)	Noise Level (L_{AFmax})	Comments
12:50 pm	71 dB	87 dB	Noise levels controlled by machines operating and seagulls
13:05 pm	71 dB	85 dB	
13:20 pm	69 dB	84 dB	Controlled by gulls (machines idling)

6.3 Noise assessment

6.3.1 Noise predictions

The nearest receivers are approximately 600 m from the electricity generator, 540 m from Area B and 40 m from the entrance road where the weighbridge is located. Noise predictions and the applicable HDC noise limits are set out in the following sections for each of these noise-generating areas on site.

6.3.1.1 Area B – Operation of landfill

Noise levels for landfill operations in Area B have been calculated using source levels measured for the existing operation of the landfill. Calculations are based on the maximum $L_{Aeq(15\ min)}$ measured on site. The operation of the landfill will not change when the landfilling area moves to Area B, with operating hours and machinery to remain as for the current operation.

Noise predictions are at the notional boundary.

Gull noise contributed to the measured levels to a minor degree and from variable distances, but could not be removed. HDC is continually trying to eliminate seagulls from the site and is currently commencing a poisoning programme. The predicted noise levels may be slightly lower if valid measurements of the site specific plant could be obtained in the absence of bird noise, but this was not possible. We note that it is HDC's intention to reduce the number of gulls at the landfill; notwithstanding, our assessment is based conservatively on the source measurements which include contribution from seagulls.

Table 6.3: Area B operation – noise predictions and applicable HDC criteria

Address	Distance (notional boundary)	Predicted noise level (L_{Aeq} 15 min)	Permitted noise limit (L_{Aeq} 15 min)
419 Omarunui Road	520 m	36	55 dB L_{Aeq}
395 Omarunui Road	880 m	31	
417 Omarunui Road	1040 m	30	
367 Omarunui Road	960 m	30	
339 Omarunui Road	810 m	32	
321 Omarunui Road	880 m	31	
305 Omarunui Road	930 m	31	
574 Swamp Road	930 m	31	
564 Swamp Road	870 m	31	
536 Swamp Road	730 m	33	
534 Swamp Road	860 m	31	
520 Swamp Road	820 m	32	
500 Swamp Road	940 m	31	

At all receivers the noise levels from the operation of the Area B landfill will be compliant with the HDC permitted activity noise limit of 55 dB L_{Aeq} during operating hours.

6.3.1.2 Trucks entering Omarunui Landfill off Omarunui Road

Noise levels at receivers near the entrance road, where trucks enter the site and stop on the weighbridge, have been calculated. The calculations use a source levels for a 9 T truck idling (63 dB L_{A10} at 10 m) and assume 2 trucks entering the site and stopping on the weighbridge per 15 minute period[3]., The noise from trucks will be controlling the noise levels at receivers for approximately 25 % of the 15 minute assessment period.

Table 6.4: Entrance road – noise predictions and applicable HDC criteria

Address	Distance (notional boundary)	Predicted noise level (L_{Aeq} 15 min)	Permitted noise limit (L_{Aeq} 15 min)
339 Omarunui Road	42 m	51 dB	55 dB L_{Aeq}
321 Omarunui Road	130 m	41 dB	
305 Omarunui Road	270 m	34 dB	

At all receivers the noise levels from rubbish trucks entering and / or exiting Omarunui Landfill will be compliant with the HDC permitted activity noise limit of 55 dB L_{Aeq} during operating hours.

[3] This is based on current average daily truck volumes.

6.3.1.3 Generator noise

The generator on site runs 24/7 and is therefore required to comply with the night-time noise limit of 45 dB L_{Aeq}. Noise levels have been calculated using source data from the manufacturer and the separation distances to the nearest receivers. The generator will remain in the same location on site as it is currently, south of Area A.

The manufacturer's specifications for the generator give a sound pressure level of 101 dB L_{Aeq} at 1 m. The generator is contained within a purpose built building that has been acoustically treated to reduce noise emissions, including 150 mm thick concrete walls and acoustic doors. Noise levels of this same set up on another site were measured to be 60 dB L_{A10} at 24 m from the building when operating continuously at full load. This source level has been used in our calculations (68 dB L_{A10} at 10 m).

The closest receiver to the generator is 500 Swamp Road, north-west of the site. The assessment position is 790 m from the generator and due to the local topography does not have line of sight to the generator building. Compliance with the night-time noise criteria can be achieved at 134 m from the generator and therefore the generator will be compliant with the HDC permitted activity noise limits at all times at all receivers.

6.3.1.4 Construction noise

The preparatory earthworks for the landfill will involve use of excavators, dump trucks and other earthworks machinery. The assessment of construction noise is based on the requirements of NZS 6803:1999, using library sound level data taken from BS 5228-1:2009. These noise predictions are considered to be conservative because they only represent construction activities in the closest part of the site to the receiver.

Table 6.5 lists the equipment proposed for the construction activities on site and the separation distances for compliance with the weekday daytime noise criteria set out in Section 5.2 (70 dB L_{Aeq}). We have added 3 dB to all noise predictions to take into account the possibility of cumulative noise effects if any two items of plant are operating at similar distances from a receiver at the same time.

Table 6.5: Plant expected on site and minimum compliance distances

Equipment Description	% operating time	L_{Aeq} at 10m (dB)	Minimum compliance distance / m
Excavator 20t	100	71	22
Dump Truck	50	70	14
Grader	100	77	43
Roller	100	80	60
Tractor	100	80	60
Back hoe	100	69	17
Front end loader	100	76	38
Dozer	100	77	43

Construction noise is assessed at 1 m from the façade of the nearest occupied dwelling. The closest dwellings are at least 500 m from Area B where earthworks will take place.

There will be stockpiles on site for material from the Area B preparatory earthworks. There are at least 6 different areas on site used for stockpiling material; north and west of Area C, west of Area D, south of Area A, east of Area B, within Area B and south of the access road around 450 m south-east of Area A. The closest stock pile area to any receiving site is at least 200 m away.

The minimum compliance distance for any activity for the earthworks for Area B (including stock piling work) is 60 m for use of a roller or a tractor.

The nearest receiver to where trucks will enter / exit the site, if any material needs to be removed from site using dump trucks, is approximately 60 m. Noise from these movements will only be present for a short duration of the 15 minute assessment period.

Construction works will be compliant with the permitted noise limits at all times.

6.3.1.5 Cumulative noise effects

Earthworks for Area B will be undertaken while Area D is operational. Area's B and D are 250 m apart, with Area D located to the west of Area B.

The noise from activities in these areas will not be within 10 dB of each other at any receivers and therefore will not generate any cumulative noise effects.

7 Summary and conclusions

This assessment has been prepared to support the resource consent application for the proposed development and operation of Area B of the Omarunui Landfill (the Site).

The nearest affected receivers in respect of the noise effects are the surrounding rural sites on Omarunui Road and Swamp Road.

The preparation of Area B for it to operate as a landfill will require 2 to 3 years of earthworks including approximately 570,000 m^3 of excavations. Once complete, there will be no changes to the operation or intensity of use of the landfill; the only change will be the area being filled, as the current area (D) will be closed at the time Area B commences receiving waste by around 2025. The only residual activity in Area D when Area B is operational, will be the placement of the final capping system during the first 1 to 2 years of operation of Area B. Area E will also continue to be available for accepting cleanfill and is over 400 m from Area B. There will not be any cumulative noise levels arising from Area B, Area D and Area E for any receivers during the construction and operation of Area B.

The noise assessment indicates that the permitted activity criteria can be complied with at all receivers without any mitigation requirements for all preparatory construction works, rubbish trucks entering and exiting the site, the operation of Area B (including truck and machinery use) and the generator that runs on site 24/7.

8 Applicability

This report has been prepared for the exclusive use of our client Hastings District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

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