New Plymouth District Council

Mangapouri Cemetery

Monitoring Programme

Annual Report

2020-2021

Technical Report 2021-84

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Taranaki Regional Council

Taranaki Regional Council
Private Bag 713
Stratford

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Executive summary

New Plymouth District Council (NPDC) operates the Mangapouri Cemetery (the Cemetery) located on Junction Road (SH3) between New Plymouth and Egmont Village, in the Waiwhakaiho catchment. The Cemetery site is gated and includes an access road, landscaped greens, storage buildings and washroom facilities. This report covers the reporting period July 2020 to June 2021 and describes the monitoring programme implemented by the Taranaki Regional Council (the Council) to assess NPDC's environmental performance during the period under review. This report details the results of the monitoring undertaken in relation to the site, and any potential environmental impacts.

During the monitoring period, NPDC demonstrated an overall good level of environmental performance.

NPDC held one resource consent that allows for the discharge of contaminants into land where it may enter water. The consent included a total of eight conditions setting out the requirements that they must satisfy.

The Cemetery opened to the public in May 2019 and the compliance monitoring programme commenced following the first internment in July 2019. The monitoring programme for the period under review included an annual site inspection, water quality sampling of the receiving waters (groundwater and surface water) and continuous groundwater level monitoring. The monitoring programme also included a significant data review component, with all data submitted by NPDC assessed for compliance upon receipt.

The monitoring showed that the activities were generally being carried out in compliance with the conditions of the resource consent. The results of surface and groundwater quality monitoring undertaken show no adverse effects of the activity on local fresh water resources. Site visits undertaken found the site to be tidy and well managed and there were no Unauthorised Incidents in relation to the consent.

A breach of consent conditions occurred on 26 November and 10 December 2020 when, following higher than average rainfall the minimum separation distance between burial sites and the water table was not met in some areas of the Cemetery.

During the year, NPDC demonstrated a good level of environmental and high level of administrative performance with the resource consents

For reference, in the 2020-2021 year, consent holders were found to achieve a high level of environmental performance and compliance for 86% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 11% of the consents, a good level of environmental performance and compliance was achieved.

This report includes recommendations to be implemented during the 2021–2022 monitoring period.

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1 Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

This report is for the period July 2020 to June 2021 by the Taranaki Regional Council (the Council) describing the results of the monitoring programme associated with the resource consent held by New Plymouth District Council (NPDC).

NPDC operate the Mangapouri Cemetery (the Cemetery) located on Junction Road (SH3) between New Plymouth and Egmont Village. NPDC held one resource consent authorising the discharge to land at the Cemetery during the reporting period. The consent includes a number of special conditions which set out specific requirements that NPDC must satisfy.

This report covers the results and findings of the monitoring programme implemented by the Council in respect of the consent held by NPDC. The report also discusses the planned activities and any associated potential environmental impacts. This is the third report prepared by the Council in relation to the consent held by NPDC for the Mangapouri Cemetery and the second to cover the discharges to land and their effects since the Cemetery opened to the public.

1.1.2 Structure of this report

Section 1 of this report is a background section. It sets out general information about:

- consent compliance monitoring under the *Resource Management Act 1991* (RMA) and the Council's obligations;
- the Council's approach to monitoring sites though annual programmes;
- the resource consent held by NPDC in the Waiwhakaiho Catchment;
- the nature of the monitoring programme in place for the period under review; and
- a description of the activities and operations conducted by NPDC at the Cemetery site.

Section 2 presents the results of monitoring during the period under review, including scientific and technical data.

Section 3 discusses the results, their interpretations, and their significance for the environment.

Section 4 presents recommendations to be implemented in the 2021-2022 monitoring year.

A glossary of common abbreviations and scientific terms, and a bibliography, are presented at the end of the report.

1.1.3 The Resource Management Act 1991 and monitoring

The RMA primarily addresses environmental 'effects' which are defined as positive or adverse, temporary or permanent, past, present or future, or cumulative. Effects may arise in relation to:

a. the neighbourhood or the wider community around an activity, and may include cultural and social-economic effects;
b. physical effects on the locality, including landscape, amenity and visual effects;
c. ecosystems, including effects on plants, animals, or habitats, whether aquatic or terrestrial;

d. natural and physical resources having special significance (for example recreational, cultural, or aesthetic); and

e. risks to the neighbourhood or environment.

In drafting and reviewing conditions on discharge permits, and in implementing monitoring programmes, the Council is recognising the comprehensive meaning of 'effects' inasmuch as is appropriate for each activity. Monitoring programmes are not only based on existing permit conditions, but also on the obligations of the RMA to assess the effects of the exercise of consents. In accordance with Section 35 of the RMA, the Council undertakes compliance monitoring for consents and rules in regional plans, and maintains an overview of the performance of resource users and consent holders. Compliance monitoring, including both activity and impact monitoring, enables the Council to continually re-evaluate its approach and that of consent holders to resource management and, ultimately, through the refinement of methods and considered responsible resource utilisation, to move closer to achieving sustainable development of the region's resources.

1.1.4 Evaluation of environmental and administrative performance

Besides discussing the various details of the performance and extent of compliance by NPDC, this report also assigns them a rating for their environmental and administrative performance during the period under review.

Environmental performance is concerned with actual or likely effects on the receiving environment from the activities during the monitoring year. Administrative performance is concerned with NPDC's approach to demonstrating consent compliance in site operations and management including the timely provision of information to Council (such as contingency plans and water take data) in accordance with consent conditions.

Events that were beyond the control of the consent holder and unforeseeable (that is a defence under the provisions of the RMA can be established) may be excluded with regard to the performance rating applied. For example loss of data due to a flood destroying deployed field equipment.

The categories used by the Council for this monitoring period, and their interpretation, are as follows:

Environmental Performance

High: No or inconsequential (short-term duration, less than minor in severity) breaches of consent or regional plan parameters resulting from the activity; no adverse effects of significance noted or likely in the receiving environment. The Council did not record any verified unauthorised incidents involving significant environmental impacts and was not obliged to issue any abatement notices or infringement notices in relation to such impacts.

Good: Likely or actual adverse effects of activities on the receiving environment were negligible or minor at most. There were some such issues noted during monitoring, from self reports, or in response to unauthorised incident reports, but these items were not critical, and follow-up inspections showed they have been dealt with. These minor issues were resolved positively, co-operatively, and quickly. The Council was not obliged to issue any abatement notices or infringement notices in relation to the minor non-compliant effects; however abatement notices may have been issued to mitigate an identified potential for an environmental effect to occur.

For example:

- High suspended solid values recorded in discharge samples, however the discharge was to land or to receiving waters that were in high flow at the time;
- Strong odour beyond boundary but no residential properties or other recipient nearby.

Improvement required: Likely or actual adverse effects of activities on the receiving environment were more than minor, but not substantial. There were some issues noted during monitoring, from self reports, or in response to unauthorised incident reports.

Cumulative adverse effects of a persistent minor non-compliant activity could elevate a minor issue to this level. Abatement notices and infringement notices may have been issued in respect of effects.

Poor: Likely or actual adverse effects of activities on the receiving environment were significant. There were some items noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent moderate non-compliant activity could elevate an 'improvement required' issue to this level. Typically there were grounds for either a prosecution or an infringement notice in respect of effects.

Administrative performance

High: The administrative requirements of the resource consents were met, or any failure to do this had trivial consequences and were addressed promptly and co-operatively.

Good: Perhaps some administrative requirements of the resource consents were not met at a particular time, however this was addressed without repeated interventions from the Council staff. Alternatively adequate reason was provided for matters such as the no or late provision of information, interpretation of 'best practical option' for avoiding potential effects, etc.

Improvement required: Repeated interventions to meet the administrative requirements of the resource consents were made by Council staff. These matters took some time to resolve, or remained unresolved at the end of the period under review. The Council may have issued an abatement notice to attain compliance.

Poor: Material failings to meet the administrative requirements of the resource consents. Significant intervention by the Council was required. Typically there were grounds for an infringement notice.

For reference, in the 2020-2021 year, consent holders were found to achieve a high level of environmental performance and compliance for 86% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 11% of the consents, a good level of environmental performance and compliance was achieved.

1.2 Process description

The Mangapouri Cemetery (the Cemetery) is one of three main cemeteries that NPDC operate. The other two are the Awanui and Te-Henui cemeteries, located in central New Plymouth, which are both running out of usable space. The Cemetery opened to the public in May 2019 and the first internment was undertaken in July 2019.

The Cemetery accepts conventional single plot, natural burials and ashes. Each grave will be centered on an area of 10 m^2, which will result in 1,000 graves per hectare (ha). The first two areas available to the public are Area-A which is 0.8 ha in the north of the development, and Area-B which is 0.65 ha in the south and west of the development (Figure 1).

To avoid contamination of local surface and groundwater resources, burials are required to occur at a minimum of 0.8 m above the high water table. Internments will be spread out in time and space to reduce any risks associated with point source loading.

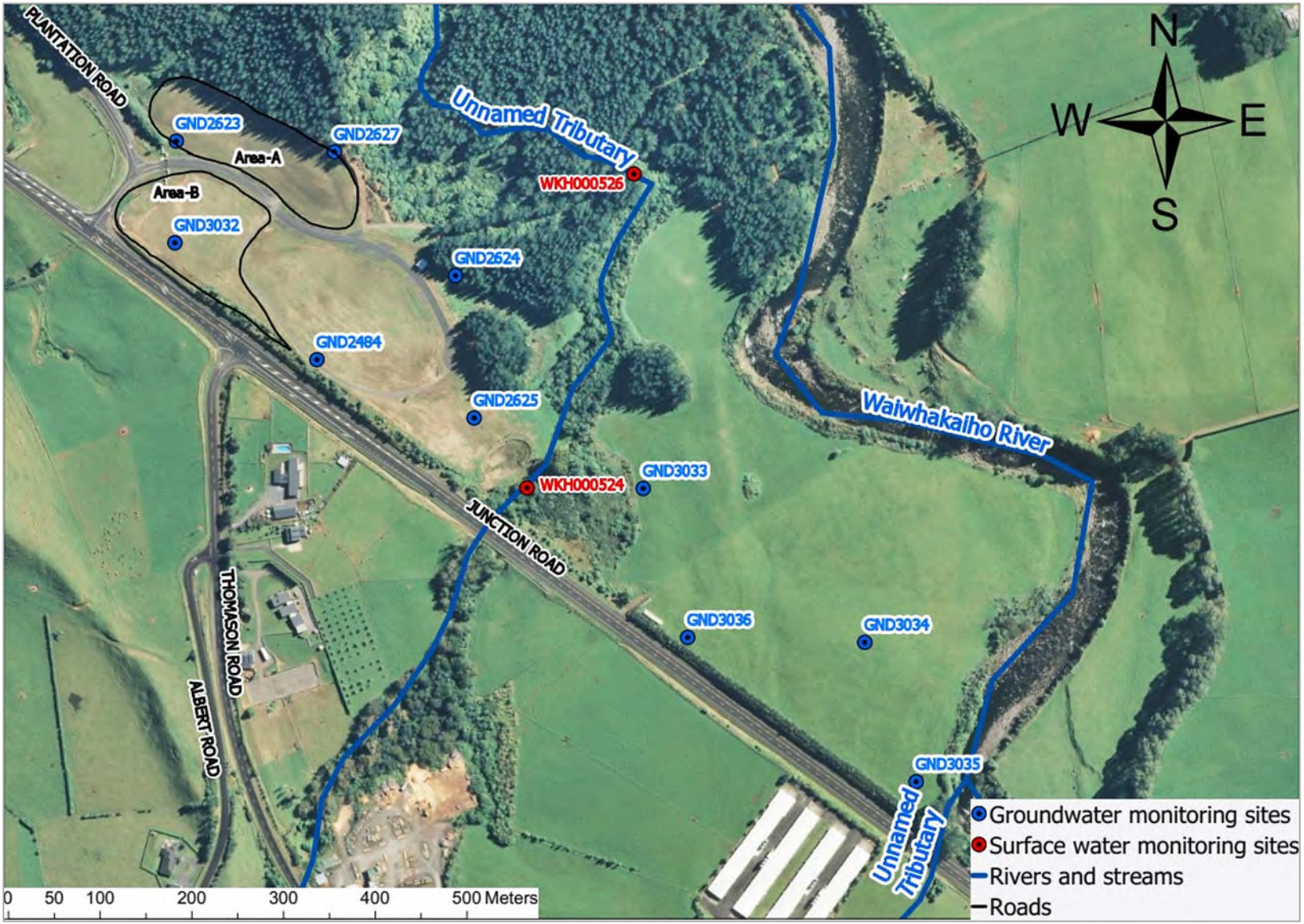

Figure 1 Mangapouri Cemetery location map

1.3 Resource consents

NPDC holds one discharge consent in relation to the Cemetery. The details of which are summarised in the table below (Table 1). A summary of the conditions attached to the permit are set out in Section 3 of this report.

A summary of the various consent types issued by the Council is included in Appendix I, as is a copy of the permit held by NPDC that authorises their discharge to land.

Table 1 Summary of resource consents held by NPDC at the Mangapouri Cemetery

Consent number	Purpose	Granted	Review	Expires
Discharges of waste to land				
7882-1.1	To discharge contaminants into land at a cemetery in circumstances where they may enter water	09 Nov 2011	June 2026	01 Jun 2046

1.4 Monitoring programme

1.4.1 Introduction

Section 35 of the RMA sets obligations upon the Council to gather information, monitor, and conduct research on the exercise of resource consents within the Taranaki region. The Council is also required to assess the effects arising from the exercising of these consents and report upon them.

The Council may therefore make and record measurements of physical and chemical parameters, take samples for analysis, carry out surveys and inspections, conduct investigations, and seek information from consent holders.

The main environmental impacts associated with the internment of human remains is related to the degradation of human corpses. Degradation normally takes 10-12 years and it is estimated that more than half the pollutant load leaches within the first year, with loadings reducing by 50% each year thereafter (SEPA, 2015).

The main point source contamination issues related to cemeteries are the following (SEPA, 2015):

- Ammoniacal nitrogen resulting from the breakdown or organic products;
- Pathogens and organisms harmful to human health can be released into the environment if present;
- Formaldehyde, used in embalming fluids and coffin resins and glues is a biocide with toxic and carcinogenic properties;
- Mercury, present in amalgam in dental fillings, is a hazardous substance;
- Phosphates and metal concentrations in ground and surface water resources, present in cremated remains, can increase; and
- Phosphate from the decomposition of skeletal remains.

The monitoring programme included the collection and analysis of a comprehensive suite of general water quality parameters and those contaminants specifically related to the degradation of human remains.

The monitoring programme in relation to the Cemetery is outlined below. The collection of field data was undertaken by Geosearch Ltd, on behalf of NPDC.

1.4.2 Programme liaison and management

There is generally a significant investment of time and resources by the Council in:

- ongoing liaison with resource consent holders over consent conditions and their interpretation and application;
- in discussion over monitoring requirements;
- preparation of any consent reviews, renewals, or new consent applications;
- advice on the Council's environmental management strategies and the content of regional plans; and
- consultation on associated matters.

1.4.2.1 Review of NPDC's monitoring data

The monitoring data was provided quarterly to the Council for review to determine compliance with consent conditions. A Burial Report, which included a detailed Burial Plan, was submitted and reviewed by the Council prior to the first interment at the cemetery. Updated plans showing internments to date are submitted annually.

1.4.2.2 Site inspections

Inspection are undertaken quarterly in relation to NPDC's discharge consent. The main points of interest during an inspection are to check for signs of water ponding or sediment runoff into local waterways and to survey the area for any potential environmental effects.

1.4.2.3 Surface water quality monitoring

Surface water quality samples were collected in an unnamed tributary of the Waiwhakaiho River, at one site upstream and one site downstream of the Cemetery. The samples were obtained during low flow and high flow conditions. The samples were submitted to Hill laboratories (Hills) for analysis.

In addition to the routine sampling, baseline samples were collected prior to the commencement of the activity to allow for an in depth comparison of any variations in surface water composition should the need arise.

The location of surface water monitoring sites are displayed on Figure 1. A description of each site is provided in Table 2.

Table 2 Surface water monitoring site details

Site	Eastings	Northings	Description	Location
WKH000524	1697720	5667352	Unnamed tributary of the Waiwhakaiho River	On the cemetery side of Junction Road, downstream of the SH3 culvert
WKH000526	1697837	5667687	Unnamed tributary of the Waiwhakaiho River	320 m downstream of SH3 culvert

1.4.2.4 Groundwater quality monitoring

Ten groundwater monitoring sites were installed by NPDC at the Cemetery site to enable the collection of comprehensive groundwater quality and level data. Monitoring was undertaken at six of the ten sites. The six sites monitored GND2623, GND2624, GND2625, GND2627, GND2484 and GND3032 are located on the western side of the unnamed tributary that intersects the Cemetery site (Figure 1). The western side of the site includes Area-A and Area-B, the first two sections of the Cemetery available to the public for burials. The groundwater sampling was undertaken quarterly and samples were submitted to Hills for analysis.

In addition to the routine sampling baseline samples have been collected from all monitored sites to allow for a more in depth assessment of variations in groundwater composition should the need arise in the future.

1.4.2.5 Groundwater level monitoring

Groundwater level data was collected using in-situ level loggers from six sites GND2623, GND2624, GND2625, GND2627 GND2484 and GND3032. Loggers recorded water level measurements at 15 minute intervals. Data was downloaded quarterly and submitted to the Council for review.

The location of all groundwater monitoring sites are displayed on Figure 1 and the details of each site included in the monitoring programme are summarised below in Table 3.

Table 3 Groundwater monitoring site details

Site code	id.	Eastings	Northings	bore depth (m)	Screen depth (m)
GND2623	MW1	1697453	5667700	8.0	1.2-8
GND2624	MW2	1697688	5667583	6.0	1.2-6
GND2625	MW3	1697703	5667463	5.6	1.6-5.6
GND2484*	MW4	1697570	5667514	8.0	1.2-8
GND2627	MW5	1697587	5667689	12.0	0-12
GND3032	MW6	1697454	5667601	8.0	4-8

**Note GND2484 is referred to as GND2626 in the burial report referenced in the following sections*

2 Results

2.1 Inspections

Quarterly inspections visits were undertaken by a Council Officer and the site appeared to be in good condition and being well managed.

No issues were identified during these inspections.

2.2 Provision of consent holder data

Groundwater levels and ground and surface water quality results were provided quarterly for review.

NPDC's Burial report outlined how they would meet compliance with condition 3 of Consent 7882-1.1, which requires NPDC to adopt the best practicable option, to avoid or minimise any adverse effects on the environment.

The report included the Burial Plan for the first five years of internments. The Burial Plan was designed to enable the spreading of burials, in both time and location, in order to reduce point source loading of contaminants (Figure 2). The Report provided a map showing which areas were suitable for which type of burial to ensure that all burials will occur no deeper than 0.8 m above the seasonally high water table.

The Burial Plan established that for the first five years of operation only Area-A and Area-B would be utilised. The type of internment recommended for each area was also determined using available groundwater level data and a 1 in 100 year high groundwater elevation scenario.

2.3 Results of receiving environment monitoring

The monitoring programme is designed to capture any seasonal changes in groundwater and surface water composition, and fluctuations in groundwater levels. The following sections display and discuss the results.

2.3.1 Surface water quality monitoring

Surface water samples were collected and analysed for an extensive suite of parameters during summer and winter/spring flow conditions. Both sites, one upstream and one downstream, are located in the unnamed tributary of the Waiwhakaiho River that flows through the centre of the Cemetery site. The results of the baseline analysis in comparison to the more recent sampling carried out are set out below in Table 4 and Table 5.

Dissolved reactive phosphorus and total organic carbon show slightly higher concentrations downstream of the site during the summer months when flows are at their lowest both pre and post commencement of the activity.

There are also some minor differences in some parameters seen between seasons. The summer samples exhibit higher total dissolved solids, carbonates and major cation and anions at both sites, when compared to the winter/spring samples. The increases in these analytes are likely related to samples being made up of predominantly groundwater sourced baseflow during the drier summer months. In comparison during the winter and spring when increases in nitrogen species can be seen, a major component of flow will be rainfall runoff received from the predominantly rural surroundings.

No significant changes in surface water quality can be seen between the upstream and downstream sites since monitoring commenced.

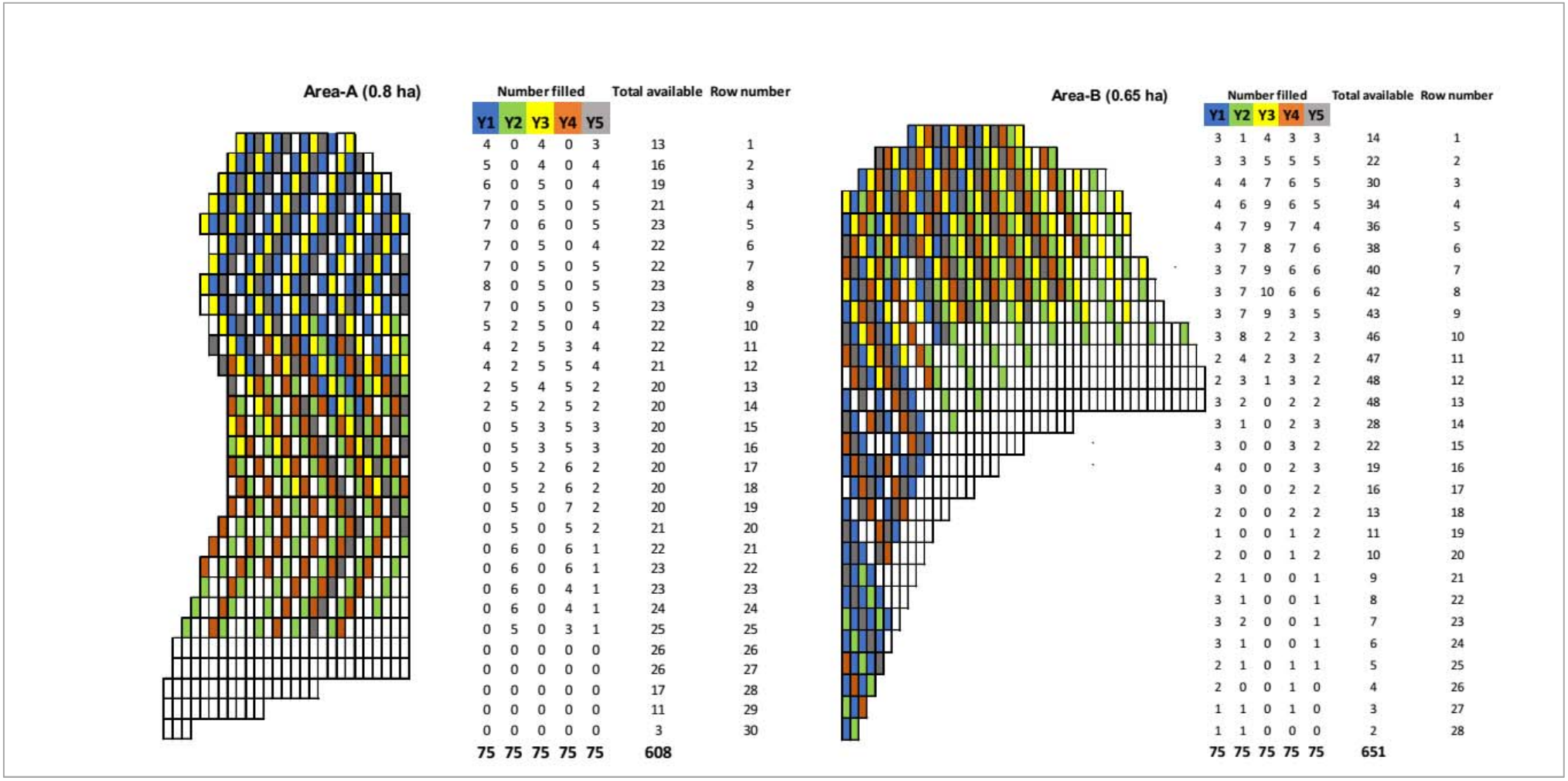

Figure 2 Burial Plan for first five years of operation

Table 4 Surface water quality results-upstream

Parameter	Bore id	WKH000524 upstream					
Duration (year)	-	Baseline (2017-2018)		Current year (2020-2021)		All years (2017-2021)	
Sample type	Unit	High flow	Low flow	High flow	Low flow	Minimum	Maximum
pH	pH	7.2	7.5	6.9	7.2	6.9	7.7
Total alkalinity	g/m^3 $CaCO_3$	36	76	37	45	33	76
Carbonate	g/m^3 CO_3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate	g/m^3 HCO_3	44	92	45	55	40	92
Total hardness	g/m^3 $CaCO_3$	43	74	43	49	40	74
Electrical conductivity	µS/cm	140	215	139	157	134	215
Total suspended solids	g/m^3	<3	<3	<3	<3	< 3	<3
Total dissolved solids	g/m^3	95	146	96	100	90	146
Dissolved calcium	g/m^3	10.2	16.0	10.6	11.4	9.7	16.0
Dissolved magnesium	g/m^3	4.3	8.2	4.1	4.9	3.8	8.2
Dissolved potassium	g/m^3	2.9	3.5	2.6	2.9	2.6	3.5
Dissolved sodium	g/m^3	8.9	13.5	9.1	9.8	8.7	13.5
Chloride	g/m^3	12.7	14.5	12.5	12.5	12.4	14.6
Total nitrogen	g/m^3	1.58	0.79	1.66	1.28	0.79	1.70
Ammoniacal nitrogen	g/m^3	0.057	0.040	0.054	0.042	0.04	0.058
Nitrite nitrogen	g/m^3 N	0.007	0.004	0.003	0.004	0.003	0.007
Nitrate nitrogen	g/m^3 N	1.33	0.63	1.56	1.18	0.63	1.61
Nitrate & nitrite nitrogen	g/m^3 N	1.34	0.63	1.57	1.18	0.63	1.61
Total kjeldahl nitrogen	g/m^3	0.24	0.17	< 0.10	< 0.10	< 0.10	0.24
Dissolved reactive phosphorus	g/m^3	<0.004	0.005	0.005	0.010	<0.004	0.010
Total phosphorus	g/m^3	0.016	0.029	0.014	0.023	0.014	0.029
Sulphate	g/m^3	5.9	7.2	6.1	5.8	5.5	7.2
Biological oxygen demand	g O_2/m^3	<2	<2	<2	<2	<2	<2
Chemical oxygen demand	g O_2/m^3	<6	<6	<6	<6	<6	6
Total organic carbon	g/m^3	0.7	1.3	0.8	1.8	<0.5	1.8
Escherichia coli	MPN / 100 mL	>200	579	110	613	110	613

Table 5 Surface water quality results-downstream

Parameter	Bore id	WKH000526 downstream					
Duration (year)	-	Baseline (2017-2018)		Current year (2020-2021)		All years (2017-2021)	
Sample type	Unit	High flow	Low flow	High flow	Low flow	Min	Max
pH	pH	7.1	7.7	6.9	7.2	6.9	7.8
Total alkalinity	g/m^3 $CaCO_3$	36	73	37	45	32	73
Carbonate	g/m^3 CO_3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate	g/m^3 HCO_3	43	89	45	55	40	89
Total hardness	g/m^3 $CaCO_3$	43	73	44	49	40	73
Electrical conductivity	µS/cm	140	211	138	154	133	211
Total suspended solids	g/m^3	<3	<3	<3	<3	<3	5
Total dissolved solids	g/m^3	108	153	75	89	75	153
Dissolved calcium	g/m^3	10.2	15.5	10.4	11.3	9.7	15.5
Dissolved magnesium	g/m^3	4.4	8.3	4.4	4.9	3.9	8.3
Dissolved potassium	g/m^3	2.9	3.7	2.6	3	2.6	3.7
Dissolved sodium	g/m^3	8.8	13.7	9.1	9.8	8.4	13.7
Chloride	g/m^3	12.7	14.6	12.5	11.7	11.7	14.6
Total nitrogen	g/m^3	1.47	0.75	1.61	1.22	0.75	1.64
Ammoniacal nitrogen	g/m^3	0.037	< 0.010	0.031	0.019	<0.01	0.041
Nitrite nitrogen	g/m^3 N	0.007	< 0.002	0.004	0.004	< 0.002	0.007
Nitrate nitrogen	g/m^3 N	1.27	0.61	1.53	1.15	0.61	1.58
Nitrate & nitrite nitrogen	g/m^3 N	1.28	0.61	1.54	1.15	0.61	1.58
Total kjeldahl nitrogen	g/m^3	0.19	0.14	<0.10	<0.10	<0.10	0.19
Dissolved reactive phosphorus	g/m^3	<0.004	0.011	0.005	0.01	<0.004	0.011
Total phosphorus	g/m^3	0.013	0.022	0.01	0.019	0.01	0.041
Sulphate	g/m^3	6.0	6.8	6.3	5.4	5.4	6.8
Biological oxygen demand	g O_2/m^3	<2	<2	<2	<2	<2	<2
Chemical oxygen demand	g O_2/m^3	<6	<6	<6	6	<6	8
Total organic carbon	g/m^3	0.8	<0.5	1.3	1.7	<0.5	2.3
Escherichia coli	MPN / 100 mL	>200	140	75	222	75	261

**Note results reported as >200 due to the lab method for clean water which has a top range of 20*

2.3.2 Groundwater quality monitoring

Groundwater sampling was undertaken at quarterly intervals during the monitoring year at six sites (GND2623, GND2624, GND2625, GND2484, GND2627 and GND3032). Results are displayed in Table 6 to Table 11.

Some minor variations in groundwater quality can be observed between bores. GND2624 and GND2625, the two shallowest bores, exhibit slightly higher electrical conductivity and ion concentrations than the other bores. The higher mineral concentrations indicate that the groundwater intercepted by these two bores may be older and more evolved. Results also point to a highly reducing environment at these two sites, which has led to a decrease in nitrates and an increase in iron and manganese concentrations.

GND3032 was added to the programme in January 2019 to monitor groundwater quality in Area-B of the Cemetery. Groundwater quality in the bore fluctuates but is generally similar to that reported in Area-A.

The majority of bores indicate occasional increases in COD and suspended solids. GND2624 also recorded an anomalously high nitrate result in April 2021.

Occasional increases in some parameters are not uncommon in shallow groundwater with some analytes being easily re-mobilised following rainfall events. The application of fertiliser at the site also has the potential to temporarily increase some parameters.

The elevated total suspended solids concentrations recorded in GND2623 in April 2020 and in GND3032 in January 2019 may be an indication that these bore holes were disturbed prior to sampling resulting in the movement of sediment through the slotted screen into the bore casing.

The majority of slight variations in analyte concentrations seen in each bore during the year are a result of seasonal fluctuations and sampling variability.

Table 6 Groundwater quality results GND2627-north

Parameter	Bore id.	MW5 (GND2627)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2017-2021	Maximum 2017-2021*
pH	pH	6.3	6.2	6.1	6.4	6.1	6.4
Total alkalinity	g/m^3 $CaCO_3$	22	24	28	26	22	38
Carbonate	g/m^3 CO_3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate	g/m^3 HCO_3	27	29	34	31	27	46
Total hardness	g/m^3 $CaCO_3$	26	25	29	32	25	38
Electrical conductivity	mS/m	10.7	11.2	12.6	12.9	10.7	14.9
Total suspended solids	g/m^3	<3	6	<3	<3	<1	9
Total dissolved solids	g/m^3	74	77	78	87	74	135
Dissolved aluminium	g/m^3	-	-	<0.003	-	<0.003	0.042
Dissolved arsenic	g/m^3	-	-	<0.0010	-	<0.0010	<0.0010
Dissolved barium	g/m^3	-	-	0.007	-	0.007	0.0092
Dissolved boron	g/m^3	-	-	0.008	-	0.008	0.011
Dissolved cadmium	g/m^3	-	-	<0.00005	-	<0.00005	<0.00005
Dissolved calcium	g/m^3	4.6	4.6	5.3	5.4	4.6	6.7
Dissolved chromium	g/m^3	-	-	0.0006	-	0.0006	0.0008
Dissolved copper	g/m^3	-	-	0.0012	-	<0.0005	0.0012
Dissolved iron	g/m^3	-	-	<0.02	-	<0.02	0.04
Dissolved lead	g/m^3	-	-	<0.00010	-	<0.00010	0.00044
Dissolved magnesium	g/m^3	3.6	3.4	4.0	4.6	3.2	5.1
Dissolved manganese	g/m^3	-	-	0.0008	-	0.0008	0.006
Dissolved mercury	g/m^3	-	-	<0.00008	-	<0.00008	<0.00008
Dissolved Nickel	g/m^3	-	-	<0.0005	-	<0.0005	<0.0005
Dissolved potassium	g/m^3	0.49	0.54	0.63	0.62	<3	0.84
Dissolved sodium	g/m^3	10.8	11.4	11.4	12.2	10.8	15.1
Dissolved zinc	g/m^3	-	-	0.0025	-	0.0012	0.0074
Chloride	g/m^3	9.7	11.2	14.1	16.6	9.6	23
Fluoride	g/m^3	-	-	<0.05	-	<0.05	<0.05
Total nitrogen	g/m^3	1.92	1.2	1.07	1.21	0.52	1.92
Ammoniacal nitrogen	g/m^3	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nitrite nitrogen	g/m^3 N	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nitrate nitrogen	g/m^3 N	1.92	1.15	1.04	1.19	0.48	1.92

Parameter	Bore id.	MW5 (GND2627)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2017-2021	Maximum 2017-2021*
Nitrate & nitrite nitrogen	g/m^3 N	1.92	1.15	1.04	1.19	0.48	1.92
Total kjeldahl nitrogen	g/m^3	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dissolved reactive phosphorus	g/m^3	<0.004	<0.004	0.004	<0.004	<0.004	0.008
Dissolved reactive silica	g/m^3 SiO_2	-	-	24	-	20	30
Total phosphorus	g/m^3	<0.004	0.005	0.003 #1	<0.002	<0.004	0.017
Sulphate	g/m^3	7.3	6.6	5.8	6.7	4.9	7.4
Biological oxygen demand	g O_2/m^3	<2	<2	<2	<2	<2	<2
Chemical oxygen demand	g O_2/m^3	<6	<6	<6	<6	<6	<6
Total organic carbon	g/m^3	<0.5	0.5	<0.5	<0.5	<0.5	1.2
Escherichia coli	MPN/100 mL	<1	<1	<1	<1	<1	<1
Formaldehyde	g/m^3	-	-	<0.02	-	<0.02	<0.02

- *Note some maximum results (including nitrate) have been updated since the previous report following the discovery of an inaccuracy in the results reported for October 2019*

Table 7 Groundwater quality results GND2624-north

Parameter	Bore id.	MW2 (GND2624)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2017-2021	Maximum 2017-2021
pH	pH	6.1	6.5	6.2	6.0	6.0	6.5
Total alkalinity	g/m^3 $CaCO_3$	163	137	158	114	84	180
Carbonate	g/m^3 CO_3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate	g/m^3 HCO_3	199	167	192	138	102	220
Total hardness	g/m^3 $CaCO_3$	200	137	120	109	75	210
Electrical conductivity	mS/m	49.5	42.4	42.7	37.9	24.9	49.5
Total suspended solids	g/m^3	7	90	7	<3	<3	90
Total dissolved solids	g/m^3	280	250	240	220	161	320
Dissolved aluminium	g/m^3	-	-	<0.003	-	<0.003	0.004
Dissolved arsenic	g/m^3	-	-	<0.0010	-	<0.0010	<0.0010
Dissolved barium	g/m^3	-	-	0.21	-	0.072	0.21
Dissolved boron	g/m^3	-	-	0.006	-	0.006	0.011
Dissolved cadmium	g/m^3	-	-	0.00012	-	0.0001	0.00016
Dissolved calcium	g/m^3	62	35	25	21	16.9	69
Dissolved chromium	g/m^3	-	-	<0.0005	-	<0.0005	<0.0005
Dissolved copper	g/m^3	-	-	0.0053	-	0.0011	0.0053

Parameter	Bore id.	MW2 (GND2624)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2017-2021	Maximum 2017-2021
Dissolved iron	g/m^3	-	-	11.9	-	0.07	11.9
Dissolved lead	g/m^3	-	-	<0.00010	-	<0.00010	<0.00010
Dissolved magnesium	g/m^3	10.7	12	14.1	13.9	7.9	14.1
Dissolved manganese	g/m^3	-	-	25	-	6.8	25
Dissolved mercury	g/m^3	-	-	<0.00008	-	<0.00008	<0.00008
Dissolved Nickel	g/m^3	-	-	0.0007	-	<0.0005	0.0007
Dissolved potassium	g/m^3	4.4	4.1	5.7	4.5	3.3	5.7
Dissolved sodium	g/m^3	15.2	16.8	17.9	16.3	11.1	17.9
Dissolved zinc	g/m^3	-	-	0.022	-	0.0061	0.022
Chloride	g/m^3	19.2	16.6	22	18.3	13.4	22
Fluoride	g/m^3	-	-	<0.05	-	<0.05	<0.05
Total nitrogen	g/m^3	1.9	3.6	1.8	13.5	0.5	13.5
Ammoniacal nitrogen	g/m^3	1.77	0.41	1.73	0.187	0.128	1.77
Nitrite nitrogen	g/m^3 N	<0.002	0.003	0.003	0.108	<0.002	0.108
Nitrate nitrogen	g/m^3 N	<0.002	3.0	<0.002	12.9	<0.002	12.9
Nitrate & nitrite nitrogen	g/m^3 N	<0.002	3.0	0.004	13.0	<0.002	13.0
Total kjeldahl nitrogen	g/m^3	1.91	0.59	1.81	0.54	0.33	1.91
Dissolved reactive phosphorus	g/m^3	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Dissolved reactive silica	g/m^3 SiO_2	-	-	16.4	-	16.4	21
Total phosphorus	g/m^3	0.09	0.004	0.005	0.002	<0.004	0.09
Sulphate	g/m^3	63	37	21	13.2	9.3	70
Biological oxygen demand	g O_2/m^3	<2	<2	<2	<2	<2	<2
Chemical oxygen demand	g O_2/m^3	12	<6	14	<6	<6	14
Total organic carbon	g/m^3	1.1	1.5	3.8	4.2	<0.5	4.2
Escherichia coli	MPN/100 mL	<1	<1	<1	1	<1	1
Formaldehyde	g/m^3	-	-	<0.02	-	<0.02	<0.02

Table 8 Groundwater quality results GND2625-east

Parameter	Bore id.	MW3 (GND2625)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2017-2021	Maximum 2017-2021
pH	pH	6.2	6.4	6.4	6.3	6.0	6.4
Total alkalinity	g/m^3 $CaCO_3$	124	145	152	132	60	152
Carbonate	g/m^3 CO_3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate	g/m^3 HCO_3	151	177	186	161	73	186
Total hardness	g/m^3 $CaCO_3$	95	88	88	83	55	95
Electrical conductivity	mS/m	30.7	34.5	36.8	31.1	18.7	36.8
Total suspended solids	g/m^3	11	22	5	15	<3	40
Total dissolved solids	g/m^3	179	180	210	166	111	210
Dissolved aluminium	g/m^3	-	-	<0.003	-	<0.003	<0.003
Dissolved arsenic	g/m^3	-	-	<0.0010	-	<0.0010	<0.0010
Dissolved barium	g/m^3	-	-	0.198	-	0.058	0.198
Dissolved boron	g/m^3	-	-	0.007	-	0.007	0.016
Dissolved cadmium	g/m^3	-	-	<0.00005	-	<0.00005	0.00013
Dissolved calcium	g/m^3	21	19.8	18.9	17.9	13.5	21.0
Dissolved chromium	g/m^3	-	-	<0.0005	-	<0.0005	<0.0005
Dissolved copper	g/m^3	-	-	0.0009	-	<0.0005	0.0009
Dissolved iron	g/m^3	-	-	14.6	-	0.25	14.6
Dissolved lead	g/m^3	-	-	<0.00010	-	<0.00010	<0.00010
Dissolved magnesium	g/m^3	10.1	9.3	9.9	9.3	5.3	10.1
Dissolved manganese	g/m^3	-	-	22	-	1.92	22
Dissolved mercury	g/m^3	-	-	<0.00008	-	<0.00008	<0.00008
Dissolved Nickel	g/m^3	-	-	<0.0005	-	<0.0005	0.0007
Dissolved potassium	g/m^3	5.7	5.5	6.1	6.3	3.7	6.3
Dissolved sodium	g/m^3	10.9	10.7	10.4	9.9	8.3	11.9
Dissolved zinc	g/m^3	-	-	0.036	-	0.0045	0.036
Chloride	g/m^3	13.6	12.5	12.8	11.1	9.9	29
Fluoride	g/m^3	-	-	<0.05	-	<0.05	<0.05
Total nitrogen	g/m^3	1.3	1.5	2.0	2.1	0.4	2.1
Ammoniacal nitrogen	g/m^3	1.19	1.28	1.61	1.78	0.28	1.78
Nitrite nitrogen	g/m^3 N	<0.002	<0.02	<0.02	<0.02	<0.002	0.017
Nitrate nitrogen	g/m^3 N	<0.002	<0.02	<0.02	<0.02	<0.002	0.009

Parameter	Bore id.	MW3 (GND2625)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2017-2021	Maximum 2017-2021
Nitrate & nitrite nitrogen	g/m^3 N	<0.002	<0.02	<0.02	<0.02	<0.002	0.018
Total kjeldahl nitrogen	g/m^3	1.3	1.5	2.0	2.1	0.4	2.1
Dissolved reactive phosphorus	g/m^3	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Dissolved reactive silica	g/m^3 SiO_2	-	-	15.9	-	15.9	22
Total phosphorus	g/m^3	0.004	0.011	0.002	0.007	0.002	0.055
Sulphate	g/m^3	15.5	15.1	14	14.5	6.3	15.5
Biological oxygen demand	g O_2/m^3	<2	<2	<2	<2	<2	5
Chemical oxygen demand	g O_2/m^3	10	6	8	<6	<6	10
Total organic carbon	g/m^3	4.4	7.1	3.4	4.4	<0.5	7.8
Escherichia coli	MPN/100 mL	<1	3	35	7	<1	35
Formaldehyde	g/m^3	-	-	<0.02	-	<0.02	<0.02

Table 9 Groundwater quality results GND3032-south

Parameter	Bore id.	MW6 (GND3032)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2019-2021	Maximum 2019-2022
pH	pH	6.1	6.4	6.2	6.1	6.1	6.7
Total alkalinity	g/m^3 $CaCO_3$	60	61	55	59	55	110
Carbonate	g/m^3 CO_3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate	g/m^3 HCO_3	74	74	67	72	67	134
Total hardness	g/m^3 $CaCO_3$	76	73	61	65	60	108
Electrical conductivity	mS/m	23.2	23.2	19.8	20.3	18.7	31.3
Total suspended solids	g/m^3	124	200	30	12	<3	680
Total dissolved solids	g/m^3	147	145	124	129	124	220
Dissolved aluminium	g/m^3	-	-	<0.03	-	<0.003	0.006
Dissolved arsenic	g/m^3	-	-	<0.0010	-	<0.0010	<0.0010
Dissolved barium	g/m^3	-	-	0.033	-	0.033	0.057
Dissolved boron	g/m^3	-	-	0.011	-	0.011	0.014
Dissolved cadmium	g/m^3	-	-	<0.00005	-	<0.00005	<0.00005
Dissolved calcium	g/m^3	19.3	18.6	15.2	15.9	14.9	31.0
Dissolved chromium	g/m^3	-	-	0.0005	-	0.0005	0.0022
Dissolved copper	g/m^3	-	-	0.0022	-	0.0007	0.0022

Parameter	Bore id.	MW6 (GND3032)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2019-2021	Maximum 2019-2022
Dissolved iron	g/m^3	-	-	<0.02	-	<0.02	<0.02
Dissolved lead	g/m^3	-	-	<0.00010	-	<0.00010	<0.00010
Dissolved magnesium	g/m^3	6.7	6.4	5.6	6.3	5.5	8.1
Dissolved manganese	g/m^3	-	-	0.0148	-	0.0024	0.085
Dissolved mercury	g/m^3	-	-	<0.00008	-	<0.00008	<0.00008
Dissolved Nickel	g/m^3	-	-	<0.0005	-	0.0006	0.0014
Dissolved potassium	g/m^3	1.51	1.48	1.57	1.60	1.48	1.83
Dissolved sodium	g/m^3	14	15.7	12.2	13.4	12.2	21
Dissolved zinc	g/m^3	-	-	0.0024	-	0.0024	0.0079
Chloride	g/m^3	16.7	15.3	11.7	13.8	11.7	19.4
Fluoride	g/m^3	-	-	<0.05	-	<0.05	<0.05
Total nitrogen	g/m^3	4.3	4.2	4.2	3.9	2.9	6
Ammoniacal nitrogen	g/m^3	<0.010	<0.010	<0.010	<0.010	<0.010	0.016
Nitrite nitrogen	g/m^3 N	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nitrate nitrogen	g/m^3 N	4.3	4.0	4.1	3.9	2.9	6.0
Nitrate & nitrite nitrogen	g/m^3 N	4.3	4.0	4.1	3.9	2.9	6.0
Total kjeldahl nitrogen	g/m^3	<0.10	0.27	<0.10	<0.10	<0.10	0.7
Dissolved reactive phosphorus	g/m^3	0.004	<0.004	<0.004	<0.004	0.004	0.004
Dissolved reactive silica	g/m^3 SiO_2	-	-	30	-	30	34
Total phosphorus	g/m^3	0.108	0.163	0.025	0.01	<0.004	0.81
Sulphate	g/m^3	7.8	12.2	4.0	6.5	3.8	12.2
Biological oxygen demand	g O_2/m^3	<2	<2	<2	<2	<2	<2
Chemical oxygen demand	g O_2/m^3	<6	<6	6	<6	<6	23
Total organic carbon	g/m^3	<0.5	2.3	0.6	2.3	<0.5	22
Escherichia coli	MPN/100 mL	<1	<1	<1	<1	<1	<1
Formaldehyde	g/m^3	-	-	<0.02	-	<0.02	<0.02

Table 10 Groundwater quality results GND2484-south

Parameter	Bore id.	MW4 (GND2484)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2017-2021	Maximum 2017-2021
pH	pH	6	6	6.2	6.1	5.9	6.4
Total alkalinity	g/m^3 $CaCO_3$	31	24	35	40	24	40
Carbonate	g/m^3 CO_3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate	g/m^3 HCO_3	38	29	43	48	29	48
Total hardness	g/m^3 $CaCO_3$	27	20	28	29	20	34
Electrical conductivity	mS/m	9.5	8.1	10.2	10.2	8.1	11.7
Total suspended solids	g/m^3	<3	<3	<3	<3	<3	27
Total dissolved solids	g/m^3	72	50	71	80	50	85
Dissolved aluminium	g/m^3	-	-	<0.003	-	<0.003	0.013
Dissolved arsenic	g/m^3	-	-	<0.0010	-	<0.0010	<0.0010
Dissolved barium	g/m^3	-	-	0.012	-	0.0061	0.012
Dissolved boron	g/m^3	-	-	0.008	-	0.008	0.009
Dissolved cadmium	g/m^3	-	-	<0.00005	-	<0.00005	<0.00005
Dissolved calcium	g/m^3	6.1	4.7	6.5	6.5	4.7	7.5
Dissolved chromium	g/m^3	-	-	0.0007	-	<0.0005	0.0007
Dissolved copper	g/m^3	-	-	0.0015	-	<0.0005	0.0058
Dissolved iron	g/m^3	-	-	<0.02	-	<0.02	<0.02
Dissolved lead	g/m^3	-	-	<0.00010	-	<0.00010	<0.00010
Dissolved magnesium	g/m^3	2.7	2.0	2.8	3.1	2.0	3.7
Dissolved manganese	g/m^3	-	-	0.0051	-	0.0012	0.0071
Dissolved mercury	g/m^3	-	-	<0.00008	-	<0.00008	<0.00008
Dissolved Nickel	g/m^3	-	-	<0.0005	-	<0.0005	<0.0005
Dissolved potassium	g/m^3	1.18	1.02	1.16	1.28	1.02	1.29
Dissolved sodium	g/m^3	8.7	6.9	8.7	9.6	6.9	10.3
Dissolved zinc	g/m^3	-	-	0.0015	-	0.001	0.0033
Chloride	g/m^3	7.0	7.0	6.3	7.1	6.3	8.1
Fluoride	g/m^3	-	-	<0.05	-	<0.05	<0.05
Total nitrogen	g/m^3	0.13	<0.11	0.27	0.15	<0.11	0.37
Ammoniacal nitrogen	g/m^3	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nitrite nitrogen	g/m^3 N	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nitrate nitrogen	g/m^3 N	0.126	0.076	0.178	0.134	0.076	0.34

Parameter	Bore id.	MW4 (GND2484)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2017-2021	Maximum 2017-2021
Nitrate & nitrite nitrogen	g/m^3 N	0.126	0.076	0.178	0.134	0.076	0.34
Total kjeldahl nitrogen	g/m^3	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dissolved reactive phosphorus	g/m^3	0.008	0.005	0.014	0.008	0.005	0.016
Dissolved reactive silica	g/m^3 SiO_2	-	-	26	-	24	31
Total phosphorus	g/m^3	0.009	0.011	0.012	0.009	0.009	0.029
Sulphate	g/m^3	4.9	4.0	4.7	4.9	3.8	6.3
Biological oxygen demand	g O_2/m^3	<2	<2	<2	<2	<2	<2
Chemical oxygen demand	g O_2/m^3	<6	<6	<6	<6	<6	<6
Total organic carbon	g/m^3	<0.5	<0.5	<0.5	0.7	<0.5	1
Escherichia coli	MPN/100 mL	<1	2	<1	<1	<1	2
Formaldehyde	g/m^3	-	-	<0.02	-	<0.02	<0.02

Table 11 Groundwater quality results GND2623-west

Parameter	Bore id.	MW1 (GND2623)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2017-2021	Maximum 2017-2021
pH	pH	5.9	6.2	6.2	6.1	5.9	6.3
Total alkalinity	g/m^3 $CaCO_3$	40	44	52	53	39	68
Carbonate	g/m^3 CO_3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate	g/m^3 HCO_3	49	54	64	65	47	82
Total hardness	g/m^3 $CaCO_3$	38	40	42	38	32	56
Electrical conductivity	mS/m	13	13.8	14.9	13.8	13.0	18.3
Total suspended solids	g/m^3	22	<3	<3	<3	<3	3200
Total dissolved solids	g/m^3	82	84	103	92	82	151
Dissolved aluminium	g/m^3	-	-	<0.003	-	<0.003	0.005
Dissolved arsenic	g/m^3	-	-	<0.0010	-	<0.0010	<0.0010
Dissolved barium	g/m^3	-	-	0.009	-	0.0068	0.009
Dissolved boron	g/m^3	-	-	0.011	-	0.01	0.012
Dissolved cadmium	g/m^3	-	-	<0.00005	-	<0.00005	<0.00005
Dissolved calcium	g/m^3	9.7	10.3	10.4	9.6	7.7	13.6
Dissolved chromium	g/m^3	-	-	<0.0005	-	<0.0005	0.0005
Dissolved copper	g/m^3	-	-	0.0049	-	<0.0005	0.0049

Parameter	Bore id.	MW1 (GND2623)					
Sample date	Unit	20/07/2020	15/10/2020	14/01/2021	8/04/2021	Minimum 2017-2021	Maximum 2017-2021
Dissolved iron	g/m^3	-	-	<0.02	-	<0.02	<0.02
Dissolved lead	g/m^3	-	-	<0.00010	-	<0.00010	0.00012
Dissolved magnesium	g/m^3	3.2	3.4	3.8	3.4	3.1	5.4
Dissolved manganese	g/m^3	-	-	0.0013	-	0.001	0.0014
Dissolved mercury	g/m^3	-	-	<0.00008	-	<0.00008	<0.00008
Dissolved Nickel	g/m^3	-	-	<0.0005	-	<0.0005	<0.0005
Dissolved potassium	g/m^3	1.71	1.61	1.58	1.65	1.34	1.73
Dissolved sodium	g/m^3	10.3	11.4	13.9	12.9	10.3	14.9
Dissolved zinc	g/m^3	-	-	0.0022	-	0.0011	0.0024
Chloride	g/m^3	8.8	9.3	8.1	8.8	8.1	11.0
Fluoride	g/m^3	-	-	<0.05	-	<0.05	<0.05
Total nitrogen	g/m^3	1.1	1.34	1.06	0.99	0.94	1.89
Ammoniacal nitrogen	g/m^3	<0.010	<0.010	<0.010	<0.010	<0.010	0.012
Nitrite nitrogen	g/m^3 N	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nitrate nitrogen	g/m^3 N	1.01	1.29	1.03	0.94	0.91	1.62
Nitrate & nitrite nitrogen	g/m^3 N	1.01	1.29	1.03	0.94	0.91	1.62
Total kjeldahl nitrogen	g/m^3	<0.10	<0.10	<0.10	<0.10	<0.10	0.51
Dissolved reactive phosphorus	g/m^3	0.005	<0.004	0.014	0.006	<0.004	0.014
Dissolved reactive silica	g/m^3 SiO_2	-	-	26	-	22	32
Total phosphorus	g/m^3	0.02	<0.004	0.012	0.004	<0.004	2.2
Sulphate	g/m^3	4.8	4.2	4.3	4.5	3.8	5.5
Biological oxygen demand	g O_2/m^3	<2	<2	<2	<2	<2	<2
Chemical oxygen demand	g O_2/m^3	12	<6	<6	<6	<6	15
Total organic carbon	g/m^3	2.7	1.3	0.5	0.8	<0.5	2.7
Escherichia coli	MPN/100 mL	<1	<1	<1	<1	<1	<1
Formaldehyde	g/m^3	-	-	<0.02	-	<0.02	0.02

2.3.3 Groundwater level monitoring

Groundwater level data was collected electronically at 15 minute intervals using in-situ level loggers. Data was downloaded quarterly.

A comparison with rainfall data collected in the nearby Waiwhakaiho at Egmont Village rainfall site is included as Figure 3. An assessment of the data confirms all groundwater levels respond to sustained periods of rainfall recharge.

A summary of the range of groundwater levels at the site and the minimum required depth to water for each type of internment are included in Table 12 below. The Table indicates that some areas are not suitable for some types of burials.

Table 12 Groundwater level range and burial type

Site code	Area	Conventional double burial Minimum depth of 1.8 m BGL	Conventional single burial Minimum depth of burial is 1.2 m BGL	Natural grave Minimum depth of burial is 1.0 m BGL	Water level range (m BGL)		Range	Continuous groundwater level data (15 min. interval)
		Minimum required depth to high water table (m BGL)			High	Low	(m)	Commenced
GND2627	north	2.6	2.0	1.8	0.16	5.10	4.93	4 Mar 2017
GND2624	north				0.08	4.43	5.35	4 Mar 2017
GND2625	east				0.07	4.39	4.33	14 May 2018
GND3032	south				2.16	5.94	3.78	7 Feb 2019
GND2484	south				2.39	5.22	2.84	19 Mar 2018
GND2623	west				1.22	5.64	4.42	4 Mar 2017

Groundwater level data is illustrated for all six monitored sites in Figure 4 and Figure 5. The minimum depth to water required for shallow double plot burials (red line), conventional single burials (green line) and natural burials (purple line) have been added for reference.

An assessment of the data indicates that groundwater levels are high and fluctuate significantly in GND2624 and GND2627, ranging from <0.5 m BGL during the wetter months to >5 m BGL in the drier months (Figure 4). The flat-lined data seen in March 2019 and March-April 2020 in GND2624 is anomalous. The data is likely an artefact of groundwater levels exceeding the level loggers design range. GND2625 also exhibits high groundwater levels, fluctuating between <0.5 m BGL and >4 m BGL (Figure 4). Groundwater levels in GND2623, GND2484 and GND3032 are slightly more subdued and fluctuate to a lesser degree (Figure 4 and Figure 5). The greater fluctuations seen to the north and east may be a result of enhanced recharge, due to the close proximity of the forested hills to the north of the Cemetery.

Groundwater level data indicates that Area-A and Area-B are not suitable for conventional double plot or shallow double plot stacked burials which require internment to a minimum depth of 2.0 m BGL and 1.8 m BGL respectively. Groundwater levels also indicate that the majority of Area-A is not suitable for conventional single plot burials (1.2 m BGL) or in the north and east natural graves (1 m BGL). To ensure the long-term viability of Area-A for burials passive dewatering may be required to ensure that the water levels beneath the site remain below consented thresholds. To date eight double plot stacked burials have taken place in Area-B at the shallower depth of 1.8 m and 59 ash internments and 2 single depth casket burials have taken place in Area-A.

During the 2020-2021 monitoring period several significant rainfall events occurred between 24 November and 11 December 2020. The cumulative rainfall over this 17 day period was 559 mm equivalent to 23% of the average annual rainfall for the site. The heavy rainfall over such a short period would cause the ground to become saturated and consequentially the water table to rise. The high water table resulted in a breach of condition 3 of consent 7882-1.1, which requires the consent holder to ensure that any graves remain a minimum of 0.8 metres above the seasonally high water table, on 26 November and 10 December 2020 (Figure 5).

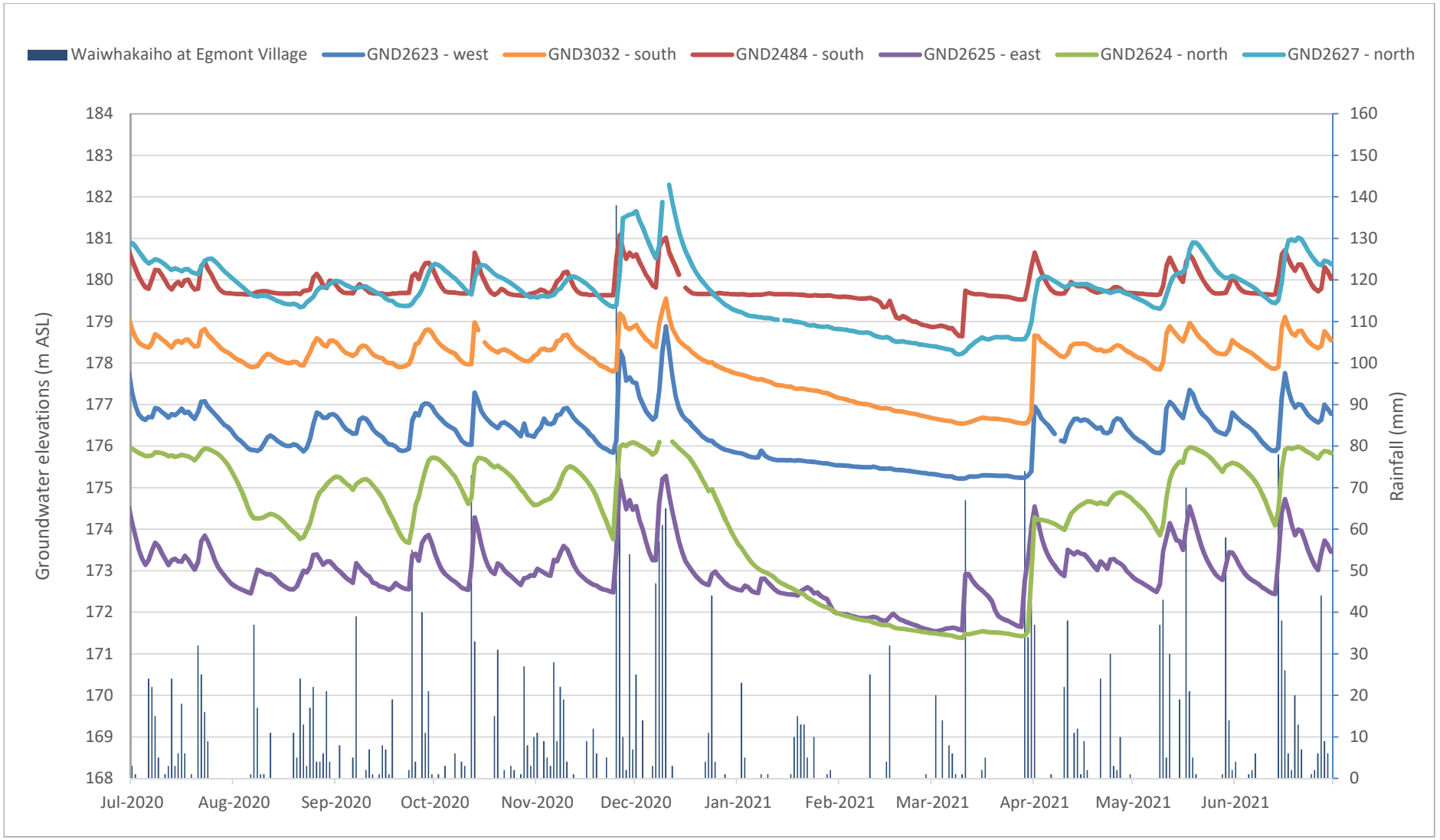

Figure 3 Groundwater elevations 2020-2021 in comparison to rainfall

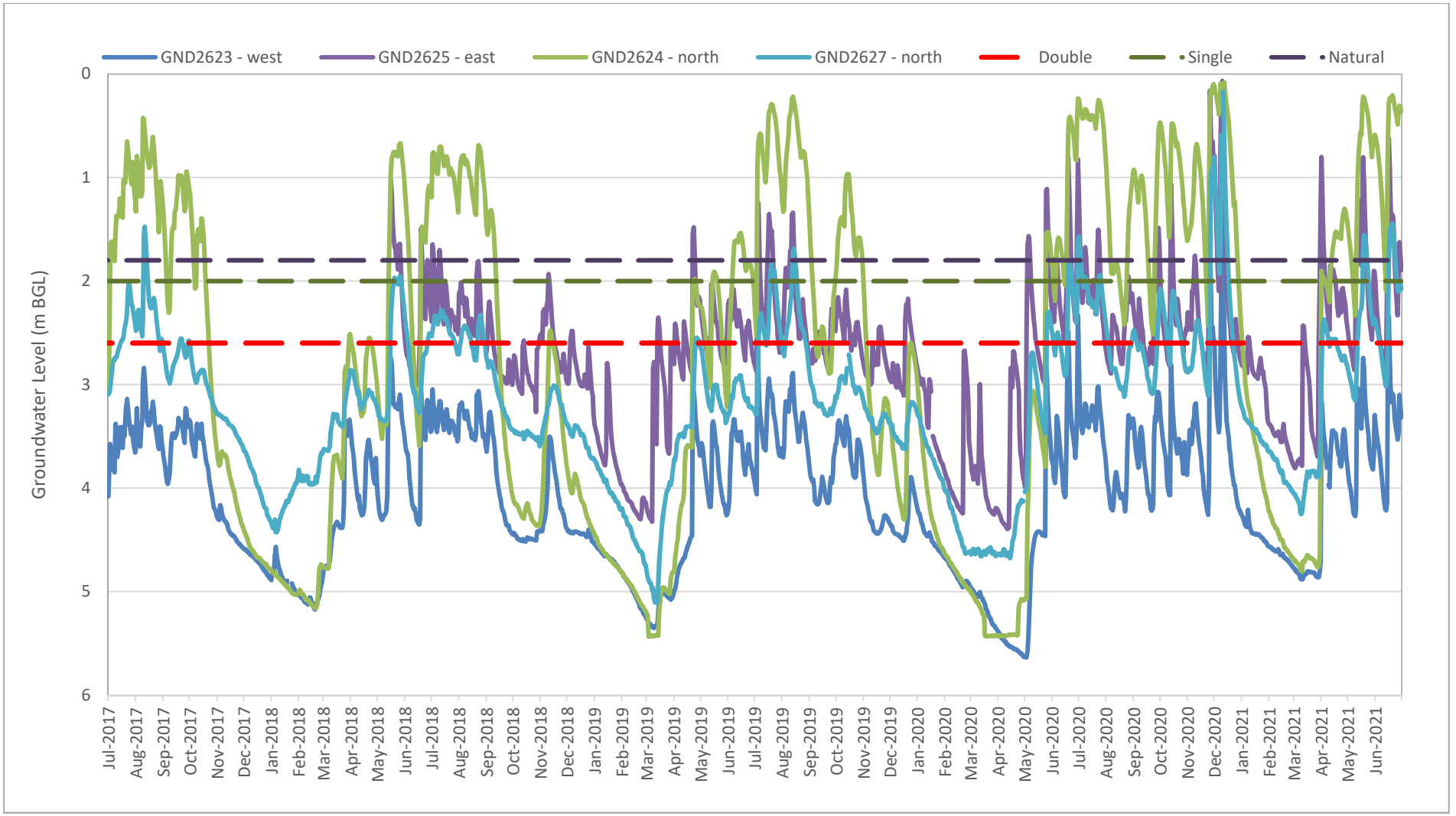

Figure 4 Groundwater levels GND2623, GND2625 and GND2624 compared to minimum required water table depths by burial type

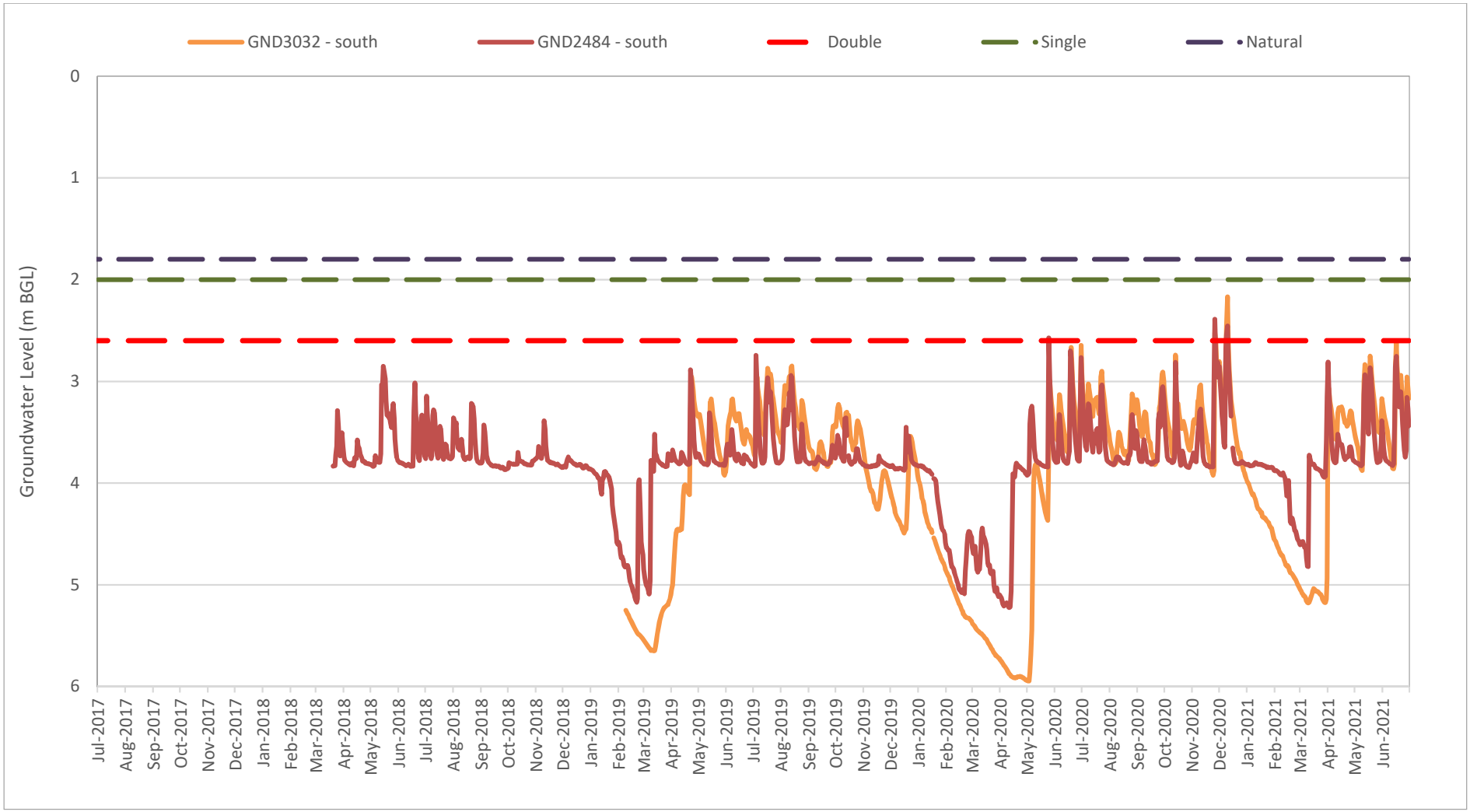

Figure 5 Groundwater levels GND2484 and GND3032 compared to minimum required water table depths by burial type

2.4 Investigations, interventions and incidents

The monitoring programme for the year was based on what was considered to be an appropriate level of monitoring, review of data, and liaison with NPDC and or their representatives. During the year matters may arise which require additional activity by the Council, for example provision of advice and information, or investigation of potential or actual causes of non-compliance or failure to maintain good practices. A pro-active approach that in the first instance avoids issues occurring is favoured.

The Council operates and maintains a register of all complaints or reported and discovered excursions from acceptable limits and practices, including non-compliance with consents, which may damage the environment. The incident register includes events where NPDC concerned has itself notified the Council. The register contains details of any investigation and corrective action taken.

Complaints may be alleged to be associated with a particular site. If there is potentially an issue of legal liability, the Council must be able to prove by investigation that the identified company is indeed the source of the incident (or that the allegation cannot be proven).

In the 2020-2021 period, the Council was not required to undertake significant additional investigations and interventions, or record incidents, in association with the Company's conditions in resource consents or provisions in Regional Plans.

On 26 November and 10 December 2020 a breach of condition 3 of consent 7882-1.1 occurred (Table 13). The non-compliance was due to high water levels recorded at the site resulting in several double plot graves being less than the required 0.8 m above the seasonally high water table.

Following discovery of the non-compliance NPDC were contacted and had already investigated the option of installing a dewatering system at the site to lower water levels. Due to financial constraints no funding was available and the project is currently on-hold. Discussions will continue and enforcement action will commence if further non-compliances occur during the 2021-2022 monitoring year.

Table 13 Incidents, investigations, and interventions summary table

Date	Details	Compliant (Y/N)	Enforcement Action Taken?	Outcome
26 November and 10 December 2020	Due to high rainfall events water levels in Area-B and Area-A were higher than permitted by condition 3 of the consent.	N	NPDC were contacted when the breach was discovered and a meeting will be held to discuss mitigation options to avoid future breaches.	Ongoing

3 Discussion

3.1 Discussion of site performance

The Cemetery opened to the public in May 2019 and the compliance monitoring programme commenced following the first internment in July 2019.

Inspections of the site during the monitoring period found it to be in good condition and being well managed. The monitoring programme was undertaken as required and data was provided to the Council for review in a timely manner.

Groundwater levels indicated that Area-A and Area-B, are both unsuitable for conventional (2 m depth) and, during wetter month's shallow double stacked plots (1.8 m depth). In addition, due to high groundwater levels parts of Area-A are also unsuitable for conventional single depth or natural burials. To date eight double plot burials have taken place in Area-B at the shallower depth of 1.8 m.

Groundwater levels for the monitoring period show that during periods of heavy sustained rainfall like those experienced in November and December 2020 the water table can rise above the consented threshold resulting in a breach of consent conditions.

Figure 6 shows the areas allocated to each type of internment.

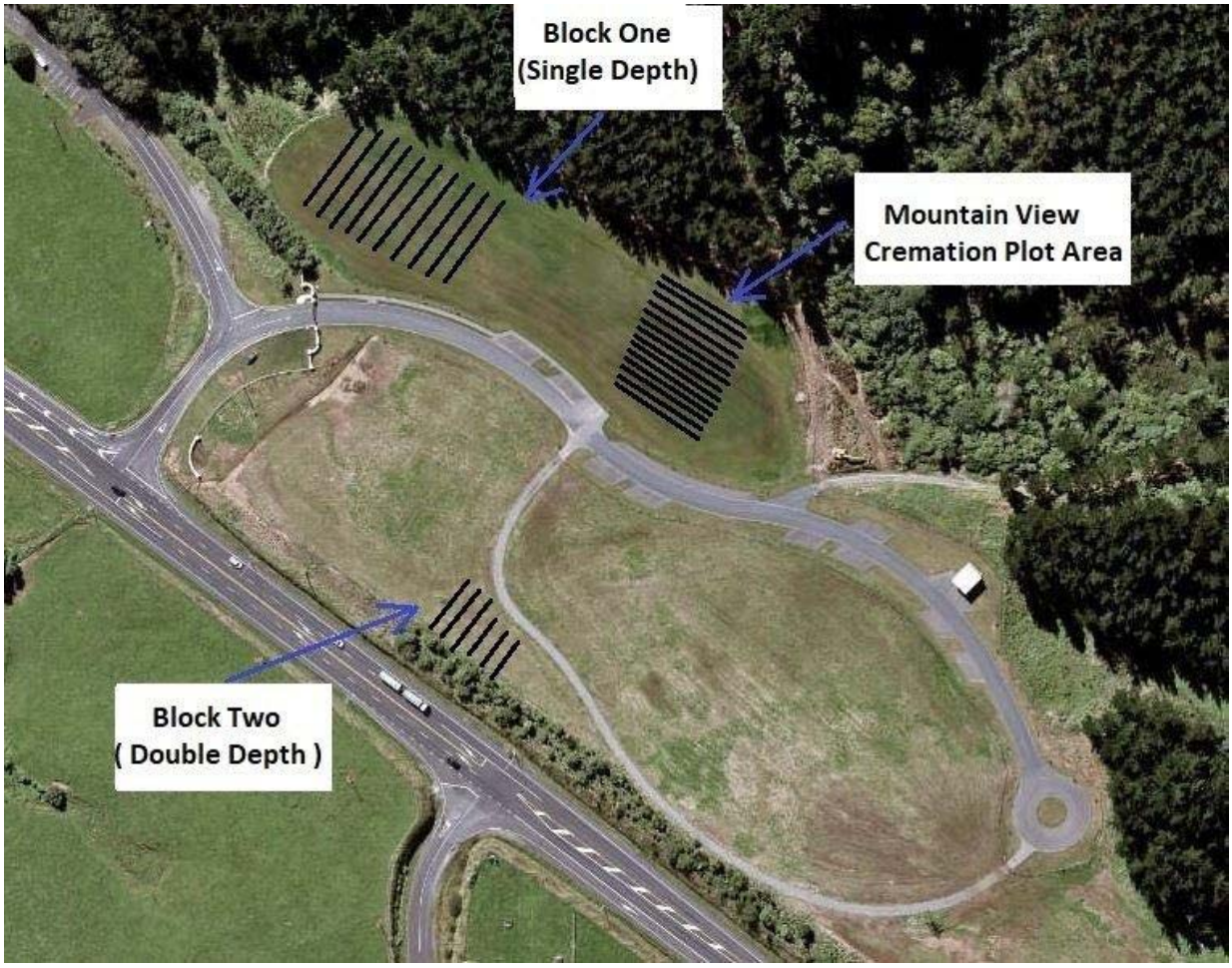

Figure 6 Type of internment planned for Area-A and Area-B

The burial plan (Figure 2) contained a provision for up to 150 internments comprising of 75 in Area-A and 75 in Area-B during the first year of operation.

Since the Cemetery opened the following internments have taken place:

- Area-A (Block 1 and cremation plot area)
  - 59 ash burials between 40-60 cm depth;
  - 2 casket single depth burial at 1 m depth; and
- Area-B (Block 2)
  - 8 casket double plot burials at 1.8 m depth.

The number of internments undertaken at the Cemetery have been significantly lower than shown in the burial plan due to the availability of plots at the Awanui and Te-Henui cemeteries. The number of internments is expected to rise significantly when the other two cemeteries close.

3.2 Environmental effects of exercise of consents

The groundwater and surface water monitoring components of this programme continued during the period under review, with 24 groundwater samples and 4 surface water samples taken from monitoring sites in the vicinity of the Cemetery. The results of the monitoring carried out show that the groundwater and surface water composition has remained relatively stable since monitoring commenced.

Groundwater and surface water monitoring included the sampling and analysis of a comprehensive suite of general water quality parameters and any contaminants related to the degradation of human remains. The monitoring programme also included the collection of groundwater level data from six bores. The data collected will allow for an in depth assessment of any variations in groundwater and surface water composition should the need arise in the future.

Surface water chemistry exhibited a distinct seasonal change. Groundwater composition in each bore remained relatively stable with only slight changes resulting from natural seasonal fluctuation and sampling variability. Groundwater composition differed slightly between bores due to depth and redox conditions.

An assessment of the groundwater level data concluded that groundwater levels fluctuate in response to rainfall and are slightly higher in the northern and eastern areas of the site close to the forested hills. The range of levels differs between bores with the greatest range (>5 m) seen in GND2624.

There is no evidence to suggest that any activity undertaken at the Cemetery during the review period has had any adverse effect on local groundwater or surface water quality.

No complaints were received from the public with regard to the discharge consent during the period under review.

A breach of consent conditions did occur following a period of sustained heavy rainfall during November and December 2020. Discussions with NPDC regarding viable mitigation methods to prevent further non-compliances are currently underway.

Compliance with the conditions of NPDC's discharge consent during the review period is summarised below in Section 3.3.

3.3 Evaluation of performance

A tabular summary of the consent holder's compliance record for the year under review is set out in Table 14. A summary of the consent holder's compliance record from 2018 is set out in Table 15.

Table 14 Summary of performance for consent 7882-1.1

Purpose: *To discharge contaminants into land at a cemetery in circumstances where they may enter water*		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
1. Burials to occur within designated areas	Review burial plan	Yes
2. Burials must occur more than 50 m from a surface water body	Review of burial plan	Yes
3. Best practicable option condition. Ensure graves remain > 0.8 m above water table and spread burials in time and remain location	Updates to burial plan and review of water level data	No
4. Reporting provision	Receipt of report	Yes
5. Provision of a report detailing how compliance with Condition 3 will be achieved	Receipt of report	Yes
6. Notification requirement	Receipt of notification	Yes
7. Lapse condition	Commencement of activity prior to lapse date	N/A
8. Optional review provision re environmental effects	Option not available. Next review date June 2026	N/A
Overall assessment of environmental performance in respect of this consent Overall assessment of administrative performance in respect of this consent		**Good** **High**

During the year, NPDC demonstrated a good level of environmental and high level of administrative performance with the resource consents as defined in Section 1.1.4.

Table 15 Evaluation of environmental performance since 2018

Year	Consent no	High	Good	Improvement required	Poor
2020-2021	7882-1.1	-	1	-	-
2019-2020	7882-1.1	1	-	-	-
2018-2019	7882-1.0	1	-	-	-
Totals	-	2	1	-	-

3.4 Recommendations from the 2019-2020 Annual Report

1. THAT in the first instance, monitoring of consented activities in the 2020-2021 year continue at the same level as in 2019-2020.

2. THAT should there be issues with environmental or administrative performance in 2020-2021, monitoring may be adjusted to reflect any additional investigation or intervention as found necessary.

The recommendations above were implemented during the period under review.

3.5 Alterations to monitoring programmes for 2021-2022

In designing and implementing the monitoring programmes for air/water discharges in the region, the Council has taken into account:

- the extent of information already made available through monitoring or other means to date;
- its relevance under the RMA;
- the Council's obligations to monitor consented activities and their effects under the RMA;
- the record of administrative and environmental performances of the consent holder; and
- reporting to the regional community.

The Council also takes into account the scope of assessments required at the time of renewal of permits, and the need to maintain a sound understanding of industrial processes within Taranaki exercising resource consents.

It is proposed that for 2021-2022:

1. THAT in the first instance, monitoring of consented activities in the 2021-2022 year continue at the same level as in 2020-2021.
2. THAT should there be any ongoing issues with environmental or administrative performance in 2021-2022, monitoring may be adjusted to reflect any additional investigation or intervention as found necessary.

It should be noted that the proposed programme represents a reasonable and risk-based level of monitoring for the site(s) in question. The Council reserves the right to subsequently adjust the programme from that initially prepared, should the need arise if potential or actual non-compliance is determined at any time during 2021-2022.

4 Recommendations

1. THAT in the first instance, monitoring of consented activities in the 2021-2022 year continue at the same level as in 2020-2021.
2. THAT should there be any ongoing issues with environmental or administrative performance in 2021-2022, monitoring may be adjusted to reflect any additional investigation or intervention as found necessary.

Glossary of common terms and abbreviations

The following abbreviations and terms may be used within this report:

Al*	Aluminium.
As*	Arsenic.
BOD	Biochemical oxygen demand. A measure of the presence of degradable organic matter, taking into account the biological conversion of ammonia to nitrate.
BODF	Biochemical oxygen demand of a filtered sample.
CBOD	Carbonaceous biochemical oxygen demand. A measure of the presence of degradable organic matter, excluding the biological conversion of ammonia to nitrate.
COD	Chemical oxygen demand. A measure of the oxygen required to oxidise all matter in a sample by chemical reaction.
Conductivity	Conductivity, an indication of the level of dissolved salts in a sample, usually measured at 25°C and expressed in µS/cm.
DO	Dissolved oxygen.
DRP	Dissolved reactive phosphorus.
E.coli	Escherichia coli, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
F	Fluoride.
FC	Faecal coliforms, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
g/m^3	Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.
Incident	An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred.
Intervention	Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.
Investigation	Action taken by Council to establish what were the circumstances/events surrounding an incident including any allegations of an incident.
Incident Register	The Incident Register contains a list of events recorded by the Council on the basis that they may have the potential or actual environmental consequences that may represent a breach of a consent or provision in a Regional Plan.
L/s	Litres per second.
m^3	Cubic Metres.
m BGL	Metres below ground level
mS/m	Millisiemens per metre.
µS/cm	Microsiemens per centimetre
NH_4	Ammonium, normally expressed in terms of the mass of nitrogen (N).

NH_3	Unionised ammonia, normally expressed in terms of the mass of nitrogen (N).
NNN	Nitrate and nitrate combined, expressed in terms of the mass of nitrogen (N).
NO_3	Nitrate, normally expressed in terms of the mass of nitrogen (N).
pH	A numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline. The scale is logarithmic i.e. a change of 1 represents a ten-fold change in strength. For example, a pH of 4 is ten times more acidic than a pH of 5.
Physicochemical	Measurement of both physical properties (e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment.
Resource consent	Refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15).
Redox	Short for reduction-oxidation. A redox reaction is a chemical reaction that involves a transfer of electrons between two species. Groundwater can be reduced (low in oxygen) or oxidised (high in oxygen).
RMA	*Resource Management Act 1991* and including all subsequent amendments.
SS	Suspended solids.
Temp	Temperature, measured in °C (degrees Celsius).
Turb	Turbidity, expressed in NTU.
UI	Unauthorised Incident.
Zn*	Zinc.

*an abbreviation for a metal or other analyte may be followed by the letters 'As', to denote the amount of metal recoverable in acidic conditions. This is taken as indicating the total amount of metal that might be solubilised under extreme environmental conditions. The abbreviation may alternatively be followed by the letter 'D', denoting the amount of the metal present in dissolved form rather than in particulate or solid form.

For further information on analytical methods, contact a Science Services Manager.

Bibliography and references

Environment Agency 2004. Assessing the groundwater pollution potential of cemetery developments.

Geosearch Limited 2018. Mangapouri Cemetery, pre-burial groundwater level and water quality assessment. 26 April 2018

Ministry of Health 2008. Drinking-Water Standards for New Zealand 2005 (Revised 2008) Wellington: Ministry of Health.

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Taranaki Regional Council (2020). 2020-86 New Plymouth District Council Mangapouri Cemetery monitoring programme annual report 2019-2020. Frodo id 2497237

Taranaki Regional Council (2018). 2019-67 New Plymouth District Council Mangapouri Cemetery monitoring programme annual report 2018-2019. Frodo id 2245542

World Health Organisation 1998. The impacts of cemeteries on the environment and public health – An introductory briefing.

Appendix I

Resource consent held by New Plymouth District Council

(For a copy of the signed resource consent
please contact the TRC Consents department)

Water abstraction permits

Section 14 of the RMA stipulates that no person may take, use, dam or divert any water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or it falls within some particular categories set out in Section 14. Permits authorising the abstraction of water are issued by the Council under Section 87(d) of the RMA.

Water discharge permits

Section 15(1)(a) of the RMA stipulates that no person may discharge any contaminant into water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or by national regulations. Permits authorising discharges to water are issued by the Council under Section 87(e) of the RMA.

Air discharge permits

Section 15(1)(c) of the RMA stipulates that no person may discharge any contaminant from any industrial or trade premises into air, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Permits authorising discharges to air are issued by the Council under Section 87(e) of the RMA.

Discharges of wastes to land

Sections 15(1)(b) and (d) of the RMA stipulate that no person may discharge any contaminant onto land if it may then enter water, or from any industrial or trade premises onto land under any circumstances, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Permits authorising the discharge of wastes to land are issued by the Council under Section 87(e) of the RMA.

Land use permits

Section 13(1)(a) of the RMA stipulates that no person may in relation to the bed of any lake or river use, erect, reconstruct, place, alter, extend, remove, or demolish any structure or part of any structure in, on, under, or over the bed, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Land use permits are issued by the Council under Section 87(a) of the RMA.

Coastal permits

Section 12(1)(b) of the RMA stipulates that no person may erect, reconstruct, place, alter, extend, remove, or demolish any structure that is fixed in, on, under, or over any foreshore or seabed, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Coastal permits are issued by the Council under Section 87(c) of the RMA.

Discharge Permit

Pursuant to the Resource Management Act 1991
a resource consent is hereby granted by the
Taranaki Regional Council

Name of Consent Holder:	New Plymouth District Council Private Bag 2025 New Plymouth 4342
Decision Date (Change):	28 May 2018
Commencement Date (Change):	28 May 2018 (Granted Date: 9 November 2011)

Conditions of Consent

Consent Granted:	To discharge contaminants into land at a cemetery in circumstances where they may enter water
Expiry Date:	1 June 2046
Review Date(s):	June 2020, June 2026, June 2032, June 2038
Site Location:	279 Junction Road, New Plymouth
Grid Reference (NZTM)	1697558E-5667612N
Catchment:	Waiwhakaiho

For General, Standard and Special conditions
pertaining to this consent please see reverse side of this document

General condition

a. The consent holder shall pay to the Taranaki Regional Council all the administration, monitoring and supervision costs of this consent, fixed in accordance with section 36 of the Resource Management Act 1991.

Special conditions

1. This consent authorises the discharge of contaminants to land associated with the burial of deceased persons at a cemetery. Subject to the other conditions of this consent, burials shall occur only in the areas identified as 'potential burial areas' on the plan titled 'Location of burial areas' attached to this document.

2. No burial shall occur within 50 metres of any surface water body.

3. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimise any actual or likely adverse effect on the environment associated with the discharge. The best practicable option includes, but is not limited to:

   a) ensuring graves are no deeper than 0.8 metres above the seasonally high watertable; and

   b) spreading the burials, in both time and location, to reduce point source loading of contaminants.

4. At least three months before the first burial, and at five-yearly intervals thereafter, the consent holder shall provide the Chief Executive, Taranaki Regional Council with a plan showing the specific areas where burials will occur.

5. The consent holder shall prepare a report that details how compliance with condition 3 will be achieved. The report shall be submitted for the approval of the Chief Executive, Taranaki Regional Council, acting in a certification capacity, at least three months before the first burial, and at five-yearly intervals thereafter.

6. The consent holder shall notify the Chief Executive, Taranaki Regional Council, in writing of the date that the cemetery will become operative, at least 1 month before. Notification shall include the consent number and a brief description of the activity consented and shall be emailed to worknotification@trc.govt.nz.

7. This consent shall lapse on 31 December 2021, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

8. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2014 and/or June 2020 and/or 2026 and/or June 2032 and/or June 2038 and for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Signed at Stratford on 28 May 2018

For and on behalf of
Taranaki Regional Council

_____

A D McLay
Director - Resource Management