Todd Petroleum Mining Company Ltd and Todd Energy Seismic Surveys

Monitoring Programme Annual Report 2015/21

Technical Report 2023-87

Taranaki Regional Council

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Executive summary

Todd Petroleum Mining Company Limited held Consent 10276-1 and Todd Energy Limited Consent 10352-1, 10353-1, and Shell Todd Oil Services Limited (STOS) held Consent 10303-1. All companies are subsidiaries of Todd Corporation (the Company).

This report for the period July 2015 to June 2021 describes the monitoring programme implemented by Taranaki Regional Council (the Council) in relation to the discharges to land associated with two seismic surveys. The report details the results of the monitoring undertaken, assesses the Company's environmental performance during the period under review and the environmental effects of each seismic survey.

During the period, the Company demonstrated a high level of environmental performance and a high level of administrative performance with the resource consents.

The Company held four resource consents in relation to the discharges and potential effects associated with a seismic survey. Consents included a total of 23 conditions setting out the requirements that the Company must satisfy.

The consents authorised discharges from two separate survey areas. The first undertaken was the Kapuni 3D seismic survey covered a large area of approximately 450km^2 within the South Taranaki and Stratford districts. The second and smaller Mangahewa 3D Survey covered an area approximately 85km^2 across Tikorangi and extending outward toward Tarata. The remaining two consents 10303-1 and 10353-1 were issued in relation to drilling a well within 100m of a water supply well and for the discharge of contaminants into land from the use of drilling muds respectively.

This report covers the results and findings of the monitoring programme implemented by the Council in respect of the consents held by the Company. This is the sole report to be prepared by the Council to cover the Company's discharges and potential effects in relation to the Kapuni and Mangahewa 3D seismic surveys.

The Council's monitoring programme for the period under review included 99 groundwater samples collected for physicochemical analysis. The monitoring programme also included a significant data review component, with all data submitted by the Company assessed for compliance on receipt.

The monitoring showed that the Company's activities were carried out in compliance with the conditions of the applicable resource consents. There were no unauthorised incidents recording non-compliance in respect of the resource consents held by the Company in relation to these activities or provisions in regional plans, during the period under review. The results of groundwater quality monitoring undertaken show no adverse effects of the activity on local groundwater resources.

During the period, the Company demonstrated a high level of environmental performance and a high level of administrative performance with the resource consents.

For reference, in the 2021-2022 year, consent holders were found to achieve a high level of environmental performance and compliance for 88% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 10% of the consents, a good level of environmental performance and compliance was achieved.

In terms of overall environmental and compliance performance by the Company over the last several years, this report shows that the Company's performance generally remains at a high level.

This report includes recommendations to be implemented during any subsequent seismic surveys.

Table of contents

Page

1. Introduction 1
   1.1 Compliance monitoring programme reports and the Resource Management Act 1991 1
      1.1.1 Introduction 1
      1.1.2 Structure of this report 1
      1.1.3 The Resource Management Act 1991 and monitoring 2
      1.1.4 Evaluation of environmental and administrative performance 2
   1.2 Process description 2
   1.3 Resource consents 4
   1.4 Monitoring programme 7
      1.4.1 Introduction 7
      1.4.2 Programme liaison and management 7
      1.4.3 Site selection 7
         1.4.3.1 Kapuni 3D seismic survey 7
         1.4.3.2 Mangahewa 3D seismic survey 8
      1.4.4 Groundwater sampling 8
      1.4.5 Assessment of data submitted by the Company 9

2. Results 11
   2.1 Groundwater sampling 11
   2.2 Provision of consent holder data 21
      2.2.1 Kapuni 3D 21
      2.2.2 Mangahewa 3D 21
   2.3 Investigations, interventions, and incidents 22

3. Discussion 24
   3.1 Discussion of site performance 24
   3.2 Environmental effects of exercise of consents 24
   3.3 Evaluation of performance 25
   3.4 Alterations to future monitoring programmes 28

4. Recommendations 29

Glossary of common terms and abbreviations 30

Bibliography and references 32

Appendix I Resource consents held by Todd Petroleum Mining Company Ltd and Todd Energy Ltd

Appendix III Kapuni 3D seismic survey groundwater sampling results

Appendix IV Mangahewa 3D seismic survey groundwater sampling results

List of tables

Table 1 Resource consents held by the Company during the monitoring period 4
Table 2 Groundwater monitoring sites Kapuni 3D (blue) and Mangahewa 3D (purple) 9
Table 3 Kapuni 3D monitoring site type, primary purpose and number of samples used in assessment 11
Table 4 Mangahewa 3D monitoring site type, primary purpose and number of samples used in assessment 12
Table 5 Minimum and maximum results compared to baseline GND2565 and GND1755 13
Table 6 Range of results compared to baseline GND0971 and GND0941 14
Table 7 Range of results compared to baseline GND1142 and GND1113 15
Table 8 Range of results compared to baseline GND0027 and GND1119 16
Table 9 Range of results compared to baseline GND2566 and GND2589 17
Table 10 Range of results compared to baseline GND2705 and GND2706 18
Table 11 Range of results compared to baseline GND2707 and GND2708 19
Table 12 Range of results compared to baseline GND2709 and GND2710 20
Table 13 A summary of data provided under consent conditions 22
Table 14 Summary of performance for Consent 10276-1 25
Table 15 Summary of performance for Consent 10303-1 26
Table 16 Summary of performance for Consent 10352-1 26
Table 17 Summary of performance for Consent 10353-1 27

List of figures

Figure 1 Seismic survey schematic example 3
Figure 2 Kapuni 3D seismic survey area and monitoring site locations 5
Figure 3 Mangahewa 3D seismic survey area and monitoring site locations 6
Figure 4 Image of the movement of a water through the groundwater system (USGS Graphic) 8

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 2015 to June 2021 by Taranaki Regional Council (the Council) on the monitoring programme associated with resource consents held by Todd Energy Limited and its subsidiary[1] (the Company) in relation to seismic survey activities. During the period under review, the Company held four resource consents. Two for the discharge of contaminants to land related to the detonation of explosives. One in relation to the discharge to land of drilling muds and one in relation to a seismic survey detonation point within 100m of a pre-existing groundwater abstraction. The consents authorised discharges from two separate survey areas.

The first survey (Kapuni 3D) was across a large area approximately 450km^2 of South Taranaki and Stratford districts. The consent for this survey was originally held by STOS however, in 2017, Todd Energy Limited acquired STOS assets and inherited the Kapuni 3D monitoring requirements.

Consent 10276-1 permitted the discharge of explosives related to a seismic survey to land. Consent 10303-1 was issued for undertaking the survey within 100m of a groundwater supply.

The second survey (Mangahewa 3D) was undertaken under Consent 10352-1 across an area approximately 85km^2 covering a large part of Tikorangi and extending outward toward Tarata. Consent 10353-1 was issued for the discharge to land of drilling muds associated with the Mangahewa 3D seismic drilling programme.

This report covers the results and findings of the monitoring programme implemented by the Council in respect of the consents held by the Company. This is the sole report to be prepared by the Council to cover the Company's seismic surveys and their effects.

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 consents held by the Company for activities related to a seismic survey;
- the nature of the monitoring programme in place for the period under review; and
- a description of the activities and operations conducted by the Company.

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 future programmes.

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[1] Todd Petroleum Mining Company Ltd hold consent 10276-1.

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' in as much 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 the Company, this report also assigns a rating as to each Company's environmental and administrative performance during the period under review. The rating categories are high, good, improvement required and poor for both environmental and administrative performance. The interpretations for these ratings are found in Appendix II.

For reference, in the 2021-2022 year, consent holders were found to achieve a high level of environmental performance and compliance for 88% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 10% of the consents, a good level of environmental performance and compliance was achieved.[2]

1.2 Process description

Hydrocarbon exploration activities, with the authorisation of New Zealand Petroleum and Minerals, can include a seismic survey designed to gather information about the geological structure at depth. Surveys are conducted by deploying an array of energy sources and an array of sensors or receivers in the area of interest. The source of the seismic waves is either an explosive, which directly generates the seismic wavelet, or a mechanical source which is commonly a vibrator, that uses a steel base plate in contact with the ground to transmit seismic waves beneath the ground. The seismic waves that travel through the

[2] The Council has used these compliance grading criteria for more than 21 years. They align closely with the 4 compliance grades in the MfE Best Practice Guidelines for Compliance, Monitoring and Enforcement, 2018

ground are received on geophone sensors planted on the surface at different offsets or incremental distances away from the source point. The seismic traces are recorded as a function of time delay from the initiation of the source.

In a two-dimensional (2D) seismic survey both the energy source and the sensors are set along a straight line with the same line containing recording cables and sensors as well as the source points.

In a three-dimensional (3D) seismic survey, the energy source and sensors are planted in a grid or "array" formation with sensors set in way that enables them to pick up waves from multiple sources.

The primary risks related to a Seismic Survey are those related to point source contamination from the explosives themselves (detonated and undetonated) and diffuse or point source contamination created by the open drill holes which may provide a pathway to the aquifer from surface runoff.

The key products[3] that may arise from the detonation of explosives during a seismic survey are:

- Aluminium oxide; (as a solid)
- Carbon; (soot as a solid)
- Carbon dioxide; (gas)
- Carbon monoxide; (gas)
- Nitrogen (gas) which has the potential to convert to nitrate and ammonia; and
- Water.

The main contaminants related to any undetonated charges[2] are:

- Trinitrotoluene (TNT);
- Pentaerythritol tetranitrate (PETN); and
- Aluminium powder.

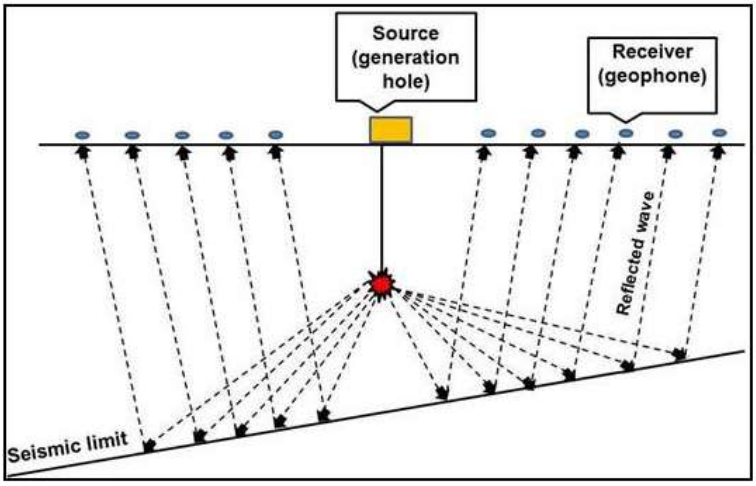

Figure 1 Seismic survey schematic example

[3] Pattle Delamore Partners Limited (PDP) April 2016. Kapuni 2016 Seismic Survey – Discharge of Explosive Residues to Land and Water

1.3 Resource consents

The Company held four consents during the monitoring period being reported. A summary of each consent is included in Table 1 below. Summaries of the conditions attached to each permit are set out in Section 3 of this report. All four consents have now expired.

A summary of the various consent types issued by the Council is included in Appendix I, as are copies of all permits held by the Company during the period under review.

Consents 10276-1 and 10352-1 were issued for the discharge of contaminants related to the detonation and degradation of explosive charges in relation to the Kapuni 3D and Mangahewa 3D seismic surveys respectively. Consent 10353-1 was issued for the discharge of drilling muds in relation to the Mangahewa 3D survey and Consent 10303-1 due to the identification of a pre-existing ground water supply located within 100m of a seismic survey source hole.

Consents 10276-1 and 10303-1 were issued to Shell Todd Oil Services Limited (STOS) a joint venture between Todd Energy Limited and Shell Oil Services. Consent 10303-1 expired on 31 December 2016 and Consent 10276-1 and all its remaining responsibilities were transferred solely to the Company on 31 May 2019.

Table 1 summarises the details of all four consents which are all now expired.

Figure 2 shows the location of the Kapuni 3D survey and Figure 3 the location of the Mangahewa 3D survey

Table 1 Resource consents held by the Company during the monitoring period

Consent number	Purpose	Granted	Review	Expired
Discharges to land related to a Seismic Survey				
10276-1	To discharge contaminants to land where they may enter groundwater, including residues from detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey.	11 April 2016	N/A	01 Jun 2021
10352-1	To discharge contaminants to land where they may enter groundwater, including residues from detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey.	03 November 2016	N/A	01 Jun 2021
10353-1	To discharge contaminants into land where they may enter groundwater from use of drilling muds associated with undertaking a seismic survey	03 Nov 2016	N/A	01 Jun 2021
Installation of a bore within 100m of a water supply				
10303-1	To drill a well for seismic survey purposes	7 Jun 2016	N/A	30 Dec 2016

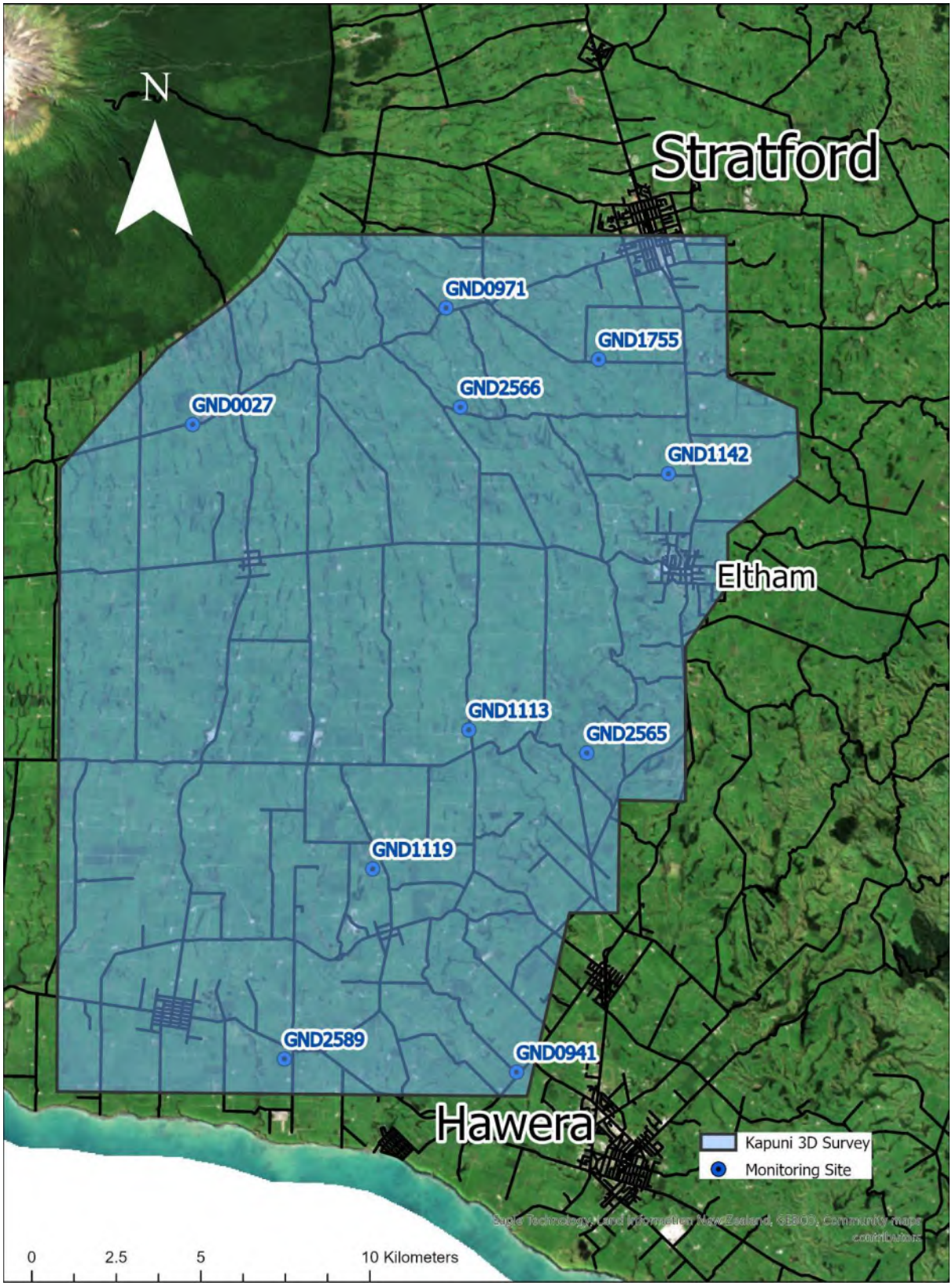

Figure 2 Kapuni 3D seismic survey area and monitoring site locations

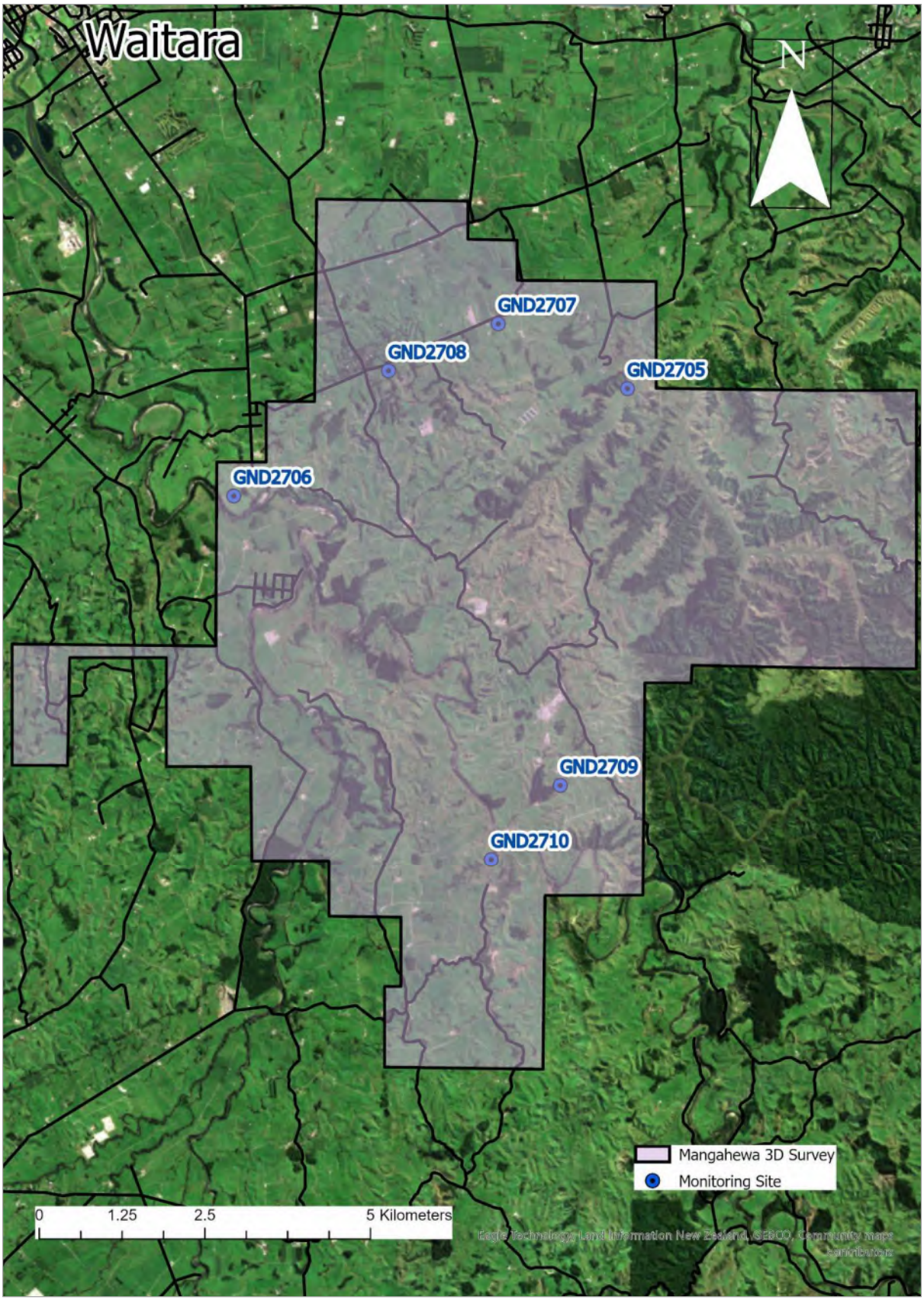

Figure 3 Mangahewa 3D seismic survey area and monitoring site locations

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 monitoring programme for the Company's seismic surveys consisted of five primary components.

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 for any consent reviews, renewals or new consent applications;
- advice on the Council's environmental management strategies and content of regional plans; and
- consultation on associated matters.

All costs associated with programme liaison and management are covered by the consent holder.

1.4.3 Site selection

The criteria for site selection differed between the two surveys. The Kapuni 3D monitoring programme included predominantly pre-existing sites and the Mangahewa 3D following lessons learned from the Kapuni and Tamarind (which is reported on separately) seismic surveys a mixture of converted exploration geotechnical holes (geoholes) and purpose built monitoring bores. Site selection criteria is summarised below.

1.4.3.1 Kapuni 3D seismic survey

The Kapuni 3D seismic survey activities were consented retrospectively. Therefore, as the activities had already commenced and the risk of any significant groundwater contamination was considered low, the main purpose of site selection was to provide for good spatial coverage of the seismic survey footprint. Sites selected included predominantly pre-existing bores and wells required to meet the following criteria:

- Located down-gradient of source points; and
- Cover a range of geological units and land use types

Following completion of the survey, one purpose built bore was also installed to enable monitoring down gradient of an unexploded charge.

1.4.3.2 Mangahewa 3D seismic survey

Site selection for the Mangahewa 3D seismic survey was undertaken prior to commencement of the activities and included both recently drilled converted exploration holes and purpose built monitoring bores. Site selection and subsequent bore installation were required to meet the following criteria:

- Down-gradient of source points;
- Good spatial coverage to include:
  - At least one site in each main land-use zone;
  - At least one site in each major geological unit; and
- Head works on each site to be secured to avoid any potential surface water ingress.

1.4.4 Groundwater sampling

Ten monitoring sites were included in the monitoring programme undertaken in relation to the Kapuni 3D seismic survey. All sites were between 100 to 400 m away from a source point. Monitoring sites were chosen from available pre-existing sites across the survey footprint.

Groundwater samples were obtained following drilling of the seismic holes and prior to detonation of the explosives. The main purpose of the monitoring programme was to monitor shallow groundwater resources across the seismic survey footprint to ensure that they remained suitable for current use.

Six monitoring sites were included in the monitoring programme undertaken in relation to the Mangahewa 3D Seismic Survey which covered a significantly smaller area than the Kapuni survey. All monitoring sites were located between 30 to 90m from a source point.

In addition to the primary purpose of the monitoring programme, which was to ensure groundwater resources remained suitable for their current use, the Mangahewa 3D survey also enabled the collection of water quality data in closer proximity to the discharges. To ascertain if any detectable contamination remained in the groundwater system following detonation of the explosives.

To enable the secondary purpose of the programme monitoring sites need to intercept groundwater flow, which moves both laterally and vertically under gravitational and locally induced hydraulic gradients, directly from the location of the detonated explosive charges. (Figure 4).

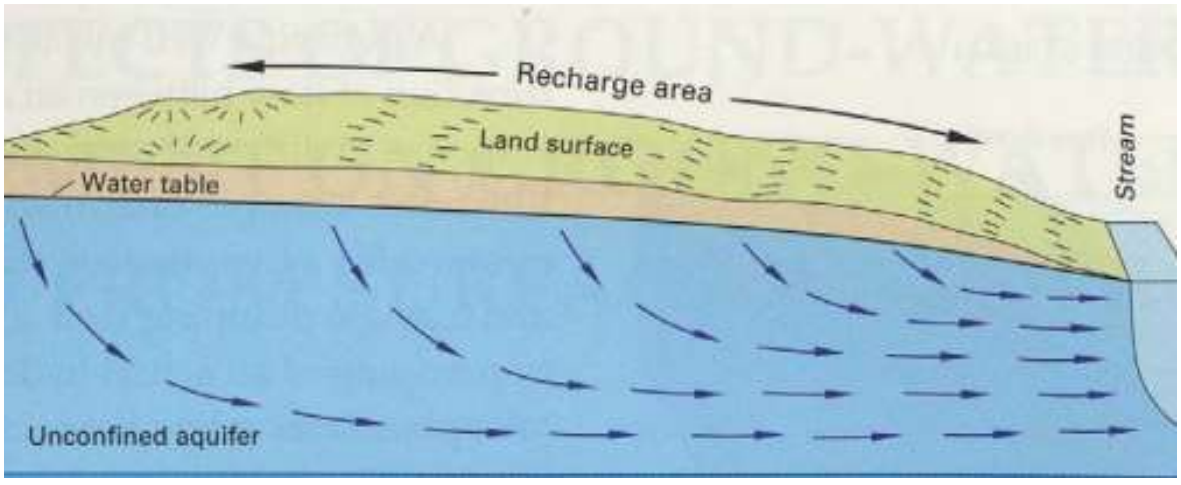

Figure 4 Image of the movement of a water through the groundwater system (USGS Graphic)

Details of the groundwater monitoring sites are listed below in Table 2. The location of each monitoring site in relation to the seismic survey footprint being monitored are illustrated in Figure 2 and Figure 3.

Table 2 Groundwater monitoring sites Kapuni 3D (blue) and Mangahewa 3D (purple)

Site code	NZTM	NZTM	Distance to closest source point	Type	Interval (m BMP)**	Depth (m BMP)
GND0027	1697264	5638923	250	Supply bore	43.6-53.6	53.6
GND0941	1706848	5619765	216	Supply bore	Open hole at 43	43.0
GND0971	1704760	5642367	272-277	Supply bore	unknown	42.6
GND1113*	1705435	5629886	216	Unused well	0.5-17	17
GND1119	1702590	5625776	123	Unused well	0.5-20.1	20.1
GND1142	1711338	5637465	365	Supply bore	36-39	39
GND1755	1709272	5640847	132	Supply bore	Open ended	21
GND2565	1708924	5629204	110	Supply well	0.5-12.2	12.2
GND2566	1705186	5639432	350	Supply bore	Open ended	18
GND2589	1699983	5620155	19	Purpose built bore	9-18	18
GND2705	1716533	5677287	30	Geo hole-converted	24-30	150
GND2706	1710589	5675665	36	Geo hole-converted	Open	150
GND2707	1714583	5678265	31	Geo hole-converted	24-30	150
GND2708	1712926	5677556	33	Purpose built bore	24-30	35.7
GND2709	1715519	5671291	90	Purpose built bore	8-14	14.5
GND2710	1714476	5670168	36	Purpose built bore	30-42	86

**wellhead is open to surface ** supply well intervals are estimated (assumed unlined below surface casing*

Groundwater samples taken by BTW on behalf of the Company and by the Council were sent to Hill laboratories (Hills) and analysed for a range of parameters including the following:

- pH;
- alkalinity;
- ammonia;
- nitrate and nitrite;
- total hardness;
- free carbon dioxide;
- conductivity;
- total dissolved solids;
- magnesium, potassium, sodium, calcium, chloride and sulphate;
- dissolved boron, copper, iron, manganese, zinc and phosphorus; and
- Escherichia coli (*E. coli*).

The parameters above are deemed sufficient to enable identification of any significant changes in groundwater quality related to a seismic survey.

1.4.5 Assessment of data submitted by the Company

A significant component of the monitoring programme was the assessment of consent holder submitted data. The Company was required to submit a wide range of data under the conditions of their discharge consents as follows:

- The locations and depths of each shot hole and explosive;
- The date that each charge was detonated;
- Details of any misfires; and
- The date and method of each hole abandonment.

As required by the conditions of each consent, The Company was also required to submit a groundwater monitoring programme for review that included:

- Water quality criteria for applicable existing uses;
- The location of each sampling point and the frequency of sampling;
- A list of the analysis to be undertaken for contaminants that could result from the discharges authorised; and
- How and when the results of monitoring will be reported to the Council.

Additional reports were also required at 6 monthly intervals following completion of each groundwater sampling round.

2. Results

2.1 Groundwater sampling

Groundwater sampling in relation to the activity was undertaken by BTW, on behalf of the Company with the exception of the final round of sampling which was undertaken by the Council.

Results were reported and discussed in the scheduled reports submitted by BTW on behalf of the Company. The final round of sampling was undertaken by the Council and the baseline water quality sampling at each site and each post activity sampling round were compared to ascertain any trends. There was insufficient data available to undertake an additional robust statistical analysis.

Water quality results show there were no significant changes in groundwater composition attributable to the detonation of explosives, at any site monitored across the reporting period. This is demonstrated by the relatively narrow ranges between the pre-detonation and post-detonation results.

Kapuni 3D monitoring sites

Pre-existing wells and bores

- Two sites GND1113 and GND1119 which are both wide diameter unused wells reported the presence of *E. coli* during some of the sampling rounds. This is not uncommon in these types of wells and indicates the wells may have been receiving surface water runoff.
- GND2589 reported the presence of *E. coli* in 2019. This bore is located on the fence line of a paddock and is flush with the ground making it susceptible to contamination from the surface especially during sampling when the lid is removed.
- Nitrate could be seen increasing and carbon dioxide decreasing in GND2565, likely an indicator of impacts from local agricultural use.
- GND0971 and GND1755 both reported an increase in carbon dioxide following detonation. Although GND0971 also showed a significant increase in 2019 so these concentrations are also likely a result of local activities, rather than a result of a more widespread decrease in water quality.
- Most monitoring sites exhibited fluctuations in some parameters but none of the sites exhibited any significant decrease in water quality that would result in it becoming unsuitable for its current use.

Purpose built monitoring bore

- GND2589 recorded PETN concentrations below detection limits during 2016 and 2017 sampling rounds. No further analysis was undertaken for the presence of PETN due the logistical issues of sending the samples overseas and as the unexploded charges had likely degraded after two years of burial. No other parameters reported indicated that the charges had impacted local groundwater resources.

Table 3 Kapuni 3D monitoring site type, primary purpose and number of samples used in assessment

Site code	Type	Primary purpose	Samples (n)
GND0027	Supply well	Residue from exploded charges and water quality changes over time	6
GND0941	Supply bore	Residue from exploded charges and water quality changes over time	8
GND0971	Supply bore	Residue from exploded charges and water quality changes over time	8
GND1113	Unused well	Water quality changes over time (*E. coli* present pre-detonation)	6
GND1119	Unused well	Water quality changes over time (*E. coli* present pre-detonation)	6
GND1142	Supply bore	Residue from exploded charges and water quality changes over time	6

Site code	Type	Primary purpose	Samples (n)
GND1755	Supply bore	Residue from exploded charges and water quality changes over time	8
GND2565	Supply well	Water quality changes over time (*E. coli* present pre-detonation)	8
GND2566	Supply bore	Residue from exploded charges and water quality changes over time	7
GND2589	Purpose built bore	Degradation of unexploded charges	7

There were some anomalous results, considered to be unrelated to the seismic survey reported across the period. These results are summarised below:

Mangahewa 3D monitoring sites

Converted geoholes

- The high pH and elevated concentrations of calcium carbonate, total dissolved solids and electrical conductivity reported in the baseline sample taken from the converted geohole GND2705 indicated that the borehole may have been contaminated with residual drilling muds. This hole was resampled in April by which time concentrations had reduced significantly.
- The artesian groundwater and elevated concentrations of ammoniacal nitrogen and manganese in the converted geohole GND2706 indicate the aquifer interval intercepted by the bore is anoxic. The occasional presence of *E. coli* is also likely a result of contamination during sampling.
- The increase in TDS, electrical conductivity and ammoniacal nitrogen indicates that the converted geohole GND2707 may have collapsed at depth.

Purpose built monitoring bores

- The presence of *E. coli* and elevated free carbon dioxide during all sampling rounds and the increase in EC in Nov 2018 and June 2019 in the purpose built monitoring bore GND2709 indicate that the bore may have been receiving surface water inflow.
- *E. coli* was recorded in both the purpose built monitoring bores GND2708 and GND2710 during the baseline sampling round undertaken in March 2017 indicating these bores had not been adequately airlifted following installation. Both bores were re-airlifted and sampled again in April 2017. There was no *E. coli* recorded in GND2710 and although *E. coli* was still recorded in GND2709 these had died off by the October 2017 sampling round.

Table 4 Mangahewa 3D monitoring site type, primary purpose and number of samples used in assessment

Site code	Type	Primary purpose	Samples (n)
GND2705	Geohole	Residue from exploded charges and water quality changes over time	6
GND2706	Geohole	Residue from exploded charges and water quality changes over time	4
GND2707	Geohole	Residue from exploded charges and water quality changes over time	3
GND2708	Mon. bore	Water quality changes over time (*E. coli* present pre-detonation)	6
GND2709	Mon. bore	Water quality changes over time (*E. coli* present pre-detonation)	6
GND2710	Mon. bore	Residue from exploded charges and water quality changes over time	4

A summary of the results for the Kapuni monitoring programme are included below in Table 5 to Table 9 and for the Mangahewa monitoring programme Table 10 to Table 12. The complete suite of sampling results are included as Appendix III.

Table 5 Minimum and maximum results compared to baseline GND2565 and GND1755

Bore id		GND2565			GND1755		
Sample range		Baseline	Minimum	Maximum	Baseline	Minimum	Maximum
Date		24/02/2016	2016-2021		28/04/2016	2016-2021	
pH	-	6.7	6.5	7	7.2	6.9	7.2
Alkalinity	g/m^3 $CaCo_3$	49	40	55	58	34	61
Free carbon dioxide	g/m^3 @25 ˚C	22	8.9	23	6.5	6.5	21
Total hardness	$CaCo_3$	55	49	72	46	44	96
Electrical conductivity	µS/cm	236	220	256	180	173	302
Total dissolved solids	g/m^3	158	143	172	121	116	200
Boron	g/m^3	0.0168	0.016	0.018	0.0143	0.0138	0.017
Calcium	g/m^3	12.3	11.1	15.8	13.2	11.9	13.2
Magnesium	g/m^3	5.9	5.2	7.9	3.2	3.2	16.2
Potassium	g/m^3	-	3.5	3.5	-	0	0
Sodium	g/m^3	22	22	25	13.3	11.4	17.1
Chloride	g/m^3	25	22	31	12.8	11.9	59
Manganese	g/m^3	0.00155	0.00025	0.0027	0.0036	0.0011	0.049
Dissolved Copper	g/m^3	0.00057	0.00025	0.0017	0.004	0.0006	0.0092
Dissolved Iron	g/m^3	0.01	0.01	0.054	0.42	0.01	0.52
Dissolved zinc	g/m^3	0.0046	0.0015	0.0195	0.048	0.0177	0.3
Ammoniacal nitrogen	g/m^3	-	0.005	0.015	-	0.005	<0.010
Nitrite	g/m^3 N	-	0.001	<0.10	-	0.001	<0.10
Nitrate	g/m^3 N	3.6	3.6	6.5	1.73	1.11	3
Nitrite and nitrate	g/m^3 N	-	4.6	6.5	-	1.5	3
Sulphate	g/m^3	11	7.9	13.1	5.3	5	7.1
Phosphorus	g/m^3	NR	0.01	0.05	NR	0.01	0.11
E. coli	MPN/100mL	45	1	201	<1	<1	19

Table 6 Range of results compared to baseline GND0971 and GND0941

Bore id		GND0971			GND0941		
		Baseline	Minimum	Maximum	Baseline	Minimum	Maximum
Date		28/04/2016	2016-2021		12/02/2016	2016-2021	
pH	-	7.1	6.8	7.3	6.8	6.8	7.4
Alkalinity	g/m^3 $CaCo_3$	77	75	81	72	44	72
Free carbon Dioxide	g/m^3 @25 ˚C	13.1	8.3	93	21	6.1	21
Total hardness	$CaCo_3$	68	60	76	83	79	104
Electrical conductivity	µS/cm	226	208	255	338	335	393
Total dissolved solids	g/m^3	151	139	171	230	220	260
Boron	g/m^3	0.0182	0.017	0.0182	0.027	0.024	0.029
Calcium	g/m^3	16.6	14.2	18.1	17.3	16.8	20
Magnesium	g/m^3	6.4	6	7.5	9.7	9	12.8
Potassium	g/m^3	-	6.9	6.9	-	6.1	6.1
Sodium	g/m^3	14.9	14.9	16.9	31	27	33
Chloride	g/m^3	15.8	11.8	20	45	40	47
Manganese	g/m^3	0.092	0.056	0.103	0.4	0.36	0.4
Dissolved Copper	g/m^3	0.0085	0.00025	0.0085	0.0046	0.00025	0.0046
Dissolved Iron	g/m^3	19.1	0.01	19.1	3.7	0.22	4.1
Dissolved zinc	g/m^3	0.189	0.0112	0.93	0.023	0.0059	0.27
Ammoniacal nitrogen	g/m^3	-	0.005	0.005	-	<0.010	0.133
Nitrite	g/m^3 N	-	0.001	<0.10	-	0.001	<0.10
Nitrate	g/m^3 N	0.47	0.147	0.83	0.025	0.001	<0.10
Nitrite and nitrate	g/m^3 N	-	0.149	0.29	-	0.001	<0.10
Sulphate	g/m^3	-	8.9	9.8	22	22	73
Phosphorus	g/m^3	Not required	0.031	0.17	Not required	0.01	0.21
E. coli	MPN/100mL	<1	<1	3	<1	<1	<1

Table 7 Range of results compared to baseline GND1142 and GND1113

Bore id		GND1142			GND1113		
		Baseline	Minimum	Maximum	Baseline	Minimum	Maximum
Date		22/06/2016	2016-2021		16/06/2016	2016-2021	
pH	-	7.4	6.8	7.6	7.1	6.4	7.1
Alkalinity	g/m^3 $CaCo_3$	71	70	79	43	23	43
Free carbon Dioxide	g/m^3 @25 ˚C	6.2	3.7	22	6.8	6.8	30
Total hardness	$CaCo_3$	59	58	62	60	28	62
Electrical conductivity	µS/cm	227	226	240	254	113	254
Total dissolved solids	g/m^3	152	146	161	170	76	170
Boron	g/m^3	0.0164	0.0164	0.02	0.062	0.024	0.112
Calcium	g/m^3	14.3	13.9	14.7	12.6	6.3	13
Magnesium	g/m^3	5.6	5.6	6.2	7	3	7.3
Potassium	g/m^3	-	7.1	7.1	-	-	-
Sodium	g/m^3	19.5	19.5	22	23	8.9	23
Chloride	g/m^3	19.4	19.4	20	22	12.6	24
Manganese	g/m^3	0.15	0.149	0.2	0.00025	0.00025	0.0079
Dissolved Copper	g/m^3	0.00025	0.00025	0.0022	0.00082	0.0008	0.0041
Dissolved Iron	g/m^3	4.9	0.18	5	0.01	0.01	0.12
Dissolved zinc	g/m^3	0.0076	0.001	0.0163	0.0006	0.0006	0.0096
Ammoniacal nitrogen	g/m^3	0.142	0.104	0.61	0.005	0.005	0.046
Nitrite	g/m^3 N	0.01	0.001	<0.10	0.001	0.001	<0.10
Nitrate	g/m^3 N	0.025	0.001	0.35	4.2	1.38	6.4
Nitrite and nitrate	g/m^3 N	-	0.01	0.36	-	1.38	6.5
Sulphate	g/m^3	12.8	6.5	12.8	27	4.8	27
Phosphorus	g/m^3	Not required	0.01	0.18	Not required	0.01	0.11
E. coli	MPN/100mL	<1	<1	<1	11	11	727

Table 8 Range of results compared to baseline GND0027 and GND1119

Bore id		GND0027			GND 1119		
		Baseline	Minimum	Maximum	Baseline	Minimum	Maximum
Date		22/06/2016	2016-2021		13/07/2016	2016-2021	
pH	-	6.5	6.5	7.2	8.1	6.5	8.1
Alkalinity	g/m^3 $CaCo_3$	34	30	42	43	35	43
Free carbon Dioxide	g/m^3 @25 ˚C	23	5.6	23	23	3.5	27
Total hardness	$CaCo_3$	38	34	46	85	85	125
Electrical conductivity	µS/cm	141	134	160	334	334	452
Total dissolved solids	g/m^3	95	95	107	220	220	300
Boron	g/m^3	0.0157	0.014	0.016	0.028	0.026	0.032
Calcium	g/m^3	11	10.3	12.4	16.2	16.2	25
Magnesium	g/m^3	2.5	2.1	3.5	10.8	10.7	15.9
Potassium	g/m^3	-	6.4	6.4	-	4.4	4.4
Sodium	g/m^3	8.9	8.9	10.9	28	28	36
Chloride	g/m^3	13.2	12.6	14.1	37	37	48
Manganese	g/m^3	0.003	0.0027	0.012	0.00025	0.00025	<0.0005
Dissolved Copper	g/m^3	0.0058	0.0016	0.0058	0.0021	0.0006	0.0021
Dissolved Iron	g/m^3	0.041	0.01	0.041	0.015	0.01	<0.02
Dissolved zinc	g/m^3	0.041	0.0116	0.102	0.0134	0.001	0.0186
Ammoniacal nitrogen	g/m^3	0.005	0.005	<0.010	1.7	0.005	1.7
Nitrite	g/m^3 N	0.001	0.001	<0.10	0.001	0.001	<0.10
Nitrate	g/m^3 N	1.64	1.53	2.4	0.001	0.001	21
Nitrite and nitrate	g/m^3 N	-	1.53	2.4	-	14.6	21
Sulphate	g/m^3	6.3	5.9	6.3	35	19.8	35
Phosphorus	g/m^3	Not required	0.01	0.01	NR	0.01	0.01
E. coli	MPN/100mL	<1	<1	<1	1	1	19

Table 9 Range of results compared to baseline GND2566 and GND2589

Bore id		GND2566			GND2589		
		Baseline	Minimum	Maximum	Baseline	Minimum	Maximum
Date		9/03/2016	2016-2021		23/08/2016	2016-2021	
pH	-	6.9	6.8	7.5	6.4	6.4	6.8
Alkalinity	g/m^3 $CaCo_3$	56	54	80	41	41	56
Free carbon Dioxide	g/m^3 @25 ˚C	14.6	9.9	18.4	32	25	69
Total hardness	$CaCo_3$	60	58	82	280	130	280
Electrical conductivity	µS/cm	204	201	257	1099	698	1099
Total dissolved solids	g/m^3	137	130	172	730	470	730
Boron	g/m^3	0.0137	0.013	0.019	0.029	0.023	0.03
Calcium	g/m^3	14.8	14	16.2	58	28	58
Magnesium	g/m^3	5.7	5.7	10.1	33	14.6	33
Potassium	g/m^3	-	5.9	5.9	-	14.9	15.1
Sodium	g/m^3	14.6	14.6	19.9	80	71	84
Chloride	g/m^3	16.4	15.4	16.4	188	89	188
Manganese	g/m^3	0.0039	0.00025	0.166	1.66	0.33	1.66
Dissolved Copper	g/m^3	0.0057	0.00025	0.0057	0.0006	0.00025	0.0006
Dissolved Iron	g/m^3	0.179	0.01	1.23	23	1.78	25
Dissolved zinc	g/m^3	0.0128	0.0047	0.61	0.0097	0.0015	0.0181
Ammoniacal nitrogen	g/m^3	-	0.005	0.011	1	0.006	1
Nitrite	g/m^3 N	-	0.001	<0.10	0.012	0.001	0.61
Nitrate	g/m^3 N	4.2	0.22	4.2	0.07	0.01	0.66
Nitrite and nitrate	g/m^3 N	-	0.22	4	-	0.35	0.54
Sulphate	g/m^3	4.3	4.1	20	194	134	194
Phosphorus	g/m^3	Not required	0.06	0.07	0.19	0.01	0.25
E. coli	MPN/100mL	<1	<1	<1	<1	<1	59
PETN	ppm	Not required	Not required	Not required	<200	<200	<200

Table 10 Range of results compared to baseline GND2705 and GND2706

Bore id	Unit	GND2705			GND2706		
	-	Baseline	Minimum	Maximum	Baseline	Minimum	Maximum
Date	-	April-2017	2017-2021		March-2017	2017-2021	
pH	-	11.3	9.1	11.3	8.5	7.9	8.8
Alkalinity	g/m^3 $CaCo_3$	168	55	168	49	47	190
Free carbon Dioxide	g/m^3 @25 ˚C	<1.0	<1.0	86	<1.0	<1.0	4.9
Total hardness	CaCo3	29	14.3	49	169	169	320
Electrical conductivity	µS/cm	2550	326	3580	1556	1556	1828
Total dissolved solids	g/m^3	1710	220	2400	1040	1040	1220
Boron	g/m^3	1.57	0.21	3.9	0.022	0.022	0.065
Calcium	g/m^3	11.7	5.6	19.5	34	32	84
Magnesium	g/m^3	<0.04	<0.04	8.8	20	20	28
Potassium	g/m^3	-	3.8	4.4	-	4.9	4.9
Sodium	g/m^3	480	52	780	220	220	260
Chloride	g/m^3	610	49	1090	450	450	470
Manganese	g/m^3	<0.0010	<0.0010	0.025	0.48	0.27	0.59
Dissolved Copper	g/m^3	<0.0010	<0.0010	0.0007	<0.0005	0.0021	0.0021
Dissolved Iron	g/m^3	<0.04	<0.02	<0.04	<0.02	0.99	4
Dissolved zinc	g/m^3	<0.002	<0.0010	<0.005	<0.0010	<0.0010	0.0162
Ammoniacal nitrogen	g/m^3	8.7	0.89	8.7	2	1.64	2
Nitrite	g/m^3 N	<0.002	< 0.002	<0.10	<0.002	<0.002	<0.10
Nitrate	g/m^3 N	<0.002	< 0.002	<0.10	<0.002	<0.002	<0.10
Nitrite and nitrate	g/m^3 N	<0.002	< 0.002	0.01	<0.002	<0.002	<0.10
Sulphate	g/m^3	17.7	3.7	17.7	<0.5	<0.5	<0.5
Phosphorus	g/m^3	<0.04	<0.004	<0.2	<0.02	<0.02	<0.02
E. coli	MPN/100mL	<1	<1	<1	<1	<1	5

Table 11 Range of results compared to baseline GND2707 and GND2708

Bore id	Unit	GND2707 (samples - 3)			GND2708 (samples 6)		
	-	Baseline	Post survey	Post survey	Baseline	Minimum	Maximum
Date	-	Mar-2017	Oct-2017	May 2018	Apr-2017	2017-2021	
pH	-	10.3	10.6	10.2	7.6	7.3	7.6
Alkalinity	g/m^3 $CaCo_3$	137	66	68	95	87	95
Free carbon Dioxide	g/m^3 @25 ˚C	<1.0	<1.0	<1.0	5.3	5.3	109
Total hardness	CaCo3	55	17.4	12.9	82	82	89
Electrical conductivity	µS/cm	462	1288	2120	227	213	227
Total dissolved solids	g/m^3	310	860	1420	152	143	152
Boron	g/m^3	0.38	0.94	1.67	0.017	0.012	0.017
Calcium	g/m^3	18.3	69	5.1	17.8	17.6	19.1
Magnesium	g/m^3	2.2	0.02	0.06	9.2	8.8	10.1
Potassium	g/m^3	-	-	-	-	1.34	1.47
Sodium	g/m^3	73	260	410	14	11.9	14
Chloride	g/m^3	54	320	590	12.2	11.4	12.4
Manganese	g/m^3	0.0029	<0.0005	0.0012	0.22	0.0007	0.22
Dissolved Copper	g/m^3	0.0007	<0.0005	<0.0005	<0.0005	< 0.0005	0.0009
Dissolved Iron	g/m^3	0.11	<0.02	<0.02	0.16	<0.02	0.16
Dissolved zinc	g/m^3	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0046
Ammoniacal nitrogen	g/m^3	1.4	4.6	6.6	0.044	< 0.010	0.046
Nitrite	g/m^3 N	0.044	<0.002	<0.002	0.005	< 0.002	0.005
Nitrate	g/m^3 N	0.012	<0.002	0.006	0.012	< 0.002	0.72
Nitrite and nitrate	g/m^3 N	0.056	0.003	0.006	0.017	< 0.002	0.72
Sulphate	g/m^3	9.3	18.5	15.1	4.6	3.6	4.6
Phosphorus	g/m^3	0.16	0.03	0.03	<0.02	<0.02	0.052
E. coli	MPN/100mL	<1	<1	<1	61*	<1	61*

Note- high baseline result due to ineffective bore development

Table 12 Range of results compared to baseline GND2709 and GND2710

Bore id	Unit	GND2709 (Samples 6)			GND2710 (Samples 4)		
	-	Baseline	Minimum	Maximum	Baseline	Minimum	Maximum
Date	-	1/04/2017	2017-2021		1/04/2017	2017-2021	
pH	-	6.8	6.1	8.7	8.7	8.5	8.7
Alkalinity	g/m^3 $CaCo_3$	75	31	620	600	600	630
Free carbon Dioxide	g/m^3 @25 ˚C	25	25	720	2.5	2.3	3.6
Total hardness	CaCo3	60	14.5	67	18.6	15.6	18.6
Electrical conductivity	µS/cm	207	151	1174	1162	1155	1193
Total dissolved solids	g/m^3	139	101	790	780	770	800
Boron	g/m^3	0.018	0.015	2.6	2.3	2.3	2.7
Calcium	g/m^3	13	3.2	14.2	4	3.3	4
Magnesium	g/m^3	6.6	1.59	7.7	2.1	1.69	2.1
Potassium	g/m^3	-	1.59	1.77	-	1.69	1.69
Sodium	g/m^3	15	14.4	310	300	290	320
Chloride	g/m^3	15.7	15.3	41	42	38	42
Manganese	g/m^3	0.33	0.0048	0.33	0.0111	0.0042	0.144
Dissolved Copper	g/m^3	<0.0005	<0.0005	0.0014	<0.0005	<0.0005	<0.0005
Dissolved Iron	g/m^3	6.1	< 0.02	12.6	0.03	<0.02	0.03
Dissolved zinc	g/m^3	0.0026	< 0.0010	0.0058	<0.0010	<0.0010	0.0028
Ammoniacal nitrogen	g/m^3	1.1	<0.10	1.58	0.9	0.46	1
Nitrite	g/m^3 N	0.004	<0.10	0.007	<0.002	<0.002	<0.10
Nitrate	g/m^3 N	0.007	< 0.002	0.36	<0.002	<0.002	<0.10
Nitrite and nitrate	g/m^3 N	0.011	0.003	0.36	<0.002	<0.002	<0.10
Sulphate	g/m^3	3	< 0.5	9.9	<0.5	<0.5	<0.5
Phosphorus	g/m^3	<0.02	<0.02	0.19	0.23	0.08	0.26
E. coli	MPN/100mL	2	<1	11	<1	<1	<1

Note all Mangahewa baseline samples reported for April 2017 are repeat samples that replaced original baseline samples that returned erroneous results due to ineffective airlifting and/or bore disinfection prior to sampling.

2.2 Provision of consent holder data

2.2.1 Kapuni 3D

The Kapuni 3D seismic survey comprised of >23,000 GEOPRIME dbx charges that were detonated at depths between 2.5m and 19m below ground. A summary of the programme is as follows:

- Holes were drilled between 13 December 2015 and 3 May 2016;
- Charges detonated between 25 February 2016 and 5 May 2016;
- Holes were all backfilled between 28 February and 31 May 2016;
- The majority of holes (99.5%) were backfilled within 30 days of detonation;
- The remaining 134 holes (<0.5%) were backfilled within 31-75 days of detonation;
- 28 miss fires were recorded; and
- 31 shots could not be detonated due to access issues.

Several of the monitoring sites included in the programme could not be sampled prior to commencement of detonation (GND0971, GND1142, GND1113, GND0027, GND1119) however due to the slow movement of groundwater, the distance of the monitoring locations to active source points and the purpose of the programme, which was to monitor any discharges from detonation and/or significant changes in water quality over the longer-term the first sample collected from each site is considered indicative of baseline.

Holes were backfilled with cuttings, and a plastic cap was placed in each hole approximately 1m below ground and the top soil replaced and compacted to ground level. Where artesian groundwater was encountered the hole was pumped, backfilled, and capped with a bentonite plug. Abandonment of all shot holes was undertaken between 28 February and 31 May 2016. A small percentage of explosives were either not detonated (31) or not abandoned within the 30 day requirement (134). Due to either artesian water delaying the abandonment or landowner access issues.

The date each hole was drilled, the shot was placed and detonated and the day each holes was backfilled and abandoned were all provided.

Specific monitoring of the effects of unexploded charges on groundwater quality were undertaken following installation of a purpose built bore.

A monitoring programme was provided, and additional reports were also submitted following the analysis of each scheduled interim water quality sampling round.

2.2.2 Mangahewa 3D

The Mangahewa 3D seismic survey comprised of >5,000 GEOPRIME dbx charges that were detonated at depths between 4m and 59m below ground. A summary of the programme is as follows:

- Holes were drilled between 22 November 2016 and 19 December 2017;
- Charges were detonated between 14 March 2017 and 2 April 2017;
- Holes were all backfilled between 28 March 2017 and 8 May 2017;
- All holes were backfilled within 30 days of detonation;
- 14 miss fires were recorded and
- Miss fires were detonated between 26 March 2017 and 10 April 2017; and

- All shots were detonated

As required by the conditions of their consent, the Company also submitted a groundwater monitoring programme which included details of the location and frequency of sampling. A list of the analysis to be undertaken, and how and when the results of monitoring would be reported to the Council.

Specific monitoring of the effects of unexploded charges on groundwater quality was not required as all charges were successfully detonated.

All charges were detonated between 14 May and 2 May 2017. There were 14 misfires reported, and no undetonated charges remaining in the ground following the survey. The method and date of abandonment for each shot hole was also provided. Holes were backfilled with cuttings and topsoil and where groundwater was encountered in the hole, bentonite was used to seal the hole and prevent surface water ingress. Abandonment of all shot holes was undertaken between 28 March 2017 and 8 May 2017.

All data was provided within the required timeframes with the exception of the Monitoring Programme as discussed below.

A summary of the data provided is included in Table 13 below.

There were some minor issues with timely submission of some reports but generally all required data was submitted within the consented timeframe.

Table 13 A summary of data provided under consent conditions

Survey	Survey area (m^2)	Number of shots set	Drilled depths (range m)	Shot depths (range m)	Shots that were not detonated	Abandonment within 30 days (% shots)
Kapuni 3D	450	23,822	7-22	2.5-19	59	>99.5
Mangahewa 3D	85	5,115	4-59	4-59	0	100

2.3 Investigations, interventions, and incidents

The monitoring programme for the period was based on what was considered to be an appropriate level of monitoring, review of data, and liaison with the Company. During the period 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.

For all significant compliance issues, as well as complaints from the public, the Council maintains a database record. The record includes events where the individual/organisation concerned has itself notified the Council. Details of any investigation and corrective action taken are recorded for non-compliant events.

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 individual/organisation is indeed the source of the incident (or that the allegation cannot be proven).

One minor non-compliance was recorded due to inconsistencies between the analytes required to be analysed as part of the Mangahewa 3D monitoring programme and the analytes actually analysed following sample collection.

Phosphorus was analysed on several occasions in place of potassium. The Company and their consultants were contacted and asked to update the lab template to ensure future samples were analysed as per the requirements of the monitoring programme.

A breach of condition 6b of Consent 10276-1 was also recorded. Two sites were not abandoned within the 30 day requirement following detonation. The Company were contacted on 13 June 2016 for an explanation. The Company advised that two seismic holes had intercepted artesian groundwater and therefore the first

attempt to seal the hole within the 30 day limit had been unsuccessful. Several attempts were made by the restoration crew and the holes were effectively sealed and abandoned within the following ten days.

3. Discussion

3.1 Discussion of site performance

Potential bi-products from the detonation of explosives include the release of carbon dioxide and, nitrogen gas which has the potential to convert to nitrate and ammonia.

Nitrate and ammonia results from all monitoring sites remained similar from pre-activity through to the final sampling round and there were no significant increases recorded in free carbon dioxide concentrations.

General ions and cations which are indicative of general water quality and local geology differed slightly between sites and fluctuated between sampling rounds.

The pre-detonation results indicated the presence of *E. coli* in some bores/wells which is generally indicative of poor wellhead protection and therefore also potentially surface water ingress. Although the presence of *E. coli* is not ideal, as due to the low volume of potential contaminants produced by a seismic survey any surface water infiltration could mask any potential effects from the activity. Due to the significant number of seismic holes that were drilled, which although not requiring consent for installation under the RFWP, do have the potential to provide a conduit directly into the aquifer. These sites were still considered of value and remained in the programme to assess any significant water quality changes in the aquifer over the longer term.

The vast majority of charges were detonated successfully and the majority of holes were abandoned within consented timeframes. There has been no evidence to suggest that the activities undertaken in relation to either seismic survey have had any adverse effect on local groundwater quality that could result in it becoming unsuitable for its current use.

Overall the seismic programmes were successfully undertaken with the vast majority of explosives detonated, backfilled and abandoned within the agreed timeframes, resulting in the reduction of the risk of any potential adverse effects.

Although no adverse environmental effects have been recorded by the Council in relation to the monitored seismic surveys.

Monitoring of these two large surveys did not find any adverse effects on the receiving environment however, these two surveys represent a small portion of ongoing seismic work undertaken in the region therefore, a recommendation that groundwater monitoring remain an integral part of any future seismic survey activities has been included in this report. Once several surveys have been undertaken and the risk assessment has been satisfied, then the possibility of groundwater sampling could possibly be removed from future programmes.

In addition, due to the nature of gases in the groundwater system and the predominant land-uses across the region, which include intensive dairy, farming and oil and gas production the source of any significant changes in the concentrations of carbon dioxide or nitrogen species if found, would be difficult to ascertain. Therefore, a recommendation that any future programmes include the installation of purpose built bores, if no other bores exist in close proximity, under the supervision of an experienced and qualified hydrogeologist to ensure the monitoring sites are secure, has also been included in this report.

3.2 Environmental effects of exercise of consents

No adverse environmental effects have been recorded by the Council in relation to either of the seismic surveys.

The groundwater monitoring component of this programme included the collection, analysis and assessment of 70 samples from ten monitoring sites in the vicinity of the Kapuni seismic survey footprint

and 29 samples from six sites in the vicinity of the Mangahewa 3D seismic survey footprint. The results of the monitoring carried out show that the groundwater composition at each site was similar pre-detonation and post-detonation. Some minor fluctuations in analyte concentrations are attributable to standard sampling variability, and or likely a result of land-use and natural groundwater evolution over time, The presence of *E. coli* in some samples indicate that some sites may have received some surface water runoff, unrelated to the survey.

There is no evidence to suggest that activities undertaken by the Company during either seismic survey have had any adverse effect on local groundwater quality.

Compliance with the conditions of the Company's seismic survey related consents during the reporting 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 period under review is set out in Tables 14 to Table 17.

Table 14 Summary of performance for Consent 10276-1

Purpose: To discharge contaminants to land where they may enter groundwater, including residues from detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
1. Activity to be undertaken in accordance with the information provided in the application	Assessment of consent holder records and data	Yes
2. Discharge of contaminants to remain within the designated area	Receipt of final shot hole locations	Yes
3. No more than 1 charge per shot hole	Assessment of consent holder records and data	Yes
4. No detonations to occur after 30 September 2018	Receipt of data required by condition 5	Yes
5. Data is to be provided monthly and must include: • Shot hole locations; • Hole and explosive depths • Amount of explosive in each hole; • The date of discharge; • Locations and details of misfires; and • The date each hole was appropriately abandoned	Review of monthly reports.	Yes
6. The consent holder shall minimise any effects on groundwater by; • Ensuring charge is placed and recapped on the same day; and • Holes are restored and abandoned within 30 working days of detonation	Review of detonation and abandonment records	No
7. The consent holder shall not cause any change in water quality that would result in it being unsuitable for its current use	Assessment of groundwater quality data	Yes

Purpose: To discharge contaminants to land where they may enter groundwater, including residues from detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
8. The consent holder shall undertake a programme of sampling and testing (the 'Monitoring Programme') that monitors the effects of the exercise of this consent on freshwater resources	Monitoring Programme submitted to the Chief Executive, Taranaki Regional Council.	No- the Monitoring Programme was not submitted in a timely manner which resulted in sampling being undertaken prior to certification by the Council.
9. The Monitoring Programme is required to be implemented within 10 working days of consent issue	Implementation of Monitoring Programme	Yes
10. Consent review provision	N/A	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent Overall assessment of administrative performance in respect of this consent		**High** **Good**

Table 15 Summary of performance for Consent 10303-1

Purpose: To drill a well for seismic survey purposes		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
1. The well be capped at the surface to on the same day that the charge is placed and re-capped on the same day as detonation	Receipt of satisfactory information	Yes
2. Backfilled and sealed before 30 November 2016	Receipt of satisfactory information	Yes
Overall assessment of consent compliance and environmental performance in respect of this consent Overall assessment of administrative performance in respect of this consent		**High** **High**

Table 16 Summary of performance for Consent 10352-1

Purpose: *To* discharge contaminants to land where they may enter groundwater, including residues from detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
1. Activity to be undertaken in accordance with the information provided in the application	Assessment of consent holder records and data	Yes
2. Discharge of contaminants to remain within the designated area	Receipt of final shot hole locations	Yes
3. No more than 1 charge per shot hole	Assessment of consent holder records and data	Yes
4. No detonations to occur after 30 September 2018	Receipt of data required by condition 5	Yes

Purpose: *To* discharge contaminants to land where they may enter groundwater, including residues from detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
5. Data is to be provided monthly and must include: • Shot hole locations; • Hole and explosive depths • Amount of explosive in each hole; • The date of discharge; • Locations and details of misfires; and • The date each hole was appropriately abandoned	Review of monthly reports.	Yes
6. The consent holder shall minimise any effects on groundwater by; • Ensuring charge is placed and recapped on the same day; and • Holes are restored and abandoned within 30 working days of detonation	Review of detonation and abandonment records	Yes
7. The consent holder shall not cause any change in water quality that would result in it being unsuitable for its current use	Assessment of groundwater quality data	Yes
8. The consent holder shall undertake a programme of sampling and testing (the 'Monitoring Programme') that monitors the effects of the exercise of this consent on freshwater resources	Monitoring Programme submitted to the Chief Executive, Taranaki Regional Council.	Yes
9. Consent review provision	N/A	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent Overall assessment of administrative performance in respect of this consent		**High** **High**

Table 17 Summary of performance for Consent 10353-1

Purpose: To discharge contaminants into land where they may enter groundwater from use of drilling muds associated with undertaking a seismic survey		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
1. Activity to be undertaken in accordance with information provided within the consent application	Receipt of satisfactory information	Yes
2. BPO condition	Receipt of satisfactory information	Yes
Overall assessment of consent compliance and environmental performance in respect of this consent Overall assessment of administrative performance in respect of this consent		**High** **High**

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

3.4 Alterations to future monitoring programmes

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 any future programmes that the range of monitoring carried out during the Kapuni and Mangahewa 3D seismic surveys be continued.

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 in the future.

4. Recommendations

1. THAT in the first instance, monitoring of consented activities for future programmes continue at the same level these programmes; and
2. THAT future programmes include installation of fit for purpose site specific monitoring bores under the supervision of a qualified and experienced hydrogeologist following consultation with Taranaki Regional Council.

Glossary of common terms and abbreviations

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

Aquifer (freshwater)	A formation, or group or part of a formation that contains sufficient saturated permeable media to yield exploitable quantities of fresh water.
BPO	Best practicable option.
Conductivity	A measure of the level of dissolved salts in a sample. Usually measured at 25°C and expressed as microsiemens per metre (µS/cm or as Total Dissolved Solids (g/m^3).
Confining layer	A geological layer or rock unit that is impermeable to fluids.
Deep well injection (DWI)	Injection of fluids at depth for disposal or enhanced recovery.
Fracture gradient	A measure of how the pressure required to fracture rock in the earth's crust changes with depth. It is usually measured in units of "pounds per square inch per foot" (psi/ft) and varies with the type of rock and the strain of the rock.
g/m^3	Grams per cubic metre. A measure of concentration which is equivalent to milligrams per litre (mg/L), or parts per million (ppm).
Hydraulic fracturing (HF)	The process of increasing reservoir permeability by injecting fluids at pressures sufficient to fracture rock within the reservoir ("fracking").
Injectate	Fluid disposed of by deep well injection.
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.
IR	Unauthorised 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 BGL	Metres below ground level.
m BMP	Metres below measuring point.
µS/cm	Microsiemens per metre.
mS/m	Millisiemens per metre.
m TVD	Metres true vertical depth.
m TVDBGL	Metres true vertical depth below ground level.
m^3	Cubic metre.
N/A	Not applicable.

pH	Numerical system for measuring acidity in solutions, with 7 as neutral. Values lower than 7 are acidic and higher than 7 are 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.
Produced water	Water associated with oil and gas reservoirs that is produced along with the oil and gas. Typically highly saline with salt concentrations similar to seawater and containing low levels of hydrocarbons.
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).
UI	Unauthorised Incident.
Water flooding	A method of thermal recovery in which hot water is injected into a reservoir through specially distributed injection wells. Hot water flooding reduces the viscosity of the crude oil, allowing it to move more easily toward production wells.

For further information on analytical methods, contact a manager within Environment Quality Department.

Bibliography and references

API (2006) Downward Solute Plume Migration: Assessment, Significance, and Implications for Characterization and Monitoring of "Diving Plumes" Bulletin 24 April 2006.

BTW (2016) STOS Kapuni Seismic Groundwater Monitoring Programme V6 final #1754843.

BTW (2017) Todd Mangahewa 3D Groundwater Monitoring Programme V5 final #1894716.

BTW (2019) Todd Kapuni Groundwater Monitoring Programme Report July 2019 #2299452.

BTW (2019) Todd Mangahewa 3D Seismic Groundwater Monitoring Programme July 2019 #2299455.

Ministry for the Environment. 2018. Best Practice Guidelines for Compliance, Monitoring and Enforcement under the Resource Management Act 1991. Wellington: Ministry for the Environment.

Stevens G. (2001): Taranaki: In: *Groundwaters of New Zealand*, M.R, Rosen and P.A. White (eds). New Zealand Hydrological Society Inc., Wellington. P381-386.

STOS – Kapuni 3D Seismic Survey all charges spreadsheet Frodo #1696143.

Todd- Mangahewa 3D Seismic Survey all charges spreadsheet Frodo #2794644.

Appendix I

Resource consents held by
Todd Petroleum Mining Company Ltd and Todd Energy Ltd

(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:	Todd Petroleum Mining Company Limited PO Box 802 New Plymouth 4340
Decision Date:	11 April 2016
Commencement Date:	11 April 2016

Conditions of Consent

Consent Granted:	To discharge contaminants to land where they may enter groundwater, including residues from detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey
Expiry Date:	1 June 2021
Review Date(s):	3 months of receiving a report under condition 5 and/or 8
Site Location:	Various locations throughout the South Taranaki District & Stratford Districts
Catchment:	Various

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. The activity shall be undertaken in general accordance with the information provided in support of the application for this consent. Where there is conflict between the application and the consent conditions the conditions shall prevail.

2. This consent authorises the discharge of contaminants resulting from undertaking a seismic survey only within the area shown on the map attached. The contaminants include:
   (a) those arising from placing charges of Dyno Nobel Geoprime® dBX™ explosive, each no more than 2 kg, at depths between 2 and 20 metres below ground; and
   (b) residues from detonating charges of Dyno Nobel Geoprime® dBX™ explosive, each no more than 2 kg, at depths between 2 and 20 metres below ground.

3. No more than one charge shall be placed in each shot hole unless it is necessary to address a misfire, in which case another charge of up to 2 kg may be added.

4. The discharges shall be from the progressive detonation of charges with no detonations occurring after 31 December 2016.

5. The consent holder shall report the following information to the Chief Executive, Taranaki Regional Council on the first day of each month, with the first monthly report to include information in relation to all previous activity:
   (a) the NZTM grid reference of the location of each shot hole;
   (b) the depth of each shot hole and depth of the explosive;
   (c) the amount of explosive in each shot hole;
   (d) the date that each charge was detonated;
   (e) the location of shot holes where the charge misfired and details of any additional charge that may have been placed in the hole; and
   (f) the date that each shot hole is abandoned and details of the method of abandonment.

6. To minimise any effects on groundwater all shot holes shall be:
   (a) capped at surface to minimise the ingress of surface water on the same day that the charge is placed and re-capped on the same day as detonation and data acquisition occurs; and
   (b) restored and abandoned within 30 working days of detonation.

7. The activity shall not cause any change in groundwater quality that results in it being unsuitable for its current use.

8. The consent holder shall undertake a programme of sampling and testing that identifies the effects of the exercise of this consent on groundwater resources over the duration of the consent (the 'Monitoring Programme'). The Monitoring Programme may be reviewed from time to time but at all times shall be certified by the Chief Executive, Taranaki Regional Council, and shall include:

   (a) water quality criteria for applicable existing uses;

   (b) the location of each sampling point and the frequency of sampling;

   (c) a listing of analyses to be undertaken for contaminants that could result from the discharges authorised;

   (d) specific monitoring of the effects of unexploded charges on groundwater quality; and

   (e) details of how and when the results of monitoring will be reported to the Taranaki Regional Council.

9. The Monitoring Programme required by condition 8 shall be implemented within 10 working days of this consent being issued and remain in place for the term of the consent. Until the Monitoring Programme is implemented the current monitoring regime shall continue.

10. 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 within 3 months of receiving a report in accordance with condition 5 and/or 8 above, 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.

Transferred at Stratford on 1 August 2017

For and on behalf of
Taranaki Regional Council

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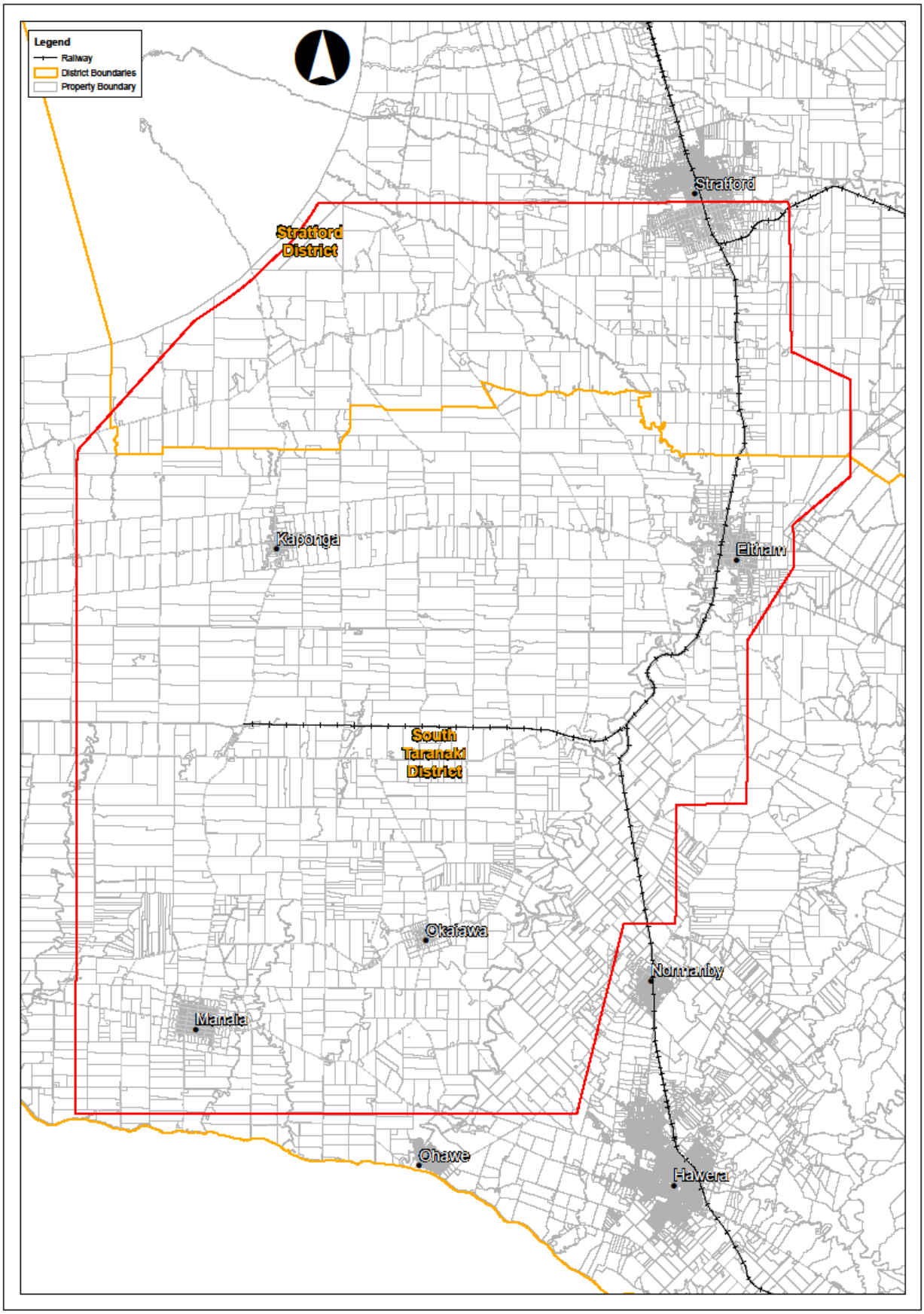
A D McLay
Director - Resource Management



Map showing area of Kapuni 3d seismic survey

Discharge Permit

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

Name of Consent Holder:	Todd Energy Limited PO Box 802 New Plymouth 4340
Decision Date:	03 November 2016
Commencement Date:	03 November 2016

Conditions of Consent

Consent Granted:	To discharge contaminants to land where they may enter groundwater, including residues from detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey
Expiry Date:	01 June 2021
Review Date(s):	In accordance with special conditions 5 & 8
Site Location:	Various locations in the Tikorangi area as per Appendix 1
Grid Reference (NZTM)	Various
Catchment:	Various

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. The activity shall be undertaken in general accordance with the information provided in support of the application for this consent. Where there is conflict between the application and the consent conditions the conditions shall prevail.

2. This consent authorises the discharge of contaminants resulting from undertaking a seismic survey only within the area shown on the map attached (Appendix 1). The contaminants include:

   (a) those arising from placing charges of Dyno Nobel Geoprime® dBX™ explosive, each no more than 2 kg, at depths between 10 and 50 metres below ground; and

   (b) residues from detonating charges of Dyno Nobel Geoprime® dBX™ explosive, each no more than 2 kg, at depths between 10 and 50 metres below ground.

3. No more than one charge shall be placed in each shot hole unless it is necessary to address a misfire, in which case another charge of up to 2 kg may be added.

4. The discharges shall be from the progressive detonation of charges with no detonations occurring after 30 April 2017.

5. The consent holder shall report the following information to the Chief Executive, Taranaki Regional Council on the first day of each month, with the first monthly report to include information in relation to all previous activity:

   (a) the NZTM grid reference of the location of each shot hole;

   (b) the depth of each shot hole and depth of the explosive;

   (c) the amount of explosive in each shot hole;

   (d) the date that each charge was detonated;

   (e) the location of shot holes where the charge misfired and details of any additional charge that may have been placed in the hole; and

   (f) the date that each shot hole is abandoned and details of the method of abandonment.

6. To minimise any effects on groundwater all shot holes shall be:

   (a) capped at surface to minimise the ingress of surface water on the same day that the charge is placed and re-capped on the same day as detonation and data acquisition occurs; and
   (b) restored and abandoned within 30 working days of detonation.

7. The activity shall not cause any change in groundwater quality that results in it being unsuitable for its current use.

8. The consent holder shall undertake a programme of sampling and testing that identifies the effects of the exercise of this consent on groundwater resources over the duration of the consent (the 'Monitoring Programme'). The Monitoring Programme may be reviewed from time to time but at all times shall be certified by the Chief Executive, Taranaki Regional Council, and shall include:

   (a) water quality criteria for applicable existing uses;

   (b) the location of each sampling point and the frequency of sampling;

   (c) a listing of analyses to be undertaken for contaminants that could result from the discharges authorised;

   (d) specific monitoring of the effects of unexploded charges on groundwater quality; and

   (e) details of how and when the results of monitoring will be reported to the Taranaki Regional Council.

9. 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 within 3 months of receiving a report in accordance with condition 5 and/or 8 above, 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 03 November 2016

For and on behalf of
Taranaki Regional Council

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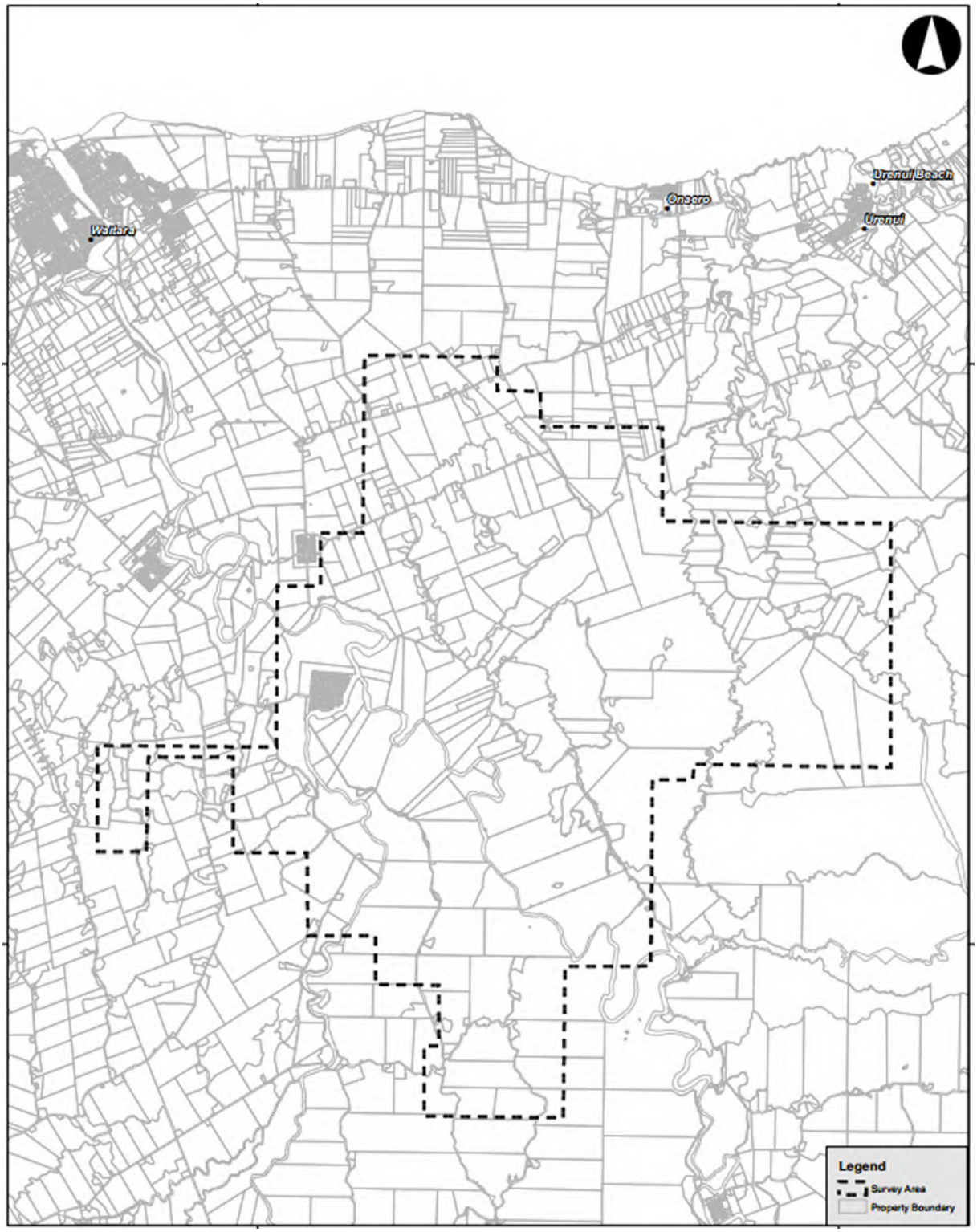
A D McLay
Director - Resource Management

Appendix 1



Mangahewa 3D seismic survey depicted by dotted line

Discharge Permit

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

Name of Consent Holder:	Todd Energy Limited PO Box 802 New Plymouth 4340
Decision Date:	03 November 2016
Commencement Date:	03 November 2016

Conditions of Consent

Consent Granted:	To discharge contaminants into land where they may enter groundwater from use of drilling muds associated with undertaking a seismic survey
Expiry Date:	01 June 2021
Site Location:	Various locations throughout the Tikorangi area
Grid Reference (NZTM)	Various
Catchment:	Various

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. The activity shall be undertaken in general accordance with the information provided in support of the application for this consent. Where there is conflict between the application and the consent conditions the conditions shall prevail.

2. 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 of contaminants from the site, including but not limited to effects on any water body or soil.

Signed at Stratford on 03 November 2016

For and on behalf of
Taranaki Regional Council

_____

A D McLay
Director - Resource Management

Appendix II

Categories used to evaluate environmental and administrative performance

Categories used to evaluate environmental and administrative performance

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 the Company'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 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 during investigations of incidents reported to the Council by a third party 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 during investigations of incidents reported to the Council by a third party. 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 during investigations of incidents reported to the Council by a third party. 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.

Appendix III

Kapuni 3D seismic survey groundwater sampling results

TECHNICAL REPORT

Kapuni Groundwater Monitoring Programme Report

for Todd Energy Limited

Rev 4 - 04/07/2019



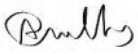
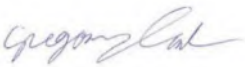



BTW COMPANY

SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

Kapuni Groundwater Monitoring Programme Report

for Todd Energy Limited

	Reviewed	
Report Author		04/07/2019
	Alex Connolly Environmental Scientist, MSc Env Sci	Date
Reviewed by		04/07/2019
	Greg Larkin, Senior Environmental Scientist, MSc Env Sci	Date

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Rev 4 - 04/07/2019

CONTENTS

1 INTRODUCTION 1

1.1 Kapuni 3D Groundwater Monitoring Programme-Background 1
1.2 Objectives 1
1.3 Scope 1
1.4 Applicable Guideline Values 1

2 GROUNDWATER MONITORING EVENT (GME) METHODOLOGY 2

2.1 Specific Site Details 2
2.2 Groundwater Sampling Methodology 2
2.3 Chain of Custody 2

3 RESULTS 3

3.1 Groundwater Monitoring Event (GME) 3
3.2 Groundwater quantity 3
3.3 Groundwater Quality 4

4 DISCUSSION 7

4.1 Suitability of GMP Sites: Review 7
4.1.1 GND 2589's Suitability 7
4.1.2 GND 0971's Suitability 8

5 CONCLUSION AND RECOMMENDATIONS 9

6 LIMITATIONS 10

REFERENCES 11

APPENDIX A KAPUNI GMP SITE LOCATION MAP 12
APPENDIX B KAPUNI GMP SITE SPECIFIC DETAILS 13
APPENDIX C KAPUNI GMP FIELD SHEETS 13
APPENDIX D KAPUNI GMP CHAIN OF CUSTODY FORMS 15
APPENDIX E KAPUNI GMP HILL LABORATORIES REPORT 16
APPENDIX F TRC DISCHARGE PERMIT 10276-1.0 17

TABLES

Table 3.1: GME Groundwater Level Data 3
Table 3.2: GME Results for GND 0971 4
Table 3.3: GME Results for GND 2589 5
Table 3.4: GMP Site Medians 6

1 INTRODUCTION

1.1 Kapuni 3D Groundwater Monitoring Programme-Background

In 2016, Shell Todd Oil Services (STOS) was granted resource consent 10276-1.0 to "discharge contaminants to land where they may enter groundwater, including residues from the detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey". Special conditions 8 and 9 in this resource consent outline the requirement to establish a long-term monitoring programme of the groundwater resources adjacent to activated source points and a single site monitoring an inactivated source point. See Appendix F for resource consent.

The Ground Water Monitoring Programme (GMP) was developed in conjunction with Taranaki Regional Council (TRC) Science staff with ten groundwater monitoring sites selected in the original GMP. In 2018, the GMP was reviewed by Todd Energy (Todd) and TRC staff, with only two sites selected for continued inclusion.

1.2 Objectives

The primary objective of the monitoring programme was to provide water chemistry data from representative groundwater wells/bores adjacent to activated and an inactivated source point within the Kapuni 3D seismic survey area. The water chemistry data would assist in delineating any potential or actual adverse effects to the groundwater resources as a result of the discharge of contaminants associated with the Kapuni 3D seismic survey. The water chemistry data also provides valuable data for landowners and the regulatory authorities on the shallow groundwater quality in the South Taranaki area.

1.3 Scope

Todd took over operation of the Kapuni natural gas field from STOS in August 2017. This included all assets and associated TRC discharge consents. The Kapuni 3D Groundwater Monitoring Programme (GMP) was then transferred to the control of Todd. Todd engaged BTW Company (BTW) to continue the groundwater monitoring under the previous scope of works. All information pertaining to previous GMP reports, including site selection criteria, is available upon request from Todd.

1.4 Applicable Guideline Values

As agreed upon with the TRC during the establishment of the GMP, the two most applicable standards/guidelines were the New Zealand Drinking Water Standard (NZDWS 2008) and the Australia and New Zealand Environment Conservation Council (ANZECC 2000) guidelines.

- The New Zealand Drinking Water Standard (NZDWS 2008) is a conservative standard to use as part of this monitoring programme. The NZDWS (2008) assesses risk to human health, even though the water resources sampled for the monitoring programme are generally only used for stock drinking water purposes. However, comparing the data to the NZDWS (2008) does provide reassurance to landowners about the chemistry of the water in terms of a human health perspective.
- The Australia and New Zealand Environment Conservation Council (ANZECC 2000) guidelines allows for the 95% protection of species in slightly-to-moderately disturbed ecosystems. The ANZECC (2000) guidelines are applied to the receiving water environment after reasonable mixing within the receiving water body.

2 GROUNDWATER MONITORING EVENT (GME) METHODOLOGY

The winter 2019 GME was undertaken over one day (June 19th) across two groundwater monitoring sites. The current round of monitoring is the seventh GME in the GMP, with the GMP to be externally reviewed by the TRC Science team and Todd representatives at the end of 2019.

An overview map of the site locations is contained in Appendix A of this report.

2.1 Specific Site Details

Two groundwater monitoring sites are included in the GMP, with one (GND0971) used for farming and/or domestic water supply. The remaining bore (GND2589) was specifically drilled for the purpose of monitoring an undetonated source point and is not used for any other purpose. Appendix A contains the specific details of each monitoring bore/well, including available depths to groundwater.

2.2 Groundwater Sampling Methodology

During the June 2019 GME all field measurements and observations were recorded as per BTW's internal standard operating procedures (SOP) for groundwater sampling. All field sheets are contained in 0 and a copy of the Groundwater Sampling SOP is part of the monitoring programme methodology report which was approved and provided to the TRC.

2.3 Chain of Custody

As per standard procedures with Hill Laboratories, a chain of custody (COC) form was completed and sent to the laboratory with the water samples. Information included; sample name, date of sample, test required, type of material, sent by whom, date received by lab and sample temperature.

All GME samples were chilled on ice then sent to Hill Laboratories by courier with COC maintained at all times to meet Hill Laboratories strict timeframe requirements for testing.

Hill Laboratories sent the COC form back via email the following day to complete the chain of custody requirements (Appendix D). The analysis could be tracked via an online service Hill Laboratories provides to customers, and the samples were processed under a high priority status.

3 RESULTS

3.1 Groundwater Monitoring Event (GME)

The wells/bores were sampled for the agreed test parameters for water chemistry, and the complete set of the sampling results from this GME and the previous GMEs is shown in Table 3.2 , Table 3.3 and Table 3.4.

3.2 Groundwater quantity

Available depths to groundwater for all previous GMEs are presented in Table 3.1 . Note, groundwater level data is not available for GND 0971 as it is a fully encased bore head and is, therefore, not included in this table. For GND 0971 the bore pump was operated for 1-2 minutes prior to sampling.

Table 3.1: GME Groundwater Level Data

Site	Depth to Groundwater (m below TOC)					
	13/06/2016	10/10/2016	2/05/2017	17/10/2017	15/05/2018	19/06/2019
GND 2589	4.34	4.85	4.69	2.615	4.54	5.14

TOC=*top of well casing*

Available depth to groundwater recorded in the June 2019 GME for GND 2589 was 0.6m lower than the previous May 2018 GME. These results indicate that there are large natural fluctuations in groundwater levels.

3.3 Groundwater Quality

The below tables show the monitoring results for the GME programme at site GND 0971 and GND 2589. An equipment blank was undertaken in June 2019 for quality control purposes. This was tested for *E. coli* which was <1.0 CFU/100mls.

Table 3.2: GME Results for GND 0971

Test parameter	Guideline NZDWS (2008)	GND 0971 Pre det 28-Apr-2016	GND 0971 Post Det 17-May-2016	GND 0971 Post det 10-Oct-2016	GND 0971 28-Apr-2017	GND 0971 17-Oct-2017	GND 0971 15-May-2018	GND 0971-19 - Jun-2019
Turbidity (NTU)	<2.5	**170**	**23**	**5.3**	**9.7**	**2.9**	1.91	**7**
pH (pH Units	7.0-8.5	7.1	**6.8**	**6.8**	7.3	**6.9**	**6.9**	7.1
Total Alkalinity (g/m3 as CaCO3)		77	81	153	76	75	75	76
Free Carbon Dioxide (g/m3 at 25°C)		13.1	27	76	8.3	18.5	19.8	93
Total Hardness (g/m3 as CaCO3)	<200	68	76	25	62	66	60	65
Electrical Conductivity (EC) (mS/m)		22.6	25.5	68	21.4	21.6	20.8	21
Electrical Conductivity (EC) (µS/cm)		226	255	22.9	214	216	208	210
Total Dissolved Salts (g/m3)	<1000	151	171	229	143	145	139	140
Dissolved Boron (g/m3)	1.4	0.0182	0.0172	0.017	0.017	0.018	0.017	0.018
Dissolved Calcium (g/m3)		16.6	18.1	16.2	14.4	15.4	14.2	14.5
Dissolved Copper (g/m3)	<1	0.0085	0.0022	0.001	< 0.0005	< 0.0005	0.0005	< 0.0005
Dissolved Iron (g/m3)	<0.2	**19.1**	**2.7**	0.1	<0.02	<0.02	0.07	< 0.02
Dissolved Magnesium (g/m3)		6.4	7.5	6.7	6.4	6.6	6	7.1
Dissolved Manganese (g/m3)	0.4	0.092	0.056	0.057	0.068	0.065	0.066	0.103
Dissolved Potassium (g/m3)		7.2	8.1					6.4
Dissolved Phosphorus (g/m3)				0.17	0.12	0.16	0.14	0.031
Dissolved Sodium (g/m3)	<200	14.9	16.9	16.6	16.3	16.2	16.2	15.1
Dissolved Zinc (g/m3)	<1.5	0.189	0.0112	0.03	0.93	0.32	0.43	0.152
Chloride (g/m3)	<250	15.8	20	16.6	12.8	13.5	12.7	12.3
Total Ammoniacal-N (g/m3)	<1.2			<0.010	<0.010	<0.010	<0.010	< 0.010
Nitrite-N (g/m3)				0.002	<0.002	<0.002	0.002	< 0.002
Nitrate-N (g/m3)	11.3	0.47	0.83	0.49	0.23	0.28	0.174	0.147
Nitrate-N + Nitrite-N	11.3					0.29	0.176	0.149
Sulphate (g/m3)	<250	9.9	9.2	9.6	9.8	9.5	9.8	8.9
Escherichia coli (MPN/100mls)	<1.0	<1.0	<1.0	<1.0	**3**	<1.0	<1.0	< 1.0

Note: **Bold** is above applicable guideline criteria

Table 3.3: GME Results for GND 2589

Test parameter	Guideline	GND2589 Post det 23-Aug-2016	GND 2589 Post det 12-Oct-2016	GND 2589 Post det 07-Dec-2016	GND2589 02-May-2017	GND 2589 17-Oct-2017	GND 2589 14-May-2018	GND 2589 19-Jun-2019
Turbidity (NTU)	<2.5	**55**	**5.4**		**93**	**2.7**	**29**	**113**
pH (pH Units	7.0-8.5	**6.4**	**6.5**		**6.6**	**6.5**	**6.5**	**6.8**
Total Alkalinity (g/m3 as CaCO3)		41	50		52	48	54	56
Free Carbon Dioxide (g/m3 at 25°C)		32	29		25	29	31	69
Total Hardness (g/m3 as CaCO3)	<200	**280**	**230**		**260**	130	150	**240**
Electrical Conductivity (EC) (mS/m)		109.9	94.8		106.7	69.8	74.2	92.8
Electrical Conductivity (EC) (µS/cm)		1,099	948		1,067	698	742	928
Total Dissolved Salts (g/m3)	<1000	730	600		710	470	500	620
Dissolved Boron (g/m3)	1.4	0.029	0.028		0.029	0.024	0.023	0.028
Dissolved Calcium (g/m3)		58	49		54	28	32	49
Dissolved Copper (g/m3)	<1	0.0006	<0.0005		<0.0005	<0.0005	0.0006	< 0.0005
Dissolved Iron (g/m3)	<0.2	**23**	**21**		**25**	**1.78**	**8.3**	**16.8**
Dissolved Magnesium (g/m3)		33	27		32	14.6	17	28
Dissolved Manganese (g/m3)	0.4	**1.66**	**1.49**		**1.59**	0.33	**0.49**	**1.33**
Dissolved Potassium								15.1
Dissolved Phosphorus (g/m3)		0.19	0.25		<0.02	0.02	0.1	0.019
Dissolved Sodium (g/m3)	<200	80	73		84	79	71	72
Dissolved Zinc (g/m3)	<1.5	0.0097	0.0039		0.0017	0.0181	0.0104	0.0057
Chloride (g/m3)	<250	188	155		182	89	111	151
Total Ammoniacal-N (g/m3)	<1.2	1	0.006		0.99	0.096	0.25	0.8
Nitrite-N (g/m3)		0.012	0.61		<0.02	0.015	0.014	0.049
Nitrate-N (g/m3)	11.3	0.07	0.66		<0.02	0.52	0.41	0.31
Nitrate-N + Nitrite-N	11.3					0.54	0.42	0.35
Sulphate (g/m3)	<250	194	169		178	134	135	141
Escherichia coli (MPN/100mls)	<1.0	<1.0	<1.0		<1.0	<1.0	**59**	<1.0
PETN	ppm	<200	N/A	<200	<200			

Note: **Bold** is above applicable guideline criteria

Table 3.4: GMP Site Medians

Test parameter	Guideline NZDWS (2008)	GND 2589	GND 0971
Turbidity (NTU)	<2.5	**42**	**7**
pH (pH Units	7.0-8.5	**6.5**	**6.9**
Total Alkalinity (g/m3 as CaCO3)		51	76
Free Carbon Dioxide (g/m3 at 25°C)		30	19.8
Total Hardness (g/m3 as CaCO3)	<200	**235**	65
Electrical Conductivity (EC) (mS/m)		93.8	21.6
Electrical Conductivity (EC) (µS/cm)		938	214
Total Dissolved Salts (g/m3)	<1000	610	145
Dissolved Boron (g/m3)	1.4	0.028	0.0172
Dissolved Calcium (g/m3)		49	15.4
Dissolved Copper (g/m3)	<1	0.00025	0.0005
Dissolved Iron (g/m3)	<0.2	**18.9**	0.07
Dissolved Magnesium (g/m3)		27.5	6.6
Dissolved Manganese (g/m3)	0.4	**1.41**	0.066
Dissolved Potassium (g/m3)		15.1	7.2
Dissolved Phosphorus (g/m3)		0.06	0.14
Dissolved Sodium (g/m3)	<200	76	16.2
Dissolved Zinc (g/m3)	<1.5	0.0077	0.189
Chloride (g/m3)	<250	153	13.5
Total Ammoniacal-N (g/m3)	<1.2	0.525	0.005
Nitrite-N (g/m3)		0.0145	0.001
Nitrate-N (g/m3)	11.3	0.36	0.28
Nitrate-N + Nitrite-N	11.3	0.42	0.176
Sulphate (g/m3)	<250	155	9.6
Escherichia coli (MPN/100mls)	<1.0	<1.0	<1.0

Note: **Bold** is above applicable guideline criteria

4 DISCUSSION

The analytical groundwater results from the June 2019 GME indicate there is no measurable adverse impacts to shallow groundwater in South Taranaki that could be attributed to the 2015-16 Kapuni 3D seismic survey. The following main points summarise the results from the June 2019 GME:

- Turbidity values were recorded above the NZDWS (2008) in the two sites monitored this year, being GND 2589 and GND 0971.
- There were no recorded *E.coli* concentrations above the NZDWS (2008) for either of the two bores monitored this year. The purpose-built monitoring bore, GND 2589, had *E.coli* concentrations above the NZDWS (2008) in the previous year.
- pH values in the June 2019 GME were generally consistent with all the previous GME's. However, site GND 0971 recorded pH median values below the NZDWS (2008) pH guideline value of 7.0-8.5.
- Detection of Iron above the NZDWS (2008) guidelines values has been a common occurrence in all GME's, including the June 2019 GME. Site GND 2589 recorded Iron concentrations above the NZDWS (2008) guidelines values in the June 2019 GME. The GND 0971 site historically did breach the NZDWS (2008) guideline but, since October 2016, has met the guideline. The results provide evidence to date there has been no significant difference in the Iron concentration between pre-and post-source point activation and the following seven GME's.
- The results from all the GME's to date indicate the majority of the monitoring sites are representative of shallow unconfined groundwater quality in the South Taranaki District and that no adverse impacts to groundwater can be attributed to the 2015/16 Kapuni 3D Seismic Survey. Given that, over the last two years of the monitoring programme, no adverse impacts have been recorded it is recommended that the programme be reviewed in conjunction with the Taranaki Regional Council.

4.1 Suitability of GMP Sites: Review

As per resource consent 10276-1.0 condition 8 the GMP should be reviewed by the TRC Science team and Todd Representatives. Section 4.1 provides a brief assessment of the suitability of each GMP sampling site in relation to the site specifics and monitoring data.

4.1.1 GND 2589's Suitability

GND 2589 is a 20-metre-deep purpose-built monitoring bore which is 19 metres (lateral distance) from an unexploded source point. The depth to groundwater has varied between 2.615 and 5.14 metres below ground level (mbgl), with a screened interval of 9.0 to 18 metres. Groundwater samples have been collected in seven GMEs, with groundwater quality recording elevated turbidity and total hardness and with low pH values, along with significantly elevated concentrations of iron, manganese and potassium. *E. coli* has only been recorded in one GME - May 2018, there has been no recording of *E. coli* in June 2019 GME. The equipment blank collected prior to sampling GND2589 in the May 2018 and in the June 2019 GME recorded no *E. coli.* No surface water was ponding in the bore cap during the June 2019 GME but the area adjacent the bore was very wet, and the bore is flush with the ground in a paddock used for grazing cattle. No Pentaerythritol tetranitrate (PETN) or Trinitrotoluene (TNT) has been recorded from GND 2589 in 2016 and 2017. The recorded metals, salts and turbidity are assessed as elevated but within what is considered background concentrations for coastal New Zealand.

Recommendation: GND 2589 is assessed as appropriate for continued inclusion in the GMP if it is deemed necessary to continue this study.

4.1.2 GND 0971's Suitability

GND 0971 is a fully cased 43-metre-deep water abstraction bore. The depth to water is currently not known. Groundwater samples have been collected in seven GMEs, with turbidity recorded outside the NZDFWS (2008) in six GMEs and pH values in four GMEs. Concentrations of iron have been recorded outside the NZDWS (2008) in two GMEs but not since October 2016 and *E. coli* has been recorded in one of the GMEs.

Recommendation: GND 0971 is assessed as appropriate for continued inclusion in the GMP if it is deemed necessary to continue this study.

5 CONCLUSION AND RECOMMENDATIONS

The results from the June 2019 GME and all of the previous GMEs can be summarised by the following main points:

- The available data recorded from the monitoring sites in the GMP indicate there has been no measurable adverse effects on the shallow unconfined groundwater resource due to the Kapuni 3D seismic survey.
- It is recommended to continue monitoring of the two sites (GND 2589 and GND 0971) until the expiration of the Resource Consent on June 1, 2021.

6 LIMITATIONS

All information in this report is provided strictly in accordance with the following limitations and recommendations:

- This report has been produced in accordance with the project specific brief and scope of works and, therefore, should be read in its entirety.
- The responsibility of BTW Company is solely to the client Todd Energy Limited. This report is not intended for any third party and, as such, no liability is undertaken to any third party.
- Conclusions in this report are based solely on the information and findings of the June 2019 GME and all previous sampling rounds.
- Groundwater and soil conditions are subject to continual natural and anthropogenic influences and can, therefore, exhibit a range of spatial and temporal variances. The collected data in this report is only directly relevant to the groundwater resources at the sampling sites and at the time the GME was undertaken.
- If different groundwater conditions are encountered subsequent to the production of this report, BTW Company should be notified and allowed to provide an opportunity to review both the findings of this report and the new evidence.

REFERENCES

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Stevens, G. (2001). Taranaki In Groundwater's of New Zealand, M.R. Rosen and P.A. White (eds). New Zealand Hydrological Society Inc. wellington. Pg. 381-386.

Taranaki Regional Council (2014) State of the Environment Monitoring Groundwater Levels 1989-2013, Technical report 2014-126

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APPENDIX A KAPUNI GMP SITE LOCATION MAP

1,700,000

1,710,000

5,640,000

5,630,000

5,620,000

GND0971

Kaponga

Eltham

Okaiawa

Normanby

Manaia

GND2589

Ohawe

Hawera

Legend

Well/Bore

GENERAL NOTES
1. Coordinates are in terms of New Zealand Transverse Mercator

DISCLAIMER
GIS data and imagery are for indicative purposes only.
Cadastral information sourced from LINZ. Crown copyright reserved.
No works may be undertaken in the vicinity of pipelines without a work permit and 2 days' notice.
Contact Details: FirstGas: (06) 755-0861 Core Group: (06) 769-9391, (0800) 267-347

TITLE

KAPUNI GROUNDWATER MONITORING PLAN
GROUNDWATER BORE LOCATIONS

DRAWN	T.MASTERS	04.07.2019
CHECKED	G.JOHNSTON	04.07.2019
PROJECT No	181084.03	
LOCATION	SOUTH TARANAKI	
SCALE	1:75,000	
ORIGINAL SIZE	A3	

TODD ENERGY

BTW COMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

NO	DATE	BY	CHKD.

REVISIONS

0 500 1,000 2,000 3,000 4,000 5,000 Meters

1:75,000

DRAWING No 181084-03-101-GIS

SHEET 1

REVISION 0

APPENDIX B KAPUNI GMP SITE SPECIFIC DETAILS

Site	Easting	Northing	Aquifer	Casing/well dia (m)	Well/Bore Depth (mbgl)	DTW (mbgl)	TOC RL 9NZTM)	Casing Height (m)	GRL (NZTM)	GW_RL(NZTM)	GWL (DTW) not pumping (mbgl)
GND 0971	1704760	5642367	N/A	0.0635	42.6	NR	405.70	0.4	405.29	NR	NR
GND 2589	1699983	5620155	N/A	0.05	20.3	2.615-5.14	55.67	0	55.81	50.53-53.05	N/A

N/A- not applicable

NR- not recorded

APPENDIX C KAPUNI GMP FIELD SHEETS

GND2900 — ecoli equipment blank.

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

ENVIRONMENT FORMS

Section: ENV02
No. of Pages: 1
Issue: 3
Date: 8.11.2016

FIELD SHEET - GROUNDWATER MONITORING

(Kapuni GMP)

Site: GND 2589 Bore ID# GND 2589 Sampled by: TS & AC BTW Job No: 181084 Lab Quote: 71869 Date: 19/06/19

Well Depth: _____ Screen Depth: _____ Purge Method: Bladder Time started: 9:15 Time Stopped: _____

PID = 0.2

Field Analysis							
SWL (m)	Time NZST	Volume purged (L)	Temp (°C)	pH	Chloride (mg/L)	Conductivity (µS)	Comments (odour, colour, conductivity stable after purging)
5.14	9:30	100mL/min	13.7	7.43	37329	933	Clear, some fine silt, no odour
	2:00	200	13.6	7.39	382.91	931	
	3:00	300	13.6	7.35	389.66	932	
	4:00	400	13.6	7.32	390.27	934	
	5:00	500	13.6	7.31	393.36	930	
	6:00	600	13.7	7.29	392.75	929	
	7:00	700	13.5	7.29	391.24	930	
	8:00	800	13.7	7.28	388.28	929	
	9:00	900	13.8	7.26	388.85	925	
	10:00	1000	13.8	7.25	388.21	922	
5.16		1100	13.8	7.25	388.23	918.	stable & sampled.

Purge Volume Calculation = 3.14(well depth-depth to water)*(well radius)^2*1000. Note well radius must be in metres, a 6.5 cm PVC casing is 0.065m*

APPENDIX D KAPUNI GMP CHAIN OF CUSTODY FORMS

Hill Laboratories
TRIED, TESTED AND TRUSTED

ANALYSIS REQUEST

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

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Job No: **219 5745**
Date Recv: 20-Jun-19 06:19
Received by: Sarah Marsh

3121957456

Quote No 95455

Primary Contact Greg Larkin 201912

Submitted By ~~Greg Larkin~~ Teone Smith 201912

Client Name BTW Company Limited 40949

Address PO Box 551, New Plymouth 4340

Phone 06 759 5040 *Mobile* 027 660 6664

Email

Charge To BTW Company Limited 40949

Client Reference Kapuni Groundwater Bores

Order No 181084

Results To *Reports will be emailed to Primary Contact by default. Additional Reports will be sent as specified below.*

☑ Email Primary Contact ☑ Email Submitter ☐ Email Client
☐ Email Other
☐ Other

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories
☑ Tick if you require COC to be emailed back
Date & Time: 19/06/19 15:00
Name: Teone Smith
Signature: Smith

Received at Hill Laboratories
Date & Time:
Name:
Signature:

Condition ☐ Room Temp ☐ Chilled ☐ Frozen Temp: 7.1

☐ Sample & Analysis details checked
Signature:

ADDITIONAL INFORMATION

As per Quote plus Potassium please

Priority ☐ Low ☐ Normal ☑ High
☐ **Urgent** (ASAP, extra charge applies, please contact lab first)

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 5 working days following the day of receipt of the samples at the laboratory.

Quoted Sample Types

Requested Reporting Date:

Ground Water (GW)

No.	Sample Name	Sample Date/Time	Sample Type	Tests Required
1	GND 2589	19/06/19 10:00	H_2O	As per Quote plus potassium
2				
3	GND 0971	" " 11:00	H_2O	" "
4	GND 2900	" " 9:45	H_2O	Equipment Blank
5				
6				
7				
8				
9				
10				

APPENDIX E KAPUNI GMP HILL LABORATORIES REPORT

Hill Laboratories
TRIED, TESTED AND TRUSTED

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

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	BTW Company Limited	**Lab No:**	2195745 SPv1
Contact:	Greg Larkin	**Date Received:**	20-Jun-2019
	C/- BTW Company Limited	**Date Reported:**	27-Jun-2019
	PO Box 551	**Quote No:**	95746
	New Plymouth 4340	**Order No:**	181084
		Client Reference:	Kapuni Groundwater Bores
		Submitted By:	Teone Smith

Sample Type: Aqueous

Sample Name:		GND 2989 19-Jun-2019 10:00 am	GND 0971 19-Jun-2019 11:00 am	GND 2900 19-Jun-2019 9:45 am	
Lab Number:		2195745.1	2195745.3	2195745.4	
Sum of Anions	meq/L	8.3	2.1	-	-
Sum of Cations	meq/L	9.0	2.1	-	-
Turbidity	NTU	113	7.0	-	-
pH	pH Units	6.8	7.1	-	-
Total Alkalinity	g/m³ as $CaCO_3$	56	76	-	-
Bicarbonate	g/m³ at 25°C	69	93	-	-
Total Hardness	g/m³ as $CaCO_3$	240	65	-	-
Electrical Conductivity (EC)	mS/m	92.8	21.0	-	-
Approx Total Dissolved Salts	g/m³	620	140	-	-
Dissolved Boron	g/m³	0.028	0.018	-	-
Dissolved Calcium	g/m³	49	14.5	-	-
Dissolved Copper	g/m³	< 0.0005	< 0.0005	-	-
Dissolved Iron	g/m³	16.8	< 0.02	-	-
Dissolved Magnesium	g/m³	28	7.1	-	-
Dissolved Manganese	g/m³	1.33	0.103	-	-
Dissolved Potassium	g/m³	15.1	6.4	-	-
Dissolved Sodium	g/m³	72	15.1	-	-
Dissolved Zinc	g/m³	0.0057	0.152	-	-
Chloride	g/m³	151	12.3	-	-
Total Ammoniacal-N	g/m³	0.80	< 0.010	-	-
Nitrite-N	g/m³	0.049	< 0.002	-	-
Nitrate-N	g/m³	0.31	0.147	-	-
Nitrate-N + Nitrite-N	g/m³	0.35	0.149	-	-
Dissolved Reactive Phosphorus	g/m³	0.019	0.031	-	-
Sulphate	g/m³	141	8.9	-	-
Escherichia coli	MPN / 100mL	< 1 #1	< 1 #1	< 1 #1	-

Analyst's Comments

#1 Please interpret this microbiological result with caution as the sample was > 24 hours old at the time of testing in the laboratory. The sample was receipted by the laboratory within 24 hrs of sample collection, but due to sample registration delays it was not processed within the required time frame.

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.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-3

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
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 23rd ed. 2017.	0.07 meq/L	1-3
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 23rd ed. 2017.	0.05 meq/L	1-3
Turbidity	Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 23rd ed. 2017.	0.05 NTU	1-3
pH	pH meter. APHA 4500-H^+ B 23rd ed. 2017. 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	1-3
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1-3
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 23rd ed. 2017.	1.0 g/m³ at 25°C	1-3
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1-3
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.1 mS/m	1-3
Approx Total Dissolved Salts	Calculation: from Electrical Conductivity.	2 g/m³	1-3
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23rd ed. 2017.	-	1-3
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.005 g/m³	1-3
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1-3
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1-3
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1-3
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1-3
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1-3
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1-3
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1-3
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m³	1-3
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	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) 23rd ed. 2017.	0.010 g/m³	1-3
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1-3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1-3
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1-3
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m³	1-3
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1-3
Escherichia coli	MPN count using Colilert , Incubated at 35°C for 24 hours. APHA 9223 B 23rd ed. 2017.	1 MPN / 100mL	1-4

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 F TRC DISCHARGE PERMIT 10276-1.0

Taranaki Regional Council

Discharge Permit

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

Name of Consent Holder:	Shell Todd Oil Services Limited Private Bag 2035 New Plymouth 4342
Decision Date:	11 April 2016
Commencement Date:	11 April 2016

Conditions of Consent

Consent Granted:	To discharge contaminants to land where they may enter groundwater, including residues from detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey
Expiry Date:	1 June 2021
Review Date(s):	3 months of receiving a report under condition 5 and/or 8
Site Location:	Various locations throughout the South Taranaki & Stratford Districts
Catchment:	Various

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

47 Cloten Road · Private Bag 713 · Stratford 4352 · New Zealand
T: 06 765 7127 · F: 06 765 5097 · www.trc.govt.nz
Please quote our document number in your reply

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. The activity shall be undertaken in general accordance with the information provided in support of the application for this consent. Where there is conflict between the application and the consent conditions the conditions shall prevail.

2. This consent authorises the discharge of contaminants resulting from undertaking a seismic survey only within the area shown on the map attached. The contaminants include:
   (a) those arising from placing charges of Dyno Nobel Geoprime® dBX™ explosive, each no more than 2 kg, at depths between 2 and 20 metres below ground; and
   (b) residues from detonating charges of Dyno Nobel Geoprime® dBX™ explosive, each no more than 2 kg, at depths between 2 and 20 metres below ground.

3. No more than one charge shall be placed in each shot hole unless it is necessary to address a misfire, in which case another charge of up to 2 kg may be added.

4. The discharges shall be from the progressive detonation of charges with no detonations occurring after 31 December 2016.

5. The consent holder shall report the following information to the Chief Executive, Taranaki Regional Council on the first day of each month, with the first monthly report to include information in relation to all previous activity:
   (a) the NZTM grid reference of the location of each shot hole;
   (b) the depth of each shot hole and depth of the explosive;
   (c) the amount of explosive in each shot hole;
   (d) the date that each charge was detonated;
   (e) the location of shot holes where the charge misfired and details of any additional charge that may have been placed in the hole; and
   (f) the date that each shot hole is abandoned and details of the method of abandonment.

6. To minimise any effects on groundwater all shot holes shall be:
   (a) capped at surface to minimise the ingress of surface water on the same day that the charge is placed and re-capped on the same day as detonation and data acquisition occurs; and
   (b) restored and abandoned within 30 working days of detonation.

7. The activity shall not cause any change in groundwater quality that results in it being unsuitable for its current use.

8. The consent holder shall undertake a programme of sampling and testing that identifies the effects of the exercise of this consent on groundwater resources over the duration of the consent (the 'Monitoring Programme'). The Monitoring Programme may be reviewed from time to time but at all times shall be certified by the Chief Executive, Taranaki Regional Council, and shall include:

   (a) water quality criteria for applicable existing uses;

   (b) the location of each sampling point and the frequency of sampling;

   (c) a listing of analyses to be undertaken for contaminants that could result from the discharges authorised;

   (d) specific monitoring of the effects of unexploded charges on groundwater quality; and

   (e) details of how and when the results of monitoring will be reported to the Taranaki Regional Council.

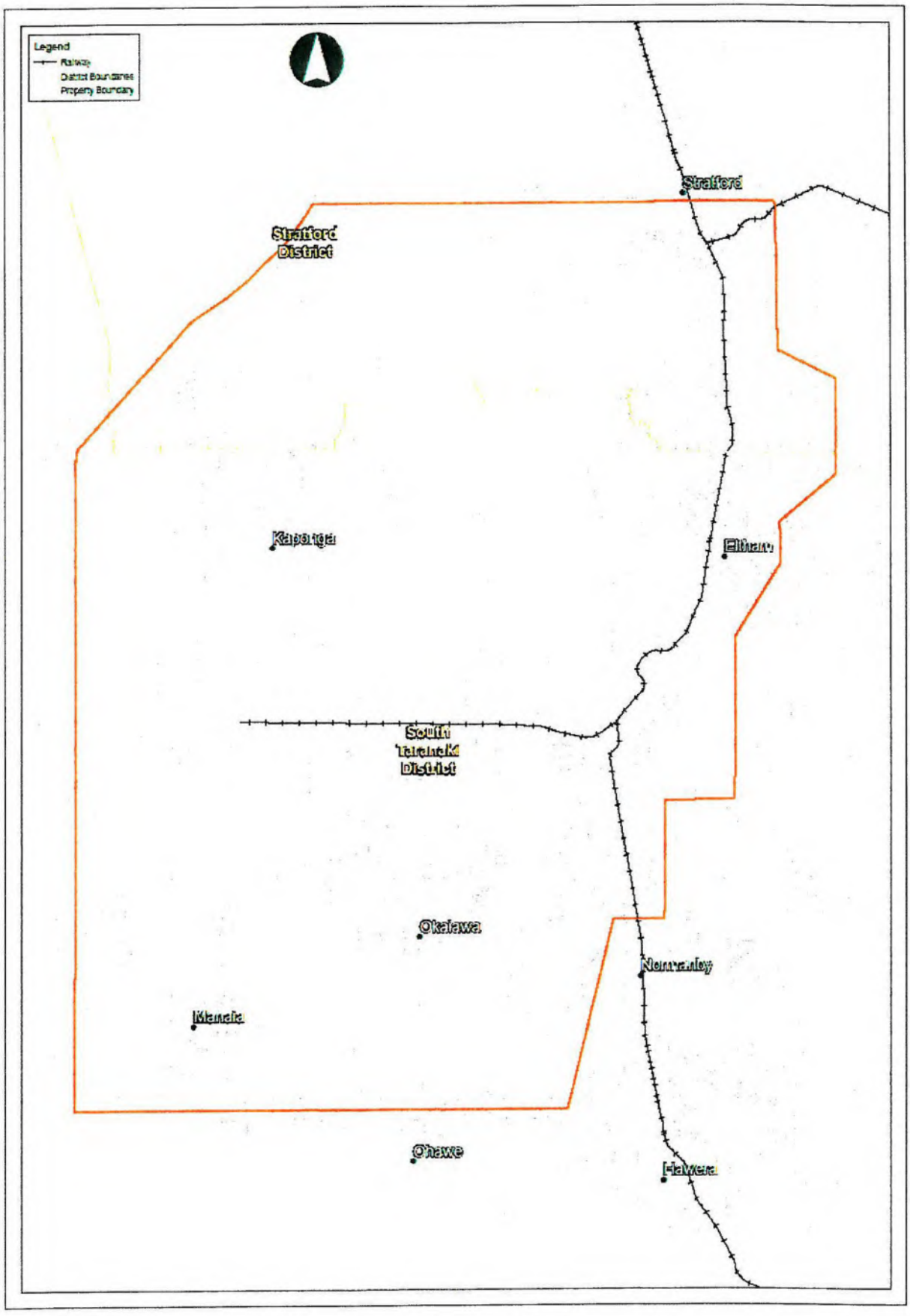
9. The Monitoring Programme required by condition 8 shall be implemented within 10 working days of this consent being issued and remain in place for the term of the consent. Until the Monitoring Programme is implemented the current monitoring regime shall continue.

10. 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 within 3 months of receiving a report in accordance with condition 5 and/or 8 above, 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 11 April 2016

For and on behalf of
Taranaki Regional Council

A D McLay
Director - Resource Management



Map showing area of Kapuni 3d seismic survey

Appendix IV

Mangahewa 3D seismic survey groundwater sampling results

TECHNICAL REPORT

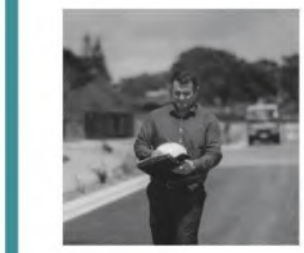
Mangahewa 3D Seismic Groundwater Monitoring Programme

for Todd Energy Limited

Rev 2 - 26/03/2019








BTW COMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

Mangahewa 3D Seismic Groundwater Monitoring Programme

for Todd Energy Limited

Reviewed

Report Author	Campbell Graham	
	Campbell Graham Environmental Assistant BSc	Date 26/03/2019
Reviewed by		
	Dave Bolger Team Leader Environment CEnvP	Date 26/03/2019

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Rev 2 - 26/03/2019

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CONTENTS

1 INTRODUCTION 1

1.1 Mangahewa 3D Groundwater Monitoring programme-background 1
1.2 Objectives 1
1.3 Scope 1
1.4 Applicable Guideline Values 1

2 GROUNDWATER MONITORING EVENT (GME) METHODOLOGY 2

2.1 Specific site details 2
2.2 Groundwater Sampling Methodology 2
2.3 Chain of Custody for Hills Laboratories 2

3 RESULTS 3

November 2018 Groundwater Monitoring Event 3
3.1 Groundwater Quantity 3
3.2 Groundwater Quality 5

4 DISCUSSION 7

5 CONCLUSIONS AND RECOMMENDATIONS 8

6 LIMITATIONS 9

REFERENCES 10

APPENDIX A MANGAHEWA 3D SITE LOCATION MAP 11
APPENDIX B MANGAHEWA GMP SITE DETAILS 12
APPENDIX C NOVEMBER 2018 CHAIN OF CUSTODY FORMS 13
APPENDIX D NOVEMBER 2018 GME FIELD SHEETS 14
APPENDIX E NOVEMBER 2018 GME HILLS LABS REPORT 15
APPENDIX F TRC DISCHARGE PERMIT 10352-1.0 16
APPENDIX G VISIBLE CORROSION ON BLADDER PUMP IN GND 2705 17

TABLES

Table 3.1: MWH 3D GME Groundwater Level Data 3
Table 3.2: November GME results 1/2 5
Table 3.3: November GME results 2/2 6

FIGURES

Figure 6.1: Bladder pump post sample collection in GND 2705 17

1 INTRODUCTION

1.1 Mangahewa 3D Groundwater Monitoring programme-background

In November 2016, Todd Energy Limited (Todd) was granted resource consent 10352-1.0 to "*discharge contaminants to land where they may enter groundwater, including residues from the detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey*". Special conditions 8 and 9 in Consent 10352-1.0 outline the requirement for the consent holder to establish a long-term monitoring programme of the groundwater resources adjacent to activated source points in the Mangahewa permit block. See Appendix F for a copy of the discharge consent (10352-1.0) from the Taranaki Regional Council (TRC).

1.2 Objectives

The primary objective of the Mangahewa 3D groundwater monitoring programme (MWH 3D GMP) is to provide water chemistry data from representative groundwater bores adjacent to activated source points within the Mangahewa 3D seismic survey area. The water chemistry data would assist in delineating any potential or actual adverse effects to the groundwater resources as a result of the discharge of contaminants associated with discharge consent 10352-1.0.

1.3 Scope

BTW Company (BTW) was engaged by Todd to continue the Groundwater Monitoring Programme (GMP) under the previous scope of works. All information pertaining to previous GMP reports, including the site selection criteria is available upon request from Todd. This November 2018 GMP report encompasses the fifth round of groundwater sampling associated with the monitoring of discharge permit 10352-1.0.

An overview map of the monitoring and permit area is contained in Appendix A.

1.4 Applicable Guideline Values

As agreed upon during the establishment of the GMP, the two most applicable standards/guidelines are the New Zealand Drinking Water Standard (2008) and the Australia and New Zealand Environment Conservation Council (ANZECC 2000) guidelines.

- The New Zealand Drinking Water Standard (NZDWS 2008) is a conservative standard to use as part of this monitoring programme. The standard assesses risk to human health, even though the water resources sampled for the monitoring programme are generally only used for stock drinking water purposes. However, comparing the data to the NZDWS (2008) does provide reassurance to landowners about the chemistry of the water in terms of a human health perspective.
- The Australia and New Zealand Environment Conservation Council (ANZECC 2000) guidelines allows for the 95% protection of species in slightly-to-moderately disturbed ecosystems. The ANZECC (2000) guidelines are applied to the receiving water environment after reasonable mixing within the receiving water body.

2 GROUNDWATER MONITORING EVENT (GME) METHODOLOGY

2.1 Specific site details

Six groundwater monitoring sites are included in the GMP, with three of the six sites 'purpose built' monitoring bores. The other three sites are cased but unscreened up-holes converted to monitoring bores. Appendix B contains the specific details of each monitoring bore, including available depths to groundwater.

2.2 Groundwater Sampling Methodology

During the November 2018 Groundwater Monitoring Event (GME) all field measurements and observations were recorded as per BTW's internal standard operating procedures (SOP) for groundwater sampling. The November 2018 GME field sheets are available in Appendix D and a copy of the Groundwater Sampling SOP was provided as part of the monitoring programme methodology report which was approved and provided to the TRC.

2.3 Chain of Custody for Hills Laboratories

As per standard procedures with Hill Laboratories, a chain of custody (COC) form was completed and sent to the laboratory with the water samples. Information included; sample name, date of sample, tests required, type of material, senders name, date received by lab and sample temperature.

All samples were chilled on ice then sent to Hills Laboratories by courier with COC maintained at all times to meet Hill Laboratories strict timeframe requirement for testing.

Hill Laboratories sent the COC form back via email the following day to complete the chain of custody requirements. See Appendix C The analysis could be tracked via an online service Hill Laboratories provided to customers.

3 RESULTS

November 2018 Groundwater Monitoring Event

The November 2018 GMW was carried out on the 8th and 12th November 2018. All six groundwater bores were sampled as part of this GME.

All of the up-holes and bores were sampled for the agreed test parameters for water chemistry. The complete set of the sampling results from this GME and the previous GMEs is outlined Table 3.2 and Table 3.3.

3.1 Groundwater Quantity

Available depths to the groundwater for the November 2018 GME and all previous GME's are presented in Table 3.1.

Table 3.1: MWH 3D GME Groundwater Level Data

TRC ID	Depth to Groundwater (m below TOC)				
	10/03/2017	27/04/2017	2/10/2017	16/05/2018	8+12/11/18
GND2705	22.62	NA	5.5	10.02	3.64
GND2706	Artesian	Artesian	Artesian	Artesian	Artesian
GND2707	11	3.22	3.1	3.7	11.38
GND2708	10.41	9.56	7.05	9.35	10.47
GND2709	3.65	3.39	3.62	2.4	3.89
GND2710	2.43	2.1	2.19	2.08	2.18

NA – not assessed in resample round, TOC – top of casing

3.2 Groundwater Quality

Table 3.2 and Table 3.3 outline the May 2018 GME analytical results.

Table 3.2: November GME results 1/2

		GND2705 27-Apr-2017	GND2705 03-Oct-2017	GND2705 16-May-2018	GND2705 12-Nov-2018	GND2706 06-Mar-2017	GND2706 02-Oct-2017	GND2706 16-May-2018	GND2706 12-Nov-2018	GND2707 14-Mar-2017	GND2707 03-Oct-2017	GND 2707 16-May-2018	GND 2707A 16-May-2018	GND2707 12-Nov-2018	GND2708 09-Mar-2017	GND2708 27-Apr-2017
Lab Number	Guideline Value	1765410.4	1854412.2	1983470.1	2079242.4	1735355.4	1853596.2	1983470.2	2079242.1	1740170.1	1854412.1	1983470.3	1983470.4	2079242.3	1737949.1	1765410.3
Turbidity (NTU)	<2.5	**12**	**20**	**9.4**	**56**	**9**	**3.1**	**4.5**	**9.2**	**86**	**6.5**	**13.8**	-	**5.9**	**59**	**67**
pH (pH units)	7.0-8.5	**11.3**	**10.7**	**10.6**	**9.6**	8.5	**8.8**	8.6	8.5	**10.3**	**10.6**	**10.2**	-	**10.4**	7.2	7.6
Total Alkalinity (g/m3 as CaCO3)		168	94	55	76	49	47	51	56	137	66	68	-	41	88	95
Free Carbon Dioxide (g/m3 at 25°C)		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0	< 1.0	-		11.1	5.3
Total Hardness (g/m3 as CaCO3)	<200	29	49	14.3	15.6	169	187	174	191	55	17.4	12.9	-	9.8	81	82
Electrical Conductivity (EC) (mS/m)		255	44.5	32.6	241	155.6	161.2	163.9	164.2	46.2	128.8	212	-	29.2	22.6	22.7
Electrical Conductivity (EC) (µS/cm)		2,550	445	326	2410	1,556	1,612	1,639	1,642	462	1,288	2,120	-	292	226	227
Approx Total Dissolved Salts (g/m3)	<1000	**1,710**	300	220	**1610**	**1,040**	**1,080**	**1,100**	**1,100**	310	860	**1,420**	-	196	151	152
Dissolved Boron (g/m3)	1.4	**1.57**	0.32	0.21	1.93	0.022	0.027	0.038	0.043	0.38	0.94	**1.67**	-	0.22	0.023	0.017
Dissolved Calcium (g/m3)		11.7	19.5	5.7	5.6	34	35	32	35	18.3	6.9	5.1	-	3.9	17.8	17.8
Dissolved Copper (g/m3)	<1	< 0.0010	0.0007	< 0.0005	<0.0005	< 0.0005	< 0.0005	< 0.0005	<0.0005	0.0007	< 0.0005	< 0.0005	-	<0.0005	0.0008	< 0.0005
Dissolved Iron (g/m3)	<0.2	< 0.04	< 0.02	< 0.02	<0.02	< 0.02	< 0.02	**0.99**	**<0.02**	0.11	< 0.02	< 0.02	-	<0.02	0.03	0.16
Dissolved Magnesium (g/m3)		< 0.04	< 0.02	< 0.02	0.38	20	24	23	25	2.2	0.02	0.06	-	0.05	8.8	9.2
Dissolved Manganese (g/m3)	<0.1 & 0.4	< 0.0010	< 0.0005	0.0007	0.0028	**0.48**	**0.47**	**0.59**	**0.33**	0.0029	< 0.0005	0.0012	-	0.0006	0.058	**0.22**
Dissolved Potassium (g/m3)					4.4				5.4					4.6		
Dissolved Phosphorus (g/m3)		< 0.04	0.03	< 0.02	<0.004	< 0.02	< 0.02	< 0.02	<0.004	0.16	0.03	0.03	-	4.6	0.03	< 0.02
Dissolved Sodium (g/m3)		480	64	52	490	220	240	230	240	73	260	410	-	48	15.5	14
Dissolved Zinc (g/m3)		< 0.002	< 0.0010	< 0.0010	<0.0010	< 0.0010	< 0.0010	0.0055	<0.0010	< 0.0010	< 0.0010	< 0.0010	-	<0.0010	< 0.0010	< 0.0010
Chloride (g/m3)	<250	**610**	51	49	**750**	**450**	**450**	**470**	**490**	54	**320**	**590**	-	51	11.5	12.2
Total Ammoniacal-N (g/m3)	<1.2	**8.7**	**1.44**	0.89	**7.5**	**2**	**1.84**	**1.86**	**2**	**1.4**	**4.6**	**6.6**	-	0.79	< 0.010	0.044
Nitrite-N (g/m3)	0.06	< 0.002	< 0.002	0.006	<0.002	< 0.002	< 0.002	< 0.002	<0.002	0.044	< 0.002	< 0.002	-	0.002	0.013	0.005
Nitrate-N + Nitrite-N (g/m3)	11.3	< 0.002	< 0.002	0.004	0.002	< 0.002	< 0.002	< 0.002	0.038	0.012	< 0.002	0.005	-	<0.002	0.23	0.012
Nitrate-N + Nitrite-N (g/m3)	11.3	< 0.002	< 0.002	0.01	0.002	< 0.002	< 0.002	< 0.002	0.038	0.056	0.003	0.006	-	0.003	0.24	0.017
Sulphate (g/m3)	<250	17.7	13.5	12.9	13	< 0.5	< 0.5	< 0.5	<0.5	9.3	18.5	15.1	-	11.1	8.3	4.6
Escherichia coli (MPN / 100mL)	<1	< 1	< 1	<1	<1	< 1	**5**	**3**	<1	< 1	< 1	< 1	< 1	<1	**88**	**61**

BOLD denotes NZDWS (2008) or ANZECC (2000) guideline exceedance

Table 3.3: November GME results 2/2

		GND2708 10-Oct-2017	GND2708 16-May-2018	GND 2708A 16-May-2018	GND2708 12-Nov-2018	GND2709 14-Mar-2017	GND2709 14-Mar-2017 Dup	GND2709 27-Apr-2017	GND2709 03-Oct-2017	GND2709 16-May-2018	GND2709 08-Nov-2018	GND2710 15-Mar-2017	GND2710 27-Apr-2017	GND2710 02-Oct-2017	GND2710 16-May-2018	GND2710 08-Nov-2018
Lab Number	Guideline Value	1858146.1	1984304.1	1984304.4	2079242.2	1740170.2	1740170.3	1765410.2	1854412.3	1984304.2	2077880.2	1741125.1	1765410.1	1853596.1	1984304.3	2077880.1
Turbidity (NTU)	<2.5	1.53	0.49	1.01	0.32	**67**	-	**74**	**85**	**8.3**	**10.8**	**136**	**23**	1.89	**3**	1.36
pH (pH units)	7.0-8.5	7.3	7.5	7.8	7.5	**6.8**	-	**6.8**	**6.8**	**6.2**	**6.3**	**8.7**	**8.7**	8.5	**8.7**	**8.6**
Total Alkalinity (g/m3 as CaCO3)		90	90	-	90	114	-	75	90	39	34	550	600	610	630	34
Free Carbon Dioxide (g/m3 at 25°C)		9.6	5.8	-		37	-	25	27	52		2.2	2.5	3.6	2.6	
Total Hardness (g/m3 as CaCO3)	<200	84	83	-	86	85	-	60	67	40	39	23	18.6	16.6	15.6	14.5
Electrical Conductivity (EC) (mS/m)		21.9	21.3	21.4	21.7	31.1	-	20.7	22.7	16.8	16	104.5	116.2	119.3	115.8	116.7
Electrical Conductivity (EC) (µS/cm)		219	213	-	217	311	-	207	227	168	160	1,045	1,162	1,193	1,158	1,167
Approx Total Dissolved Salts (g/m3)	<1000	147	143	-	145	210	-	139	152	113	107	700	780	800	780	780
Dissolved Boron (g/m3)	1.4	0.012	0.017	-	0.017	0.034	-	0.018	0.022	0.016	0.0014	**2.1**	**2.3**	**2.7**	**2.6**	**2.5**
Dissolved Calcium (g/m3)		18.7	18.6	-	18.7	23	-	13	14.2	9.1	8.8	5.4	4	3.6	3.4	3.2
Dissolved Copper (g/m3)	<1	0.0007	< 0.0005	-	<0.0005	0.0016	-	< 0.0005	< 0.0005	< 0.0005	0.0022	0.001	< 0.0005	< 0.0005	< 0.0005	0.0011
Dissolved Iron (g/m3)	<0.2	< 0.02	0.13	-	0.16	**1.35**	**-**	**6.1**	**12.6**	**1.62**	0.07	0.04	0.03	< 0.02	0.02	0.02
Dissolved Magnesium (g/m3)		9	8.8	-	9.6	6.4	-	6.6	7.7	4.1	4.1	2.3	2.1	1.84	1.69	1.59
Dissolved Manganese (g/m3)	<0.1 & 0.4	**0.112**	**0.14**	-	**0.113**	**0.31**	**-**	**0.33**	**0.33**	0.038	0.0159	0.0093	0.0111	0.0144	0.0072	0.0064
Dissolved Potassium (g/m3)					1.47						1.52					1.73
Dissolved Phosphorus (g/m3)		0.04	0.05	-	0.052	< 0.02	-	< 0.02	0.04	< 0.02	<0.004	0.18	0.23	0.08	0.26	0.19
Dissolved Sodium (g/m3)		12.6	11.9	-	12.4	26	-	15	15.5	14.9	14.5	240	300	320	290	310
Dissolved Zinc (g/m3)		0.0012	< 0.0010	-	0.001	0.0026	-	0.0026	0.0049	0.004	0.0133	< 0.0010	< 0.0010	0.0028	< 0.0010	0.0022
Chloride (g/m3)	<250	12.4	11.7	11.9	12.4	17.8	-	15.7	15.3	18.4	19.9	38	42	42	40	41
Total Ammoniacal-N (g/m3)	<1.2	0.046	< 0.010	-	0.016	**1.3**	-	1.1	**1.58**	0.114	0.028	1	0.9	0.46	0.49	0.78
Nitrite-N (g/m3)	0.06	< 0.002	< 0.002	-	<0.002	0.066	-	0.004	0.002	0.002	0.007	0.034	< 0.002	0.002	0.002	<0.002
Nitrate-N + Nitrite-N (g/m3)	11.3	0.119	< 0.002	-	<0.002	0.077	-	0.007	< 0.002	0.08	0.59	0.031	< 0.002	0.004	< 0.002	<0.002
Nitrate-N + Nitrite-N (g/m3)	11.3	0.119	< 0.002	-	<0.002	0.144	-	0.011	0.003	0.082	0.59	0.065	< 0.002	0.007	0.003	0.003
Sulphate (g/m3)	<250	3.6	3.6	-	3.7	17.8		3	<0.5	9.9	9.1	1.7	< 0.5	< 0.5	< 0.5	<0.5
Escherichia coli (MPN / 100mL)	<1	< 1	< 1	-	<1	**24**	**2**	**2**	<1	< 1	**11**	**43**	< 1	< 1	< 1	**10**

BOLD denotes NZDWS (2008) or ANZECC (2000) guideline exceedance

4 DISCUSSION

The results from the November 2018 GME and the previous GME's indicate that the Mangahewa 3D seismic project carried out during 2016-2017, has had no measurable adverse impacts on groundwater resources in North Taranaki.

The following main points summarise the results from the November 2018 GME:

- Turbidity values recorded in the November 2018 GME exceeded the NZDWS (2008) in four of the six monitoring sites with GND2705 recording the highest turbidity value of 56.0 NTU.
- GND2709 and GND2710 recorded *E. coli* concentrations above the NZDWS (2008).
- pH values in the November 2018 GME were recorded outside the NZDWS (2008) in GND 2705, GND 2707, GND 2709 and GND 2710. Consistent with previous GMEs, up-holes GND 2705 and GND 2707 recorded the highest pH values, which reflect the lack of bore development after initial drilling in early 2017.
- Concentrations of Chloride in GND 2705 and GND 2706 also exceeded the NZDWS (2008) which supports that drilling lubricants are still within the up-holes and impacting upon water quality.
- Total Ammoniacal-N concentrations in the November 2018 GME exceeded the NZDWS (2008) in GND 2705 and GND 2706. This is similar to the May 2018 testing, where two exceedances (GND 2706 and GND2707) were recorded, but lower than the October 2017 GME, where four sites exceeded the same guideline.
- Field observation indicated that up-hole GND 2705 continues to have corrosion in the well pipe casing, indicated by orange discolouring and rust sediment on equipment. Refer to the photograph in Appendix G.

5 CONCLUSIONS AND RECOMMENDATIONS

The results from the November 2018 GME and previous GMEs can be summarised by the following:

- The available groundwater level and water quality data recorded from the six sites in the MWH 3D GMP indicate that there has been no measurable adverse effect on the groundwater resources in North Taranaki because of the Mangahewa 3D seismic survey.
- The monitoring bores of the GMP satisfy the requirements and objectives as outlined in Special Conditions 8 and 9 in consent 1032-1.0. However, it is recommended that the up-holes GND 2705 and GND 2707 be further developed to a satisfactory condition or be removed from the GMP.
- It is recommended that Todd and the TRC review the MWH 3D GMP in accordance with special condition 8 of Consent 10276-1.0.

6 LIMITATIONS

All information in this report is provided strictly in accordance with the following limitations and recommendations;

- This report has been produced in accordance with the project specific brief and scope of works and, therefore, should be read in its entirety.
- The responsibility of BTW Company is solely to Todd. This report is not intended for any third party and, as such, no liability is undertaken to any third party.
- Conclusions in this report are based solely on the information and findings of the November 2018 GWE and the previous GMEs.
- Groundwater conditions are subject to continual natural and anthropogenic influences and can, therefore, exhibit a range of spatial and temporal variances. The collected data in this report is only directly relevant to the groundwater resources at sampling sites and at the time this GME was undertaken.
- If different groundwater conditions are encountered subsequent to the production of this report, BTW Company should be notified and allowed to provide an opportunity to review both the findings of this report and the new evidence.

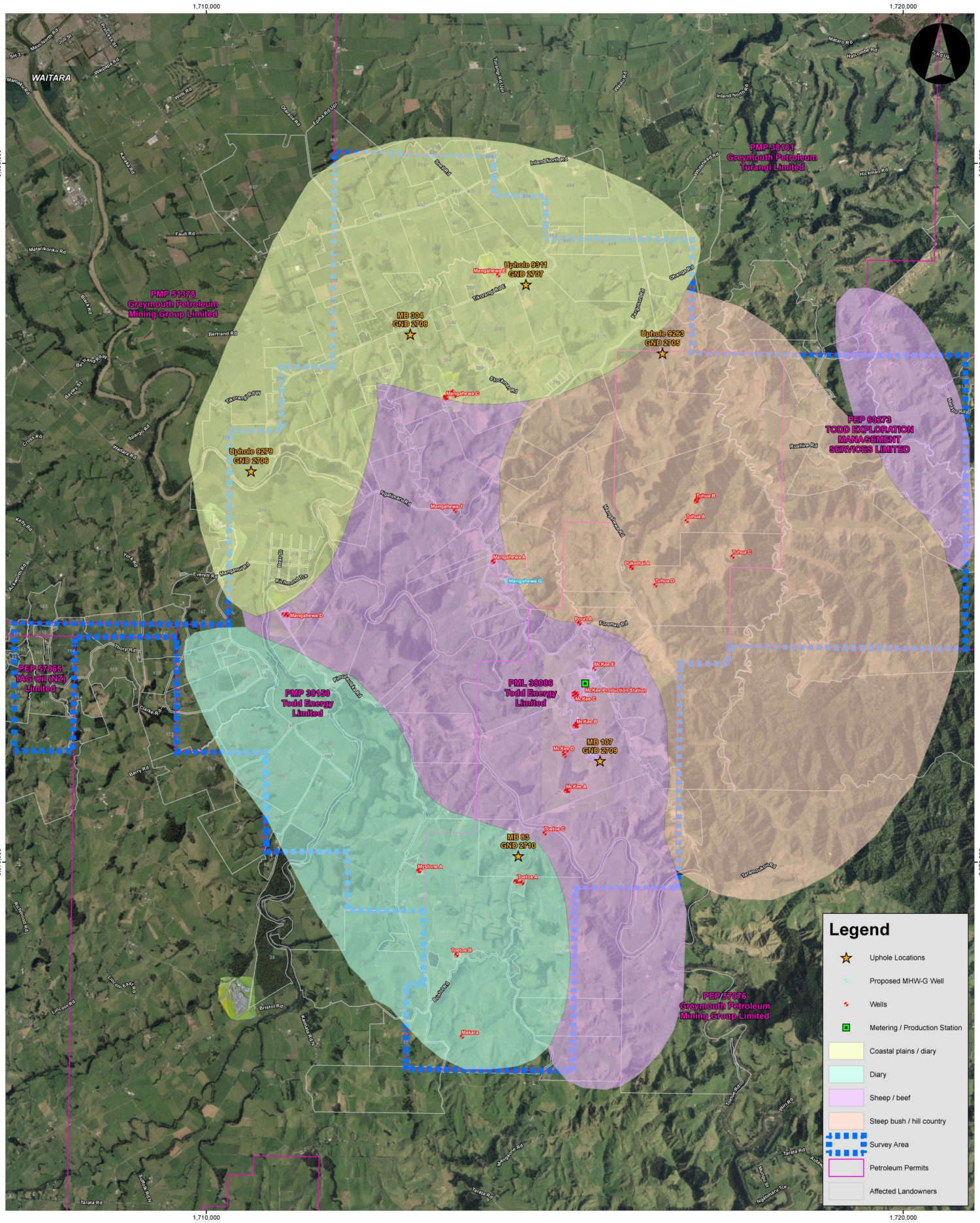
REFERENCES

Australian and New Zealand Environment and Conservation Council (ANZECC) (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Volume 1.

Ministry of Health (2008). *Drinking-water Standards for New Zealand 2005* (Revised 2008). Wellington: Ministry of Health, ISBN 978-0-478-31809-8

Todd Energy NZ (2018) *Mangahewa 3D Seismic Groundwater Monitoring Programme*, report prepared by BTW Company

APPENDIX A MANGAHEWA 3D SITE LOCATION MAP



GENERAL NOTES
1. Coordinates are in terms of New Zealand Transverse Mercator

DISCLAIMER
GIS data and imagery are for indicative purposes only.
Cadastral information sourced from LINZ. Crown copyright reserved.
No works may be undertaken in the vicinity of pipelines without a work permit and 2 days' notice.
Contact Details: FirstGas: (06) 755-0861 Core Group: (06) 769-9391, (0800) 267-347

TITLE

MHW3D TERRAIN TYPES AND GMP SITES

DRAWN	T. STANDEN	07.03.17
CHECKED	G. LARKIN	07.03.17
PROJECT No	16441	
LOCATION	MANGAHEWA	
SCALE	1:25,000	
ORIGINAL SIZE	A1	

TODD ENERGY

BTW COMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

NO	DATE	BY	CHKD

REVISIONS

0 250 500 1,000 1,500 2,000 2,500 Meters

1:25,000

DRAWING No	SHEET	REVISION
17929-GIS-101	1	0

APPENDIX B MANGAHEWA GMP SITE DETAILS

TRC Site ID	Landuse	Easting	Northing	Screened in Aquifer/Formation	Dominant Material	Drilled Depth (mbgl)	Screened Zone (mbgl)	DTW (mbgl)	TOC RL (NZTM_MSL)	Cased (mbgl)	GRL (NZTM_MSL)	GW_RL (NZTM_MSL)
GND2705	Steep/Hill Country	1716533.75	5677287.3	Kiore Formation	Papa (Siltstone and Sandstone)	150	24.0-30.0	5.5-22.62	26.26	24	25.26	3.64-20.76
GND2706	Coastal Plains/Dairy	1710589.65	5675665.05	Marine Terrace/Cover bed	Papa (Siltstone and Sandstone)	150	none	Artesian	45.7	none	44.7	Artesian
GND2707	Coastal Plains/Dairy	1714583.63	5678265.25	Marine Terrace/Cover bed	Papa (Siltstone and Sandstone)	150	24.0-30.0	3.1-11	70.91	24	69.91	59.91-67.81
GND2708	Coastal Plains/Dairy	1712926.44	5677556.12	Marine Terrace/Cover bed	Papa (Siltstone and Sandstone)	35.7	24.0-30.0	7.05-10.41	73.9	n/a	73.24	63.49-66.85
GND2709	Sheep/Beef	1715519	5671291	Interface	Ash/Loams/Silts/Peats/Clays	14.5	8.0-14.0	2.4-3.635	154.36	n/a	153.7	150.73-151.96
GND2710	Dairy	1714476.83	5670168	Matemateaonga Formation	Papa (Siltstone and Sandstone)	86	30.0-42.0	2.08-2.435	75.66	n/a	75	73.225-73.23

APPENDIX C NOVEMBER 2018 CHAIN OF CUSTODY FORMS

Hill Laboratories
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ANALYSIS REQUEST

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

T 0508 HILL LAB (44 555 2
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W www.hill-laboratories.com

Job No: **207 7880**
Date Recv: 09-Nov-18 05:38
Received by: Nathaniel Sue
3120778808

Quote No 95546

Primary Contact Greg Larkin 201912

Submitted By Greg Larkin 201912

Client Name BTW Company Limited 40949

Address PO Box 551, New Plymouth 4340

Phone 06 759 5040 *Mobile*

Email

Charge To BTW Company Limited 40949

Client Reference

Order No

Results To *Reports will be emailed to Primary Contact by default. Additional Reports will be sent as specified below.*

- [x] Email Primary Contact
- [ ] Email Submitter
- [ ] Email Client
- [x] Email Other dave.bolger@btw.nz
- [ ] Other

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories
- [x] Tick if you require COC to be emailed back

Date & Time: 8/11/18
Name: Teo Smith
Signature: Smith

Received at Hill Laboratories
Date & Time:
Name:
Signature:

Condition
- [ ] Room Temp
- [ ] Chilled
- [ ] Frozen

Temp: 7.4

- [ ] Sample & Analysis details checked

Signature:

ADDITIONAL INFORMATION

As per quote plus Potassium (K)

Priority
- [ ] Low
- [ ] Normal
- [x] High
- [ ] Urgent (ASAP, extra charge applies, please contact lab first)

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 5 working days following the day of receipt of the samples at the laboratory.

Requested Reporting Date:

Quoted Sample Types

Ground Water (GW)

No.	Sample Name	Sample Date/Time	Sample Type	Tests Required
1	GND2710	8/11/18 14:30	GW	As per quote - plus Potassium (K)
2	GND2709	8/11/18 15:40	GW	" "
3				
4				
5				
6				
7				
8				
9				
10				

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Job Information Summary

Client:	BTW Company Limited	**Lab No:**	2077880
Contact:	Greg Larkin	**Date Registered:**	09-Nov-2018 6:52 am
	C/- BTW Company Limited	**Priority:**	High
	PO Box 551	**Quote No:**	95546
	New Plymouth 4340	**Order No:**	
		Client Reference:	
		Add. Client Ref:	
		Submitted By:	Greg Larkin
		Charge To:	BTW Company Limited
		Target Date:	16-Nov-2018 4:30 pm

Samples

No	Sample Name	Sample Type	Containers	Tests Requested
1	GND 2710 08-Nov-2018 2:30 pm	Ground Water	UP500, SterThio, NWU100	Anion / Cation profile, dissolved metals trace level; Turbidity; Approx Total Dissolved Salts; Escherichia coli; Dissolved Boron; Dissolved Copper; Dissolved Iron; Dissolved Manganese; Dissolved Potassium; Dissolved Zinc; Total Ammoniacal-N; Dissolved Reactive Phosphorus
2	GND 2709 08-Nov-2018 3:40 pm	Ground Water	UP500, SterThio, NWU100	Anion / Cation profile, dissolved metals trace level; Turbidity; Approx Total Dissolved Salts; Escherichia coli; Dissolved Boron; Dissolved Copper; Dissolved Iron; Dissolved Manganese; Dissolved Potassium; Dissolved Zinc; Total Ammoniacal-N; Dissolved Reactive Phosphorus

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.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
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
Turbidity	Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 22nd ed. 2012.	0.05 NTU	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
Approx Total Dissolved Salts	Calculation: from Electrical Conductivity.	2 g/m^3	1-2

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
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
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 Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 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 Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 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
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 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
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
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1-2
Escherichia coli	MPN count using Colilert , Incubated at 35°C for 24 hours. APHA 9223 B (2004), 22nd ed. 2012.	1 MPN / 100mL	1-2

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ANALYSIS REQUEST

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

T 0508 HILL LAB (44 555 2)
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W www.hill-laboratories.com

Job No: 207 9242
Date Recv: 13-Nov-18 05:42
Received by: Jason Meadows
3120792427

Quote No ~~91374~~ 95546

Primary Contact Greg Larkin 201912

Submitted By ~~Greg Larkin~~ Teo Smith. 201912

Client Name BTW Company Limited 40949

Address PO Box 551, New Plymouth 4340

Phone 06 759 5040 *Mobile* 027660666

Email

Charge To BTW Company Limited 40949

Client Reference MHW 3D

Order No

Results To *Reports will be emailed to Primary Contact by default. Additional Reports will be sent as specified below.*

☑ Email Primary Contact ☑ Email Submitter ☐ Email Client
☐ Email Other Dave.Bolger@bhtw.nz.
☐ Other

ADDITIONAL INFORMATION

As per Quote #95546
plus Potassium (K).

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories
☐ Tick if you require COC to be emailed back
Date & Time: 12/11/18
Name: Teone Smith
Signature: Smith

Received at Hill Laboratories
Date & Time:
Name:
Signature:

Condition ☐ Room Temp ☐ Chilled ☐ Frozen
Temp: 5.2

☐ Sample & Analysis details checked
Signature:

Priority ☐ Low ☐ Normal ☑ High
☐ **Urgent** (ASAP, extra charge applies, please contact lab first)

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 5 working days following the day of receipt of the samples at the laboratory.

Quoted Sample Types

Requested Reporting Date:

Ground Water (GW) + Potassium

No.	Sample Name	Sample Date/Time	Sample Type	Tests Required
1	GND 2706	12-11-18 15:30	GW	As per Quote 95546 plus Potassium (K).
2	GND 2708	12-11-18 14:40	GW	" "
3	GND 2707	12-11-18 13:15	GW	" "
4	GND 2705	12-11-18 11:30	GW	" "
5				
6				
7				
8				
9				
10				

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Hamilton 3240 New Zealand

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W www.hill-laboratories.com

Job Information Summary

Client:	BTW Company Limited	**Lab No:**	2079242
Contact:	Greg Larkin	**Date Registered:**	13-Nov-2018 6:27 am
	C/- BTW Company Limited	**Priority:**	High
	PO Box 551	**Quote No:**	95546
	New Plymouth 4340	**Order No:**	
		Client Reference:	MHW 3D
		Add. Client Ref:	
		Submitted By:	Teone Smith
		Charge To:	BTW Company Limited
		Target Date:	20-Nov-2018 4:30 pm

Samples

No	Sample Name	Sample Type	Containers	Tests Requested
1	GND 2706 12-Nov-2018 3:30 pm	Ground Water	UP500, SterThio, NWU100	Anion / Cation profile, dissolved metals trace level; Turbidity; Approx Total Dissolved Salts; Escherichia coli; Dissolved Boron; Dissolved Copper; Dissolved Iron; Dissolved Manganese; Dissolved Potassium; Dissolved Zinc; Total Ammoniacal-N; Dissolved Reactive Phosphorus
2	GND 2708 12-Nov-2018 2:40 pm	Ground Water	UP500, SterThio, NWU100	Anion / Cation profile, dissolved metals trace level; Turbidity; Approx Total Dissolved Salts; Escherichia coli; Dissolved Boron; Dissolved Copper; Dissolved Iron; Dissolved Manganese; Dissolved Potassium; Dissolved Zinc; Total Ammoniacal-N; Dissolved Reactive Phosphorus
3	GND 2707 12-Nov-2018 1:15 pm	Ground Water	UP500, SterThio, NWU100	Anion / Cation profile, dissolved metals trace level; Turbidity; Approx Total Dissolved Salts; Escherichia coli; Dissolved Boron; Dissolved Copper; Dissolved Iron; Dissolved Manganese; Dissolved Potassium; Dissolved Zinc; Total Ammoniacal-N; Dissolved Reactive Phosphorus
4	GND 2705 12-Nov-2018 11:30 am	Ground Water	UP500, SterThio, NWU100	Anion / Cation profile, dissolved metals trace level; Turbidity; Approx Total Dissolved Salts; Escherichia coli; Dissolved Boron; Dissolved Copper; Dissolved Iron; Dissolved Manganese; Dissolved Potassium; Dissolved Zinc; Total Ammoniacal-N; Dissolved Reactive Phosphorus

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.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-4
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	1-4
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	1-4
Turbidity	Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 22nd ed. 2012.	0.05 NTU	1-4

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
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	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-4
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/m³ at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-4
Approx Total Dissolved Salts	Calculation: from Electrical Conductivity.	2 g/m³	1-4
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-4
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m³	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1-4
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m³	1-4
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/m³	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1-4
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/m³	1-4
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified). 22nd ed. 2012.	0.004 g/m³	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m³	1-4
Escherichia coli	MPN count using Colilert , Incubated at 35°C for 24 hours. APHA 9223 B (2004), 22nd ed. 2012.	1 MPN / 100mL	1-4

APPENDIX D NOVEMBER 2018 GME FIELD SHEETS

NLWRSD.

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

ENVIRONMENT FORMS

Section: ENV02
No. of Pages: 1
Issue: 3
Date: 8.11.2016

FIELD SHEET - GROUNDWATER MONITORING

SWL = 2.18 (start)
SWL = 2.38 (end)

Site: _____ Bore ID# GND2710 Sampled by: DB/TS BTW Job No: _____ Lab Quote: _____ Date: 8/11/18

Well Depth: 42 Screen Depth: _____ Purge Method: Bladder Time started: 14:00 Time Stopped: 14:25

Field Analysis								
SWL (m)	Time (min)	Volume (L)	Temp (°C)	DO2 (mg/l)	SP Condy (µS)	pH	Cl- (mg/L)	Comments (odour, colour, constant head, head works damage)
2.18	1-00	100ml	15.5	5.11	1135	8.72	18.82	Pump @ approx 10m. Clear & No odour.
2.26	2-00	"	15.4	4.06	1126	8.73	17.30	
	3-00	"	15.4	3.58	1124	8.74	18.56	
	4-00	"	15.3	3.75	1123	8.74	17.78	
	5-00	"	15.3	3.81	1122	8.74	19.35	
	6-00	"	15.2	4.01	1122	8.74	18.00	
	7-00	"	15.2	4.00	1122	8.74	18.82	
	8-00	"	15.2	3.71	1122	8.74	18.86	
	13-00	"	15.2	3.34	1122	8.74	22.00	
	18-00	"	15.1	3.32	1122	8.74	21.42	
	23-00	"	15.1	3.29	1121	8.74	23.02	
		"						
		"						
		"						
		"						

temp +-0.2
Ph -0.1
condy +/- 3%.
DO2

FIELD SHEET - GROUNDWATER MONITORING

Site: _____ Bore ID# GW02709 Sampled by: DB/TS BTW Job No: _____ Lab Quote: _____ Date: 8/11/18

Well Depth: 14.8m Screen Depth: _____ Purge Method: Bladder Time started: 3:05 Time Stopped: 3:30

Field Analysis								
SWL (m)	Time (min)	Volume (L)	Temp (°C)	DO2 (mg/l)	SP Condy (µS)	pH	Cl- (mg/L)	Comments (odour, colour, constant head, head works damage)
3.89 (pump in)	1.00 min	100 ml	14.9	1.68	152.2	5.93	6.54	Iron staining on tubing, Clear no odour
4.25	2.00 min	"	14.7	1.26	151.8	5.90	6.93	
4.20	5.00 min	"	14.6	1.54	150.8	5.91	7.29	
	10:00 min	"	14.6	1.89	149.9	5.92	8.06	
	15:00 min	"	14.8	2.06	150.0	5.93	8.43	
	20:00 min	"	14.8	2.09	150.2	5.94	8.51	Clear no odour
	25:00 min	"	14.8	2.10	150.4	5.94	8.62	— Sample Iron flecks noted

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ENVIRONMENT FORMS

Section: ENV02
No. of Pages: 1
Issue: 3
Date: 8.11.2016

FIELD SHEET - GROUNDWATER MONITORING

Site: Uphole 9263 Bore ID# GND2705 (Tarkwa Valley) Sampled by: TS & CG BTW Job No: 181084.05 Lab Quote: 72247 Date: 12.11.18

Well Depth: _____ Screen Depth: _____ Purge Method: Bladder Time started: 10.50 Time Stopped: 11:30

Pump @ 6.0m

Field Analysis

SWL (m)	Time (min)	Volume (L)	Temp (°C)	DO2 (mg/l)	SP Condy (µS)	pH	Cl- (mg/L)	Comments (odour, colour, constant head, head works damage)
3.64	02:00	100ml/min	15.3	0.77	2322	10.41	1090.9	discoloured, no odour.
3.75	05:00	100ml	14.9	0.32	2320	10.37	1152.3	discoloured
3.82	10:00	100ml	15.0	0.25	2317	10.49	1217.7	
	15:00	100ml	15.0	0.24	2318	10.74	1262.3	
3.96	20:00	100ml	15.0	0.27	2315	10.78	1231.7	
4.05	25:00	100ml	14.9	0.29	2316	10.78	1247.8	
4.15	30:00	100ml	15.0	0.29	2314	10.77	1250.1	Orange iron staining throughout.

Semi-Stable and sampled @ 11:30am

SWL @ finish 4.35

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ENVIRONMENT FORMS

Section: ENV02
No. of Pages: 1
Issue: 3
Date: 8.11.2016

FIELD SHEET - GROUNDWATER MONITORING

Site: Uphole 9311 Bore ID# GND270887 (Tiko) Sampled by: TS & GG BTW Job No: 181084.05 Lab Quote: 72247 Date: 12.11.18

Well Depth: _____ Screen Depth: _____ Purge Method: Bladder Time started: 13.00 Time Stopped: 13:30

Field Analysis								
SWL (m)	Time (min)	Volume (L)	Temp (°C)	DO2 (mg/l)	SP Condy (µS)	pH	Cl- (mg/L)	Comments (odour, colour, constant head, head works damage)
11.38	0	.1	15.7	0.51	289.8	11.28	33.17	Clear, no odour.
11.39	5	0.1	15.7	0.31	288.1	11.30	33.64	
11.39	10	0.1	15.6	0.24	287.8	11.29	34.01	
11.395	15	0.1	15.6	0.22	288.1	11.15	34.28	
	20	0.1	15.7	0.22	288.5	11.21	34.56	

SWL = 11.37

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ENVIRONMENT FORMS

Section: ENV02
No. of Pages: 1
Issue: 3
Date: 8.11.2016

FIELD SHEET - GROUNDWATER MONITORING

Site: MB304 Bore ID# C-site GW02708 Sampled by: TS & GC BTW Job No: 181684.05 Lab Quote: 72247 Date: 12.11.18

Purge ~~Well~~ Depth: 13.5 Screen Depth: _____ Purge Method: Bladder Time started: 14:20 Time Stopped: 14:45

Field Analysis

SWL (m)	Time (min)	Volume (L)	Temp (°C)	DO2 (mg/l)	SP Condy (µS)	pH	Cl- (mg/L)	Comments (odour, colour, constant head, head works damage)
10.47m	0	100	17.3	0.56	212.2	7.58	4.32	Clear, Strong Sulfur Odour
	5	100	17.4	0.3	211.4	7.64	4.94	
	10:00	100	17.6	0.27	210.9	7.67	4.92	
	15	100	17.6	0.21	210.1	7.71	5.14	Stable & Sampled.

FIELD SHEET - GROUNDWATER MONITORING

Site: _____ Bore ID# GND2708 (Megan) Sampled by: TS & GC BTW Job No: 181084.05 Lab Quote: _____ Date: _____

Well Depth: _____ Screen Depth: _____ Purge Method: Bladder Time started: 15:00 Time Stopped: _____

Field Analysis								
SWL (m)	Time (min)	Volume (L)	Temp (°C)	DO2 (mg/l)	SP Condy (µS)	pH	Cl- (mg/L)	Comments (odour, colour, constant head, head works damage)
								Artesian bore hole extremely low flow... Unable to collect water so hand syringe H_2O out.

APPENDIX E NOVEMBER 2018 GME HILLS LABS REPORT

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

Client:	BTW Company Limited	**Lab No:**	2077880	SPv1
Contact:	Greg Larkin	**Date Received:**	09-Nov-2018	
	C/- BTW Company Limited	**Date Reported:**	16-Nov-2018	
	PO Box 551	**Quote No:**	95546	
	New Plymouth 4340	**Order No:**		
		Client Reference:		
		Submitted By:	Greg Larkin	

Sample Type: Aqueous

Sample Name:		GND 2710 08-Nov-2018 2:30 pm	GND 2709 08-Nov-2018 3:40 pm			
Lab Number:		2077880.1	2077880.2			
Sum of Anions	meq/L	13.6	1.46	-	-	-
Sum of Cations	meq/L	13.8	1.45	-	-	-
Turbidity	NTU	1.36	10.8	-	-	-
pH	pH Units	8.6	6.3	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$	620	34	-	-	-
Bicarbonate	g/m³ at 25°C	730	41	-	-	-
Total Hardness	g/m³ as $CaCO_3$	14.5	39	-	-	-
Electrical Conductivity (EC)	mS/m	116.7	16.0	-	-	-
Approx Total Dissolved Salts	g/m³	780	107	-	-	-
Dissolved Boron	g/m³	2.5	0.014	-	-	-
Dissolved Calcium	g/m³	3.2	8.8	-	-	-
Dissolved Copper	g/m³	0.0011	0.0022	-	-	-
Dissolved Iron	g/m³	0.02	0.07	-	-	-
Dissolved Magnesium	g/m³	1.59	4.1	-	-	-
Dissolved Manganese	g/m³	0.0064	0.0159	-	-	-
Dissolved Potassium	g/m³	1.73	1.52	-	-	-
Dissolved Sodium	g/m³	310	14.5	-	-	-
Dissolved Zinc	g/m³	0.0022	0.0133	-	-	-
Chloride	g/m³	41	19.9	-	-	-
Total Ammoniacal-N	g/m³	0.78	0.028	-	-	-
Nitrite-N	g/m³	< 0.002	0.007	-	-	-
Nitrate-N	g/m³	< 0.002	0.59	-	-	-
Nitrate-N + Nitrite-N	g/m³	0.003	0.59	-	-	-
Dissolved Reactive Phosphorus	g/m³	0.190	< 0.004	-	-	-
Sulphate	g/m³	< 0.5	9.1	-	-	-
Escherichia coli	MPN / 100mL	10	11	-	-	-

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.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
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

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
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
Turbidity	Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 22nd ed. 2012.	0.05 NTU	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/m³ 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/m³ at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-2
Approx Total Dissolved Salts	Calculation: from Electrical Conductivity.	2 g/m³	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
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m³	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-2
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-2
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-2
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-2
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1-2
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m³	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/m³	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	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/m³	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified). 22nd ed. 2012.	0.004 g/m³	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m³	1-2
Escherichia coli	MPN count using Colilert , Incubated at 35°C for 24 hours. APHA 9223 B (2004), 22nd ed. 2012.	1 MPN / 100mL	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.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

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Hamilton 3240 New Zealand

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W www.hill-laboratories.com

Certificate of Analysis

Client:	BTW Company Limited	**Lab No:**	2079242	SPv1
Contact:	Greg Larkin C/- BTW Company Limited PO Box 551 New Plymouth 4340	**Date Received:** **Date Reported:** **Quote No:** **Order No:** **Client Reference:** **Submitted By:**	13-Nov-2018 20-Nov-2018 95546 MHW 3D Teone Smith	

Sample Type: Aqueous

Sample Name:		GND 2706 12-Nov-2018 3:30 pm	GND 2708 12-Nov-2018 2:40 pm	GND 2707 12-Nov-2018 1:15 pm	GND 2705 12-Nov-2018 11:30 am	
Lab Number:		2079242.1	2079242.2	2079242.3	2079242.4	
Sum of Anions	meq/L	14.8	2.2	2.5	23	-
Sum of Cations	meq/L	14.7	2.3	2.5	22	-
Turbidity	NTU	9.2	0.32	5.9	56	-
pH	pH Units	8.5	7.5	10.4	9.6	-
Total Alkalinity	g/m³ as $CaCO_3$	56	90	41	76	-
Bicarbonate	g/m³ at 25°C	65	109	11.6	67	-
Total Hardness	g/m³ as $CaCO_3$	191	86	9.8	15.6	-
Electrical Conductivity (EC)	mS/m	164.2	21.7	29.2	241	-
Approx Total Dissolved Salts	g/m³	1,100	145	196	1,610	-
Dissolved Boron	g/m³	0.043	0.017	0.22	1.93	-
Dissolved Calcium	g/m³	35	18.7	3.9	5.6	-
Dissolved Copper	g/m³	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-
Dissolved Iron	g/m³	< 0.02	0.16	< 0.02	< 0.02	-
Dissolved Magnesium	g/m³	25	9.6	0.05	0.38	-
Dissolved Manganese	g/m³	0.33	0.113	0.0006	0.0028	-
Dissolved Potassium	g/m³	5.4	1.47	4.6	4.4	-
Dissolved Sodium	g/m³	240	12.4	48	490	-
Dissolved Zinc	g/m³	< 0.0010	0.0010	< 0.0010	< 0.0010	-
Chloride	g/m³	490	12.4	51	750	-
Total Ammoniacal-N	g/m³	2.0	0.016	0.79	7.5	-
Nitrite-N	g/m³	< 0.002	< 0.002	0.002	< 0.002	-
Nitrate-N	g/m³	0.038	< 0.002	< 0.002	0.002	-
Nitrate-N + Nitrite-N	g/m³	0.038	< 0.002	0.003	0.002	-
Dissolved Reactive Phosphorus	g/m³	< 0.004	0.052	< 0.004	< 0.004	-
Sulphate	g/m³	< 0.5	3.7	11.1	13.0	-
Escherichia coli	MPN / 100mL	< 1	< 1	< 1	< 1	-

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.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-4
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	1-4

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
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	1-4
Turbidity	Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 22nd ed. 2012.	0.05 NTU	1-4
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	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-4
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/m³ at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-4
Approx Total Dissolved Salts	Calculation: from Electrical Conductivity.	2 g/m³	1-4
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-4
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m³	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1-4
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m³	1-4
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/m³	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1-4
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/m³	1-4
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified). 22nd ed. 2012.	0.004 g/m³	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m³	1-4
Escherichia coli	MPN count using Colilert , Incubated at 35°C for 24 hours. APHA 9223 B (2004), 22nd ed. 2012.	1 MPN / 100mL	1-4

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

APPENDIX F TRC DISCHARGE PERMIT 10352-1.0

Taranaki Regional Council

Discharge Permit

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

Name of Consent Holder:	Todd Energy Limited PO Box 802 New Plymouth 4340
Decision Date:	03 November 2016
Commencement Date:	03 November 2016

Conditions of Consent

Consent Granted:	To discharge contaminants to land where they may enter groundwater, including residues from detonation of explosive charges and degradation of unexploded charges, associated with undertaking a seismic survey
Expiry Date:	01 June 2021
Review Date(s):	In accordance with special conditions 5 & 8
Site Location:	Various locations in the Tikorangi area as per Appendix 1
Grid Reference (NZTM)	Various
Catchment:	Various

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

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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. The activity shall be undertaken in general accordance with the information provided in support of the application for this consent. Where there is conflict between the application and the consent conditions the conditions shall prevail.

2. This consent authorises the discharge of contaminants resulting from undertaking a seismic survey only within the area shown on the map attached (Appendix 1). The contaminants include:
   (a) those arising from placing charges of Dyno Nobel Geoprime® dBX™ explosive, each no more than 2 kg, at depths between 10 and 50 metres below ground; and
   (b) residues from detonating charges of Dyno Nobel Geoprime® dBX™ explosive, each no more than 2 kg, at depths between 10 and 50 metres below ground.

3. No more than one charge shall be placed in each shot hole unless it is necessary to address a misfire, in which case another charge of up to 2 kg may be added.

4. The discharges shall be from the progressive detonation of charges with no detonations occurring after 30 April 2017.

5. The consent holder shall report the following information to the Chief Executive, Taranaki Regional Council on the first day of each month, with the first monthly report to include information in relation to all previous activity:
   (a) the NZTM grid reference of the location of each shot hole;
   (b) the depth of each shot hole and depth of the explosive;
   (c) the amount of explosive in each shot hole;
   (d) the date that each charge was detonated;
   (e) the location of shot holes where the charge misfired and details of any additional charge that may have been placed in the hole; and
   (f) the date that each shot hole is abandoned and details of the method of abandonment.

6. To minimise any effects on groundwater all shot holes shall be:
   (a) capped at surface to minimise the ingress of surface water on the same day that the charge is placed and re-capped on the same day as detonation and data acquisition occurs; and
   (b) restored and abandoned within 30 working days of detonation.

7. The activity shall not cause any change in groundwater quality that results in it being unsuitable for its current use.

8. The consent holder shall undertake a programme of sampling and testing that identifies the effects of the exercise of this consent on groundwater resources over the duration of the consent (the 'Monitoring Programme'). The Monitoring Programme may be reviewed from time to time but at all times shall be certified by the Chief Executive, Taranaki Regional Council, and shall include:

   (a) water quality criteria for applicable existing uses;

   (b) the location of each sampling point and the frequency of sampling;

   (c) a listing of analyses to be undertaken for contaminants that could result from the discharges authorised;

   (d) specific monitoring of the effects of unexploded charges on groundwater quality; and

   (e) details of how and when the results of monitoring will be reported to the Taranaki Regional Council.

9. 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 within 3 months of receiving a report in accordance with condition 5 and/or 8 above, 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 03 November 2016

For and on behalf of
Taranaki Regional Council

A D McLay
Director - Resource Management

APPENDIX G VISIBLE CORROSION ON BLADDER PUMP IN GND 2705

Figure 6.1: Bladder pump post sample collection in GND 2705