

Todd Taranaki Limited
Mangahewa-A Hydraulic Fracturing
Groundwater Monitoring Programme Report
2012-2013
Technical Report 2013–19

ISSN: 0114-8184 (Print)
ISSN: 1178-1467(Online)
Document: 1212802 (Word)
Document: 1230406 (Pdf)

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September 2013

Executive summary

Todd Taranaki Limited (the Company) established the Mangahewa-A wellsite in 1996. The wellsite is located on Otaraoa Road, Tikorangi. The resource consents held by the Company permit the drilling of up to eight wells from the wellsite.

As of 30 June 2013, 2 wells have been drilled from the Mangahewa-A wellsite since its establishment, Mangahewa-02 and Mangahewa-05. In order to stimulate production from the Mangahewa-05 well, a total of 2 distinct producing zones were stimulated by hydraulically fracturing on 18 July and 4 August 2012. The fractured zones were located within the Mangahewa Formation, ranging in depth from 3,437 to 4,093 metres below ground level (total vertical depth).

The discharges to land associated with the hydraulic fracturing of the Mangahewa-05 well were permitted under resource consent 9238-1. The consent includes a number of special conditions, including specific conditions relating to the protection of local groundwater resources and groundwater sampling and analysis requirements. The Council was contracted by the Company to undertake the sampling and analysis of groundwater required by the conditions of the exercised consent.

The following report describes the groundwater monitoring programme implemented by the Taranaki Regional Council (the Council) to assess the potential effects of hydraulic fracturing activities at the Mangahewa-A wellsite on groundwater resources in the area surrounding the site. The results of the monitoring undertaken allow for an assessment of the Company's environmental performance to be made in relation to hydraulic fracturing activities and whether compliance with the conditions of consent 9238-1, relating specifically to the monitoring and protection of groundwater resources, has been achieved. The report covers the monitoring period 1 July 2012 to 30 June 2013.

The monitoring programme implemented by the Council included the sampling and analysis of groundwater samples taken from 4 private water supply wells in the area surrounding the Mangahewa-A wellsite. Groundwater samples were submitted to Hills Laboratory for comprehensive physicochemical analysis. Groundwater samples were obtained from the private water supplies prior to the hydraulic fracturing of the Mangahewa-05 well (baseline) and at intervals of 1 week and 3 months post hydraulic fracturing. Samples of the hydraulic fracturing fluid used during the fracture treatment, and the formation fluids produced immediately following hydraulic fracturing were also obtained for analysis. In total, 14 samples were obtained for analysis during the period under review, over a total of 7 sampling visits.

The results of the analyses carried out on samples taken from private water supplies show that the concentrations of each parameter analysed for remained consistent across the sampling period, with no significant changes detected post hydraulic fracturing.

There is no evidence to suggest that the hydraulic fracturing of the Mangahewa-05 well has resulted in any adverse effects on shallow groundwater in the vicinity of the Mangahewa-A wellsite. The Company has demonstrated a high level of environmental performance and compliance with regard to relevant conditions of resource consent 9238-1.

This report includes recommendations concerning the nature of on-going groundwater monitoring in the vicinity of the Mangahewa-A wellsite.

A separate report (Todd Taranaki Limited, Mangahewa-A Exploration Wellsite Monitoring Programme Report, Technical Report 2012-85, Taranaki Regional Council, September 2013) outlines all other wellsite activities carried out during the period September 2011 to December 2012 and the monitoring of these activities undertaken by the Council.

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1. Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act (1991)

1.1.1 Introduction

The following report describes the groundwater monitoring programme implemented by the Taranaki Regional (the Council) in relation to hydraulic fracturing activities undertaken by Todd Taranaki Limited (the Company) at their Mangahewa-A wellsite, Otaraoa Road, Tikorangi. The report also outlines and assesses the results of the monitoring carried out, and provides an assessment of Company performance with regard to consent compliance. The report encompasses the monitoring period 1 July 2012 to 30 June 2013.

As of 30 June 2013, 2 wells have been drilled from the Mangahewa-A wellsite since its establishment. The first well drilled from the wellsite, Mangahewa-02, was drilled by Fletcher Challenge Energy between December 1996 and February 1997. Following completion of drilling operations the well was hydraulically fractured in May 1997. The fracture intervals were located between 3,608 and 4,124 m below ground level (total vertical depth - mTVD).

As part of the on-going well development programme at the wellsite, the Mangahewa-05 well was drilled by Todd Taranaki Limited between 18 April and 6 May 2012. In order to stimulate production from the well, 2 distinct producing zones within the Mangahewa Formation were hydraulically fractured. Zone 1, from 4,078 to 4,093 mTVD, was fractured on 18 July 2012 and Zone 2, from 3,437 to 3,453 mTVD, on 4 August 2012.

The discharges to land associated with hydraulic fracturing of the Mangahewa-05 well were permitted under resource consent 9238-1. . The consent includes a number of special conditions, including specific conditions relating to the protection of local groundwater resources and groundwater sampling and analysis requirements. The Council was contracted by the Company to undertake the sampling and analysis of groundwater required by the conditions of the exercised consent.

The overall record of consent compliance and environmental performance at the Mangahewa-A wellsite is set out in the Council's exploration wellsite monitoring report for the site¹. This report has been prepared by the Taranaki Regional Council to address specific monitoring investigations into the potential effects of hydraulic fracturing on groundwater resources in the vicinity of the Mangahewa-A wellsite.

1.1.2 Structure of this report

Section 1 of this report is a background section. It sets out general information about compliance monitoring under the Resource Management Act and the Council's obligations and general approach to monitoring sites through monitoring programmes. Section 1 also describes the environment in which the Mangahewa-A wellsite is located, the process of hydraulic fracturing, details the resource consent held by the Company for hydraulic fracturing at the Mangahewa-A wellsite, outlines

¹ See bibliography

hydraulic fracturing activities carried out at the site during the period under review, and the nature of the monitoring programme implemented by the Council.

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

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

Section 4 presents recommendations regarding the on-going monitoring of groundwater in the vicinity of the site.

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

1.1.3 The Resource Management Act (1991) and monitoring

The Resource Management Act (the Act) 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 a discharger, and may include cultural and socio-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 (eg, recreational, cultural, or aesthetic);
- (e) risks to the neighbourhood or environment.

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

1.1.4 Evaluation of environmental performance

Besides discussing the various details of the performance and extent of compliance by the Company during the period under review, this report also assigns an overall environmental performance rating. The categories used by the Council, and their interpretation, are as follows:

- a **high** level of environmental performance and compliance indicates that essentially there were no adverse environmental effects to be concerned about, and no, or inconsequential (such as data supplied after a deadline) non-compliance with conditions.
- a **good** level of environmental performance and compliance indicates that adverse environmental effects of activities during the monitoring period were negligible or minor at most, or, the Council did not record any verified unauthorised incidents involving significant environmental impacts and was not obliged to issue any abatement notices or infringement notices, or, there were perhaps some items noted on inspection notices for attention but these items were not urgent nor critical, and follow-up inspections showed they have been dealt with, and inconsequential non-compliances with conditions were resolved positively, co-operatively, and quickly.
- **improvement desirable** indicates that the Council may have been obliged to record a verified unauthorised incident involving measureable environmental impacts, or, there were measureable environmental effects arising from activities and intervention by Council staff was required, and there were matters that required urgent intervention, took some time to resolve, or remained unresolved at end of the period under review, and/or abatement notices may have been issued.
- **poor performance** indicates that the Council may have been obliged to record a verified unauthorised incident involving significant environmental impacts, or, there were adverse environmental effects arising from activities and there were grounds for prosecution or an infringement notice.

1.2 Existing environment

1.2.1 Site location

The Mangahewa-A wellsite is located on Otaraoa Road, Tikorangi (Figure 1). Prior to the establishment of the wellsite, the land on which it is situated was used for livestock farming and forestry purposes.

The wellsite lies in an active petrochemical exploration and production area, which includes the McKee oil field and the Kowhai and Turangi gas fields.

The area consists of predominantly low density housing due to its rural location.

1.2.2 Geology

The hydraulically fractured intervals are located within the Mangahewa Formation, over an approximate depth range of 3,437 to 4,093 mTVD.

The fractured intervals are isolated by the overlying Turi and Otaraoa Formations. These formations are comprised of highly impermeable shale and siltstone, which have restricted the vertical migration of gas and fluids over geologic time scales, resulting in the formation of the underlying hydrocarbon reservoir. The pressure within the reservoir is known to exceed hydrostatic pressure, confirming that it is

confined from overlying formations. In addition, hundreds of metres of low permeability strata overlie the Turi and Otaraoa Formations, further reducing the potential for any migration of formation fluids or hydrocarbons from the producing zones. The geological formations underlying the site are summarised below in Table 1.

There is no evidence of any active modern day faulting in the vicinity of the Mangahewa-A wellsite.

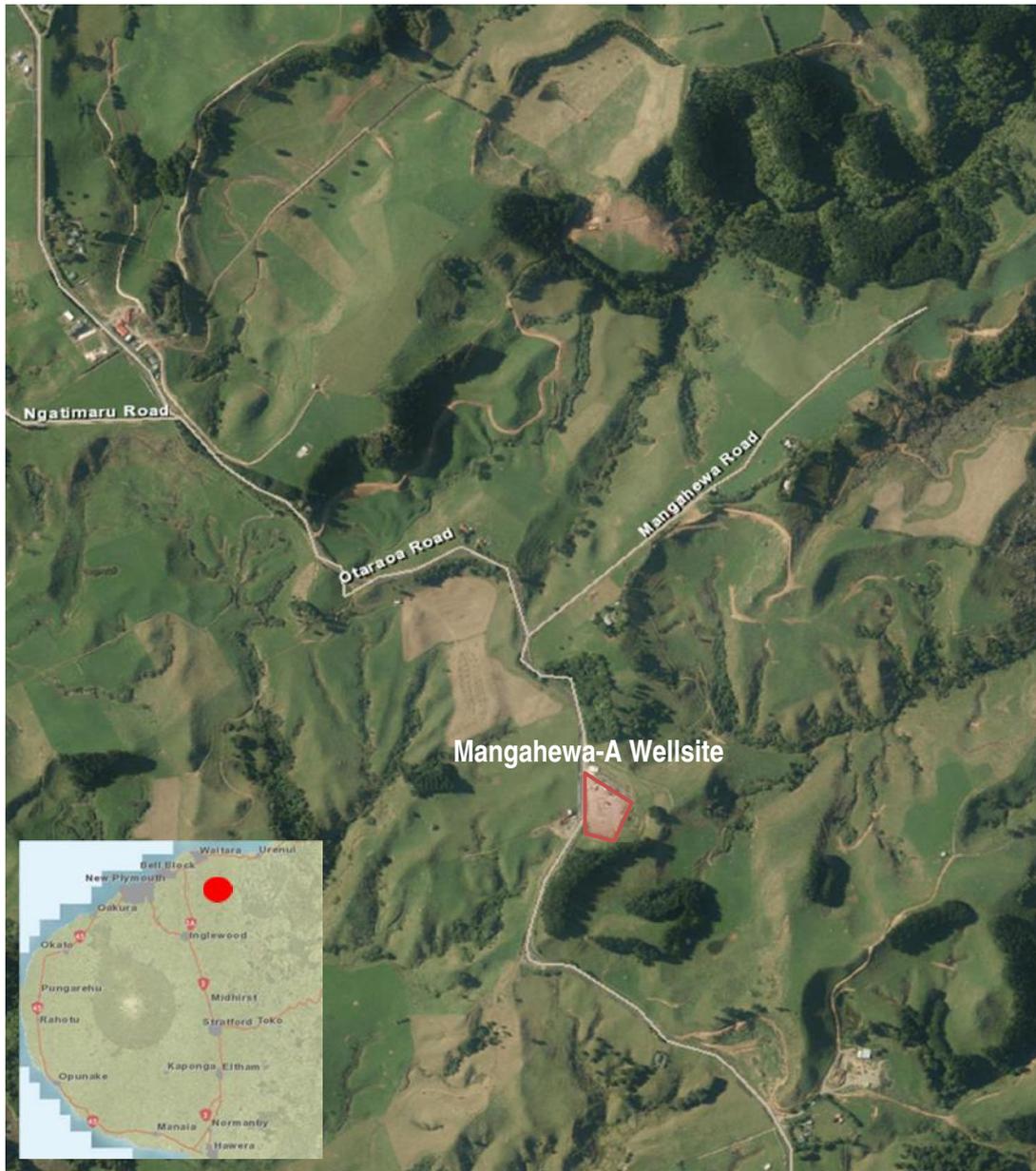


Figure 1 Location of Mangahewa-A wellsite

Table 1 Summary of geological formations underlying the Mangahewa-A wellsite

Formation	Description	Depth (mTVDSS) ²
Egmont Volcanics	River gravels and volcanic debris	GL to -10
Matemateaonga	Sandy siltstones and silty claystones	-10 to -125
Urenui	Calcareous claystone with minor interbedded siltstone and sandstone	-125 to -765
Mt. Messenger	Claystone, with very fine sandstone beds	-765 to -1280
Manganui	Claystone with minor sandstone, siltstone and limestone beds	-1280 to -2725
Taimana	Calcareous claystone grading into argillaceous limestone	-2725 to -2915
Tikorangi	Argillaceous limestone	-2915 to -2955
Otaraoa	Calcareous silty claystone with minor calcareous siltstones	-2955 to -3231
Turi	Argillaceous, carbonaceous siltstone	-3231 to -3236

1.2.3 Hydrogeology

The shallow water bearing geological deposits underlying the Mangahewa-A wellsite include the Taranaki Volcanic and Matemateaonga Formations.

Approximately 80% of all groundwater used within Taranaki is extracted from aquifers contained in volcanic deposits. Most of this is used for agricultural purposes (Taylor & Evans, 1999). Thicknesses of up to 170 m have been encountered near Stratford. However, in general the formation thins concentrically away from the volcanic source (Mount Taranaki/Egmont). The volcanic deposits comprise both coarse material (sands, breccia, agglomerates) and fine material (clay, tuff and ash), resulting in irregular lithologies and anisotropic hydrogeologic conditions (Taylor & Evans, 1999). This produces a complex groundwater system of multiple perched and partially confined aquifers. Typically the unconfined groundwater level (water table) on the ring plain is encountered at depths of 1 to 10 m below ground level; these are the aquifers that are most used in Taranaki for domestic and farm purposes. The deeper aquifers in the volcanics are usually confined, whereas the shallower aquifers are usually unconfined. In addition, perched water tables are found above various impermeable layers throughout the volcanic deposits. These are caused by localised iron pans and mudstones, and have been found at almost any depth from a few metres down to about 230 m. Groundwater levels in wells drilled in volcanic deposits on the ring plain are generally close to the surface (Taylor and Evans, 1999). Recharge of the Volcanics Formation aquifers is primarily from rainfall infiltration.

The Matemateaonga Formation comprises alternating Tertiary sandstone, conglomeratic shell and mudstone beds. The formation extends across almost the entire region, except north of Urenui (Taylor & Evans, 1999). In a hydrocarbon exploration bore near Stratford the formation was encountered from 170 to 1,086 m below ground level. It is exposed throughout large areas of the eastern hill country in central and south Taranaki. The formation contains a greater proportion of sands towards south Taranaki, and is more fine-grained in the north. The upper Matemateaonga aquifers in North Taranaki are largely unconfined. Elsewhere in the region, the aquifers are either confined or partially confined. Flowing artesian conditions exist at a number of localities, particularly in a band of incised hill country

² mTVDSS: the true vertical depth sub sea level

bordering the ring plain from Toko south to Ohangai. The Tertiary sediments that make up the inland hill country in the east of the region also underlie the volcanics deposits of the ring plain. The principal Tertiary water bearing formation is the Matemateaonga, where generally extensive aquifers are developed within sand and shellbeds between relatively impermeable mudstone layers (Allis et al, 1997).

The Council's Wells Database indicates that there are 4 private groundwater abstractions within a 2 kilometre (km) radius of the Mangahewa-A wellsite. The specific details of each abstraction are included below in Table 2. Three of the groundwater abstractions registered in the vicinity of the Mangahewa-A wellsite are shallow wells, ranging in depth from 3 metres (m) to 5 m. GND1081 is a spring discharge. The majority of abstractions are utilised as stock water rather than for consumptive purposes. The abstractions listed below all draw their water from the superficial Taranaki Volcanics Formation.

The salinity of groundwater beneath the site increases with depth. The freshwater to saline water interface is a gradational feature, above which there is potential for freshwater to occur. The salinity of groundwater can be assessed by analysing resistivity survey logs. Based on resistivity data available for surrounding wells, and their correlation with the stratigraphic sequence of the Mangahewa-A wells, the freshwater to saline water interface below the Mangahewa-A wellsite has been estimated to occur within the lower Matemateaonga Formation, at a depth of 275 m below sea level. The Mangahewa-A wellsite is elevated approximately 122 m above sea level, therefore it is estimated that potentially useable groundwater will be encountered to depth of approximately 400 m below the wellsite.

Table 2 Summary of groundwater abstractions within 2 km radius of Mangahewa-A wellsite

Site Code	Easting (NZTM)	Northing (NZTM)	Classification	Distance from Wellsite (m)	Total Depth (m)	Static Water Level (m)	Formation / Aquifer
GND1081	1714040	5674772	Spring	485	5	NA	Taranaki Volcanics
GND2258	1713501	5675128	Well	1,041	5	2.04	Taranaki Volcanics
GND2263	1714326	5674780	Well	534	5	2.755	Taranaki Volcanics
GND2279	1714263	5673737	Well	575	3	0.828	Taranaki Volcanics

1.3 Resource consents and Regional Fresh Water Plan

1.3.1 Discharge permits

Sections 15(1)(b) and (d) of the Act, stipulate that no person may discharge any contaminant onto or into 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.

The discharge of contaminants associated with hydraulic fracturing, onto and into land where contaminants may reach water, is a discretionary activity under Rule 44 of the Regional Freshwater Plan for Taranaki (RFP).

The rule is set out below:

Discharge of contaminants onto or into land restricted by s15(1)(b) [where contaminants may reach water] and s15(1)(d) [where the discharge is from industrial or trade premises] of the Act which is not expressly provided for in Rules 21-42 or which is provided for but does not meet the standards, terms or conditions and any other discharge of contaminants to land which is provided for in Rules 21-42 but which does not meet the standards, terms or conditions of those rules [irrespective of whether the discharges are from industrial or trade premises or are likely to reach water].

1.3.2 Relevant resource consent held by the Company

Resource consent 9238-1, "to discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3,200 mTVDSS beneath the Mangahewa-A wellsite," was granted to the Company on 16 April 2012, under Section 87(e) of the Act.

Consent conditions were imposed to ensure that any potential adverse environmental effects associated with the proposed activity were avoided. A summary of the conditions attached to the consent are as follows:

- Condition 1 requires the injection of fluids to be below 3,200 mTVDSS;
- Condition 2 requires that the exercise of the consent does not contaminate or put at risk actual or potential usable freshwater aquifers above the hydrocarbon reservoir;
- Conditions 3, 4 and 5 relate to groundwater monitoring requirements;
- Condition 6 requires the consent holder to carry out well and equipment pressure testing prior to fracturing;
- Condition 7 requires the consent holder to submit a "Pre-fracturing Discharge Report" at least 14 days prior to any hydraulic fracturing discharge;
- Condition 8 is a notification requirement;
- Condition 9 requires the consent holder to submit a "Post-fracturing Discharge Report" within 30 days of the discharge ceasing;
- Condition 10 details the address and format for information submission;
- Condition 11 requires the consent holder to provide access for Council staff to obtain fluid samples;
- Condition 12 requires the best practicable option to be adopted for injection;
- Condition 13 stipulates that fracturing fluids shall be comprised of no less than 95% water and proppant by volume; and
- Condition 14 is a review condition.

The consent conditions provide the Council with an option to review the conditions of the consent at specified intervals. Optional reviews are provided for on an annual basis for the duration of the consent, with the next review date being 1 June 2014.

The permit is due to expire on 1 June 2015.

At the request of the Company, the Council was contracted to undertake the groundwater monitoring required by conditions 3, 4 and 5 of the consent.

A copy of consent 9238-1 is included in Appendix I of this report.

1.4 Process description

1.4.1 Hydraulic fracturing

Hydraulic fracturing is a reservoir stimulation technique used to increase the flow of hydrocarbon fluids to the surface. The primary objective of hydraulic fracturing is to increase the area of the target reservoir that is exposed to the wellbore and which, therefore, may contribute to fluid or gas flow, once the hydraulic fracturing operation has been completed.

The process of hydraulic fracturing involves the pumping of fluids (consisting of freshwater and a small volume of chemicals) and a proppant (medium-grained sand or small ceramic pellets) down a well, through a perforated section of the well casing, and into the target reservoir. The fluid mixture is pumped at a pressure that exceeds the fracture strength of the reservoir rock in order to create artificial fractures in the receiving formation. Once fractures have been initiated, pumping continues in order to force the fluid and proppant into the fractures created. The proppant is designed to keep the fractures open when the pumping is subsequently stopped. The placement of proppant into the fractures is assisted by the use of cross-linked gels. These are solutions, which are liquid at the surface but, when mixed, form long-chain polymer bonds and thus become gels that transport the proppant into the formation. Once in the formation these gels 'break' back with time and temperature to a liquid state and are flowed back to surface without disturbing the proppant wedge. With continued flow, fluids pumped as part of hydraulic fracturing process, formation hydrocarbon fluids, and gases are drawn to the surface.

1.4.2 Well design

The Mangahewa-05 was drilled between 18 April and 6 May 2012. The well was constructed using steel casing, held in place with cement, installed as a succession of tubular sections. The annular space between the casing string and the surrounding geological formations is filled with cement. The cement provides foundation stability as well as isolating the wellbore and its contents from the surrounding formations and freshwater aquifers. The well is perforated between approximately 3,437 to 4,093 mTVD. Both the design of the well and the materials used in its construction were selected to withstand the pressure exerted during hydraulic fracturing and were thoroughly tested and evaluated prior to the hydraulic fracturing programme commencing.

1.4.3 Hydraulic fracturing programme

To date, the only hydraulic fracturing carried out by Todd Taranaki Ltd. at the Mangahewa-A wellsite is that of the Mangahewa-05 well on 18 July 2012 and 4 August 2012. Details of the hydraulic fracturing programme for the Mangahewa-05 well are listed below in Table 3.

Table 3 Summary of Manghaewa-05 hydraulic fracturing programme

Fracturing Event	Date	Formation	Depth (mTVD)	Depth (mTVDSS)
1	18 July 2012	Mangahewa	4,078 – 4,093	3,945 – 3,960
2	4 August 2012	Mangahewa	3,437 – 3,453	3,304 – 3,320

1.4.4 Post-fracturing discharge reports

As required by the conditions of the consent 9238-1, the Company provided a Post-fracturing Discharge Report following the completion of the Mangahewa-05 fracturing programme.

The conclusions from the report submitted are summarised as follows:

Fracture Event 1:

- The fracture interval was below 3,200 mTVDSS. Post job simulation indicates that the fractures were contained, and did not extend beyond this point;
- The fracturing fluid used was water based;
- The volume of fluid pumped into the formation (discharge) was 314 cubic metres (m³) with total proppant of 61 tons.
- The total duration of treatment was 82 minutes;
- In total, 177 m³ of fluid was recovered from the well post fracturing, leaving 137 m³ within the reservoir at the conclusion of the initial hydraulic fracturing flow back. Additional fracturing fluids will be returned to the surface as the well is produced. Returned fluids were trucked off-site for disposal via either deep well injection (99% of waste) or landfarming (1% of waste);
- Post fracturing modelling indicates that the total injected sand and fluids creating a propped fracture network in the reservoir 130 m in length (max. each side of the well) and 15 m in height (max.);
- The maximum wellhead pressure during the treatment was 6,200 pounds per square inch (psi). The maximum downhole pressure reached (at perforations) was 12,000 psi; and
- Pressure testing of the well annulus indicates that well integrity was maintained throughout the fracture treatment.

Fracture Event 2:

- The fracture interval was below 3,200 mTVDSS. Post job simulation indicates that the fractures were contained, and did not extend beyond this point;
- The fracturing fluid used was water based;
- The volume of fluid pumped into the formation (discharge) was 298 cubic metres (m³) with total proppant of 50 tons.
- The total duration of treatment was 78 minutes;
- In total, 166 m³ of fluid was recovered from the well post fracturing, leaving 132 m³ within the reservoir at the conclusion of the initial hydraulic fracturing flow back. Additional fracturing fluids will be returned to the surface as the well is produced. Returned fluids were trucked off-site for disposal via either deep well injection (99% of waste) or landfarming (1% of waste);
- Post fracturing modelling indicates that the total injected sand and fluids creating a propped fracture network in the reservoir 150 m in length (max. each side of the well) and 16 m in height (max.);
- The maximum wellhead pressure during the treatment was 5,011 pounds per square inch (psi). The maximum downhole pressure reached (at perforations) was 9,900 psi; and
- Pressure testing of the well annulus indicates that well integrity was maintained throughout the fracture treatment.

1.5 Monitoring programme

1.5.1 Introduction

Section 35 of the Act sets obligations upon the Council to gather information, monitor, and conduct research on the effects arising from consented activities within the Taranaki region and report upon these.

To perform its statutory obligations, the Council may be required to take 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. In addition, the Council was contracted by the Company to carry out the sampling and analysis of local groundwater resources required by the special conditions of consent 9238-1. The monitoring programme implemented by the Council in relation to the hydraulic fracturing activities at the Mangahewa-A wellsite, consisted of two main components:

- Programme design, liaison and management; and
- Physicochemical sampling;

Each component of the monitoring programme is discussed in further detail below.

1.5.2 Programme design, liaison and management

A significant amount of time was spent in the scoping and design stage of the project. Further time was spent in discussion with the Company regarding consent conditions and their interpretation and application, monitoring requirements, providing advice and guidance on the Council's environmental management strategies, the content of regional plans, and consultation on associated matters.

1.5.3 Physicochemical sampling

In order to select suitable sites for sampling, a survey of water abstraction sites within a 2 km radius of the Mangahewa-A wellsite was carried out. Initially, a desktop review of data held by the Council, including a search of the Council Wells Database, was conducted. The desktop review indicated that the Council held records of several groundwater abstractions in the area of investigation (Table 2). Following the desktop review, a field survey was undertaken on 28 June 2012 to confirm the location of known abstraction sites, to assess their suitability for sampling and to identify any additional groundwater abstraction sites that may not have been registered with the Council.

In total, 4 private groundwater abstraction sites were selected for inclusion the monitoring programme, the total number of private groundwater abstractions identified within 2 km of the Mangahewa-A wellsite. A sample of the hydraulic fracturing fluids used in the treatment of the Mangahewa-05 was also obtained for analysis, as was a sample of the fluids returning to the surface, via the wellbore, immediately following the conclusion of the fracturing programme.

Details of the sites selected for inclusion in the monitoring programme are listed below in Table 4. The locations of the sampling points are illustrated in Figure 2.

Table 4 Summary of sampling sites selected for inclusion in the monitoring programme

Site Code	Classification	Distance from Wellsite (m)	Casing Depth (m)	Total Depth (m)	High Static Water Level (m)	Aquifer	Comment
GND1081	Spring	485	N/A	5	NA	Taranaki Volcanics	Downgradient of Mangahewa-A wellsite
GND2258	Well	1,041	Dug/lined	5	2.04	Taranaki Volcanics	Downgradient of Mangahewa-A wellsite
GND2263	Well	534	Dug/lined	5	2.755	Taranaki Volcanics	Downgradient of Mangahewa-A wellsite
GND2279	Well	575	Dug/lined	3	0.828	Taranaki Volcanics	Upgradient of Mangahewa-A wellsite

Samples were obtained from each site following standard groundwater sampling methodologies and generally in accordance with the National Protocol for State of the Environment Groundwater Sampling in New Zealand (2006). Samples were obtained either via existing pumping equipment and sample taps, or directly from source using a bailer.

All samples were sent to Hills Laboratory (IANZ accredited) and transported using chain of custody procedures. All samples were analysed in the laboratory for wide range of chemical parameters, including general groundwater characterisation parameters, compounds associated with hydrocarbon reservoirs, deep formation waters and fluids used in the hydraulic fracturing process. Testing parameters were selected in consultation with GNS Science (the Institute of Geological and Nuclear Science).

The parameters included:

- Conventional groundwater characterisation parameters;
- Trace metals;
- Compounds commonly used in hydraulic fracturing fluid such as methanol, glycols and formaldehyde;
- Total petroleum hydrocarbons;
- The "BTEX" range of compounds – benzene, toluene, ethyl benzene and xylene; and
- Dissolved natural gas.

Samples were obtained from each of the 4 sampling sites included in the programme at the following frequencies:

- Pre hydraulic fracturing;
- 1 week post hydraulic fracturing; and
- 3 months post hydraulic fracturing.

As required by the conditions of consent 9238-1, the details of the Monitoring Programme to be implemented and a Sampling and Analysis Plan were compiled and submitted to the Chief Executive, Taranaki Regional Council for approval, prior to the fracturing of the Mangahewa-05 well (see Appendix II).



Figure 2 Location of groundwater sampling sites

2. Results

2.1 Physicochemical monitoring

The monitoring programme incorporated a total of 7 sampling events, which took place between 19 April 2012 and 19 October 2012. A summary of each sampling event is included below in Table 5.

Table 5 Sampling event summary

Date	Sampling event	Sites sampled	Sampling comments
19 April 2012	Pre hydraulic fracturing	GND2263	Private water supply
16 May 2012	Pre hydraulic fracturing	GND2258	Private water supply
04 July 2012	Pre hydraulic fracturing	GND1081 GND2279	Private water supplies
18 July 2012	Mangahewa-05 fracturing fluid	GND2281	Sample of hydraulic fracturing fluid pre-pumping
20 July 2012	Mangahewa-05 return fluids	GND2281	Sample of hydraulic fracturing return fluids
26 July 2012	1 week post hydraulic fracturing	GND1081 GND2258 GND2263 GND2279	Private water supplies
19 October 2012	3 month post hydraulic fracturing	GND1081 GND2258 GND2263 GND2279	Private water supplies

2.1.1 Hydraulic fracturing and return fluid analysis

A sample representative of the fluid used in the hydraulic fracturing of the Mangahewa-05 well was obtained for analysis on 18 July 2012. In addition, a sample of the fluid returning to the surface following the completion of the 18 July 2012 fracturing event was also obtained.

The results of the analyses carried out on the hydraulic fracturing fluid used in the treatment of the Mangahewa-05 well are summarised below in Table 6. Due to the viscosity of the sample obtained, the range of analyses that were able to be performed on the sample were limited. The sample taken was gel like in composition, as opposed to a liquid. While the fracturing fluid is predominantly comprised of water (97% by fluid volume), specialised additives are used to increase the viscosity of the fluid in order to suspend the proppant prior to injection (see Section 1.4.1). The results of the analyses undertaken on the hydraulic fracturing fluid indicate the presence of relatively low concentration of glycols and methanol, common ingredients in hydraulic fracturing fluids. The results also indicate that the hydraulic fracturing fluid used contained low levels of hydrocarbon additives. Due to the volume of water used in the fracturing fluid mixture, all additives included in the mixture are highly dilute.

Table 6 Results of hydraulic fracturing fluid analysis

Analyte	Units	Mangahewa-05 (18/07/2012)
Ethylene glycol	g/m ³	270
Propylene glycol	g/m ³	42
Methanol	g/m ³	29

Analyte	Units	Mangahewa-05 (18/07/2012)
Benzene	g/m ³	0.0061
Toluene	g/m ³	0.036
Ethylbenzene	g/m ³	0.0038
m&p-Xylene	g/m ³	0.011
o-Xylene	g/m ³	0.0079
C7 - C9	g/m ³	0.8
C10 - C14	g/m ³	33
C15 - C36	g/m ³	72
Total hydrocarbons (C7 - C36)	g/m ³	106

The results of the analyses carried out on the return fluid sample obtained following the hydraulic fracturing of the Mangahewa-05 well are summarised below in Table 7. Return fluids are comprised of a mixture of hydraulic fracturing fluids and formation fluids produced from the target reservoir, following the completion of the hydraulic fracturing process. The relative concentrations of each contributing fluid type change as the volume of fluid produced from the well increases. Immediately following the opening of the well following fracturing, a high proportion of the fluid returning to the wellhead is those injected during the hydraulic fracturing process. As the volume of fluid produced from the well increases, return fluids will begin to contain less hydraulic fracturing fluid and an increasing proportion of formation fluids.

A composite sample of return fluids was submitted for analysis. The composite was made up of equal proportions of 3 individual samples, all taken within 2 hours of the commencement of return flow from the well. The results of the analyses carried out on the return fluids are summarised below in Table 7. The results show traces of the methanol used in the hydraulic fracturing fluid. The concentration of glycols measured in the return fluids were below the laboratory detection limit. The high concentrations of chloride and sodium measured in the sample submitted indicate the saline nature of the deep formation fluids returning to the wellhead. The presence of elevated levels of hydrocarbon and BTEX are indicative of fluids being drawn from a hydrocarbon bearing reservoir.

Table 7 Results of return fluid analysis

Analyte	Units	Mangahewa-05 (20/07/2012)
pH	pH Units	7.3
Total Alkalinity	g/m ³ as CaCO ₃	3,100
Total Hardness	g/m ³ as CaCO ₃	87
Conductivity (EC)	mS/m	1,571
Dissolved Barium	g/m ³	6.0
Dissolved Calcium	g/m ³	28
Dissolved Copper	g/m ³	0.0077
Dissolved Iron	g/m ³	8.7
Dissolved Magnesium	g/m ³	3.9

Analyte	Units	Mangahewa-05 (20/07/2012)
Dissolved Manganese	g/m ³	2.7
Dissolved Nickel	g/m ³	0.008
Dissolved Potassium	g/m ³	960
Dissolved Sodium	g/m ³	3,100
Dissolved Sulphur	g/m ³	15.6
Dissolved Zinc	g/m ³	0.011
Bromide	g/m ³	13
Chloride	g/m ³	2,900
Nitrite-N	g/m ³	<0.02
Nitrate-N	g/m ³	<0.02
Nitrate	g/m ³	<0.09
Nitrate-N + Nitrite-N	g/m ³	<0.02
Sulphate	g/m ³	47
Ethylene glycol	g/m ³	<4
Propylene glycol	g/m ³	<4
Methanol	g/m ³	23
Benzene	g/m ³	11.3
Toluene	g/m ³	12.8
Ethylbenzene	g/m ³	0.96
m&p-Xylene	g/m ³	5.1
o-Xylene	g/m ³	2.0
Formaldehyde	g/m ³	0.18
Ethane	g/m ³	0.33
Ethylene	g/m ³	<0.004
Methane	g/m ³	1.48
C7 - C9	g/m ³	47
C10 - C14	g/m ³	119
C15 - C36	g/m ³	175
Total hydrocarbons (C7 - C36)	g/m ³	340

2.1.2 Groundwater analysis

In terms of an assessing any possible effects of hydraulic fracturing upon local aquifers, several key parameters, and the relative changes in their concentration can be used as indicators of potential contamination. Inorganic indicator parameters include pH, electrical conductivity and chloride. Changes in the concentration of these parameters may indicate the migration of deep formation water, which is highly saline in composition, via fractures or conduits created by the hydraulic fracturing process, leakage from the wellbore due to integrity issues, or the mishandling of fluids at the surface. The results of the pH, electrical conductivity and chloride analyses carried out on the samples from private water supplies are plotted below in Figure 3, Figure 4 and Figure 5; respectively. The results indicate that the

pH, electrical conductivity and chloride concentrations in all private water supplies sampled, remained consistent across the sampling period.

There were no traces of any glycols or methanol detected in any of the groundwater samples analysed, compounds presents in the fluids used in the fracturing of the Mangahewa-05 well.

The presence of hydrocarbons or any of the BTEX group of chemicals in groundwater samples may indicate the leakage or migration of deep formation or reservoir fluids. The migration of such fluids could be due to the creation of fractures or conduits by the hydraulic fracturing process, leakage from the wellbore, or the mishandling of return fluids at the surface. If the hydraulic fracturing process had created fractures or conduits within the geological seals overlying the reservoir, it would also be expected that hydrocarbon gases would be present in groundwater. It should be noted however, biogenic methane gas can be found naturally occurring in groundwater, in areas where organic material has decomposed within groundwater bearing zones. The results of the analyses undertaken on samples taken from private water supplies in the vicinity of Mangahewa-A wellsite do not show any increases in the concentration of any key indicator parameters over the monitoring period.

A full table of analytical results is included in Appendix III of this report. Laboratory Analysis Reports are included in Appendix IV.

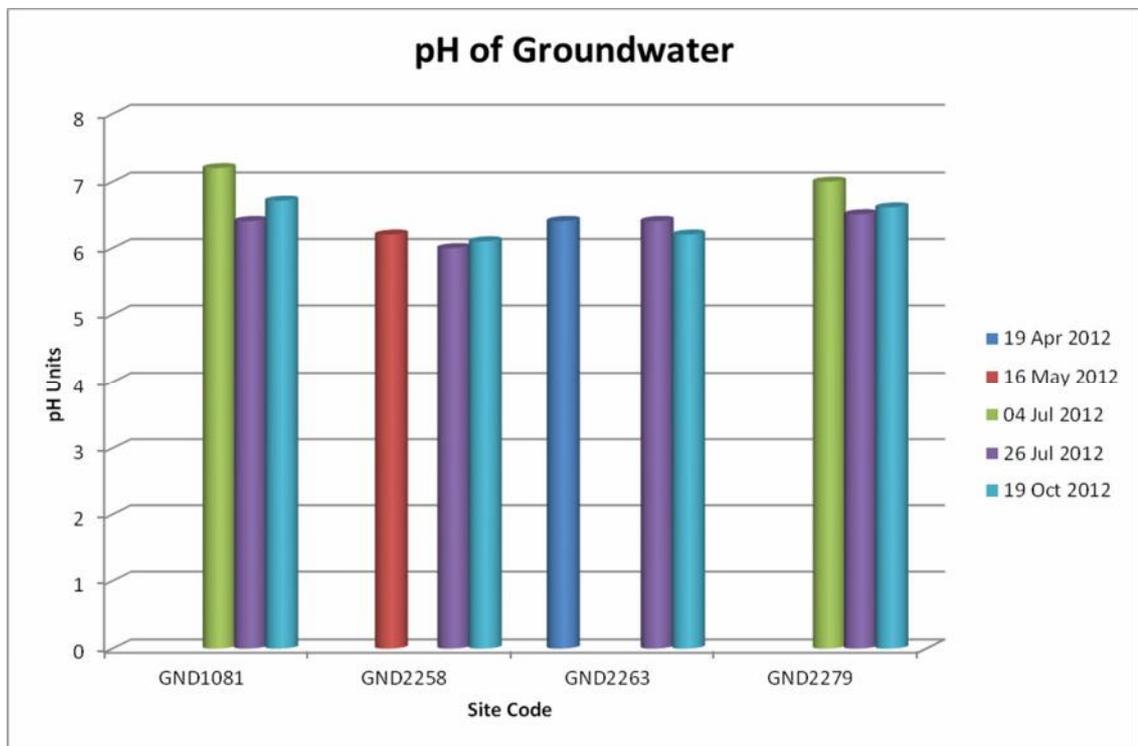


Figure 3 Results of pH analyses

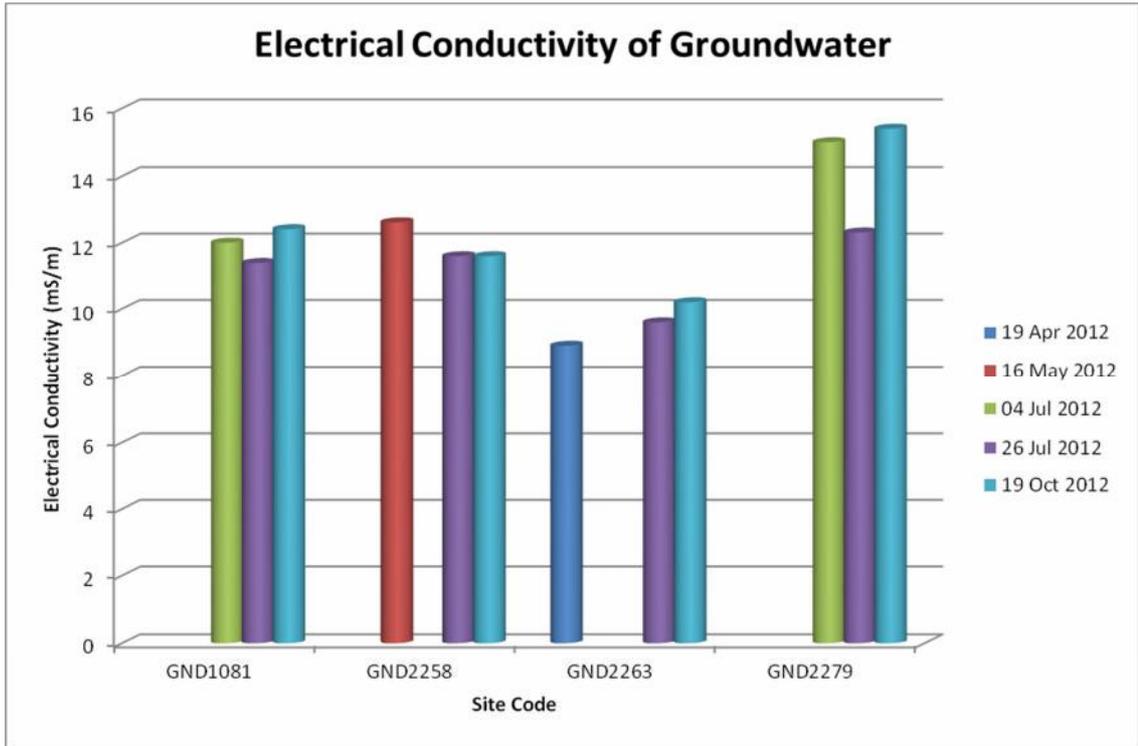


Figure 4 Results of electrical conductivity analyses

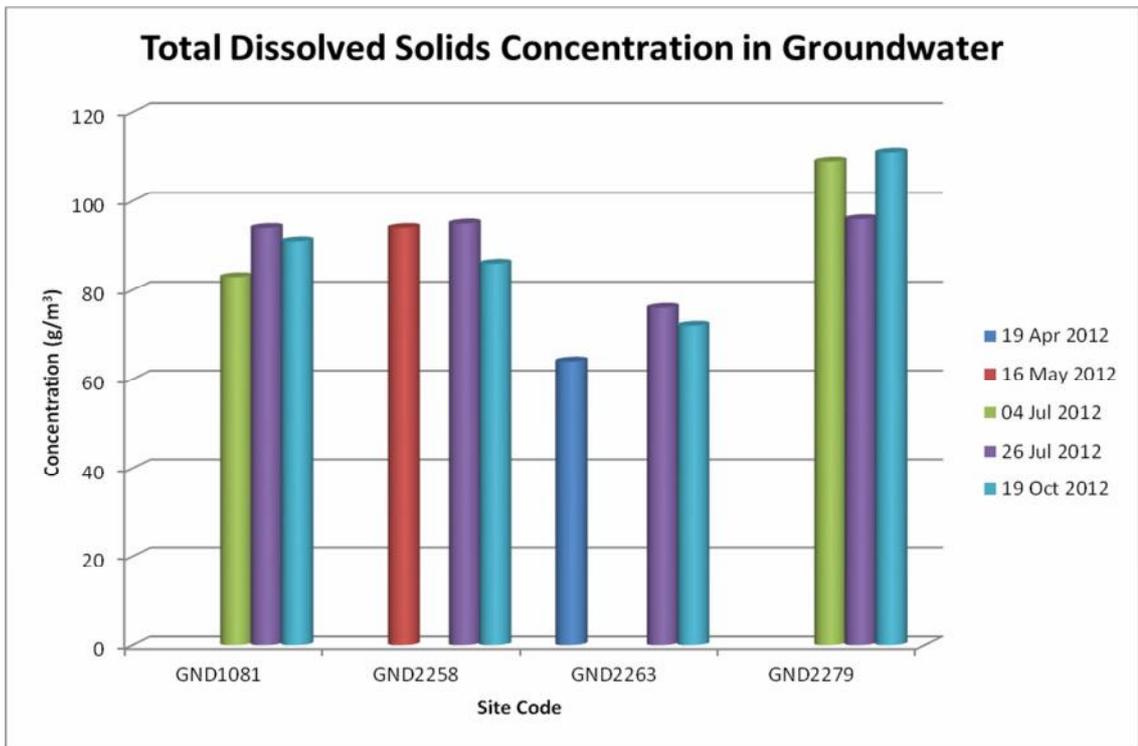


Figure 5 Results of total dissolved solids analyses

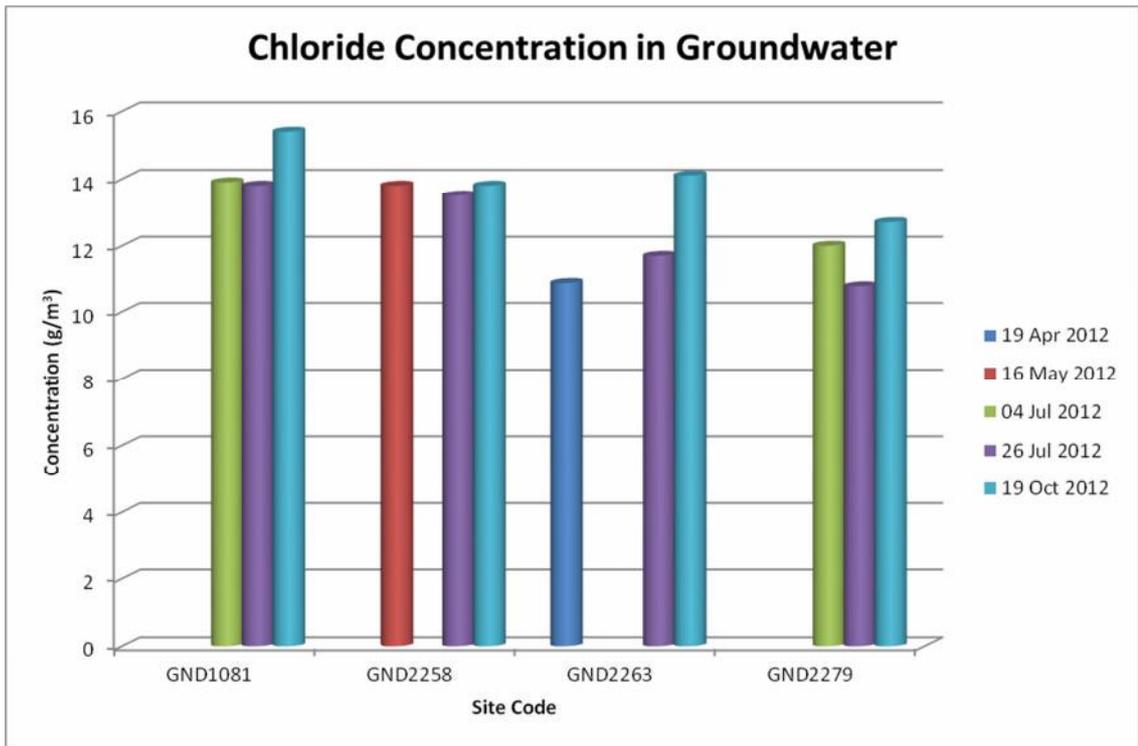


Figure 6 Results of chloride analyses

3. Discussion

3.1 Environmental effects of hydraulic fracturing on shallow groundwater

A total of 4 private groundwater supplies were selected for inclusion in the groundwater monitoring programme implemented by Council. Samples from each site were obtained pre hydraulic fracturing (baseline sampling) and at intervals of 1 week and 3 months post fracturing.

The selection of sampling sites was designed to provide a sample set representative of groundwater abstractions and usage in the investigation area. Other criteria assessed were the distance of each potential sampling site from the Mangahewa-A wellsite, and whether the site was upgradient or downgradient of the wellsite, based on the inferred groundwater flow direction in the area of investigation.

The results of the physicochemical analyses carried out on samples taken from private water supplies included in the monitoring programme show very little compositional variation across the sampling period. The concentration of all parameters analysed for during post fracturing sampling events remained consistent with pre hydraulic fracturing baseline values, including compounds present within hydraulic fracturing and return fluids analysed as part of the monitoring programme.

The results of the physicochemical analyses undertaken, show that hydraulic fracturing activities carried out at the Mangahewa-A wellsite to date, have had no adverse effects on groundwater resources in the area surrounding the site. In order to confirm this assessment and to analyse the effects of any future hydraulic fracturing activities at the site, further sampling of all sites included in the monitoring programme is proposed for the forthcoming monitoring period.

3.2 Evaluation of performance

The assessment of the Company's compliance performance for the period under review is based on the monitoring work carried out and the assessment of the results. A tabular summary of the Company's compliance record, with specific regard to the groundwater related conditions, of consent 9238-1 is set out below in Table 8.

The consent holder has achieved a high level of environmental performance and compliance in respect of the resource consent exercised. The criteria associated with a "high" level of environmental performance are outlined in Section 1.1.4 as follows:

"a high level of environmental performance and compliance indicates that essentially there were no adverse environmental effects to be concerned about, and no, or inconsequential (such as data supplied after a deadline) non-compliance with conditions."

The results of the monitoring programme implemented show no evidence of any adverse effects on groundwater due to hydraulic fracturing activities at the Mangahewa-A wellsite.

Table 8 Evaluation of compliance performance

Condition requirement	Means of monitoring during period under review	Compliance achieved?
<p>Consent 9238-1: To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3,200 mTVDS beneath the Mangahewa-A wellsite</p>		
<p>2. The consent holder shall ensure that the exercise of this consent does not result in contaminants reaching any useable fresh water (groundwater or surface water). Usable fresh groundwater is defined as any groundwater having a Total Dissolved Solids concentration of less than 1000 mg/l.</p>	<p>Assessment of groundwater sampling results</p>	<p>Yes</p>
<p>3. The consent holder shall undertake a programme of sampling and testing that monitors the effects of the exercise of this consent on fresh water resources to assess compliance with condition 2 (the 'Monitoring Programme'). The Monitoring Programme shall be certified by the Chief Executive, Taranaki Regional Council ('the Chief Executive'), before this consent is exercised, and shall include:</p> <ul style="list-style-type: none"> a) the location of the discharge point(s); b) the location of sampling sites; and c) sampling frequency with reference to a hydraulic fracturing programme. 	<p>Details of monitoring programme certified by the Chief Executive</p>	<p>Yes</p>
<p>4. All water samples taken for monitoring purposes shall be taken in accordance with recognised field procedures and analysed for:</p> <ul style="list-style-type: none"> a) pH; b) conductivity; c) total dissolved solids; d) major ions (Ca, Mg, K, Na, total alkalinity, bromide, chloride, nitrate-nitrogen, and sulphate); e) trace metals (barium, copper, iron, manganese, nickel, and zinc); f) total petroleum hydrocarbons; g) formaldehyde; h) dissolved methane and ethane gas; i) methanol; j) glycols; k) benzene, toluene, ethylbenzene, and xylenes (BTEX); and l) carbon-13 composition of any dissolved methane gas discovered (¹³C-CH₄). 	<p>Assessment of groundwater monitoring programme and sampling results</p>	<p>Yes</p>
<p>5. All sampling and analysis shall be undertaken in accordance with a <i>Sampling and Analysis Plan</i>, which shall be submitted to the Chief Executive, Taranaki Regional Council (CE) for review and certification before the first sampling is undertaken. This Plan shall specify the use of standard protocols recognized to constitute good professional practice including quality control and assurance. A properly accredited laboratory shall be used for all sample analysis. Results shall be provided to the CE within 30 calendar days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 2.</p>	<p>Details of sampling and analysis plan certified by the Chief Executive, receipt and assessment of sampling results</p>	<p>Yes</p>
<p>Overall assessment of compliance and environmental performance in relation to groundwater monitoring conditions</p>		<p>High</p>

3.3 Alterations to monitoring programmes for 2013/2014 period

In designing and implementing the monitoring programmes for discharges to land and water in the region, the Taranaki Regional Council has taken into account the extent of information made available by previous authorities, its relevance under the Resource Management Act, the obligations of the Act in terms of monitoring discharges and effects, and subsequently reporting to the regional community, 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 discharging to the environment.

It is proposed that the frequency of groundwater sampling in the vicinity of the Mangahewa-A wellsite be reduced to a minimum of one annual sampling event per monitoring year. If further hydraulic fracturing is carried out at the wellsite, the existing data gathered during the period under review will be used as a baseline to assess any potential adverse effects on groundwater. Samples will be obtained from each private water supply site included in the monitoring programme 3 months following any future hydraulic fracturing event.

Recommendations to this effect are attached to this report.

4. Recommendations

1. THAT this report be forwarded to the Company, and to any interested parties upon request;
2. THAT for the forthcoming 2013/2014 monitoring period, the sampling of private water supplies in the vicinity of the Mangahewa-A wellsite be reduced to a frequency of one annual sampling event; and
3. THAT if further hydraulic fracturing is carried out at the Mangahewa-A wellsite, a sample be obtained from each private water supply 3 months following the hydraulic fracturing programme.

Glossary of common terms and abbreviations

The following abbreviations and terms are commonly used within Council reports:

Al*	aluminium
As*	arsenic
Biomonitoring	assessing the health of the environment using aquatic organisms
BOD	biochemical oxygen demand. A measure of the presence of degradable organic matter, taking into account the biological conversion of ammonia to nitrate
BODF	biochemical oxygen demand of a filtered sample
Bore	a hole drilled into the ground and completed for the abstraction of water or hydrocarbons to a depth of greater than 20 metres below the ground surface
Bund	a wall around a tank to contain its contents in the case of a leak
CBOD	carbonaceous biochemical oxygen demand. A measure of the presence of degradable organic matter, excluding the biological conversion of ammonia to nitrate
cfu	colony forming units. A measure of the concentration of bacteria usually expressed as per 100 millilitre sample
COD	chemical oxygen demand. A measure of the oxygen required to oxidise all matter in a sample by chemical reaction
Condy	conductivity, an indication of the level of dissolved salts in a sample, usually measured at 20°C and expressed in mS/m
Cu*	copper
Cumec	A volumetric measure of flow- 1 cubic metre per second (1 m ³ s ⁻¹)
DO	dissolved oxygen
DRP	dissolved reactive phosphorus
<i>E.coli</i>	<i>escherichia coli</i> , an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample
Ent	enterococci, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre of sample
F	fluoride
FC	faecal coliforms, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample
Fresh g/m ³	elevated flow in a stream, such as after heavy rainfall grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures
GV	Guideline value (Drinking-water Standards for New Zealand 2008)
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

l/s	litres per second
MAV	Maximum acceptable value (Drinking-water Standards for New Zealand 2008)
MCI	macroinvertebrate community index; a numerical indication of the state of biological life in a stream that takes into account the sensitivity of the taxa present to organic pollution in stony habitats
mS/m	millisiemens per metre
Mixing zone	the zone below a discharge point where the discharge is not fully mixed with the receiving environment. For a stream, conventionally taken as a length equivalent to 7 times the width of the stream at the discharge point
NH ₄	ammonium, normally expressed in terms of the mass of nitrogen (N)
NH ₃	unionised ammonia, normally expressed in terms of the mass of nitrogen (N)
NO ₃	nitrate, normally expressed in terms of the mass of nitrogen (N)
NTU	Nephelometric Turbidity Unit, a measure of the turbidity of water
O&G	oil and grease, defined as anything that will dissolve into a particular organic solvent (e.g. hexane). May include both animal material (fats) and mineral matter (hydrocarbons)
Pb*	lead
pH	a numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline. The scale is logarithmic i.e. a change of 1 represents a ten-fold change in strength. For example, a pH of 4 is ten times more acidic than a pH of 5
Physicochemical	measurement of both physical properties (e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment
PM ₁₀	relatively fine airborne particles (less than 10 micrometre diameter)
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)
RMA	Resource Management Act 1991 and including all subsequent amendments
SS	suspended solids
SQMCI	semi quantitative macroinvertebrate community index;
Temp	temperature, measured in °C (degrees Celsius)
Turb	turbidity, expressed in NTU
UI	Unauthorised Incident
UIR	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
Well	a hole dug, augured or drilled, tapping the water table or springs, to a depth of less than 20 metres below the ground surface
Zn*	zinc

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

Bibliography and references

- Allis, R.G; Zhan, X; Evans, C Kroopnick, P 1997. Groundwater flow beneath Mt Taranaki. New Zealand, and implications for oil and gas migration. New Zealand Journal of Geology and Geophysics 40.
- 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.
- Taranaki Regional Council. (2012 - updated May 2012). Hydrogeologic Risk Assessment of Hydraulic Fracturing for Gas Recovery in the Taranaki Region
- Taranaki Regional Council. TRC. 2013. Todd Taranaki Limited – Mangahewa-A Exploration Wellsite Monitoring Report. Technical Report (2012-85) (Document number 1214831).
- Taranaki Regional Council. TRC. 2012. Officer Report. Todd Taranaki Limited – Mangahewa-A wellsite hydraulic fracturing discharge consent application (Consent 9238-1). (Document number 1017265).
- Taylor C.B. and Evans C.M., 1999: Isotopic indicators for groundwater hydrology in Taranaki, New Zealand. Journal of Hydrology (NZ) 38(2), pp237-270.

Appendix I

Resource consent 9238-1

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 Taranaki Limited
P O Box 802
Taranaki Mail Centre
NEW PLYMOUTH 4340

Decision Date: 16 April 2012

Commencement
Date: 16 April 2012

Conditions of Consent

Consent Granted: To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3200 mTVDss beneath the Mangahewa-A wellsite at or about (NZTM) 1714115E-5674291N

Expiry Date: 1 June 2015

Review Date(s): June 2012, June 2013, June 2014

Site Location: Mangahewa-A wellsite, Otaraoa Road, Tikorangi
(Property owner: F & K Wyatt & K & M Downs)

Legal Description: Lot 2 DP 384951 (Discharge source & site)

Catchment: Waitara

*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 discharge point shall be deeper than 3200 mTVDss.

Note: mTVDss = metres true vertical depth subsea, i.e., the true vertical depth in metres below mean sea level.

2. The consent holder shall ensure that the exercise of this consent does not result in contaminants reaching any useable fresh water (groundwater or surface water). Usable fresh groundwater is defined as any groundwater having a Total Dissolved Solids concentration of less than 1000 mg/l.
3. The consent holder shall undertake a programme of sampling and testing that monitors the effects of the exercise of this consent on fresh water resources to assess compliance with condition 2 (the 'Monitoring Programme'). The Monitoring Programme shall be certified by the Chief Executive, Taranaki Regional Council ('the Chief Executive'), before this consent is exercised, and shall include:
 - (a) the location of the discharge point(s);
 - (b) the location of sampling sites; and
 - (c) sampling frequency with reference to a hydraulic fracturing programme.
4. All water samples taken for monitoring purposes shall be taken in accordance with recognised field procedures and analysed for:
 - (a) pH;
 - (b) conductivity;
 - (c) total dissolved solids;
 - (d) major ions (Ca, Mg, K, Na, total alkalinity, bromide, chloride, nitrate-nitrogen, and sulphate);
 - (e) trace metals (barium, copper, iron, manganese, nickel, and zinc);
 - (f) total petroleum hydrocarbons;
 - (g) formaldehyde;
 - (h) dissolved methane and ethane gas;
 - (i) methanol;
 - (j) glycols;
 - (k) benzene, toluene, ethylbenzene, and xylenes (BTEX); and
 - (l) carbon-13 composition of any dissolved methane gas discovered ($^{13}\text{C-CH}_4$).

Note: The samples required, under conditions 3 and 4 could be taken and analysed by the Council or other contracted party on behalf of the consent holder.

5. All sampling and analysis shall be undertaken in accordance with a *Sampling and Analysis Plan*, which shall be submitted to the Chief Executive for review and certification before the first sampling is undertaken. This plan shall specify the use of standard protocols recognised to constitute good professional practice including quality control and assurance. An International Accreditation New Zealand (IANZ) accredited laboratory shall be used for all sample analysis. Results shall be provided to the Chief Executive within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 2.

Note: The Sampling and Analysis Plan may be combined with the Monitoring Programme required by condition 2.

6. The consent holder shall undertake well and equipment pressure testing prior to any hydraulic fracture programme on a given well to ensure any discharge will not affect the integrity of the well and hydraulic fracturing equipment.
7. Any hydraulic fracture discharge shall only occur after the consent holder has provided a comprehensive 'Pre-fracturing discharge report' to the Chief Executive. The report shall be provided at least 14 days before the discharge is proposed to commence and shall detail the hydraulic fracturing programme proposed, including as a minimum:
 - (a) the specific well in which each discharge is to occur and the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment);
 - (b) the number of discharges proposed and the geographical position (i.e. depth and lateral position) of each intended discharge point;
 - (c) the total volume of fracture fluid planned to be pumped down the well and its intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
 - (d) the results of the reviews required by condition 12;
 - (e) results of modelling showing an assessment of the likely extent and dimensions of the fractures that will be generated by the discharge;
 - (f) the preventative and mitigation measures to be in place to ensure the discharge does not cause adverse environmental effects and complies with condition 2;
 - (g) the extent and permeability characteristics of the geology above the discharge point to the surface;
 - (h) any identified faults within the modeled fracture length plus a margin of 50%, and the potential for adverse environmental effects due to the presence of the identified faults;
 - (i) the burst pressure of the well and the anticipated maximum well and discharge pressures and the duration of the pressures; and
 - (j) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal.

Note: For the avoidance of doubt, the information provided with a resource consent application would usually be sufficient to constitute a 'Pre-fracturing discharge report' for any imminent hydraulic fracturing discharge. The Pre-fracturing discharge report provided for any later discharge may refer to the resource consent application or earlier Pre-fracturing discharge reports noting any differences.

8. The consent holder shall notify the Taranaki Regional Council of each discharge by emailing worknotification@trc.govt.nz. Notification shall include the date that the discharge is to occur and identify the 'Pre-fracturing discharge report', required by condition 7, which details the discharge. Where practicable and reasonable notice shall be given between 3 days and 14 days before the discharge occurs, but in any event 24 hours notice shall be given.
9. At the conclusion of a hydraulic fracturing programme on a given well, the consent holder shall submit a comprehensive 'Post-fracturing discharge report' to the Chief Executive. The report shall be provided within 60 days after the programme is completed and, as a minimum, shall contain:
 - (a) confirmation of the interval(s) where fracturing occurred for that programme, and the geographical position (i.e. depth and lateral position) of the discharge point for each fracture interval;
 - (b) the contaminant volumes and compositions discharged into each fracture interval;
 - (c) the volume of return fluids from each fracture interval;
 - (d) an analysis for the constituents set out in conditions 4(a) to 4(k), in a return fluid sample taken within the first two hours of flow back, for each fracture interval if flowed back individually, or for the well if flowed back with all intervals comingled;
 - (e) an estimate of the volume of fluids (and proppant) remaining underground;
 - (f) the volume of water produced with the hydrocarbons (produced water) over the period beginning at the start of the hydraulic fracturing programme and ending 50 days after the programme is completed;
 - (g) an assessment of the extent and dimensions of the fractures that were generated by the discharge, based on modelling undertaken after the discharge has occurred and other diagnostic techniques, including production analysis, available to determine fracture length, height and containment;
 - (h) the results of pressure testing required by condition 6, and the well and discharge pressure durations and the maximum pressure reached during the hydraulic fracture discharge;
 - (i) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal;
 - (j) details of any incidents where hydraulic fracture fluid is unable to pass through the well perforations (screen outs) that occurred, their likely cause and implications for compliance with conditions 1 and 2; and
 - (k) an assessment of the effectiveness of the mitigation measures in place with specific reference to those described in the application for this consent.
10. The reports described in conditions 7 and 9 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.
11. The consent holder shall provide access to a location where the Taranaki Regional Council officers can obtain a sample of the hydraulic fracturing fluids and the return fluids.

12. 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 minimize any actual or likely adverse effect of the activity on the environment by, as a minimum, ensuring that:
 - (a) the discharge is contained within the fracture interval;
 - (b) regular reviews are undertaken of the preventative and mitigation measures adopted to ensure the discharge does not cause adverse environmental effects; and
 - (c) regular reviews of the chemicals used are undertaken with a view to reducing the toxicity of the chemicals used.
13. The fracture fluid shall be comprised of no less than 95% water and proppant by volume.
14. The Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review during the month of June each year, for the purposes of:
 - (a) ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this 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; and/or
 - (b) further specifying the best practicable option as required by condition 12; and/or
 - (c) ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Signed at Stratford on 16 April 2012

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Appendix II

Sampling and Analysis Plan

Sampling and Analysis Plan

Mangahewa-A Groundwater Monitoring Programme 2012/2013

Resource Consent(s) / Consent Holder(s)

9238-1 / Todd Taranaki Limited

Project Description:

Design and implement a Sampling and Analysis Plan as required by *Condition 5* of Consent 9238-1, which will provide for the assessment of the existing chemical characteristics of groundwater in the vicinity of the Mangahewa-A well site and for the identification of any changes in local groundwater quality following planned hydraulic fracturing activities at the site. By implementing the proposed Sampling and Analysis Plan, the consent holder (Todd Taranaki Ltd.) will also be deemed to be in compliance with *Conditions 3 & 4* of Consent 9238-1. The data provided by the monitoring programme will allow the Taranaki Regional Council to assess whether the consent holder has ensured that the exercise of their consent has not contaminated or put at risk actual or potential usable freshwater aquifers, as stipulated in *Condition 2* of the consent.

Sampling Locations:

A survey of groundwater abstractions within the vicinity of the Mangahewa-A wellsite was carried out on the 28th of June 2012. Following the survey, a total of three (3) groundwater abstraction sites have been selected for sampling as part of the monitoring programme. The sample results from an additional site already being monitored as part of the Mangahewa-C groundwater monitoring programme (GND2258) will also be assessed in this programme. The sampling sites have been selected based on their proximity to the Mangahewa-A wellsite, their individual construction and usage characteristics. The site selection is designed to provide a sample set representative of groundwater abstractions in the area surrounding the site.

The details of the sites selected for inclusion in the programme are listed below in *Table 1*.

Table 1: Sampling Site Details

Site No.	Owner/Occupier	Location	Type	Depth (m)	Easting (m)	Northing (m)
GND1081	SJ & SH Lye	Mangahewa Rd.	Well	5	1714040	5674772
GND2263	Jan Turner	30 Mangahewa Rd.	Well	5	1714326	5674780
GND2279	David Jupp	1084 Otaraoa Rd.	Well	3	1714263	5673737
GND2258*	Simon Payne	879 Otaraoa Rd.	Well	7	1713501	5675128

*monitored as part of Mangahewa-C groundwater monitoring programme

Sampling Frequency:

The monitoring programme covers an initial twelve (12) month monitoring period, consisting of three (3) rounds of groundwater sampling. Groundwater samples will be obtained from the sites listed in *Table 1* at the following specified intervals:

- Pre hydraulic fracturing (baseline sample)
- 1 week following initial hydraulic fracturing event
- 3 months after initial hydraulic fracturing event

During the initial hydraulic fracturing event, a sample of the fracturing fluids used and fluids returning to the well head will also be obtained and analysed for the same parameters as the groundwater samples.

Chemical Analysis:

Samples will be obtained following the protocols for groundwater sampling in New Zealand issued by the Ministry for the Environment (2006). Once collected, samples will be transported using chain of custody procedures. Samples will be submitted to Hill Laboratories, accredited to NZS/ISO/IEC 17025:2005, for analysis. Samples will be analysed for the following parameters, as specified under *Condition 4* of Consent 9238-1:

- (a) pH;
- (b) Conductivity;
- (c) Total dissolved solids;
- (d) Total suspended solids;
- (e) Major ions (Ca, Mg, K, Na, total alkalinity, chloride, nitrate-nitrogen, and sulfate);
- (f) Trace metals (cadmium, copper, iron, manganese, nickel, and zinc);
- (g) Total organic carbon;
- (h) Formaldehyde;
- (i) Dissolved methane and ethane gas;
- (j) Benzene, toluene, ethylbenzene, and xylenes (BTEX); and
- (k) Carbon-13 composition of dissolved methane gas ($^{13}\text{C-CH}_4$).

Note: $^{13}\text{C-CH}_4$ analysis to be undertaken on samples if dissolved methane gas is detected in the initial groundwater sampling run. Samples will be obtained according to established sampling procedures for this analysis.

Data Submission:

As set out in *Condition 5* of Consent 9238-1, the results of each sampling round will be provided to the Chief Executive (TRC) within 30 calendar days of sampling and shall include supporting quality control and assurance information as set out above. At the conclusion of the monitoring programme a technical report will be compiled outlining and interpreting the results of the groundwater monitoring carried out and also providing recommendations with regard to future groundwater monitoring requirements.

Appendix III

Results of physicochemical analyses

Site	Date	Sample Number	pH	Temperature (°C)	Conductivity (EC)	Total Alkalinity (g/m ³ as CaCO ₃)	Bicarbonate (g/m ³ at 25 °C)	Total Hardness (g/m ³ as CaCO ₃)	Total Dissolved Solids (g/m ³)	Barium (g/m ³)	Bromide (g/m ³)	Dissolved Calcium (g/m ³)	Dissolved Copper (g/m ³)	Dissolved Iron (g/m ³)	Dissolved Magnesium (g/m ³)	Dissolved Manganese (g/m ³)	Dissolved Nickel (g/m ³)	Dissolved Potassium (g/m ³)	Dissolved Sodium (g/m ³)	Dissolved Zinc (g/m ³)	Chloride (g/m ³)	Nitrite (g/m ³)
Private Water Supplies																						
GND1081	04 Jul 2012	122438	7.2	14.5	12	22	27	30	83	0.0165	<0.05	6.6	<0.0005	<0.02	3.3	<0.0005	<0.0005	1.45	10.3	0.0021	13.9	<0.002
	26 Jul 2012	122571	6.4	14.7	11.4	22	27	28	94	0.0153	0.07	6	0.0009	<0.02	3.1	0.0009	<0.0005	1.46	9.7	0.0061	13.8	<0.002
	19 Oct 2012	123405	6.7		12.4	21	25	30	91	0.016	0.1	6.6	0.0007	<0.02	3.3	0.0044	<0.0005	2.5	10.5	0.0036	15.4	0.007
GND2258	16 May 2012	121520	6.2	14	12.6	25	30.5	34	94	0.076	0.06	7.5	0.0042	0.1	3.7	0.053	0.0006	3.8	7.7	0.028	13.8	<0.002
	26 Jul 2012	122573	6	14.3	11.6	18	22	30	95	0.091	0.07	6.9	0.0007	<0.02	3.1	0.0011	<0.0005	3.7	7.5	0.0182	13.5	<0.002
	19 Oct 2012	123407	6.1	14.9	11.6	18.5	23	30	86	0.08	0.07	6.7	<0.0005	<0.02	3.2	0.0019	<0.0005	3.6	7.8	0.0108	13.8	<0.002
GND2263	19 Apr 2012	121223	6.4		8.9	18	22	24	64	0.0082	<0.05	4.9	<0.0005	<0.02	2.9	0.0013	<0.0005	1.42	7	0.0012	10.9	<0.002
	26 Jul 2012	122570	6.4	13.3	9.6	17.5	21	25	76	0.0097	<0.05	5.3	0.0076	<0.02	3	0.0023	<0.0005	1.61	7.1	0.0136	11.7	<0.002
	19 Oct 2012	123404	6.2	12.7	10.2	17	21	29	72	0.0102	<0.05	5.9	<0.0005	<0.02	3.4	0.0009	<0.0005	1.42	7.5	0.0022	14.1	<0.002
GND2279	04 Jul 2012	122437	7	14.3	15	47	58	49	109	0.0108	0.06	11.8	0.0007	<0.02	4.8	0.0006	<0.0005	1.54	10.1	0.0072	12	<0.002
	26 Jul 2012	122572	6.5	13.5	12.3	37	45	39	96	0.0101	<0.05	9.6	<0.0005	<0.02	3.7	<0.0005	<0.0005	1.3	8.6	0.0031	10.8	<0.002
	19 Oct 2012	123406	6.6	14.5	15.4	48	58	52	111	0.0095	0.07	12.2	<0.0005	<0.02	5.1	<0.0005	<0.0005	1.38	10.2	<0.0010	12.7	<0.002
Mangahewa-05 Hydraulic Fracturing Fluid																						
GND2281	18 Jul 2012	122554																				
Mangahewa-05 Hydraulic Fracturing Return Fluid																						
GND2281	20 Jul 2012	122555	7.3		1571	3100		87		6	13	28	0.0077	8.7	3.9	2.7	0.008	960	3100	0.011	2900	<0.02

Site	Date	Sample Number	Nitrate (g/m ³)	Nitrate + Nitrite (g/m ³)	Sulphate (g/m ³)	Ethylene Glycol (g/m ³)	Methanol (g/m ³)	Formaldehyde (g/m ³)	Ethane (g/m ³)	Ethylene (g/m ³)	Methane (g/m ³)	Total Petroleum Hydrocarbons (g/m ³)	Benzene (g/m ³)	Toluene (g/m ³)	Ethylbenzene (g/m ³)	Xylene-M&P (g/m ³)	Xylene-O (g/m ³)
Private Water Supplies																	
GND1081	04 Jul 2012	122438	2.7	2.8	4.2	<4	<2	<0.02	<0.003	<0.004	<0.002	30	<0.0010	<0.0010	<0.004	<0.002	<0.0010
	26 Jul 2012	122571	2.4	2.4	4.1	<4	<2	<0.02	<0.003	<0.004	<0.002	28	<0.0010	<0.0010	<0.004	<0.002	<0.0010
	19 Oct 2012	123405	2.7	2.7	4.3	<4	<2	<0.02	<0.003	<0.004	<0.002	30	<0.0010	<0.0010	<0.004	<0.002	<0.0010
GND2258	16 May 2012	121520	2.4	2.4	3.9	<4	<2	<0.02	<0.003	<0.004	0.003	34	<0.0010	<0.0010	<0.004	<0.002	<0.001
	26 Jul 2012	122573	3.1	3.1	4.2	<4	<2	<0.02	<0.003	<0.004	<0.002	30	<0.0010	<0.0010	<0.004	<0.002	<0.0010
	19 Oct 2012	123407	2.8	2.8	4.5	<4	<4	<0.02	<0.003	<0.004	<0.002	30	<0.0010	<0.0010	<0.004	<0.002	<0.0010
GND2263	19 Apr 2012	121223	1.03	1.03	6.3	<4	<2	<0.02	<0.003	<0.004	<0.002	24	<0.0010	<0.0010	<0.004	<0.002	<0.0010
	26 Jul 2012	122570	1.33	1.33	5.6	<4	<2	<0.02	<0.003	<0.004	<0.002	25	<0.0010	<0.0010	<0.004	<0.002	<0.0010
	19 Oct 2012	123404	1.51	1.51	5.6	<4	<2	<0.02	<0.003	<0.004	<0.002	29	<0.0010	<0.0010	<0.004	<0.002	<0.0010
GND2279	04 Jul 2012	122437	0.9	0.9	6.2	<4	<2	<0.02	<0.003	<0.004	<0.002	49	<0.0010	<0.0010	<0.004	<0.002	<0.0010
	26 Jul 2012	122572	0.65	0.65	5.4	<4	<2	<0.02	<0.003	<0.004	<0.002	39	<0.0010	<0.0010	<0.004	<0.002	<0.0010
	19 Oct 2012	123406	1.13	1.13	5.7	<4	<2	<0.02	<0.003	<0.004	<0.002	52	<0.0010	<0.0010	<0.004	<0.002	<0.0010
Mangahewa-05 Hydraulic Fracturing Fluid																	
GND2281	18 Jul 2012	122554				270	29	19.1				106	0.0061	0.036		0.011	0.0079
Mangahewa-05 Hydraulic Fracturing Return Fluid																	
GND2281	20 Jul 2012	122555	<0.02	<0.02	47	<4	23	0.18	0.33	<0.004	1.48	87	11.3	12.8	<0.004	5.1	2

Appendix IV
Laboratory Analysis Reports



ANALYSIS REPORT

Client:	Taranaki Regional Council	Lab No:	1000257	SPV1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	21-Apr-2012	
		Date Reported:	01-May-2012	
		Quote No:	47915	
		Order No:	32190	
		Client Reference:	Groundwater	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:	GND2263 19-Apr-2012 12:00 pm				
Lab Number:	1000257.1				

Individual Tests

Sum of Anions	meq/L	0.87	-	-	-	-
Sum of Cations	meq/L	0.82	-	-	-	-
pH	pH Units	6.4	-	-	-	-
Total Alkalinity	g/m ³ as CaCO ₃	18.0	-	-	-	-
Bicarbonate	g/m ³ at 25°C	22	-	-	-	-
Total Hardness	g/m ³ as CaCO ₃	24	-	-	-	-
Electrical Conductivity (EC)	mS/m	8.9	-	-	-	-
Total Dissolved Solids (TDS)	g/m ³	64	-	-	-	-
Dissolved Barium	g/m ³	0.0082	-	-	-	-
Dissolved Calcium	g/m ³	4.9	-	-	-	-
Dissolved Copper	g/m ³	< 0.0005	-	-	-	-
Dissolved Iron	g/m ³	< 0.02	-	-	-	-
Dissolved Magnesium	g/m ³	2.9	-	-	-	-
Dissolved Manganese	g/m ³	0.0013	-	-	-	-
Dissolved Nickel	g/m ³	< 0.0005	-	-	-	-
Dissolved Potassium	g/m ³	1.42	-	-	-	-
Dissolved Sodium	g/m ³	7.0	-	-	-	-
Dissolved Zinc	g/m ³	0.0012	-	-	-	-
Bromide	g/m ³	< 0.05	-	-	-	-
Chloride	g/m ³	10.9	-	-	-	-
Nitrite-N	g/m ³	< 0.002	-	-	-	-
Nitrate-N	g/m ³	1.03	-	-	-	-
Nitrate-N + Nitrite-N	g/m ³	1.03	-	-	-	-
Sulphate	g/m ³	6.3	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m ³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m ³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m ³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m ³	< 0.0010	-	-	-	-
Toluene	g/m ³	< 0.0010	-	-	-	-
Ethylbenzene	g/m ³	< 0.0010	-	-	-	-
m&p-Xylene	g/m ³	< 0.002	-	-	-	-
o-Xylene	g/m ³	< 0.0010	-	-	-	-



This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.

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

Sample Type: Aqueous						
Sample Name:	GND2263 19-Apr-2012 12:00 pm					
Lab Number:	1000257.1					
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	-	-	-	-
Ethylene	g/m ³	< 0.004	-	-	-	-
Methane	g/m ³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.10	-	-	-	-
C10 - C14	g/m ³	< 0.2	-	-	-	-
C15 - C36	g/m ³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	< 0.7	-	-	-	-

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	1
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1
pH	pH meter. APHA 4500-H ⁺ B 21 st ed. 2005.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 st ed. 2005.	1.0 g/m ³ as CaCO ₃	1
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 21 st ed. 2005.	1.0 g/m ³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 st ed. 2005.	1.0 g/m ³ as CaCO ₃	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 st ed. 2005.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21 st ed. 2005.	10 g/m ³	1
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 21 st ed. 2005.	-	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.00010 g/m ³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.05 g/m ³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 nd ed. 2005.	0.05 g/m ³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 nd ed. 2005.	0.02 g/m ³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 nd ed. 2005.	0.0010 g/m ³	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 2 nd ed. 2005.	0.05 g/m ³	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl E (modified from continuous flow analysis) 21 st ed. 2005.	0.5 g/m ³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ - I (Modified) 21 st ed. 2005.	0.002 g/m ³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N.	0.002 g/m ³	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NQ ₂ - I (Modified) 21 st ed. 2005.	0.002 g/m ³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 2 nd ed. 2005.	0.5 g/m ³	1

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

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

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Ara Heron BSc (Tech)
Client Services Manager - Environmental Division



ANALYSIS REPORT

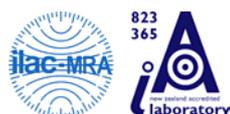
Client:	Taranaki Regional Council	Lab No:	1009096	SPV2
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	19-May-2012	
		Date Reported:	26-Jun-2013	
		Quote No:	47915	
		Order No:		
		Client Reference:	Groundwater	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:	GND2258 16-May-2012 12:50 pm				
Lab Number:	1009096.5				

Individual Tests

Sum of Anions	meq/L	1.15	-	-	-	-
Sum of Cations	meq/L	1.12	-	-	-	-
pH	pH Units	6.2	-	-	-	-
Total Alkalinity	g/m ³ as CaCO ₃	25	-	-	-	-
Bicarbonate	g/m ³ at 25°C	31	-	-	-	-
Total Hardness	g/m ³ as CaCO ₃	34	-	-	-	-
Electrical Conductivity (EC)	mS/m	12.6	-	-	-	-
Total Dissolved Solids (TDS)	g/m ³	94	-	-	-	-
Dissolved Barium	g/m ³	0.076	-	-	-	-
Dissolved Calcium	g/m ³	7.5	-	-	-	-
Dissolved Copper	g/m ³	0.0042	-	-	-	-
Dissolved Iron	g/m ³	0.10	-	-	-	-
Dissolved Magnesium	g/m ³	3.7	-	-	-	-
Dissolved Manganese	g/m ³	0.053	-	-	-	-
Dissolved Nickel	g/m ³	0.0006	-	-	-	-
Dissolved Potassium	g/m ³	3.8	-	-	-	-
Dissolved Sodium	g/m ³	7.7	-	-	-	-
Dissolved Zinc	g/m ³	0.028	-	-	-	-
Bromide	g/m ³	0.06	-	-	-	-
Chloride	g/m ³	13.8	-	-	-	-
Nitrite-N	g/m ³	< 0.002	-	-	-	-
Nitrate-N	g/m ³	2.4	-	-	-	-
Nitrate-N + Nitrite-N	g/m ³	2.4	-	-	-	-
Sulphate	g/m ³	3.9	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m ³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m ³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m ³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m ³	< 0.0010	-	-	-	-
Toluene	g/m ³	< 0.0010	-	-	-	-
Ethylbenzene	g/m ³	< 0.0010	-	-	-	-
m&p-Xylene	g/m ³	< 0.002	-	-	-	-
o-Xylene	g/m ³	< 0.0010	-	-	-	-



Sample Type: Aqueous						
Sample Name:	GND2258 16-May-2012 12:50 pm					
Lab Number:	1009096.5					
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	-	-	-	-
Ethylene	g/m ³	< 0.004	-	-	-	-
Methane	g/m ³	0.003	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.10	-	-	-	-
C10 - C14	g/m ³	< 0.2	-	-	-	-
C15 - C36	g/m ³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	< 0.7	-	-	-	-

Analyst's Comments

Supplement to test report 1009096v1 issued on 25/5/13.

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	5
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	5
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	5
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	5
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	5
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	5
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	5
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	5
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	5
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	5
pH	pH meter. APHA 4500-H+ B 21 st ed. 2005.	0.1 pH Units	5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 st ed. 2005.	1.0 g/m ³ as CaCO ₃	5
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO ₂ D 21 st ed. 2005.	1.0 g/m ³ at 25°C	5
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 st ed. 2005.	1.0 g/m ³ as CaCO ₃	5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 st ed. 2005.	0.1 mS/m	5
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21 st ed. 2005.	10 g/m ³	5
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.00010 g/m ³	5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.05 g/m ³	5
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	5
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	5
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	5

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.0005 g/m ³	5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.05 g/m ³	5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.02 g/m ³	5
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.0010 g/m ³	5
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 2 ^{1st} ed. 2005.	0.05 g/m ³	5
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl E (modified from continuous flow analysis) 21 st ed. 2005.	0.5 g/m ³	5
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ - I (Modified) 21 st ed. 2005.	0.002 g/m ³	5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N.	0.002 g/m ³	5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO ₃ - I 21 st ed. 2005.	0.002 g/m ³	5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 2 ^{1st} ed. 2005.	0.5 g/m ³	5

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

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

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Ara Heron BSc (Tech)
Client Services Manager - Environmental Division



ANALYSIS REPORT

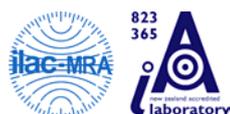
Client:	Taranaki Regional Council	Lab No:	1024037	SPV1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	06-Jul-2012	
		Date Reported:	13-Jul-2012	
		Quote No:	47915	
		Order No:		
		Client Reference:	Mangakewa - A Baseline	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:	GND2279	GND1081			
	04-Jul-2012 2:30 pm	04-Jul-2012 4:00 pm			
Lab Number:	1024037.1	1024037.2			

Individual Tests

Parameter	Unit	GND2279	GND1081			
Sum of Anions	meq/L	1.48	1.11	-	-	-
Sum of Cations	meq/L	1.46	1.08	-	-	-
pH	pH Units	7.0	7.2	-	-	-
Total Alkalinity	g/m ³ as CaCO ₃	47	22	-	-	-
Bicarbonate	g/m ³ at 25°C	58	27	-	-	-
Total Hardness	g/m ³ as CaCO ₃	49	30	-	-	-
Electrical Conductivity (EC)	mS/m	15.0	12.0	-	-	-
Total Dissolved Solids (TDS)	g/m ³	109	83	-	-	-
Dissolved Barium	g/m ³	0.0108	0.0165	-	-	-
Dissolved Calcium	g/m ³	11.8	6.6	-	-	-
Dissolved Copper	g/m ³	0.0007	< 0.0005	-	-	-
Dissolved Iron	g/m ³	< 0.02	< 0.02	-	-	-
Dissolved Magnesium	g/m ³	4.8	3.3	-	-	-
Dissolved Manganese	g/m ³	0.0006	< 0.0005	-	-	-
Dissolved Nickel	g/m ³	< 0.0005	< 0.0005	-	-	-
Dissolved Potassium	g/m ³	1.54	1.45	-	-	-
Dissolved Sodium	g/m ³	10.1	10.3	-	-	-
Dissolved Zinc	g/m ³	0.0072	0.0021	-	-	-
Bromide	g/m ³	0.06	< 0.05	-	-	-
Chloride	g/m ³	12.0	13.9	-	-	-
Nitrite-N	g/m ³	< 0.002	< 0.002	-	-	-
Nitrate-N	g/m ³	0.90	2.7	-	-	-
Nitrate-N + Nitrite-N	g/m ³	0.90	2.8	-	-	-
Sulphate	g/m ³	6.2	4.2	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m ³	< 4	< 4	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m ³	< 4	< 4	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m ³	< 2	< 2	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m ³	< 0.0010	< 0.0010	-	-	-
Toluene	g/m ³	< 0.0010	< 0.0010	-	-	-
Ethylbenzene	g/m ³	< 0.0010	< 0.0010	-	-	-
m&p-Xylene	g/m ³	< 0.002	< 0.002	-	-	-
o-Xylene	g/m ³	< 0.0010	< 0.0010	-	-	-



Sample Type: Aqueous						
Sample Name:		GND2279 04-Jul-2012 2:30 pm	GND1081 04-Jul-2012 4:00 pm			
Lab Number:		1024037.1	1024037.2			
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	< 0.02	-	-	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	< 0.003	-	-	-
Ethylene	g/m ³	< 0.004	< 0.004	-	-	-
Methane	g/m ³	< 0.002	< 0.002	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.10	< 0.10	-	-	-
C10 - C14	g/m ³	< 0.2	< 0.2	-	-	-
C15 - C36	g/m ³	< 0.4	< 0.4	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	< 0.7	< 0.7	-	-	-

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-2
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-2
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1-2
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-2
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1-2
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1-2
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	1-2
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1-2
pH	pH meter. APHA 4500-H ⁺ B 21 st ed. 2005.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 st ed. 2005.	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 21 st ed. 2005.	1.0 g/m ³ at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 st ed. 2005.	1.0 g/m ³ as CaCO ₃	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 st ed. 2005.	0.1 mS/m	1-2
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21 st ed. 2005.	10 g/m ³	1-2
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.00010 g/m ³	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.05 g/m ³	1-2
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1-2
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	1-2
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1-2
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.05 g/m ³	1-2

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.02 g/m ³	1-2
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.0010 g/m ³	1-2
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 2 ^{1st} ed. 2005.	0.05 g/m ³	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl E (modified from continuous flow analysis) 2 ^{1st} ed. 2005.	0.5 g/m ³	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₃ - I (Modified) 2 ^{1st} ed. 2005.	0.002 g/m ³	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N.	0.002 g/m ³	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NQ I (Modified) 2 ^{1st} ed. 2005.	0.002 g/m ³	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 2 ^{1st} ed. 2005.	0.5 g/m ³	1-2

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

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

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Ara Heron BSc (Tech)
Client Services Manager - Environmental Division



ANALYSIS REPORT

Client:	Taranaki Regional Council	Lab No:	1030218	SPV1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	27-Jul-2012	
		Date Reported:	07-Aug-2012	
		Quote No:	50522	
		Order No:		
		Client Reference:		
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:	GND2281 - HF 18-Jul-2012 12:00 pm				
Lab Number:	1030218.1				
Ethylene Glycol in Water					
Ethylene glycol*	g/m ³	270	-	-	-
Propylene Glycol in Water					
Propylene glycol*	g/m ³	42	-	-	-
Methanol in Water - Aqueous Solvents					
Methanol*	g/m ³	29	-	-	-
BTEX in Water by Headspace GC-MS					
Benzene	g/m ³	0.0061	-	-	-
Toluene	g/m ³	0.036	-	-	-
Ethylbenzene	g/m ³	0.0038	-	-	-
m&p-Xylene	g/m ³	0.011	-	-	-
o-Xylene	g/m ³	0.0079	-	-	-
Formaldehyde in Water by DNPH & LCMSMS					
Formaldehyde	g/m ³	19.1	-	-	-
Total Petroleum Hydrocarbons in Water					
C7 - C9	g/m ³	0.8	-	-	-
C10 - C14	g/m ³	33	-	-	-
C15 - C36	g/m ³	72	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	106	-	-	-

Analyst's Comments

It is noted that 2-Butoxyethanol was also found in the aqueous solvent analysis.

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

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

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/Mf E Petroleum Industry Guidelines	-	1



This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.

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

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

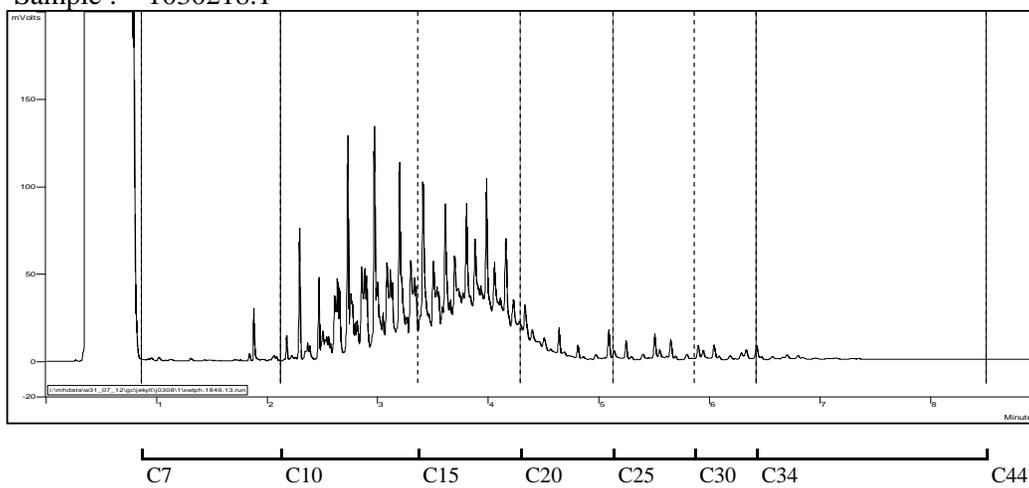
Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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A handwritten signature in blue ink, consisting of several overlapping, stylized strokes.

Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Sample : 1030218.1





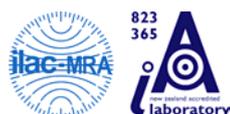
ANALYSIS REPORT

Client:	Taranaki Regional Council	Lab No:	1030266	SPV1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	27-Jul-2012	
		Date Reported:	09-Aug-2012	
		Quote No:	49265	
		Order No:		
		Client Reference:	High Salinity Produced Water	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:	MHENA-A-PW 20-Jul-2012 4:00 pm				
Lab Number:	1030266.1				

Individual Tests						
pH*	pH Units	7.3	-	-	-	-
Total Alkalinity*	g/m ³ as CaCO ₃	3,100	-	-	-	-
Total Hardness*	g/m ³ as CaCO ₃	87	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,571	-	-	-	-
Dissolved Barium*	g/m ³	6.0	-	-	-	-
Dissolved Calcium*	g/m ³	28	-	-	-	-
Dissolved Copper*	g/m ³	0.0077	-	-	-	-
Dissolved Iron*	g/m ³	8.7	-	-	-	-
Dissolved Magnesium*	g/m ³	3.9	-	-	-	-
Dissolved Manganese*	g/m ³	2.7	-	-	-	-
Dissolved Nickel*	g/m ³	0.008	-	-	-	-
Dissolved Potassium*	g/m ³	960	-	-	-	-
Dissolved Sodium*	g/m ³	3,100	-	-	-	-
Dissolved Sulphur	g/m ³	15.6	-	-	-	-
Dissolved Zinc*	g/m ³	0.011	-	-	-	-
Bromide*	g/m ³	13	-	-	-	-
Chloride*	g/m ³	2,900	-	-	-	-
Nitrite-N*	g/m ³	< 0.02	-	-	-	-
Nitrate-N*	g/m ³	< 0.02	-	-	-	-
Nitrate*	g/m ³	< 0.09	-	-	-	-
Nitrate-N + Nitrite-N*	g/m ³	< 0.02	-	-	-	-
Sulphate	g/m ³	47	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m ³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m ³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m ³	23	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m ³	11.3	-	-	-	-
Toluene	g/m ³	12.8	-	-	-	-
Ethylbenzene	g/m ³	0.96	-	-	-	-
m&p-Xylene	g/m ³	5.1	-	-	-	-
o-Xylene	g/m ³	2.0	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	0.18	-	-	-	-



Sample Type: Aqueous						
Sample Name:	MHENA-A-PW 20-Jul-2012 4:00 pm					
Lab Number:	1030266.1					
Gases in groundwater						
Ethane	g/m ³	0.33	-	-	-	-
Ethylene	g/m ³	< 0.004	-	-	-	-
Methane	g/m ³	1.48	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	47	-	-	-	-
C10 - C14	g/m ³	119	-	-	-	-
C15 - C36	g/m ³	175	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	340	-	-	-	-

Analyst's Comments

Severe matrix interferences required that a dilution be performed prior to analysis of sample 1030266/1, resulting in a detection limit higher than that normally achieved for the NO₂N, NO₃N and NO_xN analysis.

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1
pH*	Saline water, pH meter. APHA 4500-H ⁺ B 21 st ed. 2005.	0.1 pH Units	1
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m ³ as CaCO ₃	1
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 21 st ed. 2005.	1.0 g/m ³ as CaCO ₃	1
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 21 st ed. 2005.	0.10 mS/m	1
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21 st ed. 2005.	0.0006 g/m ³	1
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21 st ed. 2005.	1.0 g/m ³	1
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21 st ed. 2005.	0.0010 g/m ³	1
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21 st ed. 2005.	0.004 g/m ³	1
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21 st ed. 2005.	0.4 g/m ³	1
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21 st ed. 2005.	0.0010 g/m ³	1
Dissolved Nickel*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21 st ed. 2005.	0.006 g/m ³	1
Dissolved Potassium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21 st ed. 2005.	1.0 g/m ³	1
Dissolved Sodium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21 st ed. 2005.	0.4 g/m ³	1
Dissolved Sulphur	Filtered sample, ICP-OES.	0.10 g/m ³	1
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21 st ed. 2005.	0.004 g/m ³	1

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Bromide*	Filtered sample. Ion Chromatography. APHA 4110 B 2 nd ed. 2005.	0.05 g/m ³	1
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl ⁻ E (modified from continuous flow analysis) 21 st ed. 2005.	0.5 g/m ³	1
Nitrite-N*	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I (Modified) 21 st ed. 2005.	0.002 g/m ³	1
Nitrate-N*	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N.	0.002 g/m ³	1
Nitrate*	Calculation from Nitrate-N.	0.010 g/m ³	1
Nitrate-N + Nitrite-N*	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO ₃ ⁻ I (Modified) 21 st ed. 2005.	0.002 g/m ³	1
Soluble Sulphate	Calculation: from dissolved sulphur.	2 g/m ³	1

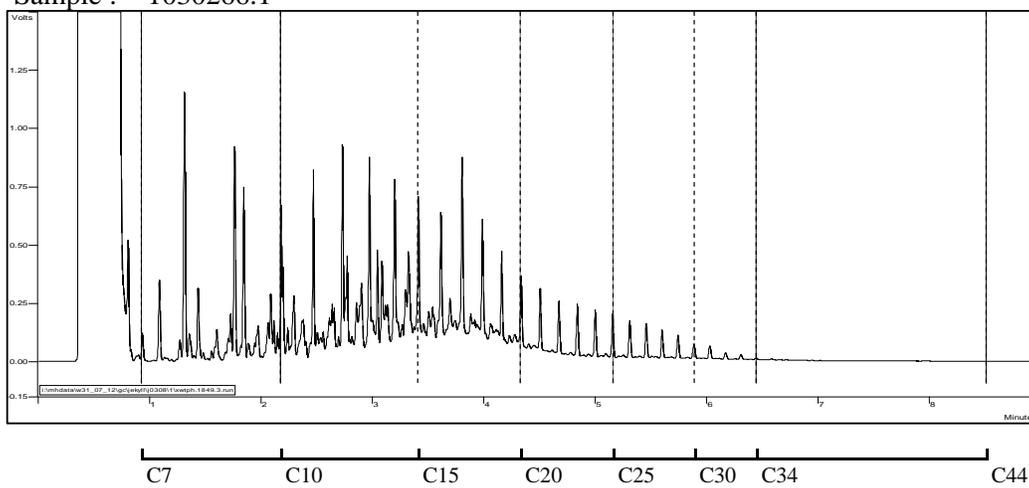
These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

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Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Sample : 1030266.1





ANALYSIS REPORT

Client:	Taranaki Regional Council	Lab No:	1030272	SPV1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	27-Jul-2012	
		Date Reported:	03-Aug-2012	
		Quote No:	47915	
		Order No:		
		Client Reference:	Groundwater	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:	GND2258 26-Jul-2012 1:00 pm				
Lab Number:	1030272.1				

Individual Tests

Sum of Anions	meq/L	1.05	-	-	-	-
Sum of Cations	meq/L	1.02	-	-	-	-
pH	pH Units	6.0	-	-	-	-
Total Alkalinity	g/m ³ as CaCO ₃	18.0	-	-	-	-
Bicarbonate	g/m ³ at 25°C	22	-	-	-	-
Total Hardness	g/m ³ as CaCO ₃	30	-	-	-	-
Electrical Conductivity (EC)	mS/m	11.6	-	-	-	-
Total Dissolved Solids (TDS)	g/m ³	95	-	-	-	-
Dissolved Barium	g/m ³	0.091	-	-	-	-
Dissolved Calcium	g/m ³	6.9	-	-	-	-
Dissolved Copper	g/m ³	0.0007	-	-	-	-
Dissolved Iron	g/m ³	< 0.02	-	-	-	-
Dissolved Magnesium	g/m ³	3.1	-	-	-	-
Dissolved Manganese	g/m ³	0.0011	-	-	-	-
Dissolved Nickel	g/m ³	< 0.0005	-	-	-	-
Dissolved Potassium	g/m ³	3.7	-	-	-	-
Dissolved Sodium	g/m ³	7.5	-	-	-	-
Dissolved Zinc	g/m ³	0.0182	-	-	-	-
Bromide	g/m ³	0.07	-	-	-	-
Chloride	g/m ³	13.5	-	-	-	-
Nitrite-N	g/m ³	< 0.002	-	-	-	-
Nitrate-N	g/m ³	3.1	-	-	-	-
Nitrate-N + Nitrite-N	g/m ³	3.1	-	-	-	-
Sulphate	g/m ³	4.2	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m ³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m ³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m ³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m ³	< 0.0010	-	-	-	-
Toluene	g/m ³	< 0.0010	-	-	-	-
Ethylbenzene	g/m ³	< 0.0010	-	-	-	-
m&p-Xylene	g/m ³	< 0.002	-	-	-	-
o-Xylene	g/m ³	< 0.0010	-	-	-	-



Sample Type: Aqueous						
Sample Name:	GND2258 26-Jul-2012 1:00 pm					
Lab Number:	1030272.1					
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	-	-	-	-
Ethylene	g/m ³	< 0.004	-	-	-	-
Methane	g/m ³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.10	-	-	-	-
C10 - C14	g/m ³	< 0.2	-	-	-	-
C15 - C36	g/m ³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	< 0.7	-	-	-	-

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	1
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1
pH	pH meter. APHA 4500-H ⁺ B 21 st ed. 2005.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 st ed. 2005.	1.0 g/m ³ as CaCO ₃	1
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 21 st ed. 2005.	1.0 g/m ³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 st ed. 2005.	1.0 g/m ³ as CaCO ₃	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 st ed. 2005.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21 st ed. 2005.	10 g/m ³	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.00010 g/m ³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.05 g/m ³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.05 g/m ³	1

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.02 g/m ³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.0010 g/m ³	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 2 ^{1st} ed. 2005.	0.05 g/m ³	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl E (modified from continuous flow analysis) 2 ^{1st} ed. 2005.	0.5 g/m ³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₃ - I (Modified) 2 ^{1st} ed. 2005.	0.002 g/m ³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N.	0.002 g/m ³	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NQ I (Modified) 2 ^{1st} ed. 2005.	0.002 g/m ³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 2 ^{1st} ed. 2005.	0.5 g/m ³	1

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

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

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Martin Cowell - BSc (Chem)
Client Services Manager - Environmental Division



ANALYSIS REPORT

Client:	Taranaki Regional Council	Lab No:	1030269	SPV1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	27-Jul-2012	
		Date Reported:	03-Aug-2012	
		Quote No:	47915	
		Order No:		
		Client Reference:	Groundwater	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:	GND2263 26-Jul-2012 8:35 am	GND1081 26-Jul-2012 9:15 am	GND2279 26-Jul-2012 9:45 am		
Lab Number:	1030269.1	1030269.2	1030269.3		
Individual Tests					
Sum of Anions	meq/L	0.89	1.08	1.20	-
Sum of Cations	meq/L	0.86	1.02	1.19	-
pH	pH Units	6.4	6.4	6.5	-
Total Alkalinity	g/m ³ as CaCO ₃	17.5	22	37	-
Bicarbonate	g/m ³ at 25°C	21	27	45	-
Total Hardness	g/m ³ as CaCO ₃	25	28	39	-
Electrical Conductivity (EC)	mS/m	9.6	11.4	12.3	-
Total Dissolved Solids (TDS)	g/m ³	76	94	96	-
Dissolved Barium	g/m ³	0.0097	0.0153	0.0101	-
Dissolved Calcium	g/m ³	5.3	6.0	9.6	-
Dissolved Copper	g/m ³	0.0076	0.0009	< 0.0005	-
Dissolved Iron	g/m ³	< 0.02	< 0.02	< 0.02	-
Dissolved Magnesium	g/m ³	3.0	3.1	3.7	-
Dissolved Manganese	g/m ³	0.0023	0.0009	< 0.0005	-
Dissolved Nickel	g/m ³	< 0.0005	< 0.0005	< 0.0005	-
Dissolved Potassium	g/m ³	1.61	1.46	1.30	-
Dissolved Sodium	g/m ³	7.1	9.7	8.6	-
Dissolved Zinc	g/m ³	0.0136	0.0061	0.0031	-
Bromide	g/m ³	< 0.05	0.07	< 0.05	-
Chloride	g/m ³	11.7	13.8	10.8	-
Nitrite-N	g/m ³	< 0.002	< 0.002	< 0.002	-
Nitrate-N	g/m ³	1.33	2.4	0.65	-
Nitrate-N + Nitrite-N	g/m ³	1.33	2.4	0.65	-
Sulphate	g/m ³	5.6	4.1	5.4	-
Ethylene Glycol in Water					
Ethylene glycol*	g/m ³	< 4	< 4	< 4	-
Propylene Glycol in Water					
Propylene glycol*	g/m ³	< 4	< 4	< 4	-
Methanol in Water - Aqueous Solvents					
Methanol*	g/m ³	< 2	< 2	< 2	-
BTEX in Water by Headspace GC-MS					
Benzene	g/m ³	< 0.0010	< 0.0010	< 0.0010	-
Toluene	g/m ³	< 0.0010	< 0.0010	< 0.0010	-
Ethylbenzene	g/m ³	< 0.0010	< 0.0010	< 0.0010	-
m&p-Xylene	g/m ³	< 0.002	< 0.002	< 0.002	-
o-Xylene	g/m ³	< 0.0010	< 0.0010	< 0.0010	-



Sample Type: Aqueous						
Sample Name:	GND2263 26-Jul-2012 8:35 am	GND1081 26-Jul-2012 9:15 am	GND2279 26-Jul-2012 9:45 am			
Lab Number:	1030269.1	1030269.2	1030269.3			
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	< 0.02	< 0.02	-	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	< 0.003	< 0.003	-	-
Ethylene	g/m ³	< 0.004	< 0.004	< 0.004	-	-
Methane	g/m ³	< 0.002	< 0.002	< 0.002	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.10	< 0.10	< 0.10	-	-
C10 - C14	g/m ³	< 0.2	< 0.2	< 0.2	-	-
C15 - C36	g/m ³	< 0.4	< 0.4	< 0.4	-	-
Total hydrocarbons (C7 - C36)	g/m ³	< 0.7	< 0.7	< 0.7	-	-

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-3
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-3
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1-3
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-3
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1-3
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1-3
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-3
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-3
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	1-3
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1-3
pH	pH meter. APHA 4500-H ⁺ B 21 st ed. 2005.	0.1 pH Units	1-3
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 st ed. 2005.	1.0 g/m ³ 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 21 st ed. 2005.	1.0 g/m ³ at 25°C	1-3
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 st ed. 2005.	1.0 g/m ³ as CaCO ₃	1-3
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 st ed. 2005.	0.1 mS/m	1-3
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21 st ed. 2005.	10 g/m ³	1-3
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.00010 g/m ³	1-3
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.05 g/m ³	1-3
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1-3
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	1-3
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	1-3
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1-3
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1-3
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.05 g/m ³	1-3

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.02 g/m ³	1-3
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.0010 g/m ³	1-3
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 2 ^{1st} ed. 2005.	0.05 g/m ³	1-3
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl E (modified from continuous flow analysis) 2 ^{1st} ed. 2005.	0.5 g/m ³	1-3
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ -I (Modified) 2 ^{1st} ed. 2005.	0.002 g/m ³	1-3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N.	0.002 g/m ³	1-3
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NQ-I (Modified) 2 ^{1st} ed. 2005.	0.002 g/m ³	1-3
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 2 ^{1st} ed. 2005.	0.5 g/m ³	1-3

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Ara Heron BSc (Tech)
Client Services Manager - Environmental Division



ANALYSIS REPORT

Client:	Taranaki Regional Council	Lab No:	1060950	SPV1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	20-Oct-2012	
		Date Reported:	30-Oct-2012	
		Quote No:	47915	
		Order No:		
		Client Reference:	Groundwater	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:	GND2263 19-Oct-2012 11:15 am	GND1081 19-Oct-2012 12:00 pm	GND2279 19-Oct-2012 12:20 pm	GND2258 19-Oct-2012 12:50 pm		
Lab Number:	1060950.1	1060950.2	1060950.3	1060950.4		
Individual Tests						
Sum of Anions	meq/L	0.96	1.14	1.51	1.05	-
Sum of Cations	meq/L	0.94	1.12	1.51	1.03	-
pH	pH Units	6.2	6.7	6.6	6.1	-
Total Alkalinity	g/m ³ as CaCO ₃	17.0	21	48	18.5	-
Bicarbonate	g/m ³ at 25°C	21	25	58	23	-
Total Hardness	g/m ³ as CaCO ₃	29	30	52	30	-
Electrical Conductivity (EC)	mS/m	10.2	12.4	15.4	11.6	-
Total Dissolved Solids (TDS)	g/m ³	72	91	111	86	-
Dissolved Barium	g/m ³	0.0102	0.0160	0.0095	0.080	-
Dissolved Calcium	g/m ³	5.9	6.6	12.2	6.7	-
Dissolved Copper	g/m ³	< 0.0005	0.0007	< 0.0005	< 0.0005	-
Dissolved Iron	g/m ³	< 0.02	< 0.02	< 0.02	< 0.02	-
Dissolved Magnesium	g/m ³	3.4	3.3	5.1	3.2	-
Dissolved Manganese	g/m ³	0.0009	0.0044	< 0.0005	0.0019	-
Dissolved Nickel	g/m ³	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-
Dissolved Potassium	g/m ³	1.42	2.5	1.38	3.6	-
Dissolved Sodium	g/m ³	7.5	10.5	10.2	7.8	-
Dissolved Zinc	g/m ³	0.0022	0.0036	< 0.0010	0.0108	-
Bromide	g/m ³	< 0.05	0.10	0.07	0.07	-
Chloride	g/m ³	14.1	15.4	12.7	13.8	-
Nitrite-N	g/m ³	< 0.002	0.007	< 0.002	< 0.002	-
Nitrate-N	g/m ³	1.51	2.7	1.13	2.8	-
Nitrate-N + Nitrite-N	g/m ³	1.51	2.7	1.13	2.8	-
Sulphate	g/m ³	5.6	4.3	5.7	4.5	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m ³	< 4	< 4	< 4	< 4	-
Propylene Glycol in Water						
Propylene glycol*	g/m ³	< 4	< 4	< 4	< 4	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m ³	< 2	< 2	< 2	< 2	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m ³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Toluene	g/m ³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Ethylbenzene	g/m ³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
m&p-Xylene	g/m ³	< 0.002	< 0.002	< 0.002	< 0.002	-
o-Xylene	g/m ³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-



Sample Type: Aqueous						
Sample Name:	GND2263 19-Oct-2012 11:15 am	GND1081 19-Oct-2012 12:00 pm	GND2279 19-Oct-2012 12:20 pm	GND2258 19-Oct-2012 12:50 pm		
Lab Number:	1060950.1	1060950.2	1060950.3	1060950.4		
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	< 0.02	< 0.02	< 0.02	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	< 0.003	< 0.003	< 0.003	-
Ethylene	g/m ³	< 0.004	< 0.004	< 0.004	< 0.004	-
Methane	g/m ³	< 0.002	< 0.002	< 0.002	< 0.002	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.10	< 0.10	< 0.10	< 0.10	-
C10 - C14	g/m ³	< 0.2	< 0.2	< 0.2	< 0.2	-
C15 - C36	g/m ³	< 0.4	< 0.4	< 0.4	< 0.4	-
Total hydrocarbons (C7 - C36)	g/m ³	< 0.7	< 0.7	< 0.7	< 0.7	-

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1-4
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-4
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1-4
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1-4
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-4
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-4
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	1-4
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1-4
pH	pH meter. APHA 4500-H ⁺ B 21 st ed. 2005.	0.1 pH Units	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 st ed. 2005.	1.0 g/m ³ 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 21 st ed. 2005.	1.0 g/m ³ at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 st ed. 2005.	1.0 g/m ³ as CaCO ₃	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 st ed. 2005.	0.1 mS/m	1-4
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21 st ed. 2005.	10 g/m ³	1-4
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.00010 g/m ³	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.05 g/m ³	1-4
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.02 g/m ³	1-4
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1-4
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.0005 g/m ³	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 st ed. 2005.	0.05 g/m ³	1-4

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.02 g/m ³	1-4
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 2 ^{1st} ed. 2005.	0.0010 g/m ³	1-4
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 2 ^{1st} ed. 2005.	0.05 g/m ³	1-4
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl E (modified from continuous flow analysis) 2 ^{1st} ed. 2005.	0.5 g/m ³	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₃ - I (Modified) 2 ^{1st} ed. 2005.	0.002 g/m ³	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N.	0.002 g/m ³	1-4
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NQ I (Modified) 2 ^{1st} ed. 2005.	0.002 g/m ³	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 2 ^{1st} ed. 2005.	0.5 g/m ³	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.

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