Todd Energy Limited
Mangahewa-C Hydraulic Fracturing Monitoring Programme Report
2013-2015

Technical Report 2015-05

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Executive summary

Todd Energy Limited (Todd) operate the Mangahewa-C wellsite, located at Turangi Road, Motunui. The wellsite lies within the Waiau catchment and contains six hydrocarbon producing wells and associated infrastructure.

Todd hold resource consent 7971-2, authorising the discharge of contaminants associated with hydraulic fracturing activities into land at depths greater than 3,290 m TVDss beneath the Mangahewa-C wellsite. The consent was issued by Taranaki Regional Council (the Council) on 30 June 2014 and contains 17 special conditions which set out the requirements that Todd must satisfy. This is a renewal of 7971-1, which authorises the discharge of contaminants associated with hydraulic fracturing activities into land at depths greater than 3,425 m TVDss beneath the Mangahewa-C wellsite. This consent was issued by the Council on 20 January 2012 and contained 13 special conditions which set out the requirements that Todd must satisfy.

The following report for the period August 2013 to October 2014 outlines and discusses the results of the monitoring programme implemented by the Council in relation to the programme of hydraulic fracturing undertaken by Todd, within their Mangahewa-C wellsite. The report also assesses Todd's level of environmental performance and compliance with the resource consent held in relation to the activity.

During the monitoring period being reported, Todd demonstrated a high level of environmental performance.

The programme of hydraulic fracturing undertaken by Todd at the Mangahewa-C wellsite during the period being reported was that of the Mangahewa-12, Mangahewa-13, Mangahewa-14 and Mangahewa-15 wells which took place between August 2013 and July 2014.

The programme of monitoring implemented by the Council in relation to fracturing activities commenced in the 2011-2012 monitoring year. The results of monitoring undertaken between April 2012 and May 2013 were presented in the 2011-2013 biennial report (Taranaki Regional Council, 2013). The results of monitoring undertaken between August 2013 and October 2014 are presented in this report. Monitoring included groundwater sampling at five sites and analysis of samples for a range of chemical and isotopic analysis.

The results of the monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by Todd have had no adverse effects on local groundwater resources. There were no Unauthorised Incidents recording non-compliance in respect of the resource consent, or provisions in regional plans, during the period under review.

Todd demonstrated a high level of environmental and high level of administrative performance and compliance with the resource consents over the reporting period.

For reference, in the 2012-2013 year, 35% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of environmental performance and compliance with their consents, while another 59% demonstrated a good level of environmental performance and compliance with their consents. In the 2013-2014 year, 60% of consent holders achieved a high level of environmental performance and compliance with their consents, while another 29% demonstrated a good level of environmental performance and compliance.

This report includes recommendations for the 2015-2016 year.

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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 outlines and discusses the results of the monitoring programme implemented by the Taranaki Regional Council (the Council) in relation to the programme of hydraulic fracturing undertaken by Todd Energy Limited (Todd) at their Mangahewa-C wellsite, Turangi Road, Motunui over the period August 2013 – November 2014. The wellsite is located in the Waiau catchment. The report also assesses Todd's level of environmental performance and compliance with the resource consents held in relation to the activity.

The programme of hydraulic fracturing undertaken by Todd at the Mangahewa-C wellsite included the fracturing of two wells; Mangahewa-9 and Mangahewa-11. Additional wells have been fractured more recently. The monitoring programme implemented by the Council commenced during the 2011-2012 period. The programme consisted of groundwater monitoring components. Surface water monitoring in relation to hydraulic fracturing events was not included in hydraulic fracturing compliance monitoring programmes by the Council when this well was fractured.

A report was completed in September 2013 which outlined and discussed the results of the monitoring carried out during the 2011-2012 and 2012-2013 monitoring periods. The following report provides an update on the results of further fracturing events that occurred at the site and further monitoring carried out since the initial report was written.

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 1991* (RMA) and the Council's obligations and general approach to monitoring sites though annual programmes, the resource consent held by Todd for discharges into land associated with hydraulic fracturing in the Waiau catchment, a description of the activities undertaken under this consent, and the nature of the monitoring programme in place for the period under review.

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

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

Section 4 presents recommendations to be implemented in the 2015-2016 monitoring year.

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

1.1.3 The Resource Management Act 1991 and monitoring

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

(a) the neighbourhood or the wider community around an activity, and may include cultural and social-economic effects;
(b) physical effects on the locality, including landscape, amenity and visual effects;
(c) ecosystems, including effects on plants, animals, or habitats, whether aquatic or terrestrial;
(d) natural and physical resources having special significance (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 activity. Monitoring programmes are not only based on existing permit conditions, but also on the obligations of the RMA to assess the effects of the exercise of consents. In accordance with section 35 of the RMA, the Council undertakes compliance monitoring for consents and rules in regional plans, and maintains an overview of the performance of resource users and consent holders. Compliance monitoring, including both activity and impact monitoring, enables the Council to continually re-evaluate its approach and that of consent holders to resource management and, ultimately, through the refinement of methods and considered responsible resource utilisation, to move closer to achieving sustainable development of the region's resources.

1.1.4 Evaluation of environmental and consent performance

Besides discussing the various details of the performance and extent of compliance by the consent holder/s during the period under review, this report also assigns a rating as to Todd's environmental and administrative performance.

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

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

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

Environmental Performance

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

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

  For example:

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

- **Improvement required** Likely or actual adverse effects of activities on the receiving environment were more than minor, but not substantial. There were some issues noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent minor non-compliant activity could elevate a minor issue to this level. Abatement notices and infringement notices may have been issued in respect of effects.

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

Administrative compliance

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

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

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

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

For reference, in the 2012-2013 year, 35% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of environmental performance and compliance with their consents, while another 59% demonstrated a good level of environmental performance and compliance with their consents. In the 2013-2014 year, 60% of consent holders achieved a high level of environmental performance and compliance with their consents, while another 29% demonstrated a good level of environmental performance and compliance.

1.2 Process description

1.2.1 Hydraulic fracturing

Hydraulic fracturing is a reservoir stimulation technique used to increase the flow of hydrocarbons to the surface. The primary objective of hydraulic fracturing is to increase the permeability of the target reservoir by creating numerous small, interconnected fractures, thus increasing the flow of hydrocarbons from the formation to a given well. The process of hydraulic fracturing has enabled companies to produce hydrocarbons at economically viable rates from extremely low permeability reservoirs and those that have become depleted using 'traditional' production techniques.

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 fractures. 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 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 fluids and hydrocarbons are drawn to the surface.

1.2.2 Mangahewa-C wellsite history

The Mangahewa-C wellsite has been in operation since 2006. It lies in an active petrochemical exploration and production area, which operates alongside rural and farming operations. The area consists of predominantly low density housing due to its rural location. The topography of the site is flat countryside. The well site is located approximately 250 metres east of an unnamed tributary of the Waiau Stream and 270 m west of another tributary of the same stream.

A summary of all hydraulic fracturing activities carried out by Todd at the Mangahewa-C wellsite during the period being reported is provided below in Table 1. The location of the wellsite is illustrated in Figure 1.

Table 1 Summary of hydraulic fracturing activity at the Mangahewa-C wellsite (2013-2014

Well	Wellsite	Consent	Date	Injection zone (m TVDss)	Formation
Mangahewa-12	Mangahewa-C	7971-1	31/08/2013	3,557 – 4,227	Mangahewa
Mangahewa-13			31-08-2013	4,124 – 4,206	Mangahewa
Mangahewa-14			27/10/2013	4,104.8- 4,107 and 4,185.9 – 4,188.2*	Mangahewa
Mangahewa-15			25/10/2013	4,074-4,089.2, 4,108.6-4,116.1 and 4,157.9-4,162.6*	Mangahewa
Mangahewa-15		7971-2	3/07/2014	4,185.9 – 4,200.5*	Mangahewa

*mTVDBRT = metres true vertical depth below rotating table

A report was completed in September 2013 (Taranaki Regional Council, 2013) which outlined and discussed the results of the monitoring carried out during the 2011-2012 and 2012-2013 monitoring periods. The following report provides an update on the results of further monitoring carried out since the report was issued.

1.3 Resource consent

1.3.1 Discharges onto and into land

Sections 15(1)(b) of the RMA stipulate that no person may discharge any contaminant onto or into land, which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations.

Todd holds resource consent **7971-2**, authorising the discharge of contaminants into land at the Mangahewa-C wellsite. Consent 7971-1 was granted to Todd Energy Limited on 20 January 2012. It is under this consent that Mangahewa-12, Mangahewa-13, Mangahewa-14 and Mangahewa-15 were hydraulically fractured. The consent was reviewed and four extra consent conditions were added and the consent became 7971-2 on 30 June 2014. It is under this consent that the second fracturing event at Mangahewa-15 took place, in July 2014. Consent 7971-1 contains 13 special conditions which set out the requirements that Todd must satisfy. The special conditions attached to each consent are summarised below:

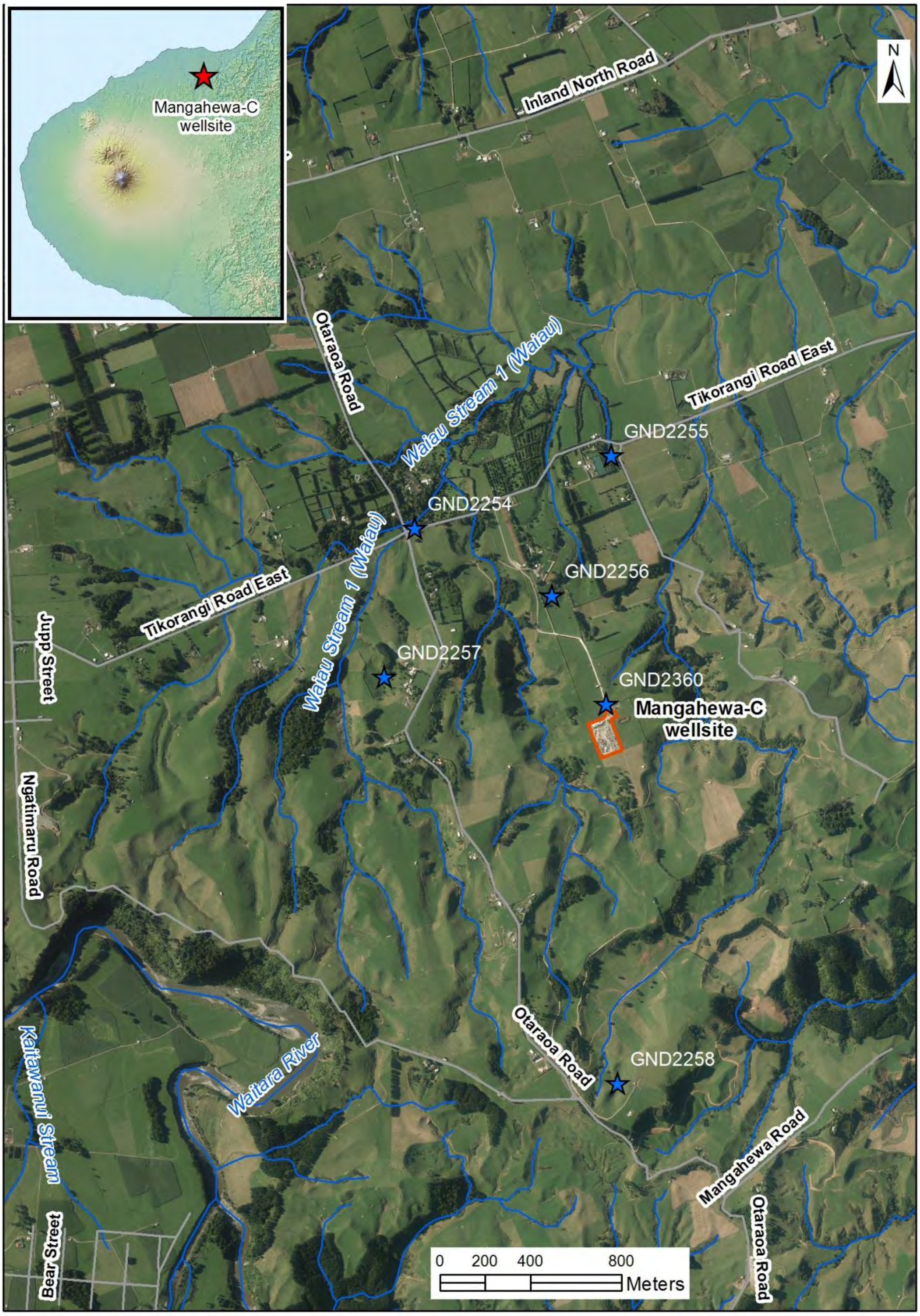

Figure 1 Location of Mangahewa-C wellsite

Consent 7971-1

Condition 1 stipulates the minimum depth below which the injection of hydraulic fracturing fluids must occur.

Condition 2 stipulates the distance horizontally from the wellsite past which discharge may not occur.

Condition 3 requires the consent holder to ensure that the exercising of the consent does not result in any contaminants reaching any useable freshwater aquifers.

Conditions 4 and 5 relate to fresh water monitoring requirements, to allow compliance with condition 3 to be assessed.

Condition 6 is a notification requirement.

Condition 7 requires the consent holder to submit a pre-fracturing discharge report at least 10 working days before the discharge commences.

Condition 8 requires the consent holder to submit a post-fracturing discharge report after the completion of the hydraulic fracturing programme.

Condition 9 stipulates how the reports required by conditions 7 and 8 are to be submitted.

Condition 10 requires the consent holder to allow the Council access to a location where samples of hydraulic fracturing and return fluids can be obtained.

Condition 11 requires the consent holder to adopt best practicable options.

Condition 12 relates to the composition of the fracturing fluid.

Condition 13 is a review provision.

Consent 7971-2

Condition 1 stipulates the minimum depth below which the injection of hydraulic fracturing fluids must occur.

Condition 2 stipulates the date after which no hydraulic fracturing discharge is to occur.

Condition 3 requires the consent holder to ensure that the exercising of the consent does not result in any contaminants reaching any useable freshwater.

Conditions 4, 5, 6 and 7 relate to fresh water monitoring requirements, to allow compliance with condition 3 to be assessed.

Condition 8 requires the consent holder to carry out pressure testing of equipment prior to discharging.

Condition 9 requires the consent holder to submit a pre-fracturing discharge report at least 14 working days before the discharge commences.

Condition 10 is a notification requirement.

Condition 11 requires the consent holder to submit a post-fracturing discharge report within 90 days of the commencement date of hydraulic fracturing.

Condition 12 stipulates how the reports required by conditions 9 and 11 are to be submitted.

Condition 13 requires the consent holder to allow the Council access to a location where samples of hydraulic fracturing and return fluids can be obtained.

Condition 14 requires the consent holder to adopt best practicable options.

Condition 15 relates to the composition of the fracturing fluid.

Condition 16 is a lapse clause.

Condition 17 is a review provision.

1.4 Monitoring programme

1.4.1 Introduction

Section 35 of the RMA sets obligations upon the Council to gather information, monitor, and conduct research on the exercise of resource consents, and the effects arising, within the Taranaki region and report upon these.

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

The monitoring programme implemented in relation to the hydraulic fracturing of the Mangahewa-C wells consisted of three primary components.

1.4.2 Programme liaison and management

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

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

1.4.3 Review of consent holder submitted data

As required by the conditions of consents 7971-1 and 7971-2, Todd provided pre and post-fracturing discharge reports to the Council for the wells fractured during the period under review. Pre-fracturing discharge reports provide an outline of the proposed fracturing operations in relation to the well, while post-fracturing reports confirm details of the fracturing activities that actually occurred. The specific range of information required in the report is stipulated in the conditions of the resource consent. The post-fracturing discharge reports for the fracturing of Mangahewa-9 and Mangahewa-11 are discussed in detail in the 2011-2013 annual report (Taranaki Regional Council, 2013).

1.4.4 Chemical sampling

The groundwater monitoring programme over the period in question included the sampling of five wells, all of which are existing groundwater supplies in the vicinity of the wellsite at which hydraulic fracturing took place, and the analysis of the results.

The details of each site are included in Table 2 and their proximity to the Mangahewa-C wellsite is illustrated in Figure 2.

Table 2 Details of groundwater sites included in the monitoring programme

Hydraulically fractured wells	Monitoring site	Distance from wellsite (m)	Total depth (m)	Aquifer
Mangahewa-12 Mangahewa-13 Mangahewa-14 Mangahewa-15	GND2254	1161	37	Volcanics
	GND2255	1158	4	Volcanics
	GND2256	595	3.15	Volcanics
	GND2257	960	5	Volcanics
	GND2360	60	533	Volcanics

Samples of groundwater were obtained before fracturing to provide a baseline reference of groundwater composition, with further rounds of sampling carried out post-fracturing for comparison with baseline results.

Four rounds of groundwater sampling occurred between April 2012 and May 2013. The results of these sampling rounds are outlined in the 2011-2013 biennial report (Taranaki Regional Council, 2013).

Where access to the bore was available, samples were obtained using a pneumatic bladder or peristaltic pump, using a low-flow sampling methodology. Where access to the bore was not available, samples were obtained at a point in the water distribution network as close to the wellhead as practicable. Samples taken from wide diameter wells were taken directly from the well. All samples were transported to Hill Laboratories Limited for analysis following standard chain of custody procedures.

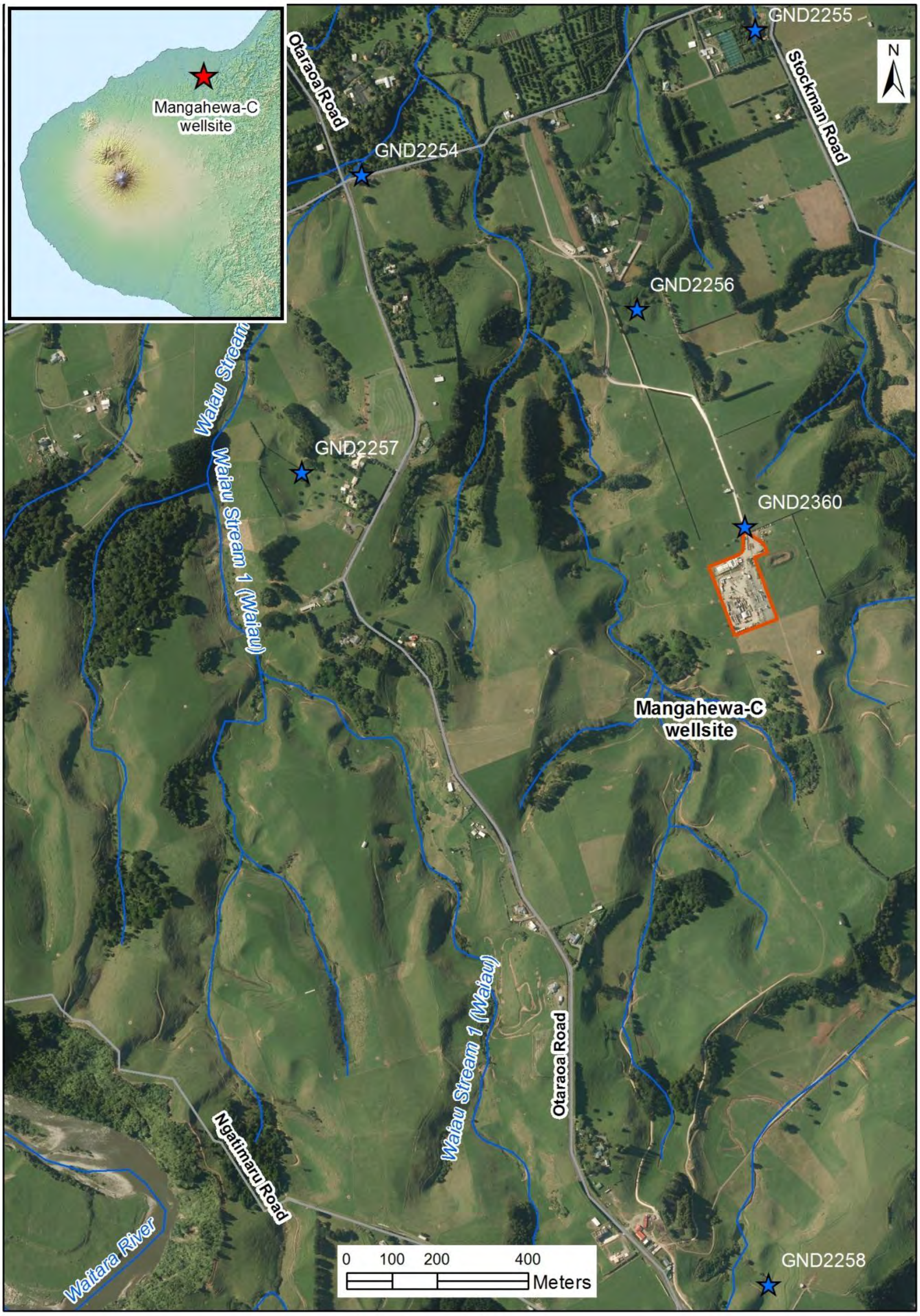

Figure 2 Location of groundwater sampling sites in relation to the Mangahewa-C wellsite

2. Results

2.1 Consent holder submitted data

2.1.1 Mangahewa-12 post-fracturing discharge report

The conclusions from the Mangahewa-12 post-fracturing discharge report are summarised as follows:

- A total of three discrete zones were fractured over the period 31 August to 06 September 2013, at depths between 3,557 to 4,227m TVDBRT.
- A total of 5,120 barrels (bbls) (814 m^3) of liquid was discharged across the three fractured zones. The total proppant weight was 122 tonnes.
- By volume the fluid injected was comprised of 92.78% (1,051 m^3) water, 6.22% proppant and 2.86% chemicals.
- Pressure testing of the tubing and well head equipment was carried out prior to fracturing commencing. The maximum pressure exerted during the fracturing programme remained below the successfully tested levels at all times.
- The Mangahewa-12 well was opened for flowback following the completion of fracturing. At the completion of all flow-back operations, approximately 2,059 bbls (327 m^3) of fracture fluid were returned to the surface, leaving approximately 3,061 bbls (487m^3) of the fluids injected remaining in the formation. Total water flowed back from this well was approximately 14,087 bbls (2,240 m^3), as of 11 October 2012, when Mangahewa-12 was shut in.
- All fluids produced during the stimulation and flowback period were piped to the Mangahewa-A site and then trucked to Todd Well McKee 1 for disposal by deep well injection as per consent 4182-2.
- The Christmas tree, isolation tool, tubing and casings and wellhead have maintained full integrity throughout the treatment.
- All fracturing treatments were placed successfully. It is considered that the mitigation measures implemented by Todd were effective in ensuring there were no adverse environmental effects associated with fracturing operations.

2.1.2 Mangahewa-13 post-fracturing discharge report

The conclusions from the Mangahewa-13 post-fracturing discharge report are summarised as follows:

- A total of three discrete zones were fractured over the period 31 August to 09 September 2013, at depths between 4,123.9 to 4,206.4 m TVDBRT.
- A total of 7,395 bbls (1,176 m^3) of liquid was discharged across the three fractured zones. The total proppant weight was 178 tonnes.

- By volume the fluid injected was comprised of 90.20% (1,061 m^3) water, 6.29% proppant and 3.51% chemicals.

- Pressure testing of the tubing and well head equipment was carried out prior to fracturing commencing. The maximum pressure exerted during the fracturing programme remained below the successfully tested levels at all times.

- The Mangahewa-13 well was opened for flowback following the completion of fracturing. At the completion of all flow-back operations, approximately 1,619 bbls (257 m^3) of fracture water were returned to the surface, leaving approximately 5,776 bbls (918m^3) of the fluids injected remaining in the formation. Total fluid flowed back from this well was approximately 11,797 bbls (1,876 m^3), as of 3 October 2012, when Mangahewa-13 was shut in.

- All fluids produced during the stimulation and flowback period were piped to the Mangahewa-A site and then trucked to Todd Well McKee 1 for disposal by deep well injection as per consent 4182-2.

- The Christmas tree, isolation tool, tubing and casings and wellhead have maintained full integrity throughout the treatment.

2.1.3 Mangahewa-14 post-fracturing discharge report

The conclusions from the Mangahewa-14 post-fracturing discharge report are summarised as follows:

- A total of three discrete zones were fractured over the period 27 October 2013 to 2 November 2013, at depths between 4,074.0 to 4,162.6 m TVDBRT.

- A total of 6,958 barrels (bbls) (1,106 m^3) of liquid was discharged across the three fractured zones. The total proppant weight was 145 tonnes.

- By volume the fluid injected was comprised of 93.85% (1,038 m^3) water, 3.78% proppant and 2.37% chemicals.

- Pressure testing of the tubing and well head equipment was carried out prior to fracturing commencing. The maximum pressure exerted during the fracturing programme remained below the successfully tested levels at all times.

- The Mangahewa-14 well was opened for flowback following the completion of fracturing. At the completion of all flow-back operations, approximately 3,100 bbls (493 m^3) of fracture water were returned to the surface, leaving approximately 3,858 bbls (613 m^3) of the fluids injected remaining in the formation. Total fluid flowed back from this well was approximately 4,976 bbls (791 m^3). It is estimated that all the proppant injected remains in the formation.

- All fluids produced during the stimulation and flowback period were piped to the Mangahewa-A site and then trucked to Todd Well McKee 1 for disposal by deep well injection as per consent 4182-2.

- The Christmas tree, isolation tool, tubing and casings and wellhead have maintained full integrity throughout the treatment.

2.1.4 Mangahewa-15 (first fracture event) post-fracturing discharge report

The conclusions from the Mangahewa-15 post-fracturing discharge report are summarised as follows:

- One discrete zone was fractured over the period 26 October 2013 to 27 October 2013, at depths between 4,104.8 to 4,107 m TVDBRT.

- A total of 2,602 barrels (bbls) (414 m^3) of liquid was discharged across the fractured zone. The total proppant weight was 52 tonnes.

- By volume the fluid injected was comprised of 94.21% (390 m^3) water, 3.70% proppant and 2.09% chemicals.

- Pressure testing of the tubing and well head equipment was carried out prior to fracturing commencing. The maximum pressure exerted during the fracturing programme remained below the successfully tested levels at all times.

- The Mangahewa-15 well was opened for flowback following the completion of fracturing. At the completion of all flow-back operations, approximately 400 bbls (64 m^3) of fracture water were returned to the surface, leaving approximately 2202 bbls (350 m^3) of the fluids injected remaining in the formation. Total fluid flowed back from this well was approximately 2,174 bbls (346 m^3). It is estimated that all the proppant injected remains in the formation.

- All fluids produced during the stimulation and flowback period were piped to the Mangahewa-A site and then trucked to Todd Well McKee 1 for disposal by deep well injection as per consent 4182-2.

- The Christmas tree, isolation tool, tubing and casings and wellhead have maintained full integrity throughout the treatment.

2.1.5 Mangahewa-15 (second fracture event) post-fracturing discharge report

The conclusions from the Mangahewa-15 post-fracturing discharge report are summarised as follows:

- One discrete zone was fractured on 3 July 2014, at depths between 4,185.9 to 4,200.5 m TVDBRT.

- A total of 853 bbls (136 m^3) of liquid was discharged across the fractured zone. The total proppant weight was 24 tonnes.

- By volume the fluid injected was comprised of 92.5% (126 m^3) water, 5.17% proppant and 2.33% chemicals.

- Pressure testing of the tubing and well head equipment was carried out prior to fracturing commencing. The maximum pressure exerted during the fracturing programme remained below the successfully tested levels at all times.

- The Mangahewa-15 well was opened for flowback following the completion of fracturing. At the completion of all flow-back operations, approximately 595 bbls (95 m^3) of fracture fluid were returned to the surface, leaving approximately 259 bbls (41 m^3) of the fluids injected remaining in the formation. Total fluid flowed back from this well was approximately 2,048 bbls (326 m^3). It is estimated that all the proppant injected remains in the formation.

- All fluids produced during the stimulation and flowback period were trucked to Todd Well McKee 1 for disposal by deep well injection as per consent 4182-2.

- The Christmas tree, isolation tool, tubing and casings and wellhead have maintained full integrity throughout the treatment.

2.2 Groundwater sampling

A total of five sites were sampled between October 2013 and October 2014 to monitor the effects of the hydraulic fracturing of the wells at the Mangahewa-C well site on local groundwater resources.

As a continuation of the 2011–2013 biennial report, key indicator parameters pH, electrical conductivity, total dissolved solids, chloride and methane in groundwater are plotted against time (Figures 3, 4, 5, 6 and 7). 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 monitoring carried out indicate that the pH concentrations in all the wells sampled remained consistent across the sampling period. The most fluctuation occurred in GND2255 but during the last sampling round it was found that pH levels at this site were almost identical to pre-fracturing results. Figures 4, 5, 6 and 7 feature GND2360 results on a secondary axis, as results at this site were generally higher than at the other sites. This is almost certainly due to the depth of the bore. GND2360 is 533 m deep whereas the other wells are mostly 5 m deep with GND2254 being 37 m deep.

Electrical conductivity values were consistent across most sites, but varied at GND2360, where they dropped throughout the monitoring period. The same occurs for total dissolved solids and chloride concentrations, with values at most sites remaining constant, except for GND2360, where values decreased. The changes in the concentrations of these analytes are a result of natural variations in water composition and are unrelated to fracturing activities.

Methane was detected in all wells except GND2257 over the course of the monitoring period. In GND2254 and GND2360, methane was detected during each sampling round. In GND2255 and GND2256 methane was detected in very low concentrations during the February 2014 sampling round. Concentrations were generally low and within the expected ranges typically seen in shallow groundwater across Taranaki.

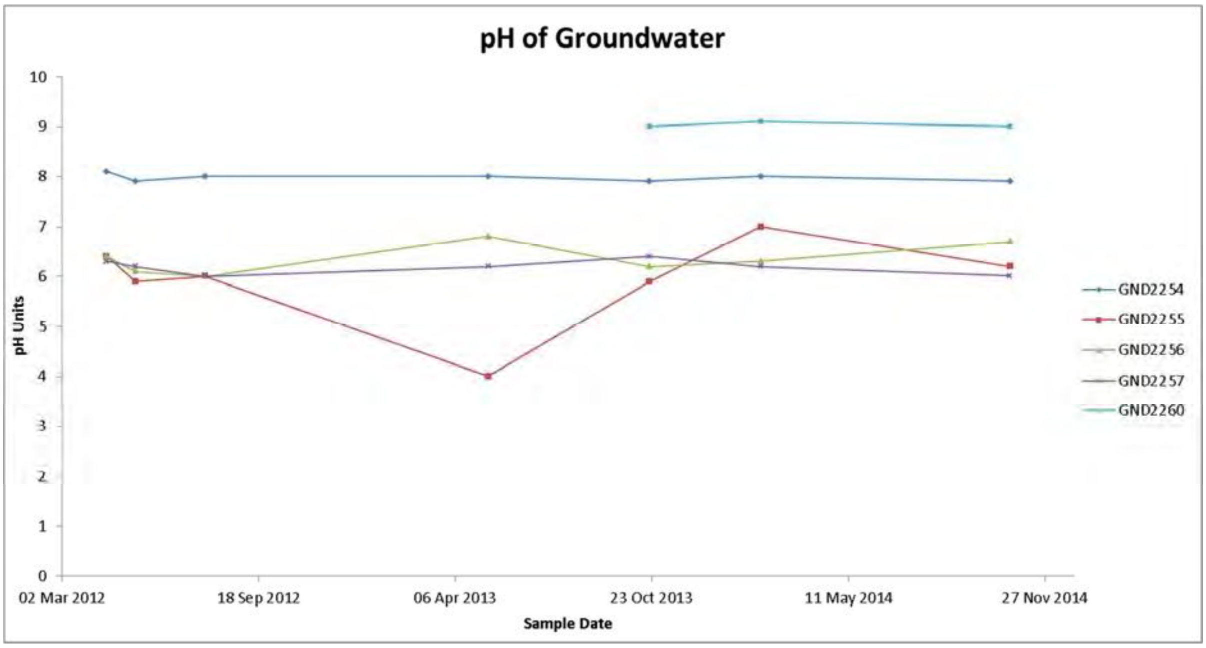

Figure 3 Results of pH analysis

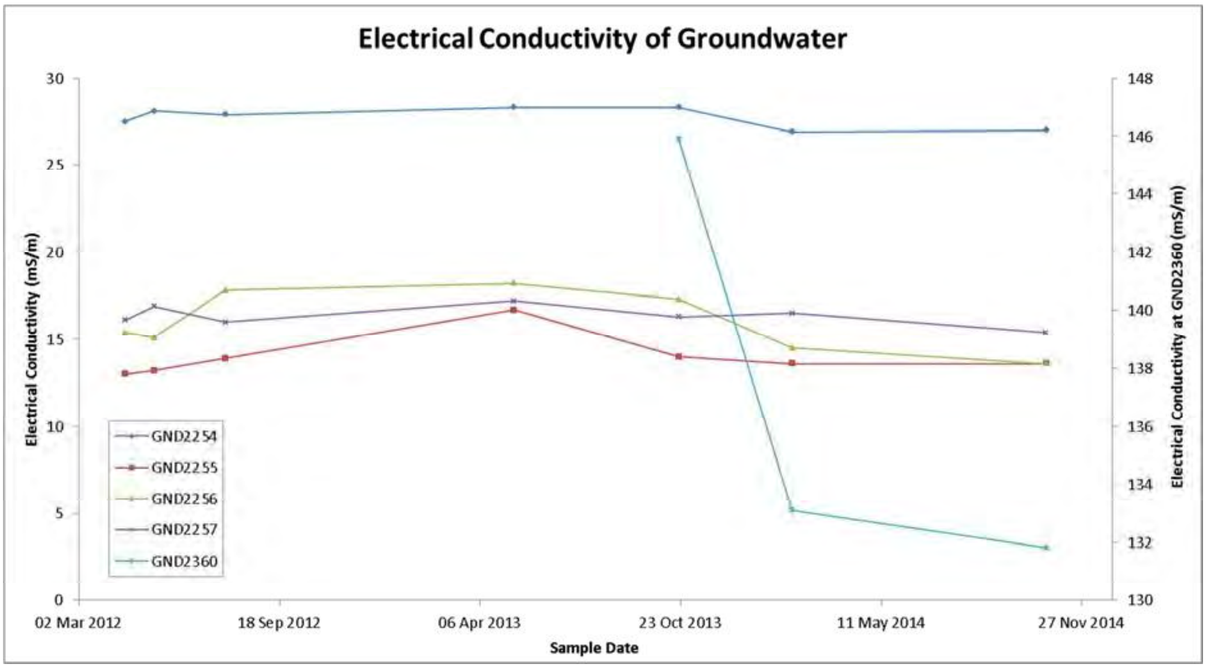

Figure 4 Results of electrical conductivity analysis

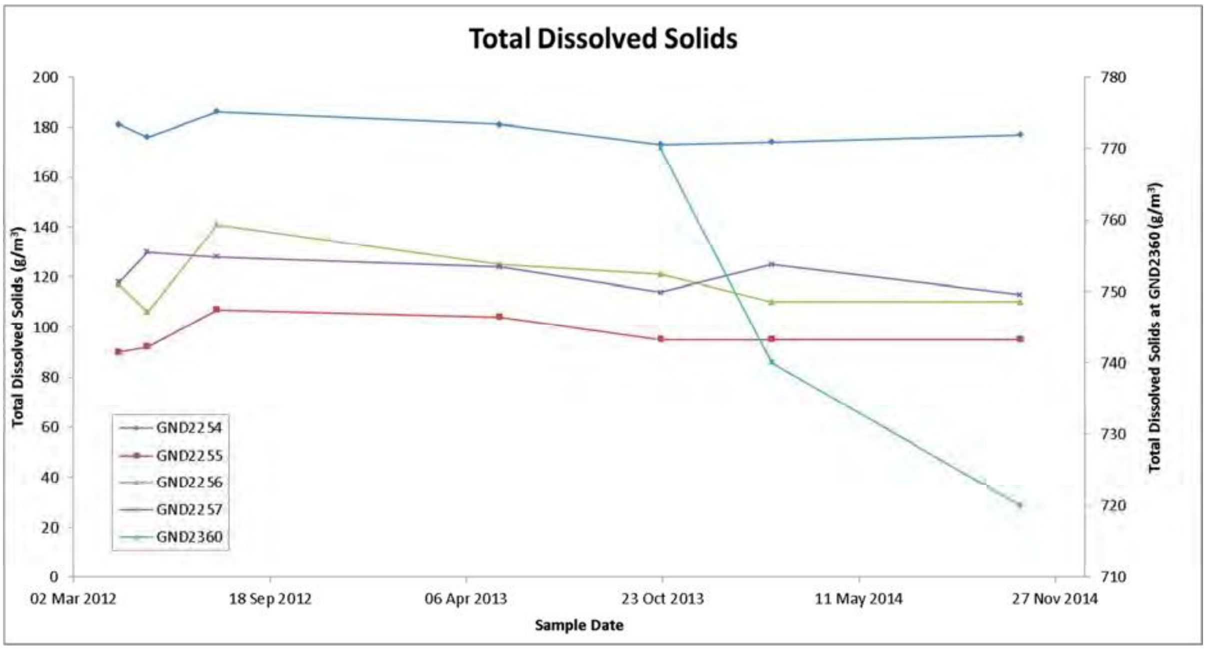

Figure 5 Results of total dissolved solids analysis

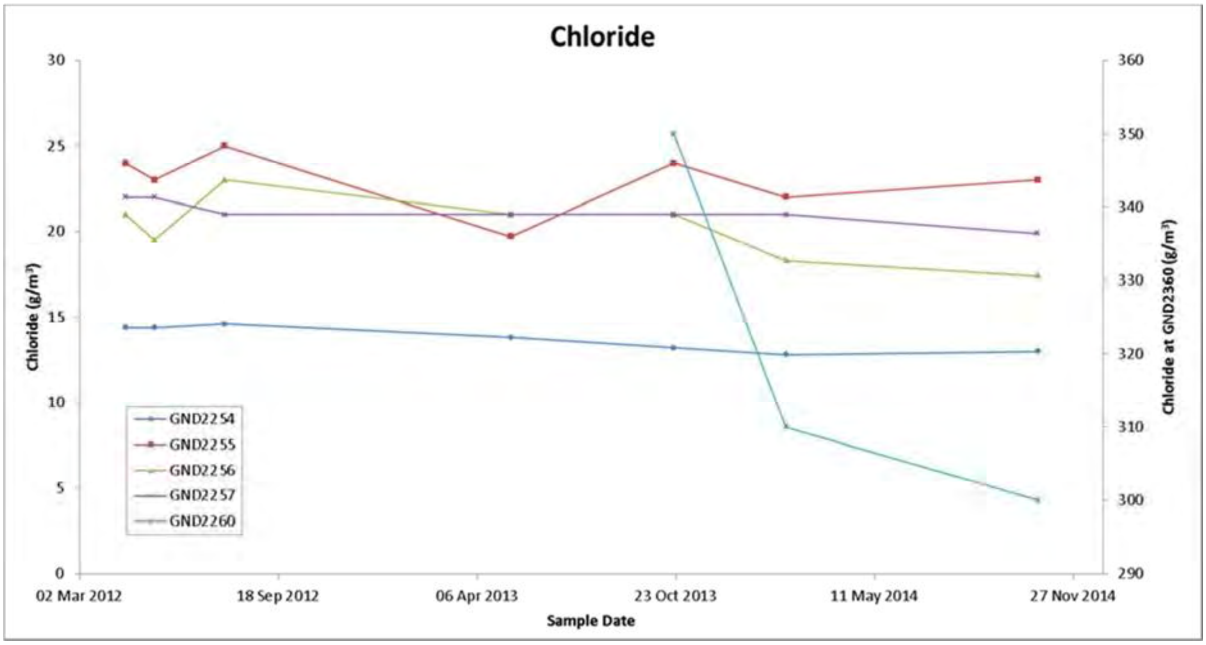

Figure 6 Results of chloride analysis

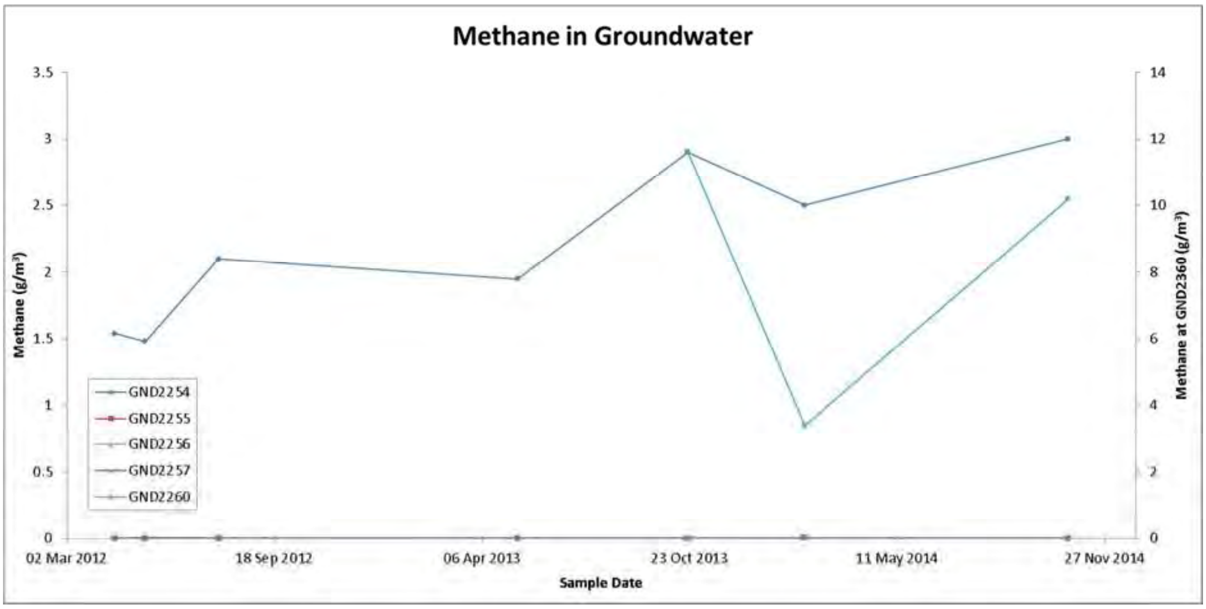

Figure 7 Results of methane analysis

There were no traces of any substance associated with hydraulic fracturing fluids, or hydrocarbons relating to fracturing activities, in any of the post-fracturing samples obtained from the private water supply wells during the monitoring period.

The full results of the groundwater monitoring carried out during the period under review are included in Appendix III. The certificates of analysis are included in Appendix II.

2.3 Carbon isotope analysis

During the period being reported, two groundwater samples were sent to GNS Science for carbon isotope analysis in their National Isotope Centre. The isotopic analysis is used to calculate a delta carbon13 ($\delta^{13}C$) value for a given sample, which is then used to determine the origin of the gas. Generally, a $\delta^{13}C$ value that exceeds -50‰ indicates biogenic methane, and a $\delta^{13}C$ value less than -50‰ indicates thermogenic methane. The higher or lower the $\delta^{13}C$ values, the stronger the isotopic signature. A $\delta^{13}C$ value in the vicinity of -50‰ can indicate a mixture of both biogenic and thermogenic methane. Results of analyses undertaken in the period being reported are compared with previous results in Table 3 below.

Table 3 Results of carbon isotope analysis at private water supplies

	GND2254	GND2360
Date	23/10/14	23/10/14
δ13C Value	-80‰	-64‰

Table 3 shows that the methane gas present in GND2254 and GND2360 is strongly biogenic.

It is important to note that the results were issued from the analysing laboratory with an uncertainty of measurement of ±10‰.

2.4 Hydraulic fracturing and return fluids

The results of the analyses carried out on samples of the hydraulic fracturing fluid used in the treatment of the Mangahewa-12, Mangahewa-13, Mangahewa-14, and Mangahewa-15 wells for the August 2013 to July 2014 fracturing events are summarised below in Table 4. The certificates of analysis are included in Appendix II.

Due to the viscosity of the fluid samples obtained, the range of analyses that were able to be performed on each sample were limited. The samples taken were gel like in composition, as opposed to a liquid. While the fracturing fluid is predominantly comprised of water, specialised additives are used to increase the viscosity of the fluid in order to suspend the proppant prior to injection.

Due to the volume of water used in the fracturing fluid mixture, all additives included in the mixture are highly dilute.

Table 4 Results of hydraulic fracturing fluid sampling

Parameter	Unit	Mangahewa-12	Mangahewa-13		Mangahewa-14	Mangahewa-15	
Sample date	-	09 Sep 2013	02 Sep 2013	09 Sep 2013	30 Oct 2013	27 Oct 2013	03 Jul 2014
Lab number	-	TRC137219	TRC137111	TRC137220	TRC137635	TRC137634	TRC1410619
Benzene	g/m^3	0.0011	<0.010	0.0012	<0.010	<0.010	<0.0010
Ethylbenzene	g/m^3	<0.0010	<0.010	<0.0010	<0.010	0.029	0.0019
Ethylene glycol	g/m^3	280	350	320	146	88	330
Total hydrocarbons	g/m^3	169	1300	117	1890	650	220
Methane	g/m^3	8	6	4	2	3	7
Propylene glycol	g/m^3	165	188	178	17	52	40
Toluene	g/m^3	0.0039	<0.010	0.0025	<0.010	0.035	0.0017
o-Xylene	g/m^3	0.002	<0.010	0.0018	0.012	0.039	0.0029
m-Xylene	g/m^3	0.003	<0.02	0.002	<0.02	0.09	0.006

Composite samples of return fluids from Mangahewa-12, Mangahewa-13, Mangahewa-14, and Mangahewa-15 were submitted for analysis. 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 post-fracturing, a high proportion of the fluid returning to the wellhead is that injected during the hydraulic fracturing process. As the volume of fluid produced from the well increases, the proportion of hydraulic fracturing fluid reduces in relation to formation fluids.

The results of the analyses carried out on the return fluid sample obtained following the hydraulic fracturing of the Mangahewa-12, Mangahewa-13, Mangahewa-14, and Mangahewa-15 wells are summarised below in Table 5 and the certificates of analysis are included in Appendix II. In all wells apart from the second fracturing event at Mangahewa-15, the relatively high levels of salinity (sodium and chloride) in the samples indicate that the composite samples prepared contained a greater proportion of saline reservoir fluids than fluids introduced during fracturing activities. The presence of elevated levels of BTEX compounds are indicative of fluids being drawn from a hydrocarbon bearing reservoir.

Table 5 Results of hydraulic fracturing return fluid sampling

Parameter	Unit	Mangahewa-12	Mangahewa 13	Mangahewa-14	Mangahewa-15	
Sample date	-	18 Sep 2013	14 Sep 2013	10 Nov 2013	06 Nov 2013	03 Jul 2014
Lab number	-	TRC137221	TRC137222	TRC137904	TRC137905	TRC1410620
Total alkalinity	g/m^3 $CaCO_3$	3200	2800	2000	2300	1180
Barium	mg/kg	50	78	34	46	4.2
Benzene	g/m^3	12.4	14.0	11.8	8.9	6.6
Bromide	g/m^3	18.9	25	17.4	26	2.2
Calcium	g/m^3	96	116	74	97	21
Chloride	g/m^3	4900	5500	5000	6500	960
Conductivity	mS/m@20^{0}C	2090	2170	1975	2770	585
Dissolved copper	g/m^3	<0.005	<0.005	0.007	0.018	0.021
Ethylbenzene	g/m^3	1.57	0.71	3.3	1.78	1.40
Ethane	g/m^3	0.182	0.47	0.40	0.49	0.78
Ethylene	g/m^3	<0.003	<0.003	<0.003	<0.003	<0.004
Dissolved iron	g/m^3	2.4	2.8	10.2	5.9	2.1
Formaldehyde	g/m^3	0.89	0.47	0.57	0.29	<1.5
Ethylene glycol	g/m^3	89	260	<4	<4	320
Total hydrocarbons	g/m^3	940	35	800	2000	260
Bicarbonate	g/m^3 HCO_3	3904.0	3416.0	2440.0		1143
Total hardness	g/m^3 $CaCO_3$	280	320	210	280	68
Potassium	g/m^3	600	670	720	550	186
Methanol	g/m^3	3	4	3	4	12
Methane	g/m^3	0.64	2.1	1.21	1.18	2.4
Magnesium	g/m^3	9	7	7	9	4
Dissolved manganese	g/m^3	2.7	5.3	3.0	2.3	1.27
Sodium	g/m^3	4700	4700	4100	6000	1190
Nickel	mg/kg	<0.03	<0.03	0.04	<0.03	0.06
Nitrate & nitrite nitrogen	g/m^3 N	1.5	0.2	0.03	<0.02	0.012
Nitrite	g/m^3 N	<0.2	<0.2	<0.02	<0.02	0.005
Nitrate	g/m^3 N	1.5	<0.2	<0.02	<0.02	0.007
pH	pH	7.4	7.1	6.9	6.8	7.7
Propylene glycol	g/m^3	24	18	80	25	30
Dissolved sulphur	g/m^3	11	8	14	24	8
Sulphate	g/m^3	34	23	42	71	25
Toluene	g/m^3	13.8	10.8	18.4	14.6	12.9
o-Xylene	g/m^3	2.6	1.28	6.3	3.4	2.5
m-Xylene	g/m^3	7.7	3.5	18.9	9.8	7.7
Dissolved zinc	g/m^3	0.06	0.05	2.6	0.23	0.57

2.5 Investigations, interventions, and incidents

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

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

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

During the period under review, there was no requirement for the Council to undertake any significant additional investigations and/or interventions, or record incidents, in association with the conditions in Todd’s resource consent for hydraulic fracturing at the Mangahewa-C wellsite or provisions in Regional Plans.

3. Discussion

3.1 Environmental effects of hydraulic fracturing on useable freshwater resources

This is a report regarding on-going monitoring of hydraulic fracturing that occurred in the 2011-2012, 2012-2013, 2013-2014 and 2014-2015 periods.

To assess the level of environmental performance and compliance by Todd during the period being reported, the monitoring programme implemented by the Council included a groundwater monitoring component. This included the sampling of groundwater at selected sites in the vicinity of the hydraulically fractured well. The groundwater system was surveyed prior to any hydraulic fracturing occurring to determine baseline conditions, allowing comparisons to be made with post-fracturing results.

The results of post-fracturing groundwater sampling carried out in the vicinity of the Mangahewa-C wellsite showed only very minor variations in water composition in comparison to baseline results. The minor variations in some analytes are a result of natural variations in water composition and unrelated to fracturing activities.

Methane was detected in all but one of the groundwater monitoring wells. Concentrations were within the expected range for shallow groundwater in Taranaki. Carbon isotope analysis carried out in 2014 indicates that the methane gas present in GND2254 and GND2360 is strongly biogenic in origin. No traces of substances associated with hydraulic fracturing fluids, or hydrocarbons relating to fracturing activities were present in the groundwater.

In summary, the monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by Todd during the period being reported had no adverse effects on local groundwater resources.

3.2 Evaluation of performance

A tabular summary of the consent holder's compliance record for the year under review is set out in Table 6.

Table 6 Summary of performance for Consent 7971-1: To discharge contaminants in association with hydraulic fracturing activities into land at depths greater than 3,425 mTVD beneath the Mangahewa-C wellsite.

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Any discharge shall occur below 3,425 mTVD	Assessment of consent holder submitted data	Yes
2. No discharge shall occur more than 500 m horizontally from the wellsite	Assessment of consent holder submitted data	Yes
3. Exercise of consent shall not result in any contaminants reaching any useable freshwater aquifers	Results of groundwater monitoring	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
4. Consent holder shall undertake sampling programme	Development and certification of a monitoring programme	Yes
5. All sampling to be carried out in accordance with a certified Sampling and Analysis Plan	Development and certification of a Sampling and Analysis Plan	Yes
6. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	Yes
7. A pre-fracturing discharge report is to be provided to the Council 10 days prior to discharge	Pre-fracturing discharge report received	Yes
8. A post-fracturing discharge report is to be provided to the Council within 30 working days after the discharge ceases	Post-fracturing discharge report received	Yes
9. The reports outlined in conditions 7 and 8 must be emailed to consents@trc.govt.nz	Reports received via email	Yes
10. The consent holder shall provide access to a location where samples of hydraulic fracturing fluids and return fluids can be obtained by the Council officers	Access provided	Yes
11. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
12. No hydrocarbon based hydraulic fracturing fluid shall be discharged	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes
13. Notice of Council to review consent	No provision for review during period	N/A
Overall assessment of environmental performance and compliance in respect of this consent		High
Overall assessment of administrative performance and compliance in respect of this consent		High

Table 7 Summary of performance for Consent 7971-2: To discharge contaminants in association with hydraulic fracturing activities into land at depths greater than 3,290 mTVD beneath the Mangahewa-C wellsite.

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Any discharge shall occur below 3,290 mTVDss	Assessment of consent holder submitted data	Yes
2. No discharge shall occur after 1 June 2019	Assessment of consent holder submitted data	N/A
3. Exercise of consent shall not result in any contaminants reaching any useable freshwater	Results of groundwater monitoring	Yes
4. Consent holder shall undertake sampling programme	Development and certification of a monitoring programme	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
5. If no suitable bores exist within 500 m of the wellsite, a monitoring bore may need to be installed	Inspection of bore	Yes
6. Sampling programme shall follow recognised field procedures and be analysed for a specified range of chemical parameters	Development and certification of a monitoring programme and assessment of results	Yes
7. All sampling to be carried out in accordance with a certified Sampling and Analysis Plan	Development and certification of a Sampling and Analysis Plan	Yes
8. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing	Assessment of consent holder submitted data	Yes
9. A pre-fracturing discharge report is to be provided to the Council 14 days prior to discharge	Pre-fracturing discharge report received	Yes
10. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	Yes
11. A post-fracturing discharge report is to be provided to the Council within 90 days of any commencement	Post-fracturing discharge report received	Yes
12. The reports outlined in conditions 9 and 11 must be emailed to consents@trc.govt.nz	Reports received via email	Yes
13. The consent holder shall provide access to a location where samples of hydraulic fracturing fluids and return fluids can be obtained by the Council officers	Access provided	Yes
14. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
15. No hydrocarbon based hydraulic fracturing fluid shall be discharged	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes
16. Lapse clause	Receive notice of exercise of consent	Yes
17. Notice of Council to review consent	No provision for review during period	N/A
Overall assessment of environmental performance and compliance in respect of this consent		High
Overall assessment of administrative performance and compliance in respect of this consent		High

During the 2013-2014 and 2014-2015 monitoring periods, Todd demonstrated a high level of environmental and a high level of administrative performance and compliance with its resource consents as defined in Section 1.1.4.

3.3 Recommendations from the previous monitoring report

In the 2011-2013 Biennial Report, it was recommended:

1. THAT this report be forwarded to the Company, and to any interested parties upon request.

   This recommendation was implemented, with the report being forwarded to Todd and 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-C wellsite be reduced to a frequency of one annual sampling event;

   Due to the fracturing of Mangahewa-12, Mangahewa-13, Mangahewa-14 and Mangahewa-15 groundwater sampling had to be carried out more than once annually.

3. THAT if further hydraulic fracturing is carried out at the Mangahewa-C wellsite, a sample be obtained from each private water supply 3 months following the hydraulic fracturing event;

   Samples were obtained from the groundwater monitoring sites in February 2014, five months after the fracturing of Mangahewa-12 and Mangahewa-13 and three months after the fracturing of Mangahewa-14 and Mangahewa-15. Samples were obtained from the groundwater monitoring sites in October 2014, three months after the second fracturing event at Mangahewa-15.

4. THAT during the 2013/2014 monitoring period, a further round of carbon isotope sampling and analysis is carried out; and

   Carbon isotope sampling was carried out for GND2254 and GND2360 in December 2014.

5. THAT bore GND2360 is included as an additional sampling site during any future monitoring of hydraulic fracturing activities at the Mangahewa-C wellsite.

   GND2360 has been used as a sampling site since the October 2013 sampling round.

3.4 Alterations to monitoring programmes for 2015-2016

In designing and implementing the monitoring programmes for air/water discharges in the region, the Council has taken into account the extent of information made available by previous authorities, its relevance under the RMA the obligations of the RMA in terms of monitoring emissions/discharges and effects, and subsequently reporting to the regional community. The Council also takes into account the scope of assessments required at the time of renewal of permits, and the need to maintain a sound understanding of industrial processes within Taranaki emitting to the atmosphere/discharging to the environment.

It is proposed that for 2015-2016 year the one year post fracturing groundwater sampling round be carried out. After that, it is recommended that no further monitoring be carried out in relation to the hydraulic fracturing events at the Mangahewa-C wellsite. Monitoring should recommence however if any further fracturing is undertaken at the site.

3.5 Exercise of optional review of consent

Resource consent 7971-2 provides for an optional review of the consent an annual basis, with the next optional review date being June 2015. Condition 17 of this consent allows the Council to review consent conditions to ensure they 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. The Council can also review the consent in order to further specify the best practicable option and/or to ensure that hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Following an assessment of the current consent conditions and the results of monitoring undertaken over the period under review, it is considered that there are no grounds that require a review to be pursued or grounds to exercise the review option.

4. Recommendations

1. THAT for the forthcoming 2015/2016 monitoring period, one one-year-post-fracturing groundwater sampling round is carried out. After that, it is recommended that no further monitoring be carried out in relation to the hydraulic fracturing events at the Mangahewa-C wellsite. Monitoring should recommence however if any further fracturing is undertaken at the site.

2. THAT the option for a review of the resource consent in June 2015, as set out in condition 17 of consent 7971-2, is not exercised, on the grounds that the current conditions of the consents are adequate to ensure that any significant adverse effects on the environment are avoided.

Glossary of common terms and abbreviations

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

g/m^3	Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.
Incident	An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred.
Intervention	Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.
Investigation	Action taken by Council to establish the circumstances/events surrounding an incident including any allegations of an incident.
mS/m	Millisiemens per metre.
m^3	Cubic metre (1,000 litres).
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.
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.

Bibliography and references

Taranaki Regional Council (2013a) Mangahewa-C Hydraulic Fracturing Groundwater Monitoring Programme Report 2011-2013. Technical Report 2013-15.

Taranaki Regional Council (2013b) Sampling and Analysis Plan Mangahewa-C Groundwater Monitoring Programme 2013/2014

Todd Energy Limited (2013c) Hydraulic Fracturing Todd Mangahewa-C Wellsite Pre-Fracturing Discharge Report – Mangahewa-12

Todd Energy Limited (2013) Hydraulic Fracturing Todd Mangahewa-C Wellsite Pre-Fracturing Discharge Report – Mangahewa-13

Todd Energy Limited (2013) Hydraulic Fracturing Todd Mangahewa-12 Post-Fracturing Discharge Report

Todd Energy Limited (2013) Hydraulic Fracturing Todd Mangahewa-13 Post-Fracturing Discharge Report

Todd Energy Limited (2013) Hydraulic Fracturing Todd Mangahewa-C Wellsite Pre-Fracturing Discharge Report – Mangahewa-14

Todd Energy Limited (2013) Hydraulic Fracturing Todd Mangahewa-C Wellsite Pre-Fracturing Discharge Report – Mangahewa-15

Todd Energy Limited (2013) Hydraulic Fracturing Todd Mangahewa-C Wellsite Post-Fracturing Discharge Report – Mangahewa-14

Todd Energy Limited (2013) Hydraulic Fracturing Todd Mangahewa-C Wellsite Post-Fracturing Discharge Report – Mangahewa-15

Todd Energy Limited (2014) Hydraulic Fracturing Todd Mangahewa-C Wellsite Post-Fracturing Discharge Report – Mangahewa-15 (For second fracturing event)

Appendix I

Resource consents held by Todd

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:	20 January 2012
Commencement Date:	20 January 2012

Conditions of Consent

Consent Granted:	To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3425mTVD beneath the Mangahewa-C wellsite at or about (NZTM) 1713435E-5676634N
Expiry Date:	1 June 2014
Review Date(s):	June 2013
Site Location:	Mangahewa-C wellsite, Tikorangi Road East, Waitara [Property owners: PG & BM Bourke]
Legal Description:	Lot 9 DP 408656 (Discharge source & site)
Catchment:	Waiau

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 to section 36 of the Resource Management Act.

Special conditions

1. Any discharge shall occur below 3425 mTVD.

   Note: mTVD = metres true vertical depth, i.e. the true vertical depth in metres below the surface.

2. No discharge shall occur more than 500 metres horizontally from each wellbore on the Mangahewa-C wellsite.

3. The consent holder shall ensure that the exercise of this consent does not contaminate or put at risk actual or potential usable freshwater aquifers above the hydrocarbon reservoir.

4. The consent holder shall undertake a programme of sampling and testing that, to the satisfaction of the Chief Executive, Taranaki Regional Council, monitor the effects of the exercise of this consent on groundwater users within 2.5 km of the Mangahewa-C wellsite. Any groundwater samples shall be taken in accordance with recognized field procedures and analysed for:

   (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) Carbon-13 composition of dissolved methane gas ($^{13}C-CH_4$); and
   (k) Benzene, toluene, ethylbenzene, and xylenes (BTEX).

5. All sampling and analysis shall be undertaken in accordance with a *Sampling and Analysis Plan*, 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 3.

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

6. The consent holder shall notify the Chief Executive, Taranaki Regional Council, in writing of the date that the discharges are expected to commence. Notification shall occur by email to worknotification@trc.govt.nz, where practicable and reasonable one working day prior to the exercise of the consent, but in any event 24 hours notice shall be given. Notification shall include the consent number and a brief description of the activity consented.

7. The second and subsequent discharges shall only occur after the consent holder has provided a comprehensive 'Pre-fracturing discharge report' to the Chief Executive, Taranaki Regional Council. The report shall be provided at least 10 working days before the discharge commences and, as a minimum, shall contain:

   (a) The intended fracturing intervals and the co-ordinates of the fracture initiation point for each fracture interval;
   (b) The total volume of material planned to be pumped down the well and its composition, including a list of the chemicals or additives to be used;
   (c) The mitigation measures that are in place to ensure the discharge does not cause adverse environmental effects;
   (d) The results of pressure testing the well;
   (e) The extent and characteristics of the geological seals in place above the discharge zone;
   (f) The anticipated well and discharge zone pressures and the duration the pressures;
   (g) The anticipated extent of fractures; and
   (h) Details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal.

8. At the conclusion of any discharge, the consent holder shall submit a comprehensive 'Post-fracturing discharge report' to the Chief Executive, Taranaki Regional Council. The report shall be provided within 30 working days after the discharge ceases and, as a minimum, shall contain:

   (a) Confirmation of the interval where fracturing occurred;
   (b) Confirmation of volumes and fluid compositions discharged;
   (c) The volume of returned fluids and an estimate of the proportion of fluids and proppant remaining in the reservoir;
   (d) The results of modeling the discharge, including a proppant concentration diagram or a similar diagram, showing the likely extent of the fractures generated by the discharge;
   (e) Well and discharge zone pressure durations and the maximum pressure reached;
   (f) Details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal; and
   (g) An assessment of the effectiveness of the mitigation measures in place with specific reference to those described in application 6949.

9. The reports described in conditions 7 and 8 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.

10. The consent holder shall provide access to a location where the Taranaki Regional Council officers can obtain a sample of the fraccing fluids and return fluids.

11. 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 on the environment; in particular, ensuring that the discharge is contained within the discharge zone.

12. No hydrocarbon based fraccing fluid shall be discharged.

13. That 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 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.

Signed at Stratford on 20 January 2012

For and on behalf of
Taranaki Regional Council

____

Director-Resource Management

Discharge Permit

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

Name of Consent Holder:	Todd Energy Limited PO Box 802 NEW PLYMOUTH 4340
Decision Date:	30 June 2014
Commencement Date:	30 June 2014

Conditions of Consent

Consent Granted:	To discharge water based hydraulic fracturing fluids into land at depths greater than 3290 mTVDss beneath the Mangahewa-C wellsite
Expiry Date:	01 June 2024
Review Date(s):	June annually
Site Location:	Mangahewa-C wellsite, Tikorangi Road, Waitara (Property owner: PG & BM Bourke)
Legal Description:	Lot 9 DP 408656 (Discharge source & site)
Grid Reference (NZTM)	1713435E-5676634N
Catchment:	Waiau

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 3290 mTVDss.

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

2. There shall be no discharge of hydraulic fracturing fluids after 1 June 2019.

3. 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.

4. 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 3 (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.

5. Depending on the suitability of existing bores within 500 metres of the wellsite for obtaining a representative groundwater sample, it may be necessary for the Monitoring Programme to include installation of, and sampling from, at least one monitoring bore. The bore(s) would be of a depth, location and design determined after consultation with the Chief Executive, Taranaki Regional Council and installed in accordance with NZS 4411:2001.

6. 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);
   (l) carbon-13 composition of any dissolved methane gas discovered ($^{13}C-CH_4$).

   Note: The samples required, under conditions 4 and 6 could be taken and analysed by the Taranaki Regional Council or other contracted party on behalf of the consent holder.

7. 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. The 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 3.

   Note: *The Sampling and Analysis Plan may be combined with the Monitoring Programme required by* condition 4.

8. 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.

9. 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, the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment), and the duration of the hydraulic fracturing programme;
   (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, including mini- fracture treatments, and their intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
   (d) the monitoring techniques to be used to determine the fate of discharged material;
   (e) the results of the reviews required by condition 14;
   (f) results of modelling showing an assessment of the likely extent and dimensions of the fractures that will be generated by the discharge;
   (g) the preventative and mitigation measures to be in place to ensure the discharge does not cause adverse environmental effects and complies with condition 3;
   (h) the extent and permeability characteristics of the geology above the discharge point to the surface;
   (i) 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;
   (j) the burst pressure of the well and the anticipated maximum well and discharge pressures and the duration of the pressures; and
   (k) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal; and
   (l) details why the contaminants in the discharge and the monitoring techniques used comply with condition 14.

   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.*

10. The consent holder shall notify the Taranaki Regional Council of the date that each discharge is intended to commence by emailing worknotification@trc.govt.nz. Notification also shall identify the 'Pre-fracturing discharge report', required by condition 9, which details the discharge and be given no less than 3 days before the intended discharge date. If any discharge occurs more than 30 days after the notification date, additional notification as specified in this condition is required.

11. Within 90 days of any commencement date as advised under condition 10, the consent holder shall submit a comprehensive 'Post-fracturing discharge report' to the Chief Executive. The report shall, as a minimum, contain:

    (a) date and time of discharge;
    (b) 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;
    (c) the contaminant volumes and composition of fluid discharged into each fracture interval;
    (d) the volume of return fluids from each fracture interval;
    (e) an analysis for the constituents set out in conditions 6(a) to 6(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;
    (f) an estimate of the volume of fluids (and proppant) remaining underground;
    (g) 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 or after that period of production;
    (h) 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;
    (i) the results of pressure testing required by condition 8, and the top hole pressure (psi), slurry rate (bpm), surface proppant concentration (lb/gal), bottom hole proppant concentration (lb/gal), and calculated bottom hole pressure (psi), as well as predicted values for each of these parameters; prior to, during and after each hydraulic fracture treatment;
    (j) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal;
    (k) 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 3; and
    (l) results of the monitoring referred to in condition 9 (d);
    (m) an assessment of the effectiveness of the mitigation measures in place with specific reference to those described in the application for this consent.

    Note: *For programs including multiple hydraulic fracturing discharges, more than one 'Post-fracturing discharge report' may be required in order to meet the specified 90 day deadline.*

12. The reports described in conditions 9 and 11 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.

13. 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.

14. 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 of monitoring techniques used to ensure the discharge does not cause adverse environmental effects are undertaken;
    (c) regular reviews are undertaken of the preventative and mitigation measures adopted to ensure the discharge does not cause adverse environmental effects; and
    (d) regular reviews of the chemicals used are undertaken with a view to reducing the toxicity of the chemicals used.

15. The fracture fluid shall be comprised of no less than 95% water and proppant by volume.

16. This consent shall lapse on 30 June 2019, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

17. 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 14; 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 30 June 2014

For and on behalf of
Taranaki Regional Council

A D McLay
Director - Resource Management

Appendix II

Certifcates of analysis

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

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Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1194203	SPv1
Contact:	Regan Phipps	**Date Registered:**	22-Oct-2013	
	C/- Taranaki Regional Council	**Date Reported:**	30-Oct-2013	
	Private Bag 713	**Quote No:**	47915	
	STRATFORD 4352	**Order No:**		
		Client Reference:	Mangahewa-C G.W	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:		GND2254 21-Oct-2013 12:00 pm	GND2255 21-Oct-2013 1:30 pm	GND2256 21-Oct-2013 1:00 pm	GND2257 21-Oct-2013 3:30 pm	GND2360 21-Oct-2013 12:30 pm
Lab Number:		1194203.1	1194203.2	1194203.3	1194203.4	1194203.5
Individual Tests						
Sum of Anions	meq/L	2.9	1.23	1.46	1.41	13.6
Sum of Cations	meq/L	2.9	1.22	1.52	1.46	11.9
pH	pH Units	7.9	5.9	6.2	6.4	9.0
Total Alkalinity	g/m^3 as $CaCO_3$	126	18.8	19.7	22	185
Bicarbonate	g/m^3 at 25°C	152	23	24	26	200 [#1]
Total Hardness	g/m^3 as $CaCO_3$	103	28	42	35	41
Electrical Conductivity (EC)	mS/m	28.3	14.0	17.3	16.3	145.9
Total Dissolved Solids (TDS)	g/m^3	173	95	121	114	770
Dissolved Barium	g/m^3	0.0149	0.047	0.062	0.021	0.025
Dissolved Bromine*	g/m^3	0.048	0.082	0.084	0.083	1.13
Dissolved Calcium	g/m^3	24	6.0	9.4	7.8	10.2
Dissolved Copper	g/m^3	< 0.0005	0.037	< 0.0005	0.0128	< 0.0005
Dissolved Iron	g/m^3	0.31	< 0.02	< 0.02	1.05	0.14
Dissolved Magnesium	g/m^3	10.2	3.1	4.4	3.9	3.9
Dissolved Manganese	g/m^3	0.027	0.0014	0.0018	0.0131	0.0081
Dissolved Mercury	g/m^3	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Potassium	g/m^3	2.3	3.5	5.1	1.82	1.36
Dissolved Sodium	g/m^3	18.2	13.3	12.6	15.2	250
Dissolved Zinc	g/m^3	< 0.0010	0.0128	0.0047	0.086	0.0055
Chloride	g/m^3	13.2	24	21	21	350
Nitrite-N	g/m^3	< 0.002	< 0.002	< 0.002	0.003	< 0.002
Nitrate-N	g/m^3	< 0.002	1.55	5.4	4.1	< 0.002
Nitrate-N + Nitrite-N	g/m^3	< 0.002	1.55	5.4	4.1	< 0.002
Sulphate	g/m^3	0.5	3.6	4.2	4.9	1.9
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	< 4	< 4	< 4	< 4
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	< 4	< 4	< 4	< 4
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	< 2	< 2	< 2	< 2
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

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:		GND2254 21-Oct-2013 12:00 pm	GND2255 21-Oct-2013 1:30 pm	GND2256 21-Oct-2013 1:00 pm	GND2257 21-Oct-2013 3:30 pm	GND2360 21-Oct-2013 12:30 pm
Lab Number:		1194203.1	1194203.2	1194203.3	1194203.4	1194203.5
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Gases in groundwater						
Ethane	g/m^3	< 0.003	< 0.003	< 0.003	< 0.003	0.017
Ethylene	g/m^3	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Methane	g/m^3	2.9	< 0.002	< 0.002	< 0.002	11.6
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7

Analyst's Comments

[#1] Please note that the calculation used to determine the carbonate and bicarbonate content is only valid when the total dissolved solids (TDS) content is <500mg/L. It was observed that the TDS content of this sample is >500mg/L, therefore these results should be treated as indicative only.

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	-	1-5
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-5
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1-5
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1-5
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1-5
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1-5
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1-5
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-5
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L.	0.07 meq/L	1-5
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L	1-5
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1-5
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 21st ed. 2005.	1.0 g/m^3 at 25°C	1-5
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-5
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) 21st ed. 2005.	10 g/m^3	1-5
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.00010 g/m^3	1-5
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.005 g/m^3	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1-5

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-5
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1-5
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3	1-5
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 21st ed. 2005.	0.002 g/m^3	1-5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m^3	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 21st ed. 2005.	0.002 g/m^3	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 g/m^3	1-5

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

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

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

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

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1234518 SPv1
Contact:	Regan Phipps	**Date Registered:**	12-Feb-2014
	C/- Taranaki Regional Council	**Date Reported:**	24-Feb-2014
	Private Bag 713	**Quote No:**	47915
	STRATFORD 4352	**Order No:**	
		Client Reference:	Mangahewa C Post HF GW
		Submitted By:	Regan Phipps

Sample Type: Aqueous

Sample Name:		GND2256 11-Feb-2014 11:50 am	GND2360 11-Feb-2014 12:25 pm	GND2255 11-Feb-2014 12:50 pm	GND2254 11-Feb-2014 1:45 pm	GND2257 11-Feb-2014 2:15 pm
Lab Number:		1234518.1	1234518.2	1234518.3	1234518.4	1234518.5
Individual Tests						
Sum of Anions	meq/L	1.27	12.4	1.19	2.8	1.45
Sum of Cations	meq/L	1.21	12.3	1.21	2.8	1.50
pH	pH Units	6.3	9.1	7.0	8.0	6.2
Total Alkalinity	g/m^3 as $CaCO_3$	23	187	20	123	24
Bicarbonate	g/m^3 at 25°C	28	200 $^{\#1}$	24	149	29
Total Hardness	g/m^3 as $CaCO_3$	32	44	28	101	37
Electrical Conductivity (EC)	mS/m	14.5	133.1	13.6	26.9	16.5
Total Dissolved Solids (TDS)	g/m^3	110	740 $^{\#1}$	95	174	125
Dissolved Barium	g/m^3	0.036	0.026	0.046	0.0149	0.0130
Dissolved Bromine*	g/m^3	0.076	1.11	0.085	0.051	0.084
Dissolved Calcium	g/m^3	7.2	10.9	6.3	24	7.7
Dissolved Copper	g/m^3	0.0006	< 0.0005	0.031	< 0.0005	0.0117
Dissolved Iron	g/m^3	< 0.02	0.20	< 0.02	0.33	1.13
Dissolved Magnesium	g/m^3	3.4	4.1	3.0	9.9	4.2
Dissolved Manganese	g/m^3	0.0026	0.0098	0.0054	0.026	0.0137
Dissolved Mercury	g/m^3	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Potassium	g/m^3	3.4	1.42	3.5	2.6	2.2
Dissolved Sodium	g/m^3	11.2	260	12.9	16.1	15.3
Dissolved Zinc	g/m^3	0.042	0.0037	0.045	< 0.0010	0.062
Chloride	g/m^3	18.3	310	22	12.8	21
Nitrite-N	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Nitrate-N	g/m^3	2.9	0.003	1.27	< 0.002	3.7
Nitrate-N + Nitrite-N	g/m^3	2.9	0.003	1.27	< 0.002	3.7
Sulphate	g/m^3	4.4	2.6	3.4	0.6	6.0
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	< 4	< 4	< 4	< 4
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	< 4	< 4	7	7
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	< 2	< 2	< 2	< 2
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

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:		GND2256 11-Feb-2014 11:50 am	GND2360 11-Feb-2014 12:25 pm	GND2255 11-Feb-2014 12:50 pm	GND2254 11-Feb-2014 1:45 pm	GND2257 11-Feb-2014 2:15 pm
Lab Number:		1234518.1	1234518.2	1234518.3	1234518.4	1234518.5
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Gases in groundwater						
Ethane	g/m^3	< 0.003	0.005	< 0.003	< 0.003	< 0.003
Ethylene	g/m^3	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Methane	g/m^3	0.004	3.4	0.003	2.5	< 0.002
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7

Analyst's Comments

[#1] Please note that the calculation used to determine the carbonate and bicarbonate content is only valid when the total dissolved solids (TDS) content is <500mg/L. It was observed that the TDS content of this sample is >500mg/L, therefore these results should be treated as indicative only.

SUMMARY OF METHODS

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

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	1-5
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	1-5
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	1-5
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	1-5
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m^3	1-5
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m^3	1-5
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m^3	1-5
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-5
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L.	0.07 meq/L	1-5
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L	1-5
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-5
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m^3 at 25°C	1-5
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-5
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) 22nd ed. 2012.	10 g/m^3	1-5
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m^3	1-5
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m^3	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1-5
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1-5
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-5
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-5
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-5
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m^3	1-5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m^3	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-5

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

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

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

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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1342436 SPv1
Contact:	Regan Phipps	**Date Registered:**	23-Oct-2014
	C/- Taranaki Regional Council	**Date Reported:**	07-Nov-2014
	Private Bag 713	**Quote No:**	47915
	STRATFORD 4352	**Order No:**	
		Client Reference:	Mangahewa C - Post HF
		Submitted By:	R McDonnell

Sample Type: Aqueous

	Sample Name:	GND2257 22-Oct-2014 10:21 am				
	Lab Number:	1342436.1				
Individual Tests						
Sum of Anions	meq/L	1.41	-	-	-	-
Sum of Cations	meq/L	1.40	-	-	-	-
pH	pH Units	6.5	-	-	-	-
Total Alkalinity	g/m^3 as CaCO$_3$	26	-	-	-	-
Bicarbonate	g/m^3 at 25°C	31	-	-	-	-
Total Hardness	g/m^3 as CaCO$_3$	35	-	-	-	-
Electrical Conductivity (EC)	mS/m	15.4	-	-	-	-
Total Dissolved Solids (TDS)	g/m^3	113	-	-	-	-
Dissolved Barium	g/m^3	0.0138	-	-	-	-
Dissolved Bromine*	g/m^3	0.085	-	-	-	-
Dissolved Calcium	g/m^3	7.0	-	-	-	-
Dissolved Copper	g/m^3	0.021	-	-	-	-
Dissolved Iron	g/m^3	0.46	-	-	-	-
Dissolved Magnesium	g/m^3	4.2	-	-	-	-
Dissolved Manganese	g/m^3	0.0158	-	-	-	-
Dissolved Mercury	g/m^3	< 0.00008	-	-	-	-
Dissolved Nickel	g/m^3	0.0008	-	-	-	-
Dissolved Potassium	g/m^3	1.56	-	-	-	-
Dissolved Sodium	g/m^3	14.8	-	-	-	-
Dissolved Zinc	g/m^3	0.134	-	-	-	-
Chloride	g/m^3	19.9	-	-	-	-
Nitrite-N	g/m^3	< 0.002	-	-	-	-
Nitrate-N	g/m^3	3.6	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	3.6	-	-	-	-
Sulphate	g/m^3	4.0	-	-	-	-
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	-	-	-	-

Sample Type: Aqueous

Sample Name:		GND2257 22-Oct-2014 10:21 am				
Lab Number:		1342436.1				
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m^3	< 0.0010	-	-	-	-
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	< 0.003	-	-	-	-
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	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m^3	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m^3	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m^3	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L.	0.07 meq/L	1
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L	1
pH	pH meter. APHA 4500-H$^+$ B 22nd ed. 2012.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as CaCO$_3$	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO$_2$ D 22nd ed. 2012.	1.0 g/m^3 at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as CaCO$_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	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) 22nd ed. 2012.	10 g/m^3	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m^3	1
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m^3	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m^3	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m^3	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	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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ANALYSIS REPORT

Client: Taranaki Regional Council
Contact: Regan Phipps
C/- Taranaki Regional Council
Private Bag 713
STRATFORD 4352

Lab No: 1343148 SPv1
Date Registered: 24-Oct-2014
Date Reported: 04-Nov-2014
Quote No: 47915
Order No:
Client Reference: Mangahewa C - Post HF
Submitted By: R McDonnell

Sample Type: Aqueous

Sample Name:		GND2254 23-Oct-2014 9:09 am	GND2255 23-Oct-2014 10:01 am	GND2360 23-Oct-2014 11:16 am	GND2256 23-Oct-2014 12:12 pm	
Lab Number:		1343148.1	1343148.2	1343148.3	1343148.4	
Individual Tests						
Sum of Anions	meq/L	2.9	1.21	12.2	1.21	-
Sum of Cations	meq/L	2.9	1.22	12.3	1.18	-
pH	pH Units	7.9	6.2	9.0	6.7	-
Total Alkalinity	g/m^3 as $CaCO_3$	124	19.6	189	20	-
Bicarbonate	g/m^3 at 25°C	150	24	210 #1	25	-
Total Hardness	g/m^3 as $CaCO_3$	106	28	44	33	-
Electrical Conductivity (EC)	mS/m	27.0	13.6	131.8	13.6	-
Total Dissolved Solids (TDS)	g/m^3	177	95	720 #1	110	-
Dissolved Barium	g/m^3	0.0146	0.044	0.024	0.040	-
Dissolved Bromine*	g/m^3	0.058	0.100	1.40	0.090	-
Dissolved Calcium	g/m^3	24	6.1	10.7	7.2	-
Dissolved Copper	g/m^3	< 0.0005	0.131	< 0.0005	< 0.0005	-
Dissolved Iron	g/m^3	0.29	< 0.02	0.17	< 0.02	-
Dissolved Magnesium	g/m^3	10.9	3.1	4.1	3.6	-
Dissolved Manganese	g/m^3	0.028	0.0015	0.0094	0.0021	-
Dissolved Mercury	g/m^3	< 0.00008	< 0.00008	< 0.00008	< 0.00008	-
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-
Dissolved Potassium	g/m^3	2.4	3.5	1.29	3.3	-
Dissolved Sodium	g/m^3	16.4	13.0	260	10.2	-
Dissolved Zinc	g/m^3	0.0012	0.084	0.0042	0.0028	-
Chloride	g/m^3	13.0	23	300	17.4	-
Nitrite-N	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	-
Nitrate-N	g/m^3	< 0.002	1.35	< 0.002	3.0	-
Nitrate-N + Nitrite-N	g/m^3	< 0.002	1.35	< 0.002	3.0	-
Sulphate	g/m^3	0.5	3.6	1.7	4.4	-
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	-

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:		GND2254 23-Oct-2014 9:09 am	GND2255 23-Oct-2014 10:01 am	GND2360 23-Oct-2014 11:16 am	GND2256 23-Oct-2014 12:12 pm	
Lab Number:		1343148.1	1343148.2	1343148.3	1343148.4	
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
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	0.013	< 0.003	-
Ethylene	g/m^3	< 0.003	< 0.003	< 0.003	< 0.003	-
Methane	g/m^3	3.0	< 0.002	10.2	< 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	-

Analyst's Comments

[#1] Please note that the calculation used to determine the carbonate and bicarbonate content is only valid when the total dissolved solids (TDS) content is <500mg/L. It was observed that the TDS content of this sample is >500mg/L, therefore these results should be treated as indicative only.

SUMMARY OF METHODS

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

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	1-4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	1-4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	1-4
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	1-4
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m^3	1-4
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m^3	1-4
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m^3	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 mEquiv/L.	0.07 meq/L	1-4
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L	1-4
pH	pH meter. APHA 4500-H$^+$ B 22nd ed. 2012.	0.1 pH Units	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/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 22nd ed. 2012.	1.0 g/m^3 at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	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) 22nd ed. 2012.	10 g/m^3	1-4
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m^3	1-4
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m^3	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-4

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-4
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1-4
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-4
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-4
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-4
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-4
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m^3	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-4
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m^3	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-4

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

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Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1176765 SPv1
Contact:	Regan Phipps	**Date Registered:**	06-Sep-2013
	C/- Taranaki Regional Council	**Date Reported:**	20-Sep-2013
	Private Bag 713	**Quote No:**	50522
	STRATFORD 4352	**Order No:**	
		Client Reference:	TODD- HF Fluid Mangetewia
		Submitted By:	Regan Phipps

Sample Type: Aqueous

Sample Name:		GND2367 02-Sep-2013 12:00 pm				
Lab Number:		1176765.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	350	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	188	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	6	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.010	-	-	-	-
Toluene	g/m^3	< 0.010	-	-	-	-
Ethylbenzene	g/m^3	< 0.010	-	-	-	-
m&p-Xylene	g/m^3	< 0.02	-	-	-	-
o-Xylene	g/m^3	< 0.010	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	5.2	-	-	-	-
C10 - C14	g/m^3	460	-	-	-	-
C15 - C36	g/m^3	840	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	1,300	-	-	-	-

Analyst's Comments

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 [KBIs:26687,3629]	-	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1

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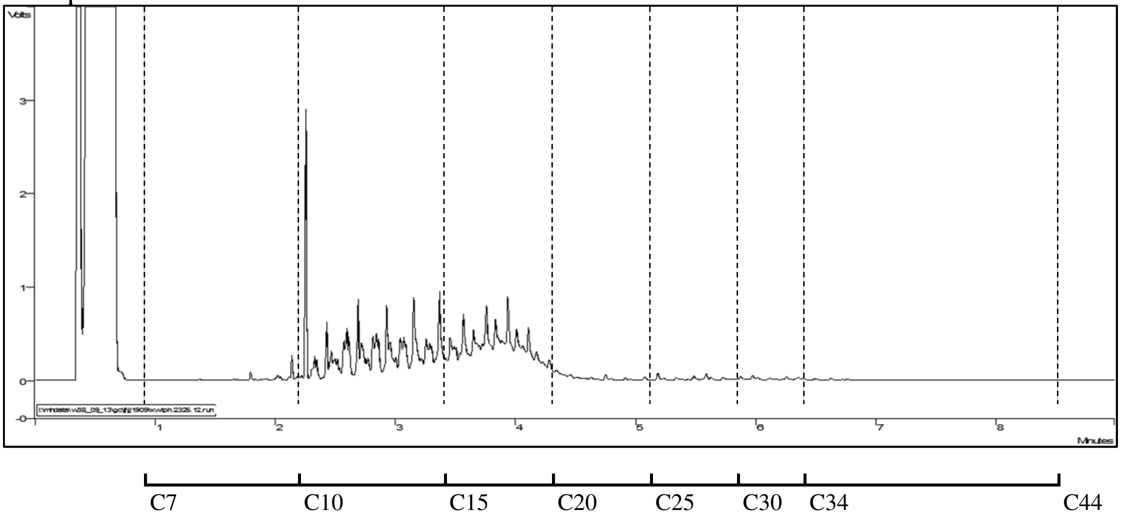
Martin Cowell - BSc
Client Services Manager - Environmental Division

Sample : 1176765.1



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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1182593 SPv1
Contact:	Regan Phipps	**Date Registered:**	20-Sep-2013
	C/- Taranaki Regional Council	**Date Reported:**	04-Oct-2013
	Private Bag 713	**Quote No:**	50522
	STRATFORD 4352	**Order No:**	
		Client Reference:	Mangahewa C HF Fluids
		Submitted By:	Regan Phipps

Sample Type: Aqueous

Sample Name:		MWH12 09-Sep-2013 12:00 pm	MWH13 09-Sep-2013 12:00 pm			
Lab Number:		1182593.1	1182593.2			
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	280	320	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	165	178	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	8	4	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	0.0011	0.0012	-	-	-
Toluene	g/m^3	0.0039	0.0025	-	-	-
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	-	-	-
m&p-Xylene	g/m^3	0.003	0.002	-	-	-
o-Xylene	g/m^3	0.0020	0.0018	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 1.2	< 1.2	-	-	-
C10 - C14	g/m^3	55	32	-	-	-
C15 - C36	g/m^3	114	85	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	169	117	-	-	-

Analyst's Comments

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	-	1-2
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 [KBIs:26687,3629]	-	1-2
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1-2

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

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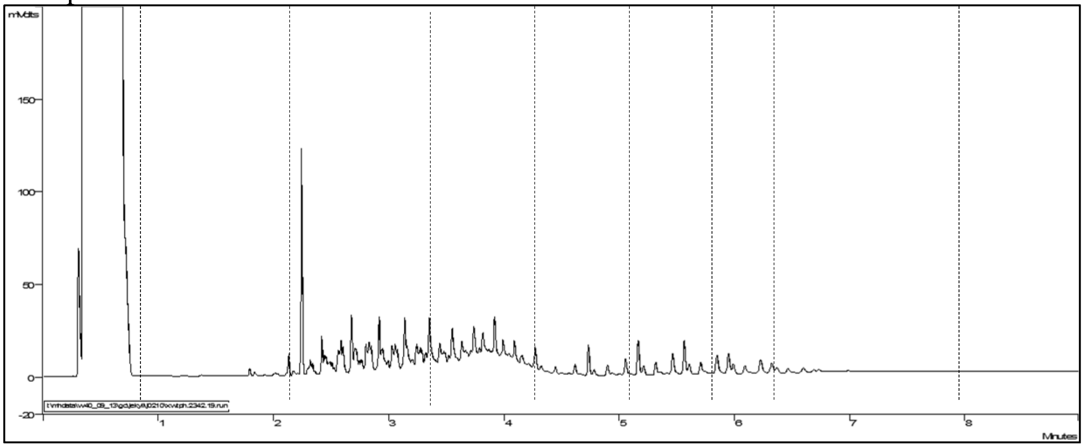
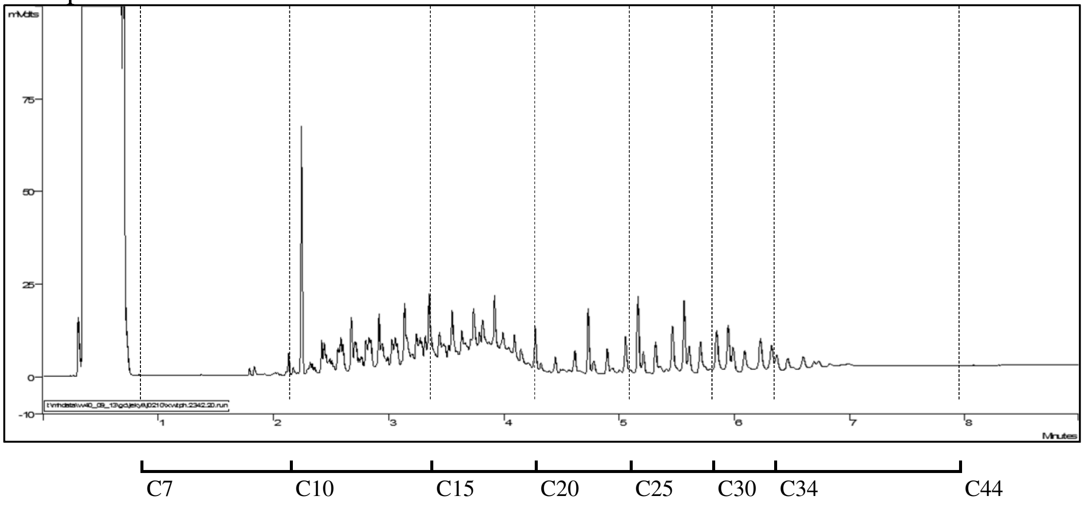
Martin Cowell - BSc
Client Services Manager - Environmental Division

Sample : 1182593.1



Sample : 1182593.2



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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1182581 SPv1
Contact:	Regan Phipps	**Date Registered:**	20-Sep-2013
	C/- Taranaki Regional Council	**Date Reported:**	30-Sep-2013
	Private Bag 713	**Quote No:**	49265
	STRATFORD 4352	**Order No:**	
		Client Reference:	High Salinity Produced Wate
		Submitted By:	Regan Phipps

Sample Type: Saline

	Sample Name:	MHW12 18-Sep-2013 12:00 pm	MHW13 14-Sep-2013 12:00 pm			
	Lab Number:	1182581.1	1182581.2			
Individual Tests						
pH*	pH Units	7.4	7.1	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	3,200	2,800	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	280	320	-	-	-
Electrical Conductivity (EC)*	mS/m	2,090	2,170	-	-	-
Dissolved Barium*	g/m^3	50	78	-	-	-
Dissolved Bromine*	g/m^3	18.9	25	-	-	-
Dissolved Calcium*	g/m^3	96	116	-	-	-
Dissolved Copper*	g/m^3	< 0.005	< 0.005	-	-	-
Dissolved Iron*	g/m^3	2.4	2.8	-	-	-
Dissolved Magnesium*	g/m^3	9	7	-	-	-
Dissolved Manganese*	g/m^3	2.7	5.3	-	-	-
Dissolved Nickel*	g/m^3	< 0.03	< 0.03	-	-	-
Dissolved Potassium*	g/m^3	600	670	-	-	-
Dissolved Sodium*	g/m^3	4,700	4,700	-	-	-
Dissolved Sulphur*	g/m^3	11	8	-	-	-
Dissolved Zinc*	g/m^3	0.06	0.05	-	-	-
Chloride*	g/m^3	4,900	5,500	-	-	-
Nitrite-N	g/m^3	< 0.2	< 0.2	-	-	-
Nitrate-N	g/m^3	1.5	< 0.2	-	-	-
Nitrate*	g/m^3	6.8	< 0.9	-	-	-
Nitrate-N + Nitrite-N	g/m^3	1.5	0.2	-	-	-
Sulphate*	g/m^3	34	23	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	89	260	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	24	18	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	3	4	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m^3	12.4	14.0	-	-	-
Toluene*	g/m^3	13.8	10.8	-	-	-
Ethylbenzene*	g/m^3	1.57	0.71	-	-	-
m&p-Xylene*	g/m^3	7.7	3.5	-	-	-
o-Xylene*	g/m^3	2.6	1.28	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m^3	0.89	0.47	-	-	-

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

Sample Type: Saline

Sample Name:		MHW12 18-Sep-2013 12:00 pm	MHW13 14-Sep-2013 12:00 pm			
Lab Number:		1182581.1	1182581.2			
Gases in groundwater						
Ethane*	g/m^3	0.182	0.47	-	-	-
Ethylene*	g/m^3	< 0.003	< 0.003	-	-	-
Methane*	g/m^3	0.64	2.1	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9*	g/m^3	90	14.5	-	-	-
C10 - C14*	g/m^3	280	8.4	-	-	-
C15 - C36*	g/m^3	570	11.8	-	-	-
Total hydrocarbons (C7 - C36)*	g/m^3	940	35	-	-	-

Sample Type: Aqueous

Sample Name:		MHW12 [Mercury Testing]	MHW13 [Mercury Testing]			
Lab Number:		1182581.3	1182581.4			
Individual Tests						
Total Mercury	g/m^3	< 0.011	< 0.011	-	-	-

Analyst's Comments

Severe matrix interferences required that a dilution be performed prior to analysis of samples 1182581.1 and .2 resulting in a detection limit higher than that normally achieved for the NOxN sal / NO2N sal 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: Saline

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 [KBIs:26687,3629]	-	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 [KBIs:2803,10734]	-	1-2
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1-2
pH*	Saline water, pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-2
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	1-2
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1-2
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.10 mS/m	1-2
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.0006 g/m^3	1-2
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.10 g/m^3	1-2
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	1.0 g/m^3	1-2
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1-2
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.004 g/m^3	1-2
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.4 g/m^3	1-2

Sample Type: Saline

Test	Method Description	Default Detection Limit	Samples
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1-2
Dissolved Nickel*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.006 g/m^3	1-2
Dissolved Potassium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	1.0 g/m^3	1-2
Dissolved Sodium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.4 g/m^3	1-2
Dissolved Sulphur*	Filtered sample, ICP-OES.	0.10 g/m^3	1-2
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.004 g/m^3	1-2
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3	1-2
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m^3	1-2
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	1-2
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 21st ed. 2005.	0.002 g/m^3	1-2
Soluble Sulphate*	Calculation: from dissolved sulphur.	2 g/m^3	1-2

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	3-4
Total Mercury	Nitric acid digestion, ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	0.0021 g/m^3	3-4

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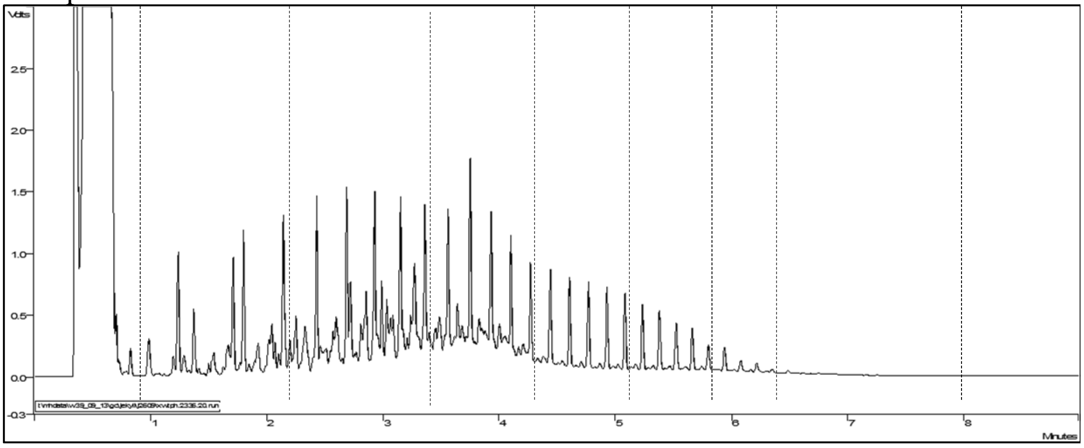
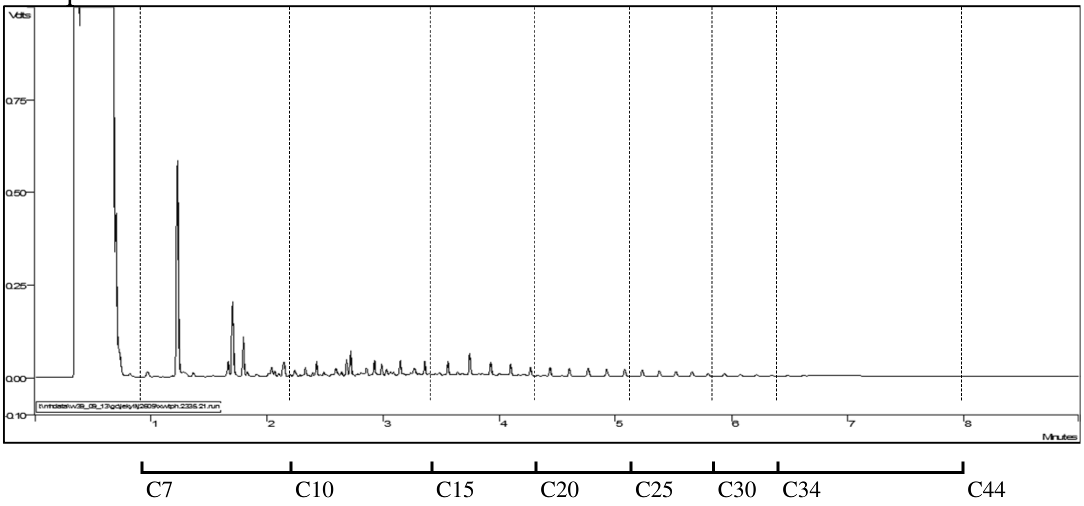
Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

Sample : 1182581.1



Sample : 1182581.2



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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1199647 SPv1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	**Date Registered:**	06-Nov-2013
		Date Reported:	20-Nov-2013
		Quote No:	50522
		Order No:	
		Client Reference:	Mangahewa C Hydraulic frac
		Submitted By:	Regan Phipps

Sample Type: Aqueous

Sample Name:		GND2375 27-Oct-2013 12:00 pm	GND2374 30-Oct-2013 12:00 pm			
Lab Number:		1199647.1	1199647.2			
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	88	146	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	52	17	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	3	2	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.010	< 0.010	-	-	-
Toluene	g/m^3	0.035	< 0.010	-	-	-
Ethylbenzene	g/m^3	0.029	< 0.010	-	-	-
m&p-Xylene	g/m^3	0.09	< 0.02	-	-	-
o-Xylene	g/m^3	0.039	0.012	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	2.6	6.6	-	-	-
C10 - C14	g/m^3	250	660	-	-	-
C15 - C36	g/m^3	400	1,210	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	650	1,890	-	-	-

Analyst's Comments

It has been noted that the duplicate for Glycol on sample 1199647.1, was run as part of our in-house QC procedure and showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample.

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	Sample No
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 [KBIs:26687,3629]	-	1-2
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	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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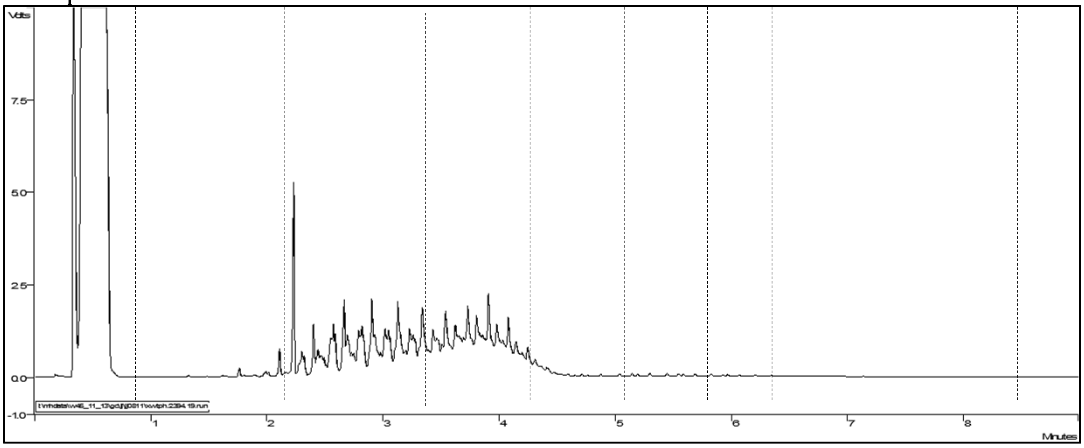
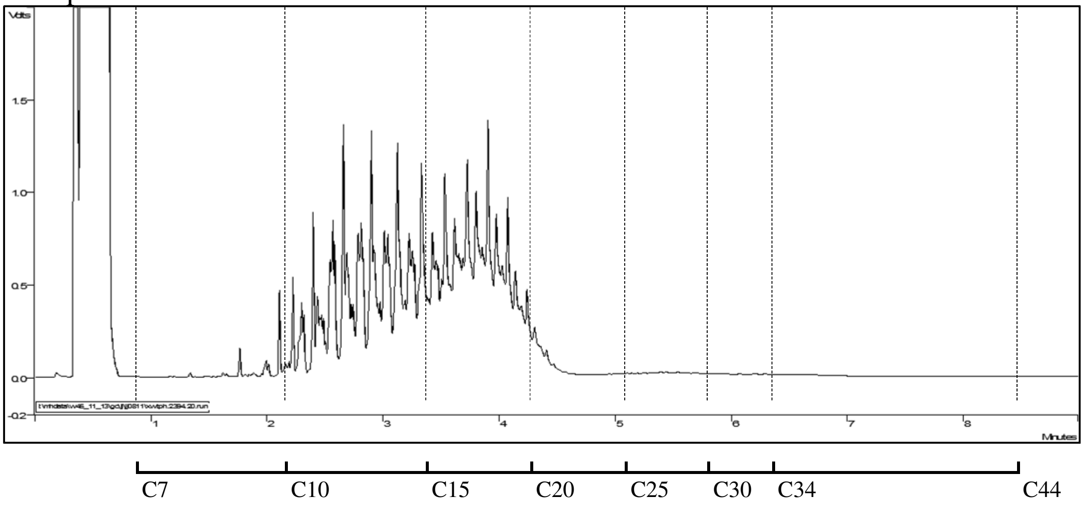
Martin Cowell - BSc
Client Services Manager - Environmental Division

Sample : 1199647.1



Sample : 1199647.2



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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1203829 SPv1
Contact:	Regan Phipps	**Date Registered:**	16-Nov-2013
	C/- Taranaki Regional Council	**Date Reported:**	25-Nov-2013
	Private Bag 713	**Quote No:**	49265
	STRATFORD 4352	**Order No:**	
		Client Reference:	Mange
		Submitted By:	R McDonnell

Sample Type: Saline

	Sample Name:	GND 2374 10-Nov-2013 7:17 pm	GND 2375 06-Nov-2013 3:25 pm			
	Lab Number:	1203829.1	1203829.2			
Individual Tests						
pH*	pH Units	6.9	6.8	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	2,000	2,300	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	210	280	-	-	-
Electrical Conductivity (EC)*	mS/m	1,975	2,770	-	-	-
Dissolved Barium*	g/m^3	34	46	-	-	-
Dissolved Bromine*	g/m^3	17.4	26	-	-	-
Dissolved Calcium*	g/m^3	74	97	-	-	-
Dissolved Copper*	g/m^3	0.007	0.018	-	-	-
Dissolved Iron*	g/m^3	10.2	5.9	-	-	-
Dissolved Magnesium*	g/m^3	7	9	-	-	-
Dissolved Manganese*	g/m^3	3.0	2.3	-	-	-
Total Mercury*	g/m^3	< 0.011	< 0.011	-	-	-
Dissolved Nickel*	g/m^3	0.04	< 0.03	-	-	-
Dissolved Potassium*	g/m^3	720	550	-	-	-
Dissolved Sodium*	g/m^3	4,100	6,000	-	-	-
Dissolved Sulphur*	g/m^3	14	24	-	-	-
Dissolved Zinc*	g/m^3	2.6	0.23	-	-	-
Chloride*	g/m^3	5,000	6,500	-	-	-
Nitrite-N	g/m^3	< 0.02	< 0.02	-	-	-
Nitrate-N	g/m^3	< 0.02	< 0.02	-	-	-
Nitrate*	g/m^3	< 0.09	< 0.09	-	-	-
Nitrate-N + Nitrite-N	g/m^3	0.03	< 0.02	-	-	-
Sulphate*	g/m^3	42	71	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	< 4	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	80	25	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	3	4	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m^3	11.8	8.9	-	-	-
Toluene*	g/m^3	18.4	14.6	-	-	-
Ethylbenzene*	g/m^3	3.3	1.78	-	-	-
m&p-Xylene*	g/m^3	18.9	9.8	-	-	-
o-Xylene*	g/m^3	6.3	3.4	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						

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Sample Type: Saline

Sample Name:		GND 2374 10-Nov-2013 7:17 pm	GND 2375 06-Nov-2013 3:25 pm			
Lab Number:		1203829.1	1203829.2			
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m^3	0.57	0.29	-	-	-
Gases in groundwater						
Ethane*	g/m^3	0.40	0.49	-	-	-
Ethylene*	g/m^3	< 0.003	< 0.003	-	-	-
Methane*	g/m^3	1.21	1.18	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9*	g/m^3	97	230	-	-	-
C10 - C14*	g/m^3	290	760	-	-	-
C15 - C36*	g/m^3	410	1,030	-	-	-
Total hydrocarbons (C7 - C36)*	g/m^3	800	2,000	-	-	-

Analyst's Comments

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: Saline

Test	Method Description	Default Detection Limit	Sample No
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 [KBIs:26687,3629]	-	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 [KBIs:2803,10734]	-	1-2
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1-2
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-2
pH*	Saline water, pH meter. APHA 4500-H^+ B 22nd ed. 2012.	0.1 pH Units	1-2
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	1-2
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.10 mS/m	1-2
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	1-2
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	1-2
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-2
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	1-2
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	1-2
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-2
Total Mercury*	Nitric acid digestion, ICP-MS, screen level. APHA 3125 B 22nd ed. 2012.	0.0021 g/m^3	1-2
Dissolved Nickel*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.006 g/m^3	1-2

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Dissolved Potassium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	1-2
Dissolved Sodium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	1-2
Dissolved Sulphur*	Filtered sample, ICP-OES.	0.10 g/m^3	1-2
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	1-2
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m^3	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.0010 g/m^3	1-2
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	1-2
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m^3	1-2
Soluble Sulphate*	Calculation: from dissolved sulphur.	2 g/m^3	1-2

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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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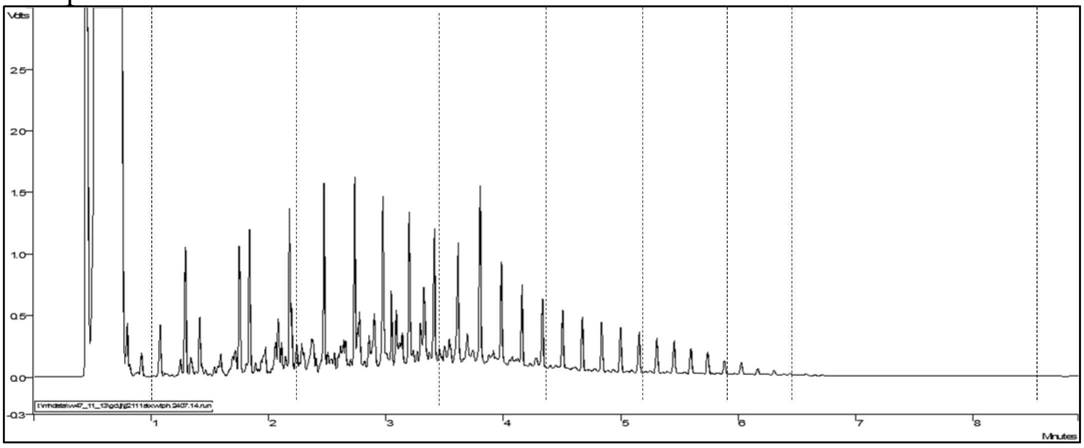
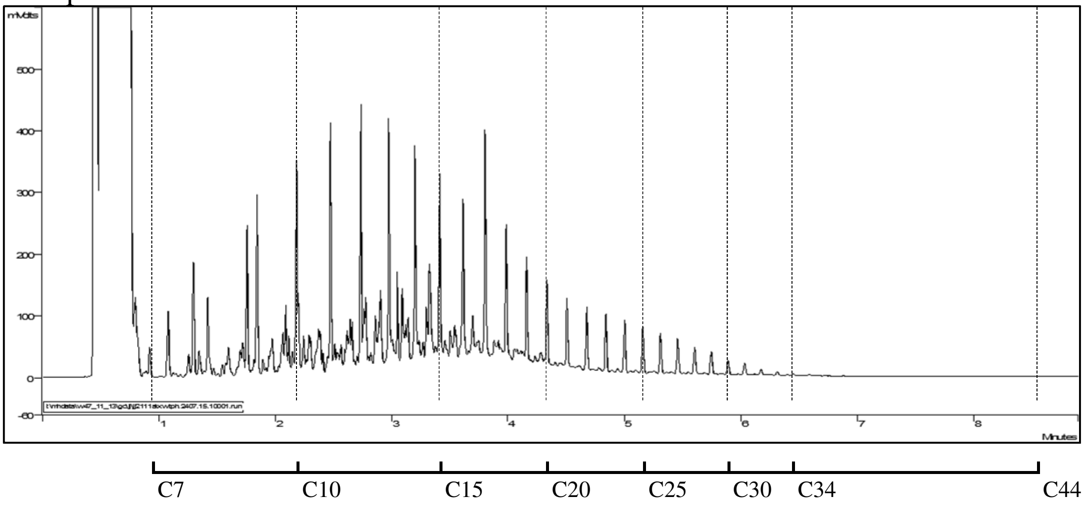
Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

Sample : 1203829.1



Sample : 1203829.2



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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1296195 SPv1
Contact:	Regan Phipps	**Date Registered:**	08-Jul-2014
	C/- Taranaki Regional Council	**Date Reported:**	21-Jul-2014
	Private Bag 713	**Quote No:**	50522
	STRATFORD 4352	**Order No:**	
		Client Reference:	Mangahewa C HF Fluid
		Submitted By:	R McDonnell

Sample Type: Aqueous

Sample Name:		GND2375 03-Jul-2014 12:00 pm				
Lab Number:		1296195.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	330	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	40	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	7	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	-	-	-	-
Toluene	g/m^3	0.0017	-	-	-	-
Ethylbenzene	g/m^3	0.0019	-	-	-	-
m&p-Xylene	g/m^3	0.006	-	-	-	-
o-Xylene	g/m^3	0.0029	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	0.96	-	-	-	-
C10 - C14	g/m^3	76	-	-	-	-
C15 - C36	g/m^3	138	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	220	-	-	-	-

Analyst's Comments

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	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m^3	1

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

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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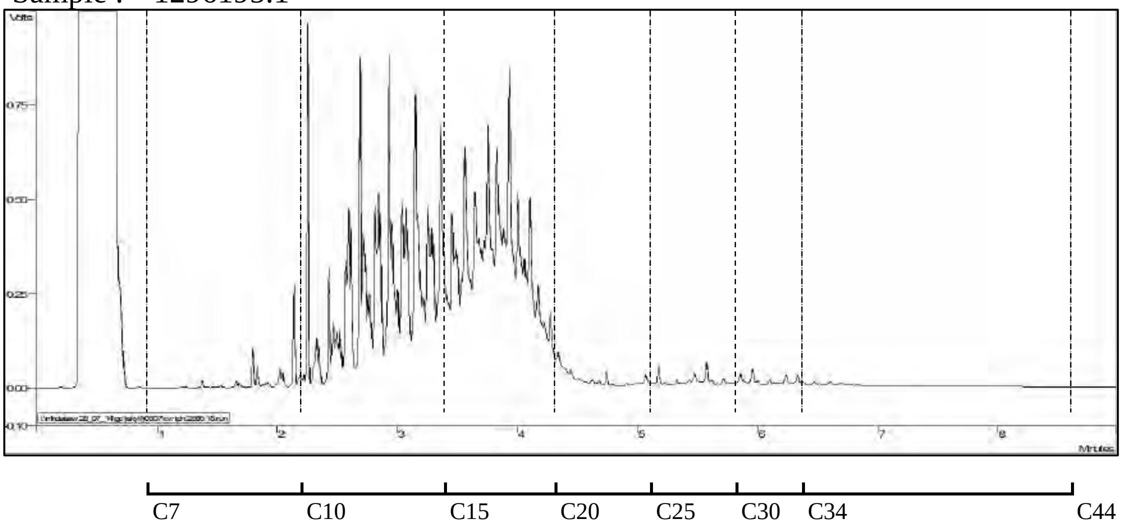
Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms - Page 1 of 1

Sample : 1296195.1



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Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1296196 SPv1
Contact:	Regan Phipps	**Date Registered:**	08-Jul-2014
	C/- Taranaki Regional Council	**Date Reported:**	21-Jul-2014
	Private Bag 713	**Quote No:**	49265
	STRATFORD 4352	**Order No:**	
		Client Reference:	Mangahewa C Return Fluid
		Submitted By:	R McDonnell

Sample Type: Saline

	Sample Name:	GND2375 03-Jul-2014 5:30 pm				
	Lab Number:	1296196.1				
Individual Tests						
pH*	pH Units	7.7	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	1,180	-	-	-	-
Analysis Temperature for Bicarbonate	°C	22	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	1,143	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	68	-	-	-	-
Electrical Conductivity (EC)*	mS/m	585	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	5,600	-	-	-	-
Dissolved Barium*	g/m^3	4.2	-	-	-	-
Dissolved Bromine*	g/m^3	2.2	-	-	-	-
Dissolved Calcium*	g/m^3	21	-	-	-	-
Dissolved Copper*	g/m^3	0.021	-	-	-	-
Dissolved Iron*	g/m^3	2.1	-	-	-	-
Dissolved Magnesium*	g/m^3	4	-	-	-	-
Dissolved Manganese*	g/m^3	1.27	-	-	-	-
Total Mercury*	g/m^3	< 0.011	-	-	-	-
Dissolved Nickel*	g/m^3	0.06	-	-	-	-
Dissolved Potassium*	g/m^3	186	-	-	-	-
Dissolved Sodium*	g/m^3	1,190	-	-	-	-
Dissolved Sulphur*	g/m^3	8	-	-	-	-
Dissolved Zinc*	g/m^3	0.57	-	-	-	-
Chloride*	g/m^3	960	-	-	-	-
Nitrite-N	g/m^3	0.005	-	-	-	-
Nitrate-N	g/m^3	0.007	-	-	-	-
Nitrate*	g/m^3	0.032	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	0.012	-	-	-	-
Sulphate*	g/m^3	25	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	320	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	30	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	12	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m^3	6.6	-	-	-	-
Toluene*	g/m^3	12.9	-	-	-	-
Ethylbenzene*	g/m^3	1.40	-	-	-	-

Sample Type: Saline

Sample Name:		GND2375 03-Jul-2014 5:30 pm				
Lab Number:		1296196.1				
BTEX in Water by Headspace GC-MS						
m&p-Xylene*	g/m^3	7.7	-	-	-	-
o-Xylene*	g/m^3	2.5	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m^3	< 1.5	-	-	-	-
Gases in groundwater						
Ethane*	g/m^3	0.78	-	-	-	-
Ethylene*	g/m^3	< 0.004	-	-	-	-
Methane*	g/m^3	2.4	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9*	g/m^3	32	-	-	-	-
C10 - C14*	g/m^3	101	-	-	-	-
C15 - C36*	g/m^3	123	-	-	-	-
Total hydrocarbons (C7 - C36)*	g/m^3	260	-	-	-	-

Analyst's Comments

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: Saline

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	1
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	1
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m^3	1
Gases in groundwater*	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m^3	1
Total Petroleum Hydrocarbons in Water*	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m^3	1
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1
pH*	Saline water, pH meter. APHA 4500-H$^+$ B 22nd ed. 2012.	0.1 pH Units	1
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	1
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	1
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	1
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.10 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) 22nd ed. 2012.	50 g/m^3	1
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	1
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	1
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	1

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	1
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	1
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1
Total Mercury*	Nitric acid digestion, ICP-MS, screen level. APHA 3125 B 22nd ed. 2012.	0.0021 g/m^3	1
Dissolved Nickel*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.006 g/m^3	1
Dissolved Potassium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	1
Dissolved Sodium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	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 22nd ed. 2012.	0.004 g/m^3	1
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl$^-$ E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m^3	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 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 22nd ed. 2012.	0.002 g/m^3	1
Soluble Sulphate*	Calculation: from dissolved sulphur.	2 g/m^3	1

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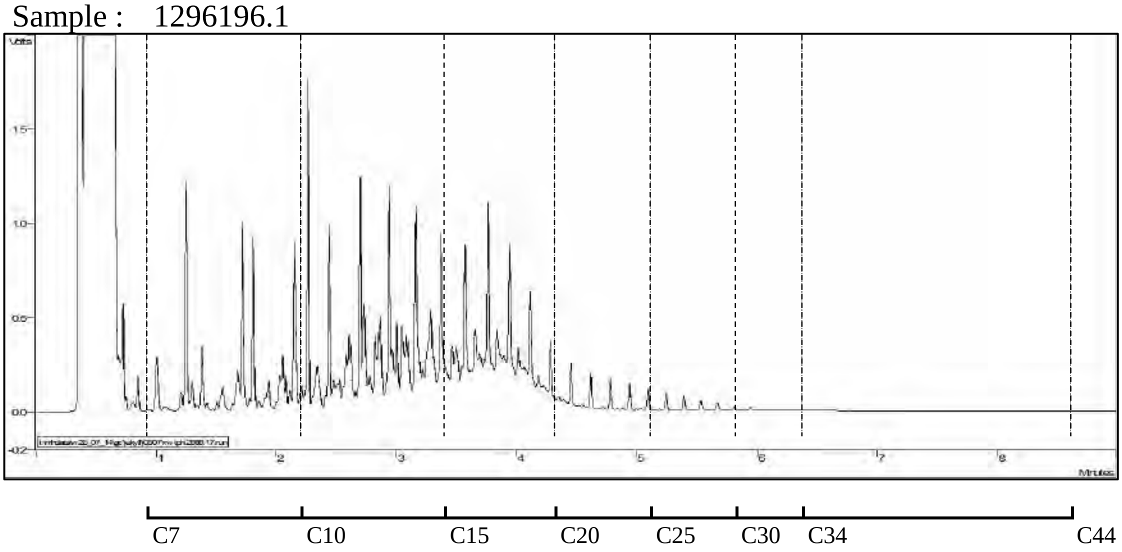
Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Sample : 1296196.1



Appendix III

Results of physico-chemical analysis

Site	Date	Total alkalinity g/m^3 CaCO$_3$	Barium mg/kg	Benzene g/m^3	Bromide g/m^3	Calcium g/m^3	Chloride g/m^3	Electrical conductiviy mS/m at 20^{0}C	Dissolved copper g/m^3	Ethyl benzene g/m^3	Ethane g/m^3	Ethylene g/m^3	Dissolved iron g/m^3	Formaldehyde g/m^3	Ethylene glycol g/m^3	Total hydrocarbons g/m^3	Bicarbonate g/m^3 HCO$_3$	Total hardness g/m^3 CaCO$_3$
GND2254	17 Apr 2012	132	0.0146	<0.0010	0.07	25	14.4	27.5	<0.0005	<0.0010	<0.003	<0.004	0.32	<0.02	<4	<0.7	161.04	104
	16 May 2012	126	0.015	<0.0010	0.05	24	14.4	28.1	<0.0005	<0.0010	<0.003	<0.0010	0.29	<0.02	<4	<0.7	153.72	107
	26 Jul 2012	131	0.0148	<0.0010	<0.05	23	14.6	27.9	<0.0005	<0.0010	<0.003	<0.004	0.31	<0.02	<4	<0.7	158	98
	10 May 2013	130	0.0168	<0.0010	0.07	24	13.8	28.3	<0.0005	<0.0010	<0.003	<0.004	0.31	<0.02	<4	<0.7	157	102
	21 Oct 2013	126	0.0149	<0.0010	0.048	24	13.2	28.3	<0.0005	<0.0010	<0.003	<0.003	0.31	<0.02	<4	<0.7	152	103
	11 Feb 2014	123	0.0149	<0.0010	0.051	24	12.8	26.9	<0.0005	<0.0010	<0.003	<0.004	0.33	<0.02	<4	<0.7	150.1	101
	23 Oct 2014	124	0.0146	<0.0010	0.058	24	13.0	27	<0.0005	<0.0010	<0.003	<0.003	0.29	<0.02	<4	<0.7	151.3	106
GND2255	17 Apr 2012	20	0.043	<0.0010	0.1	6.5	24	13	0.0072	<0.0010	<0.003	<0.004	<0.02	<0.02	<4	<0.7	24.4	31
	16 May 2012	19	0.042	<0.001	0.08	6	23	13.2	0.0194	<0.0010	<0.003	<0.004	<0.02	<0.02	<4	<0.7	23.18	107
	26 Jul 2012	19.6	0.047	<0.0010	0.11	6	25	13.9	0.033	<0.0010	<0.003	<0.004	0.03	<0.02	<4	<0.7	24	28
	10 May 2013	<1	0.048	<0.0010	0.09	5.8	19.7	16.7	0.027	<0.0010	<0.003	<0.004	0.03	<0.02	<4	<0.7	<1	28
	21 Oct 2013	18.8	0.047	<0.0010	0.082	6.0	24	14	0.037	<0.0010	<0.003	<0.003	<0.02	<0.02	<4	<0.7	22.9	28
	11 Feb 2014	20	0.046	<0.0010	0.085	6.3	22	13.6	0.031	<0.0010	<0.003	<0.004	<0.02	<0.02	<4	<0.7	24.4	28
	23 Oct 2014	19.6	0.044	<0.0010	0.100	6.1	23	13.6	0.131	<0.0010	<0.003	<0.003	<0.02	<0.02	<4	<0.7	23.9	28
GND2256	17 Apr 2012	20	0.054	<0.0010	0.1	8.6	21	15.4	0.0007	<0.0010	<0.003	<0.0010	<0.02	<0.02	<4	<0.7	24.4	39
	16 May 2012	22	0.051	<0.0010	0.08	7.9	19.5	15.1	0.0006	<0.0010	<0.003	<0.004	<0.02	<0.02	<4	<0.7	26.84	37
	26 Jul 2012	19.7	0.075	<0.0010	0.12	10.1	23	17.8	0.0006	0.001	<0.003	<0.004	<0.02	<0.02	<4	<0.7	24	45
	10 May 2013	32	0.077	<0.0010	0.11	11.5	21	18.2	0.0007	<0.0010	<0.003	<0.004	<0.02	<0.02	<4	<0.7	39	48
	21 Oct 2013	19.7	0.062	<0.0010	0.084	9.4	21	17.3	<0.0005	<0.0010	<0.003	<0.003	<0.02	<0.02	<4	<0.7	24.0	42
	11 Feb 2014	23	0.036	<0.0010	0.076	7.2	18.3	14.5	0.0006	<0.0010	<0.003	<0.004	<0.02	<0.02	<4	<0.7	28.1	32
	23 Oct 2014	20	0.040	<0.0010	0.090	7.2	17.4	13.6	<0.0005	<0.0010	<0.003	<0.003	<0.02	<0.02	<4	<0.7	24.4	33
GND2257	17 Apr 2012	24	0.0143	<0.0010	0.1	8.1	22	16.1	0.0125	<0.0010	<0.003	<0.004	1.82	<0.02	<4	<0.7	29.28	39
	16 May 2012	24	0.0144	<0.0010	0.08	7.9	22	16.9	0.02	<0.0010	<0.003	<0.004	1.25	<0.02	<4	<0.7	29.28	39
	26 Jul 2012	22	0.021	<0.0010	0.1	8.3	21	16	0.0152	<0.0010	<0.003	<0.004	1.22	<0.02	<4	<0.7	26	38
	10 May 2013	27	0.0174	<0.0010	0.1	8.4	21	17.2	0.022	<0.0010	<0.003	<0.004	1	<0.02	<4	<0.7	33	42
	21 Oct 2013	22	0.021	<0.0010	0.083	7.8	21	16.3	0.0128	<0.0010	<0.003	<0.003	1.05	<0.02	<4	<0.7	26.8	35
	11 Feb 2014	24	0.0130	<0.0010	0.084	7.7	21	16.5	0.0117	<0.0010	<0.003	<0.004	1.13	<0.02	<4	<0.7	29.3	37
	22 Oct 2014	26	0.0138	<0.0010	0.085	7.0	19.9	15.4	0.021	<0.0010	<0.003	<0.003	0.46	<0.02	<4	<0.7	31.7	35
GND2360	21 Oct 2013	185	0.025	<0.0010	1.13	10.2	350	145.9	<0.0005	<0.0010	<0.017	<0.003	0.14	<0.02	<4	<0.7	225.7	41
	11 Feb 2014	187	0.026	<0.0010	1.11	10.9	310	133.1	<0.0005	<0.0010	0.005	<0.004	0.20	<0.02	<4	<0.7	228.1	44
	23 Oct 2014	189	0.024	<0.0010	1.40	10.7	300	131.8	<0.0005	<0.0010	0.013	<0.003	0.17	<0.02	<4	<0.7	210	44

Potassium g/m^3	Methanol g/m^3	Methane g/m^3	Magnesium g/m^3	Dissolved manganese g/m^3	Sodium g/m^3	Nickel mg/kg	Nitrate + nitrite nitrogen g/m^3 N	Nitrite g/m^3 N	Nitrate g/m^3 N	pH pH units	Sulphate g/m^3	Total dissolved solids g/m^3	Temperature deg C	Toluene g/m^3	m-Xylene g/m^3	o-Xylene g/m^3	Dissolved zinc g/m^3
2.3	<2	1.54	10.5	10.5	21	<0.0005	0.005	0.003	<0.002	8.1	<0.5	181	15.2	<0.0010	<0.002	<0.0010	0.0012
2.1	<2	1.48	11.1	0.024	16.3	<0.0005	<0.002	<0.002	<0.002	7.9	<0.5	176	15.1	<0.001	<0.002	<0.001	0.0017
2.3	<2	2.1	9.8	0.024	21	<0.0005	<0.002	<0.002	<0.002	8	0.7	186	14.8	<0.0010	<0.002	<0.0010	0.002
2.3	<2	1.95	10.3	0.026	23	<0.0005	0.002	0.002	<0.002	8	<0.5	181		<0.0010	<0.002	<0.0010	0.0087
2.3	<2	2.9	10.2	0.027	18.2	<0.0005	<0.002	<0.002	<0.002	7.9	0.5	173	15.2	<0.0010	<0.0010	<0.002	<0.0010
2.6	<2	2.5	9.9	0.026	16.1	<0.0005	<0.002	<0.002	<0.002	8.0	0.6	174	15.4	<0.0010	<0.0010	<0.002	<0.0010
2.4	<2	3.0	10.9	0.028	16.4	<0.0005	<0.002	<0.002	<0.002	7.9	0.5	177	15.1	<0.0010	<0.0010	<0.002	0.0012
3.5	<2	<0.002	3.7	0.0029	12.6	<0.0005	1.22	0.003	1.22	6.4	3.1	90	15	<0.0010	<0.002	<0.0010	0.0112
3	<2	<0.002	3.4	0.0021	11.3	<0.0005	1.19	<0.002	1.19	5.9	3	92	14.5	<0.0010	<0.002	<0.001	0.0115
3.5	<2	<0.002	3.1	0.0019	12.9	<0.0005	1.75	0.005	1.75	6	3.3	107	14.9	<0.0010	<0.002	<0.0010	0.028
3.2	<2	<0.002	3.2	0.0028	11	<0.0005	0.94	<0.002	0.94	4	24	104		<0.0010	<0.002	<0.0010	0.194
3.5	<2	<0.002	3.1	0.0014	13.3	<0.0005	1.55	<0.002	1.55	5.9	3.6	95	15.4	<0.0010	<0.0010	<0.002	0.0128
3.5	<2	0.003	3.0	0.0054	12.9	<0.0005	1.27	<0.002	1.27	7	3.4	95	15.5	<0.0010	<0.0010	<0.002	0.045
3.5	<2	<0.002	3.1	0.0015	13.0	<0.0005	1.35	<0.002	1.35	6.2	3.6	95	15.1	<0.0010	<0.0010	<0.002	0.084
4.9	<2	<0.002	4.2	0.0023	12.7	<0.0005	4.8	<0.002	4.8	6.4	4.1	117	15.8	<0.0010	<0.002	<0.0010	0.0151
4.5	<2	0.007	<0.02	0.0057	10.5	<0.0005	3.7	<0.002	3.7	6.1	4.1	106	15.6	<0.0010	<0.002	<0.001	0.0097
6	<2	<0.002	4.9	0.0013	12.7	<0.0005	7	<0.002	7	6	4.5	141	15.5	<0.0010	<0.002	<0.0010	0.0091
7.1	<2	<0.002	4.7	0.014	12.6	<5	3.8	<0.002	3.8	6.8	5.3	125		<0.0010	<0.002	<0.0010	0.051
5.1	<2	<0.002	4.4	0.0018	12.6	<0.0005	5.4	<0.002	5.4	6.2	4.2	121	15.6	<0.0010	<0.0010	<0.002	0.0047
3.4	<2	0.004	3.4	0.0026	11.2	<0.0005	2.9	<0.002	2.9	6.3	4.4	110	17	<0.0010	<0.0010	<0.002	0.042
3.3	<2	<0.002	3.6	0.0021	10.2	<0.0005	3.0	<0.002	3.0	6.7	4.4	110	16.5	<0.0010	<0.0010	<0.002	0.0028
2.2	<2	<0.002	4.6	0.0199	15.5	<0.0005	4.5	0.005	4.5	6.3	4.4	118	14.8	<0.0010	<0.002	<0.001	0.047
1.99	<2	<0.002	4.7	0.053	14.6	<0.00050	4.8	<0.002	4.8	6.2	4.6	130	12.2	<0.0010	<0.002	<0.001	0.068
2.3	<2	<0.002	4.3	0.021	14.6	<0.0005	4.9	<0.002	4.9	6	4.9	128	12	<0.0010	<0.002	<0.0010	0.088
2.7	<2	<0.002	5.1	0.021	15.6	0.0006	4.3	0.003	4.3	6.2	5	124		<0.0010	<0.002	<0.0010	0.33
1.82	<2	<0.002	3.9	0.0131	15.2	<0.0005	4.1	0.003	4.1	6.4	4.9	114	14.1	<0.0010	<0.0010	<0.002	0.086
2.2	<2	<0.002	4.2	0.0137	15.3	<0.0005	3.7	<0.002	3.7	6.2	6.0	125	15.3	<0.0010	<0.0010	<0.002	0.062
1.56	<2	<0.002	4.2	0.0158	14.8	0.0008	3.6	<0.002	3.6	6.01	4.0	113	13.1	<0.0010	<0.0010	<0.002	0.134
1.36	<2	11.6	3.9	0.0081	250	<0.0005	<0.002	<0.002	<0.002	9.0	1.9	770		<0.0010	<0.0010	<0.002	0.0055
1.42	<2	3.4	4.1	0.0098	260	<0.0005	0.003	<0.002	0.003	9.1	2.6	740	19.2	<0.0010	<0.0010	<0.002	0.0037
1.29	<2	10.2	4.1	0.0094	260	0.0005	<0.002	<0.002	<0.002	9.0	1.7	720	15.7	<0.0010	<0.0010	<0.002	0.0042