

Westside New Zealand Ltd
Kauri-E Hydraulic Fracturing
Monitoring Programme
2018-2019

Technical Report 20-34

ISSN: 1178-1467 (Online)

Document: 2377711 (Word)

Document: 2523002 (Pdf)

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STRATFORD

September 2020

Executive summary

Westside New Zealand Ltd (Westside) operates the Kauri-E hydrocarbon exploration site located on Geary Road, Manutahi. This report outlines and discusses the results of the monitoring programme implemented by the Council in relation to hydraulic fracturing activities conducted by Westside at the wellsite over the period 29 August 2018 to 31 August 2018. The report also details the results of the monitoring undertaken and assesses the environmental effects of the Company's activities.

The programme of hydraulic fracturing undertaken by Westside at the Kauri-E wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Kauri-E2 well.

During the monitoring period, Westside demonstrated an overall high level of environmental performance.

The programme of monitoring implemented by the Council in relation to these hydraulic fracturing activities spanned the 2017-2018 and 2018-2019 monitoring years. Monitoring included pre and post-discharge groundwater sampling. Samples of hydraulic fracturing fluids, and fluids returning to the wellhead post-fracturing, were also obtained for physicochemical analysis in order to characterise the discharges and to determine compliance with consent conditions.

This is the second monitoring report produced by the Council in relation to the hydraulic fracturing activities at the Kauri-E wellsite.

The monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by Westside had no significant adverse effects on local groundwater resources. There were no unauthorised incidents recording non-compliance in respect of the resource consent held by Westside in relation to these activities or provisions in regional plans, during the period under review.

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

For reference, in the 2019-2020 year, consent holders were found to achieve a high level of environmental performance and compliance for 81% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 17% of the consents, a good level of environmental performance and compliance was achieved.

This report includes recommendations for the future monitoring of any hydraulic fracturing activities at the Kauri-E wellsite.

Table of contents

	Page	
1	Introduction	1
1.1	Compliance monitoring programme reports and the Resource Management Act 1991	1
1.1.1	Introduction	1
1.1.2	Structure of this report	1
1.1.3	The Resource Management Act 1991 and monitoring	1
1.1.4	Evaluation of environmental and administrative performance	2
1.2	Process description	3
1.2.1	Hydraulic fracturing	3
1.2.1.1	Gel fracturing	4
1.2.1.2	Slick water fracturing	4
1.2.1.3	Nitrogen gas fracturing	4
1.2.2	The Kauri-E wellsite and hydraulic fracturing activities	4
1.3	Resource consents	6
1.3.1	Discharges of wastes to land	6
1.4	Monitoring programme	6
1.4.1	Introduction	6
1.4.2	Programme liaison and management	6
1.4.3	Assessment of data submitted by the consent holder	7
1.4.4	Physiochemical sampling	7
1.4.4.1	Groundwater	7
1.4.4.2	Surface water	7
1.4.4.3	Hydraulic fracturing and return fluids	7
2	Results	9
2.1	Consent holder submitted data	9
2.1.1	Kauri-E2 post-fracturing discharge report	9
2.2	Physiochemical sampling	9
2.2.1	Groundwater	9
2.2.2	Hydraulic fracturing and return fluids	11
2.3	Investigations, interventions, and incidents	13
3	Discussion	15
3.1	Environmental effects of exercise of consents	15
3.2	Evaluation of performance	15

3.3	Alterations to monitoring programmes of future hydraulic fracturing events	17
3.4	Exercise of optional review of consent	17
4	Recommendations	18
	Glossary of common terms and abbreviations	19
	Bibliography and references	21
Appendix I	Resource consent held by Westside New Zealand Ltd	
Appendix II	Certificates of analysis (groundwater)	
Appendix III	Certificates of analysis (hydraulic fracturing fluids)	

List of tables

Table 1	Summary of hydraulic fracturing details	4
Table 2	resource consent held by the Company during the period under review	6
Table 3	Details of groundwater sites included in the monitoring programme	7
Table 4	Results of groundwater sampling carried out in relation to the Kauri-E2 hydraulic fracturing event	10
Table 5	Results of hydraulic fracturing fluid sampling	11
Table 6	Results of hydraulic fracturing return fluid sampling	12
Table 7	Incidents, investigations, and interventions summary table	14
Table 8	Summary of performance for consent 10544-1 & 10563-1	15

List of figures

Figure 1	Location map	5
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1 Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

This 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 Westside New Zealand Ltd (Westside) at the Kauri-E wellsite, over the period 29 August 2018 to 31 August 2018. The report also assesses Westside's level of environmental performance and compliance with the resource consent held in relation to the activity.

The programme of hydraulic fracturing undertaken by Westside at the Kauri-E wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Kauri-E2 well.

The programme of monitoring implemented by the Council in relation to these hydraulic fracturing activities spanned the 2017-2018 and 2018-2019 monitoring years. Monitoring included a mixture of groundwater and discharge monitoring components. This is the second monitoring report produced by the Council in relation to hydraulic fracturing activities at the Kauri-E wellsite. The first report covered the 2013 to 2015 period when the wellsite was operated by Origin Energy Resources Ltd (Origin).

1.1.2 Structure of this report

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

- the nature of the monitoring programme in place for the period under review; and
- a description of the activities and operations conducted at Kauri-E.

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 for the future monitoring of any hydraulic fracturing activities at the Kauri-E wellsite.

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 Resource Management Act 1991 (RMA) primarily addresses environmental 'effects' which are defined as positive or adverse, temporary or permanent, past, present or future, or cumulative. Effects may arise in relation to:

- a. the neighbourhood or the wider community around an activity, and may include cultural and social-economic effects;
- b. physical effects on the locality, including landscape, amenity and visual effects;
- c. ecosystems, including effects on plants, animals, or habitats, whether aquatic or terrestrial;
- d. natural and physical resources having special significance (for example recreational, cultural, or aesthetic); and
- e. risks to the neighbourhood or environment.

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

1.1.4 Evaluation of environmental and administrative performance

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

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

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

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

Environmental Performance

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

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

For example:

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

Improvement required: Likely or actual adverse effects of activities on the receiving environment were more than minor, but not substantial. There were some issues noted during monitoring, from self reports, or during investigations of incidents reported to the Council by a third party. Cumulative

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

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

Administrative performance

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

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

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

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

For reference, in the 2019-2020 year, consent holders were found to achieve a high level of environmental performance and compliance for 81% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 17% of the consents, a good level of environmental performance and compliance was achieved.¹

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 conventional production techniques.

The process of hydraulic fracturing involves the pumping of fluids 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

¹ The Council has used these compliance grading criteria for 15 years. They align closely with the 4 compliance grades in the MfE Best Practice Guidelines for Compliance, Monitoring and Enforcement, 2018

pumping is stopped. The placement of proppant into the fractures can be assisted by the use of cross-linked gels (gel fracturing), turbulent flow (slick-water fracturing) or the use of nitrogen gas.

1.2.1.1 Gel fracturing

Gel fracturing utilises cross-linked gel solutions, which are liquid at the surface but, when mixed, form long-chain polymer bonds and thus become viscous gels. These gels are used to transport the proppant into the formation. Once in the formation they 'break' back with time, temperature and the aid of gel breaking chemicals into a liquid state and are flowed back to surface, without disturbing the proppant which remains in place and enhances the flow of hydrocarbons back to the surface.

1.2.1.2 Slick water fracturing

Slick water fracturing utilises water based fracturing fluids with friction-reducing additives. The addition of the friction reducers allows the fracturing fluids and proppant to be pumped to the target zone at higher rates and reduced pressures, than when using water alone. The higher rate creates turbulence within the fluid column holding the proppant and enabling its placement into the open fractures and enhancing the flow of hydrocarbons back to the surface.²

1.2.1.3 Nitrogen gas fracturing

Nitrogen gas assisted fracturing involves replacing some of the fluid used in the fracturing process with nitrogen gas, which can fracture rock at high pressures much like water. While nitrogen (N₂) is a gas at room temperature, it can be maintained in a liquid state through cooling and pressurisation. Nitrogen assisted fracturing is extremely beneficial from a production standpoint as inevitably during the fracturing process some of the water pumped down the well remains underground in the rock formation, which can block some of the small pores inhibiting hydrocarbon recovery. Nitrogen gas achieves the same purpose as water but returns more easily to the surface.³ More indirectly, a reduction in the volume of water used also reduces the total concentration of chemical additives required and the volume of water returning to the surface that requires subsequent disposal.²

1.2.2 The Kauri-E wellsite and hydraulic fracturing activities

The Kauri-E wellsite is located on Geary Road, Manutahi and lies within the Waikakai catchment in close proximity to the coastline. The area surrounding the site is rural in nature and farming and forestry activities co-exist with active petroleum exploration and production operations. There are no nearby fresh surface water resources. The location of the wellsite is illustrated in Figure 1. A summary of the hydraulic fracturing activities carried out by Westside at the Kauri-E wellsite during the period being reported is provided below in Table 1.

Table 1 Summary of hydraulic fracturing details

Well	Bore id.	Date range	Injection intervals (m TVDss)	Formation
Kauri-E2	GND2643	29/08/2018 - 31/08/2018	2,433.3-2,451.9	Kauri sand
			2,591.4-2,604.0	

² <http://geology.com/energy/hydraulic-fracturing-fluids>

³ <http://frackwire.com/nitrogen-gas-fracking>



Figure 1 Location map

1.3 Resource consents

1.3.1 Discharges of wastes to land

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

The Company hold one resource consent which was issued with two consent numbers, the details of which are summarised in Table 2 below. The first consent number (10544-1) permits discharge of the hydraulic fracturing fluid into land and the second (10563-1) permits the same discharges within the coastal marine area.

Summaries of the conditions attached to the permit are set out in Section 3 of this report. A summary of the various consent types issued by the Council is included Appendix I, as is a copy of the permit held by the Company during the period under review.

Table 2 resource consent held by the Company during the period under review

Consent number	Purpose of consent	Granted	Next review	Expires
10544-1 &10563-1	To discharge water based hydraulic fracturing fluids into land including the coastal marine area at depths greater than 2,400 m TVDss beneath the Kauri-E wellsite	10/04/2018	June 2020	01/06/2034

1.4 Monitoring programme

1.4.1 Introduction

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

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

The monitoring programme for the Kauri-E wellsite consisted of four primary components.

1.4.2 Programme liaison and management

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

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

1.4.3 Assessment of data submitted by the consent holder

As required by the conditions of consent 10544-1 & 10563-1, Westside submitted pre and post-fracturing discharge reports to the Council for the well fractured during the period under review. Pre-fracturing discharge reports provide an outline of the proposed fracturing operations in relation to each well, while post-fracturing reports confirm details of what actually occurred. The specific range of information required in each report is stipulated in the conditions of the consent.

1.4.4 Physiochemical sampling

1.4.4.1 Groundwater

As a generally accepted rule, all existing bores or wells within a 1 km radius of a hydraulic fracturing activity are assessed for their suitability for sampling (or otherwise) and inclusion in the monitoring programme for the wellsite. The survey of existing sites resulted in several bores being identified in close proximity to the wellsite. Of those identified, only one (GND2371) was suitable. All other bores were either up-gradient, too shallow or had been installed to monitor land farming activities. GND2371, which was installed by Origin in 2013, specifically for monitoring hydraulic fracturing at the Kauri-E wellsite, is the sole groundwater monitoring site included in the monitoring programme. A summary of bore details for GND2371 are included in Table 3 and the location of the bore is illustrated in Figure 1.

Samples of groundwater were obtained pre-fracturing to provide a baseline reference of groundwater composition and a further two rounds of sampling were carried out following completion of the activities.

Table 3 Details of groundwater sites included in the monitoring programme

Monitoring site	Eastings (NZTM)	Northings (NZTM)	Distance from wellsite (m)	Total depth (m)	Screened/open interval (m)	Aquifer
GND2371	1718794	5605299	<20	24	15-24	Marine sediments

1.4.4.2 Surface water

There are no fresh surface water resources in close proximity to the Kauri-E wellsite consequentially, there is no surface water monitoring required in relation to hydraulic fracturing activities undertaken at the wellsite.

1.4.4.3 Hydraulic fracturing and return fluids

In addition to the sampling of local groundwater, representative samples of the hydraulic fracturing fluid and reservoir fluids produced back to the wellhead immediately following each fracturing event (return fluids) were obtained for analysis.

Samples of return fluids were collected at regular intervals during the flow-back period. Return fluids comprise 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 fluid injected during the hydraulic fracturing process. As the volume of fluid produced from the well increases, the proportion of hydraulic fracturing fluid reduces relative to formation fluids. The individual samples of return fluid are generally combined in a composite sample for laboratory analysis. Composites are designed to provide a representative sample of fluids returning to the wellhead over the entire flow-

back period. All samples were transported to Hill Laboratories Ltd (Hills) for analysis following standard chain of custody procedures.

2 Results

2.1 Consent holder submitted data

The Company submitted a pre-fracturing report that summarised the proposed programme on 4 June 2018. Following completion of hydraulic fracturing the Company submitted an interim post-fracturing report on 21 November 2018 and a final post-fracturing report on 20 March 2019.

2.1.1 Kauri-E2 post-fracturing discharge report

The conclusions from the Kauri-E2 post-fracturing discharge reports are summarised as follows:

- A total of two zones were fractured over the period 29 August to 31 August 2018 at depths between 2,433 to 2,604 m TVDss.
- Three discharges were undertaken as follows:
 - Injection test 29 August 2018;
 - Mini fracture discharge 30 August 2018; and
 - Hydraulic fracture discharge 31 August 2018.
- A total of 16,261 bbls (1,939 m³) of liquid was discharged across the two fractured zones. The total proppant weight was 300 tonnes (661,400 lbs).
- The Kauri-E2 well was opened for flow-back following completion of hydraulic fracturing. The well flowed 53 bbls (8.4 m³) of fluid and then ceased to flow naturally and the well subsequently became a vacuum.
- The well was opened to flow on 13 November 2018 following a workover.
- The water returned to the wellhead was made up of workover brine, fracture fluid and reservoir fluid.
- No measurable amount of proppant was returned from the formation following flow back.
- No screen outs occurred during hydraulic fracturing of the Kauri-E2 well.
- All return fluid was disposed of via Westside's Manutahi water flood scheme.
- Pressure testing was undertaken of all surface equipment, including flow lines and the wellhead, prior to injection.
- There was no escape of fluids during hydraulic fracturing operations.
- There were no seismic events recorded within a 5 km radius (in three dimensions) of the discharge location over the 72 hour period following hydraulic fracturing.
- It is considered that the mitigation measures implemented by Westside were effective in reducing the potential for any adverse environmental effects associated with fracturing operations.

2.2 Physiochemical sampling

2.2.1 Groundwater

Hydraulic fracturing activities commenced at the Kauri-E wellsite on 29 August 2018 and continued until 31 August 2018. A pre-fracturing baseline sample was collected on 24 May 2018. Post-fracturing samples were collected three months and 12 months following commencement of the activities on 27 November 2018 and 15 August 2019 respectively.

Samples demonstrate relatively narrow ranges between analyte concentrations over time. The subtle variation in analyte concentrations at each site are a result of natural seasonal fluctuation and sampling

variability. The results of the laboratory analysis indicate there have been no significant changes in groundwater composition over the period monitored.

A summary of the results for groundwater samples taken in relation to the hydraulic fracturing activities compared to baseline is included in Table 4. The certificates of analysis for the review period are included in Appendix II.

Table 4 Results of groundwater sampling carried out in relation to the Kauri-E2 hydraulic fracturing event

Parameter	Bore id	GND2371		
		Pre-frac (baseline)	3 mth post-frac	1 Year post-frac
-	Unit			
Sample date	-	22 May 2018	29 Nov 2018	15 Aug 2019
Sample time	-	13:15	12:45	11:55
Sample id.	-	TRC182506	TRC184946	TRC192944
pH	pH	6.9	6.6	6.6
Temperature	°C	14.4	17.0	15.3
Total alkalinity	g/m ³ CaCO ₃	62	90	79
Bicarbonate	g/m ³ HCO ₃	75	110	96
Total hardness	g/m ³ CaCO ₃	112	162	131
Electrical conductivity	mS/m	44.8	56.3	50.6
Total dissolved solids	g/m ³	300	350	380
Dissolved calcium	g/m ³	21	30	24
Chloride	g/m ³	61	74	61
Dissolved magnesium	g/m ³	14.4	21.0	17.1
Dissolved potassium	g/m ³	6.6	8.0	7.3
Dissolved sodium	g/m ³	38	44	53
Nitrite nitrogen	g/m ³ N	< 0.002	< 0.002	< 0.002
Nitrate nitrogen	g/m ³ N	9.0	8.5	9.5
Nitrate & nitrite nitrogen	g/m ³ N	9.0	8.5	9.5
Sulphate	g/m ³	23	30	25
Dissolved barium	mg/kg	0.019	0.021	0.017
Bromide	g/m ³	0.20	0.17	0.18
Dissolved copper	g/m ³	0.0014	0.0020	0.0021
Dissolved iron	g/m ³	< 0.02	< 0.02	0.06
Dissolved manganese	g/m ³	0.0007	0.0009	0.0073
Dissolved mercury	g/m ³	< 0.00008	< 0.00008	< 0.00008
Dissolved nickel	g/m ³	< 0.0005	< 0.0005	< 0.0005
Dissolved zinc	g/m ³	0.114	0.039	0.047
Ethylene glycol	g/m ³	< 4	< 4	< 4
Propylene glycol	g/m ³	< 4	< 4	< 4
Methanol	g/m ³	< 2	< 2	< 2

Parameter	Bore id	GND2371		
		Pre-frac (baseline)	3 mth post-frac	1 Year post-frac
-	Unit			
Sample date	-	22 May 2018	29 Nov 2018	15 Aug 2019
Sample time	-	13:15	12:45	11:55
Sample id.	-	TRC182506	TRC184946	TRC192944
Benzene	g/m ³	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m ³	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m ³	< 0.0010	< 0.0010	< 0.0010
m-Xylene	g/m ³	< 0.002	< 0.002	< 0.002
o-Xylene	g/m ³	< 0.0010	< 0.0010	< 0.0010
Formaldehyde	g/m ³	< 0.02	< 0.02	< 0.02
Ethane	g/m ³	< 0.003	< 0.003	< 0.003
Ethylene	g/m ³	< 0.004	< 0.004	< 0.004
Methane	g/m ³	< 0.002	< 0.002	< 0.002
C7-C9 hydrocarbons	g/m ³	< 0.06	< 0.06	< 0.06
C10-C14 hydrocarbons	g/m ³	< 0.2	< 0.2	< 0.2
C15-C36 hydrocarbons	g/m ³	< 0.4	< 0.4	< 0.4
Total hydrocarbons	g/m ³	< 0.7	< 0.7	< 0.7

2.2.2 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 Kauri-E2 well are shown below in Table 5. The certificates of analysis are included in Appendix III.

The results of the analyses carried out on the return fluid samples obtained following the hydraulic fracturing of the Kauri-E2 well are summarised below (Table 6). The certificates of analysis are included in Appendix III.

Return fluids were collected immediately following hydraulic fracturing and then again during the main flow back which occurred in November 2019. The results demonstrate the variability of groundwater composition and hydrocarbon concentrations during flow back. The relatively high levels of chloride, and sodium in the November sample indicate that return fluid contained a greater proportion of reservoir fluids than that taken in August. The results from the sample collected in August immediately following the event indicate a higher proportion of fracturing fluids introduced during the fracturing activities, which are comprised predominantly of freshwater.

Table 5 Results of hydraulic fracturing fluid sampling

Parameter	Bore id	GND2643	
		Fracturing fluid	
-	Unit		
Sample date	-	29 Aug 2018	30 Aug 2018
Lab number	-	TRC183523	TRC183522
Ethylene glycol	g/m ³	< 4	< 4
Propylene glycol	g/m ³	< 4	< 4

Parameter	Bore id	GND2643	
-	Unit	Fracturing fluid	
Sample date	-	29 Aug 2018	30 Aug 2018
Lab number	-	TRC183523	TRC183522
Methanol	g/m ³	< 2	< 2
Benzene	g/m ³	< 0.0010	< 0.0010
Toluene	g/m ³	< 0.0010	< 0.0010
Ethylbenzene	g/m ³	0.0101	< 0.0010
m-Xylene	g/m ³	< 0.002	< 0.002
o-Xylene	g/m ³	0.0011	< 0.0010
C7-C9 hydrocarbons	g/m ³	< 0.06	< 0.06
C10-C14 hydrocarbons	g/m ³	23	710
C15-C36 hydrocarbons	g/m ³	5	67
Total hydrocarbons	g/m ³	28	780

Table 6 Results of hydraulic fracturing return fluid sampling

Parameter	Bore id	GND2643	
-	Unit	Return fluid	
Sample date	-	31 Aug 2018	13 Nov 2018
Lab number	-	TRC183524	TRC185079
pH	pH	7.7	7.4
Total alkalinity	g/m ³ CaCO ₃	91	640
Bicarbonate	g/m ³ HCO ₃	137	350*
Total hardness	g/m ³ CaCO ₃	110	440
Electrical conductivity	mS/m	228	2,870
Total dissolved solids	g/m ³	2,200	Not calculated
Total barium	mg/kg	0.27	0.73
Bromide	g/m ³	0.21	53
Total calcium	g/m ³	23	110
Total copper	g/m ³	0.03	< 0.0053
Total iron	g/m ³	22	5.6
Total magnesium	g/m ³	12.7	39
Total manganese	g/m ³	0.55	1.13
Total mercury	g/m ³	0.0004	< 0.00008
Total nickel	mg/kg	< 0.03	< 0.032
Total potassium	g/m ³	22	2800
Total sodium	g/m ³	73	4100

Parameter	Bore id	GND2643	
-	Unit	Return fluid	
Sample date	-	31 Aug 2018	13 Nov 2018
Lab number	-	TRC183524	TRC185079
Total sulphur	g/m ³	133	19
Total zinc	g/m ³	0.144	< 0.021
Chloride	g/m ³	430	8,800
Nitrite nitrogen	g/m ³ N	0.0102	0.0015
Nitrate nitrogen	g/m ³ N	0.58	0.0012
Nitrate & nitrite nitrogen	g/m ³ N	0.59	0.0028
Sulphate	g/m ³	400	58
Ethylene glycol	g/m ³	< 4	< 4
Propylene glycol	g/m ³	< 4	< 4
Methanol	g/m ³	< 2	50
Benzene	g/m ³	0.0032	4.4
Toluene	g/m ³	0.0021	1.79
Ethylbenzene	g/m ³	< 0.0010	0.025
m-Xylene	g/m ³	< 0.002	1.38
o-Xylene	g/m ³	< 0.0010	0.78
Formaldehyde	g/m ³	< 0.15	< 0.15
C7-C9 hydrocarbons	g/m ³	< 0.06	8.2
C10-C14 hydrocarbons	g/m ³	49	11.2
C15-C36 hydrocarbons	g/m ³	12.1	35
Total hydrocarbons	g/m ³	61	54

*Note: The oil and water fractions of the November sample were both analysed by Hills. Results for the water fraction are provided with one exception * Bicarbonate was measured in the oil fraction as mg/kg received.*

2.3 Investigations, interventions, and incidents

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

The Council operates and maintains a register of all complaints or reported and discovered excursions from acceptable limits and practices, including non-compliance with consents, which may damage the environment. The incident register includes events where the consent holder 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, the Council was not required to undertake significant additional investigations and interventions, or record incidents, in association with Westside's conditions in resource consents or provisions in Regional Plans.

The final post-fracturing report was submitted later than required by consent conditions. The Company contacted the Council on 12 March 2019 as soon as the oversight was realised, and submitted the report as soon as was practicable following the discovery. As the interim report was submitted within the required timeframe and the late submission of the final report purely administrative, no further action was deemed necessary.

Table 7 Incidents, investigations, and interventions summary table

Date	Details	Compliant (Y/N)	Enforcement Action Taken?	Outcome
8/04/2019	Final post-fracturing report was due by 19 February 2019/within 90 days of the interim report being submitted	N	Not required	The Company contacted the Council and submitted the report on 20 March 2019

3 Discussion

3.1 Environmental effects of exercise of consents

One well (Kauri-E2) was stimulated by hydraulic fracturing at the Kauri-E wellsite during the period 29 August to 31 August 2018.

Groundwater monitoring was carried out by the Council in relation to the fracturing event undertaken. No surface water monitoring was required. The groundwater monitoring component incorporated pre and post-fracturing sampling at one groundwater monitoring site in the vicinity of the Kauri-E wellsite. The results of post-fracturing groundwater sampling carried out showed only very minor variations in water composition in comparison to baseline results. The minor variations in analytes are a result of natural variations in water composition.

In summary, the monitoring carried out by the Council during the period being reported indicated that the hydraulic fracturing activities undertaken by Westside at the Kauri-E wellsite had had no significant 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 8 below.

Table 8 Summary of performance for consent 10544-1 & 10563-1

Purpose: To discharge water based hydraulic fracturing fluids into land including the coastal marine area at depths greater than 2,400 m TVDss beneath the Kauri-E wellsite		
Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Any discharge shall occur below 3,500 m TVDss	Assessment of consent holder submitted data	Yes
2. No discharge shall occur after 1 June 2029	Assessment of consent holder submitted data	N/A
3. Seismic monitoring requirement	Notification received	N/A
4. Investigation and reporting requirements if an event occurs under condition 3	Report received	N/A
5. Exercise of consent shall not result in any contaminants reaching any useable freshwater	Results of groundwater monitoring	Yes
6. Consent holder shall undertake sampling programme	Development and certification of a monitoring programme	Yes
7. Monitoring programme to include a minimum of one suitable bore	Consultation and installation of monitoring bore	Yes
8. 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

Purpose: To discharge water based hydraulic fracturing fluids into land including the coastal marine area at depths greater than 2,400 m TVDs beneath the Kauri-E wellsite		
Condition requirement	Means of monitoring during period under review	Compliance achieved?
9. 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
10. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing	Assessment of consent holder submitted data	Yes
11. A pre-fracturing discharge report is to be provided to the Council 14 days prior to discharge	Pre-fracturing discharge report received	Yes
12. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	Yes
13. A post-fracturing discharge report is to be provided to the Council within 90 days of any commencement	Post-fracturing discharge report received	N/A
14. An interim post-fracturing discharge report is to be provided in order to meet the 90 day requirement if the consent holder cannot provide all the information required by condition 13	Interim and final post-fracturing reports received	No- final report was submitted late
15. The reports outlined in conditions 11 and 13 must be emailed to consents@trc.govt.nz	Reports received via email	Yes
16. 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
17. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
18. Fracture fluid composition no less than 95 % water and proppant by volume	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes
19. Lapse clause	Receive notice of exercise of consent	Yes
20. 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		Good

N/A = not applicable

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

3.3 Alterations to monitoring programmes of future hydraulic fracturing events

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

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

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

It is proposed that the range of monitoring carried out in relation to the hydraulic fracturing activities undertaken by Westside be replicated for any future fracturing events at the Kauri-E wellsite.

Recommendations to this effect are included in Section 4 of this report.

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

3.4 Exercise of optional review of consent

Resource consent 10544-1 & 10563-1 provide for an optional review of the consent in June 2021. Condition 20 allows the Council to review the consent, for the purpose 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 17; and/or
- c. ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Based on the results of monitoring during 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 in the first instance, the range of monitoring carried out during the reporting period in relation to Westside's hydraulic fracturing activities be replicated for any future fracturing events at the Kauri-E wellsite.
2. THAT should there be issues with environmental or administrative performance in future periods, monitoring may be adjusted to reflect any additional investigation or intervention as found necessary.
3. THAT the option for a review of resource consents in June 2021, as set out in condition 20 of the consent not be exercised.

Glossary of common terms and abbreviations

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

Biomonitoring	Assessing the health of the environment using aquatic organisms.
bbls	Barrel. Unit of measure used in the oil and gas industry (equivalent to approximately 159 litres).
Conductivity	Conductivity, an indication of the level of dissolved salts in a sample, usually measured at 25°C and expressed in $\mu\text{S}/\text{cm}$.
DO	Dissolved oxygen.
E.coli	Escherichia coli, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
EPT	Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) which are macroinvertebrates sensitive to pollution.
Fresh	Elevated flow in a stream, such as after heavy rainfall.
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.
L/s	Litres per second.
Macroinvertebrate	An invertebrate that is large enough to be seen without the use of a microscope.
masl	Metres above sea level.
MCI	Macroinvertebrate community index; a numerical indication of the state of biological life in a stream that takes into account the sensitivity of the taxa present to organic pollution in stony habitats.
mS/m	Millisiemens per metre.
m^3	Cubic metre (1,000 litres).
NZTM	New Zealand Transverse Mercator coordinates.
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.
Physicochemical	Measurement of both physical properties (e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment.
Resource consent	Refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15).
RMA	Resource Management Act 1991 and including all subsequent amendments.

Screen Out	A condition that occurs when the solids carried in a treatment fluid, such as proppant in a fracture fluid, create a bridge across the perforations or similar restricted flow area. This creates a sudden and significant restriction to fluid flow that causes a rapid rise in pump pressure.
SQMCI	Semi quantitative macroinvertebrate community index.
TVDss	True vertical depth sub-sea.
$\mu\text{S/cm}$	Microsiemens per centimetre.
Workover	The repair or stimulation of an existing production well for the purpose of restoring, prolonging or enhancing the production of hydrocarbons.

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

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- Taranaki Regional Council (2015) Origin Energy Resources NZ Ltd Kauri-E hydraulic fracturing monitoring programme report 2013-2015. June 2015. Frodo number 1503831.
- Westside New Zealand Ltd (2019) Kauri-E2 final post-fracturing discharge report resource consent number 10544-1 & 10563-1. March 2019. Frodo number #2227514.
- Westside New Zealand Ltd (2019) Kauri-E2 post-fracturing discharge report interim resource consent number 10544-1 & 10563-1. November 2018. Frodo number #2170988.
- Westside New Zealand Ltd (2018) Kauri-E2 pre-fracturing discharge report resource consent number 10544-1 & 10563-1. May 2018. Frodo number #2064744.
- Westside New Zealand Ltd (2018) Westside Petroleum Ltd hydraulic fracturing Kauri-E wellsite water quality monitoring programme. April 2018. Frodo number #2035400.

Appendix I

Resource consent held by Westside New Zealand Ltd

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

Water abstraction permits

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

Water discharge permits

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

Air discharge permits

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

Discharges of wastes to land

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

Land use permits

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

Coastal permits

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

**Discharge Permit
&
Coastal Permit**
**Pursuant to the Resource Management Act 1991
a resource consent is hereby granted by the
Taranaki Regional Council**

Name of
Consent Holder: Westside New Zealand Limited
PO Box 550
Hawera 4640

Decision Date: 10 April 2018

Commencement Date: 10 April 2018

Conditions of Consent

Consent Granted: To discharge water based hydraulic fracturing fluids into land including the coastal marine area at depths greater than 2,400 mTVDss beneath the Kauri-E wellsite

Expiry Date: 1 June 2034

Review Date(s): June annually and in accordance with special condition 20

Site Location: Kauri-E wellsite, Geary Road, Manutahi
(Property owner: AR Geary)

Grid Reference (NZTM) 1718870E-5605318N

Catchment: Waikaikai

*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 2,400 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 2029.
3. If the GeoNet seismic monitoring network records a seismic event higher than a Modified Mercalli intensity of magnitude 3.0 within 5 km of the geographical position (in 3 dimensions) of any hydraulic fracturing discharge, then:
 - (a) if a hydraulic fracturing discharge is currently being undertaken it shall cease immediately and not recommence; or
 - (b) if a hydraulic fracturing discharge has occurred within the previous 72 hours no further hydraulic fracturing discharges shall occur.
4. Following the occurrence of any seismic event described in special condition 3 the consent holder shall investigate and report to the Chief Executive, Taranaki Regional Council on the likelihood of the seismic event being induced by the exercise of this consent. Hydraulic fracturing discharges may only then continue once the Chief Executive, Taranaki Regional Council has considered the report and concluded that the environmental risk of recommencing hydraulic fracturing is acceptable and has advised the consent holder accordingly.
5. 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 1,000 mg/L.
6. 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 5 (the 'Monitoring Programme'). The Monitoring Programme shall be certified by the Chief Executive, Taranaki Regional Council, before this consent is exercised, and shall include:
 - (a) the location of the discharge point(s);
 - (b) the location and details of all bores and wells within 1000 metres of the wellsite;
 - (c) confirmation of the bores and wells identified in 6(b) above that will be sampled and the reasons they were, or weren't, chosen;
 - (d) the location of any surface water sampling sites; and
 - (e) sampling frequency with reference to a hydraulic fracturing programme.

Consent 10544-1.0 & 10563-1.0

7. 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.
8. All water samples taken for monitoring purposes shall be taken in accordance with recognised field procedures and analysed for:
 - (a) pH;
 - (b) conductivity;
 - (c) total dissolved solids;
 - (d) major ions (Ca, Mg, K, Na, total alkalinity, bromide, chloride, nitrate-nitrogen, and sulphate);
 - (e) trace metals (barium, copper, iron, manganese, nickel, and zinc);
 - (f) total petroleum hydrocarbons;
 - (g) formaldehyde;
 - (h) dissolved methane and ethane gas;
 - (i) methanol;
 - (j) glycols;
 - (k) benzene, toluene, ethylbenzene, and xylenes (BTEX); and
 - (l) carbon-13 composition of any dissolved methane gas discovered ($^{13}\text{C-CH}_4$).

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

9. 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 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, Taranaki Regional Council within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 5.

Note: The Sampling and Analysis Plan may be combined with the Monitoring Programme required by condition 6.

10. 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.

Consent 10544-1.0 & 10563-1.0

11. Any hydraulic fracture discharge 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 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 17;
 - (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 5;
 - (h) the extent and permeability characteristics of the geology above the discharge point to the surface;
 - (i) any identified faults within the modelled 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 casing and the anticipated maximum well and discharge pressures and the duration of the pressures;
 - (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 17.

12. 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 11, 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.

Consent 10544-1.0 & 10563-1.0

13. Subject to condition 14, within 90 days of any commencement date as advised under condition 12, the consent holder shall submit a comprehensive 'Post-fracturing Discharge Report' to the Chief Executive, Taranaki Regional Council.

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 8(a) to 8(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 30 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 10 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 5;
 - (l) results of the monitoring referred to in condition 11(d); and
 - (m) an assessment of the effectiveness of the mitigation measures in place with specific reference to those described in the application for this consent.
14. On occasions, including for programs involving multiple hydraulic fracturing discharges, more than one 'Post-fracturing discharge report' may be required in order to meet the 90-day deadline from commencement required by condition 13. In these situations the consent holder shall submit an 'Interim Post-fracturing Discharge Report', which includes all the information that is available, to the Chief Executive, Taranaki Regional Council within 90 days and a final Post-fracturing report as soon as practicable but within 90 days of the interim report.
15. The reports described in conditions 11 and 13 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.

Consent 10544-1.0 & 10563-1.0

16. 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.
17. 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.
18. The fracture fluid shall be comprised of no less than 95% water and proppant by volume.
19. This consent shall lapse on 30 June 2023, 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.
20. The Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review:
 - a) during the month of June each year, and/or
 - b) within 30 days of receiving any investigation and report in accordance with condition 4 above;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 17; 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 10 April 2018

For and on behalf of
Taranaki Regional Council

A D McLay
Director - Resource Management

Appendix II

Certificates of analysis (groundwater)



Certificate of Analysis

Client:	Taranaki Regional Council	Lab No:	2225310	SPV1
Contact:	Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352	Date Received:	16-Aug-2019	
		Date Reported:	23-Aug-2019	
		Quote No:	47915	
		Order No:	72831	
		Client Reference:	#5210 - Westside Kauri E 1 Yr Post frac GW	
		Submitted By:	Sarah Larkin	

Sample Type: Aqueous

Sample Name:	TRC192944 (GND2371) 15-Aug-2019 11:55 am				
Lab Number:	2225310.1				

Individual Tests

Sum of Anions	meq/L	4.5	-	-	-	-
Sum of Cations	meq/L	5.1	-	-	-	-
pH	pH Units	6.6	-	-	-	-
Total Alkalinity	g/m ³ as CaCO ₃	79	-	-	-	-
Bicarbonate	g/m ³ at 25°C	96	-	-	-	-
Total Hardness	g/m ³ as CaCO ₃	131	-	-	-	-
Electrical Conductivity (EC)	mS/m	50.6	-	-	-	-
Total Dissolved Solids (TDS)	g/m ³	380	-	-	-	-
Sample Temperature*	°C	15.3	-	-	-	-
Dissolved Barium	g/m ³	0.017	-	-	-	-
Dissolved Calcium	g/m ³	24	-	-	-	-
Dissolved Copper	g/m ³	0.0021	-	-	-	-
Dissolved Iron	g/m ³	0.06	-	-	-	-
Dissolved Magnesium	g/m ³	17.1	-	-	-	-
Dissolved Manganese	g/m ³	0.0073	-	-	-	-
Dissolved Mercury	g/m ³	< 0.00008	-	-	-	-
Dissolved Nickel	g/m ³	< 0.0005	-	-	-	-
Dissolved Potassium	g/m ³	7.3	-	-	-	-
Dissolved Sodium	g/m ³	53	-	-	-	-
Dissolved Zinc	g/m ³	0.047	-	-	-	-
Bromide	g/m ³	0.18	-	-	-	-
Chloride	g/m ³	61	-	-	-	-
Nitrite-N	g/m ³	< 0.002	-	-	-	-
Nitrate-N	g/m ³	9.5	-	-	-	-
Nitrate-N + Nitrite-N	g/m ³	9.5	-	-	-	-
Sulphate	g/m ³	25	-	-	-	-
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	-	-	-	-



Sample Type: Aqueous						
Sample Name:	TRC192944 (GND2371) 15-Aug-2019 11:55 am					
Lab Number:	2225310.1					
BTEX in Water by Headspace GC-MS						
Benzene	g/m ³	< 0.0010	-	-	-	-
Toluene	g/m ³	< 0.0010	-	-	-	-
Ethylbenzene	g/m ³	< 0.0010	-	-	-	-
m&p-Xylene	g/m ³	< 0.002	-	-	-	-
o-Xylene	g/m ³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	-	-	-	-
Ethylene	g/m ³	< 0.004	-	-	-	-
Methane	g/m ³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.06	-	-	-	-
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. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
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	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 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 mEq/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N, Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23 rd ed. 2017.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEq/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H ⁺) also included in calculation if available. APHA 1030 E 23 rd ed. 2017.	0.05 meq/L	1
pH	pH meter. APHA 4500-H ⁺ B 23 rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23 rd ed. 2017.	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 23 rd ed. 2017.	1.0 g/m ³ at 25°C	1

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23 rd ed. 2017.	1.0 g/m ³ as CaCO ₃	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23 rd ed. 2017.	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) 23 rd ed. 2017.	10 g/m ³	1
Sample Temperature*	Supplied by customer, otherwise 20°C.	0.1 °C	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017.	0.005 g/m ³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017.	0.05 g/m ³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017.	0.0005 g/m ³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017.	0.02 g/m ³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017.	0.02 g/m ³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017.	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 23 rd ed. 2017.	0.0005 g/m ³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017.	0.05 g/m ³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017.	0.02 g/m ³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017.	0.0010 g/m ³	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017.	0.05 g/m ³	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017.	0.5 g/m ³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I (modified) 23 rd ed. 2017.	0.002 g/m ³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. 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 (modified) 23 rd ed. 2017.	0.002 g/m ³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017.	0.5 g/m ³	1
C7 - C9	Head Space, GCMS analysis.	0.06 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.

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

Ara Heron BSc (Tech)
Client Services Manager - Environmental



Certificate of Analysis

Client:	Taranaki Regional Council	Lab No:	1987951	SPV1
Contact:	Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352	Date Received:	24-May-2018	
		Date Reported:	31-May-2018	
		Quote No:	47915	
		Order No:	71858	
		Client Reference:	Groundwater HF	
		Submitted By:	Sarah Larkin	

Sample Type: Aqueous

Sample Name:	GND 2371 23-May-2018 1:15 pm				
Lab Number:	1987951.1				

Individual Tests						
Sum of Anions	meq/L	4.1	-	-	-	-
Sum of Cations	meq/L	4.1	-	-	-	-
pH	pH Units	6.9	-	-	-	-
Total Alkalinity	g/m ³ as CaCO ₃	62	-	-	-	-
Bicarbonate	g/m ³ at 25°C	75	-	-	-	-
Total Hardness	g/m ³ as CaCO ₃	112	-	-	-	-
Electrical Conductivity (EC)	mS/m	44.8	-	-	-	-
Total Dissolved Solids (TDS)	g/m ³	300	-	-	-	-
Dissolved Barium	g/m ³	0.0188	-	-	-	-
Dissolved Calcium	g/m ³	21	-	-	-	-
Dissolved Copper	g/m ³	0.0014	-	-	-	-
Dissolved Iron	g/m ³	< 0.02	-	-	-	-
Dissolved Magnesium	g/m ³	14.4	-	-	-	-
Dissolved Manganese	g/m ³	0.0007	-	-	-	-
Dissolved Mercury	g/m ³	< 0.00008	-	-	-	-
Dissolved Nickel	g/m ³	< 0.0005	-	-	-	-
Dissolved Potassium	g/m ³	6.6	-	-	-	-
Dissolved Sodium	g/m ³	38	-	-	-	-
Dissolved Zinc	g/m ³	0.114	-	-	-	-
Bromide	g/m ³	0.20	-	-	-	-
Chloride	g/m ³	61	-	-	-	-
Nitrite-N	g/m ³	< 0.002	-	-	-	-
Nitrate-N	g/m ³	9.0	-	-	-	-
Nitrate-N + Nitrite-N	g/m ³	9.0	-	-	-	-
Sulphate	g/m ³	23	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m ³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m ³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m ³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m ³	< 0.0010	-	-	-	-
Toluene	g/m ³	< 0.0010	-	-	-	-
Ethylbenzene	g/m ³	< 0.0010	-	-	-	-
m&p-Xylene	g/m ³	< 0.002	-	-	-	-
o-Xylene	g/m ³	< 0.0010	-	-	-	-



Sample Type: Aqueous						
Sample Name:		GND 2371 23-May-2018 1:15 pm				
Lab Number:		1987951.1				
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	-	-	-	-
Ethylene	g/m ³	< 0.004	-	-	-	-
Methane	g/m ³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.06	-	-	-	-
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	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 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 mEq/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22 nd ed. 2012.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEq/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H ⁺) also included in calculation if available. APHA 1030 E 22 nd ed. 2012.	0.05 meq/L	1
pH	pH meter. APHA 4500-H ⁺ B 22 nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22 nd 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 22 nd ed. 2012.	1.0 g/m ³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 nd ed. 2012.	1.0 g/m ³ as CaCO ₃	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 nd 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) 22 nd ed. 2012.	10 g/m ³	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.00010 g/m ³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.05 g/m ³	1

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.0005 g/m ³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.02 g/m ³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.02 g/m ³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd 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 22 nd ed. 2012.	0.0005 g/m ³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.05 g/m ³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.02 g/m ³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.0010 g/m ³	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 nd ed. 2012.	0.05 g/m ³	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 nd ed. 2012.	0.5 g/m ³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I 22 nd ed. 2012 (modified).	0.002 g/m ³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. 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 22 nd ed. 2012 (modified).	0.002 g/m ³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 nd ed. 2012.	0.5 g/m ³	1
C7 - C9	Head Space, GCMS analysis.	0.06 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.

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

Ara Heron BSc (Tech)
Client Services Manager - Environmental



Certificate of Analysis

Client:	Taranaki Regional Council	Lab No:	2089135	SPV1
Contact:	Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352	Date Received:	30-Nov-2018	
		Date Reported:	10-Dec-2018	
		Quote No:	47915	
		Order No:	72831 340300326	
		Client Reference:	Kauri E 3 Month Post Frac GW	
		Add. Client Ref:	Survey #4706	
		Submitted By:	Jane Harvey	

Sample Type: Aqueous

Sample Name:	GND2371 TRC184946 29-Nov-2018 12:45 pm				
Lab Number:	2089135.1				

Individual Tests

Sum of Anions	meq/L	5.1	-	-	-	-
Sum of Cations	meq/L	5.4	-	-	-	-
pH	pH Units	6.6	-	-	-	-
Total Alkalinity	g/m ³ as CaCO ₃	90	-	-	-	-
Bicarbonate	g/m ³ at 25°C	110	-	-	-	-
Total Hardness	g/m ³ as CaCO ₃	162	-	-	-	-
Electrical Conductivity (EC)	mS/m	56.3	-	-	-	-
Total Dissolved Solids (TDS)	g/m ³	350	-	-	-	-
Dissolved Barium	g/m ³	0.021	-	-	-	-
Dissolved Calcium	g/m ³	30	-	-	-	-
Dissolved Copper	g/m ³	0.0020	-	-	-	-
Dissolved Iron	g/m ³	< 0.02	-	-	-	-
Dissolved Magnesium	g/m ³	21	-	-	-	-
Dissolved Manganese	g/m ³	0.0009	-	-	-	-
Dissolved Mercury	g/m ³	< 0.00008	-	-	-	-
Dissolved Nickel	g/m ³	< 0.0005	-	-	-	-
Dissolved Potassium	g/m ³	8.0	-	-	-	-
Dissolved Sodium	g/m ³	44	-	-	-	-
Dissolved Zinc	g/m ³	0.039	-	-	-	-
Bromide	g/m ³	0.17	-	-	-	-
Chloride	g/m ³	74	-	-	-	-
Nitrite-N	g/m ³	< 0.002	-	-	-	-
Nitrate-N	g/m ³	8.5	-	-	-	-
Nitrate-N + Nitrite-N	g/m ³	8.5	-	-	-	-
Sulphate	g/m ³	30	-	-	-	-
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	-	-	-	-



Sample Type: Aqueous						
Sample Name:	GND2371 TRC184946 29-Nov-2018 12:45 pm					
Lab Number:	2089135.1					
BTEX in Water by Headspace GC-MS						
Benzene	g/m ³	< 0.0010	-	-	-	-
Toluene	g/m ³	< 0.0010	-	-	-	-
Ethylbenzene	g/m ³	< 0.0010	-	-	-	-
m&p-Xylene	g/m ³	< 0.002	-	-	-	-
o-Xylene	g/m ³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	-	-	-	-
Ethylene	g/m ³	< 0.004	-	-	-	-
Methane	g/m ³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.06	-	-	-	-
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. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
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	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 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 mEq/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N, Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22 nd ed. 2012.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEq/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H ⁺) also included in calculation if available. APHA 1030 E 22 nd ed. 2012.	0.05 meq/L	1
pH	pH meter. APHA 4500-H ⁺ B 22 nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22 nd 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 22 nd ed. 2012.	1.0 g/m ³ at 25°C	1

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 nd ed. 2012.	1.0 g/m ³ as CaCO ₃	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 nd 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) 22 nd ed. 2012.	10 g/m ³	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.005 g/m ³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.05 g/m ³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.0005 g/m ³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.02 g/m ³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.02 g/m ³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd 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 22 nd ed. 2012.	0.0005 g/m ³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.05 g/m ³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.02 g/m ³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.0010 g/m ³	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 nd ed. 2012.	0.05 g/m ³	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 nd ed. 2012.	0.5 g/m ³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I 22 nd ed. 2012 (modified).	0.002 g/m ³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. 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 22 nd ed. 2012 (modified).	0.002 g/m ³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 nd ed. 2012.	0.5 g/m ³	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m ³	1

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

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

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Martin Cowell - BSc
Client Services Manager - Environmental

Appendix III

Certificates of analysis
(hydraulic fracturing fluids)



Certificate of Analysis

Page 1 of 4

Client:	Taranaki Regional Council	Lab No:	2043784	SPV1
Contact:	Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352	Date Received:	06-Sep-2018	
		Date Reported:	26-Sep-2018	
		Quote No:	71307	
		Order No:	72831	
		Client Reference:	340300326 Kauri E2 RF	
		Submitted By:	Sarah Larkin	

Sample Type: Saline

Sample Name:	Composite of GND2643 RF TRC183524 Comp1 & GND2643 RF TRC183524 Comp2				
Lab Number:	2043784.3				

Individual Tests

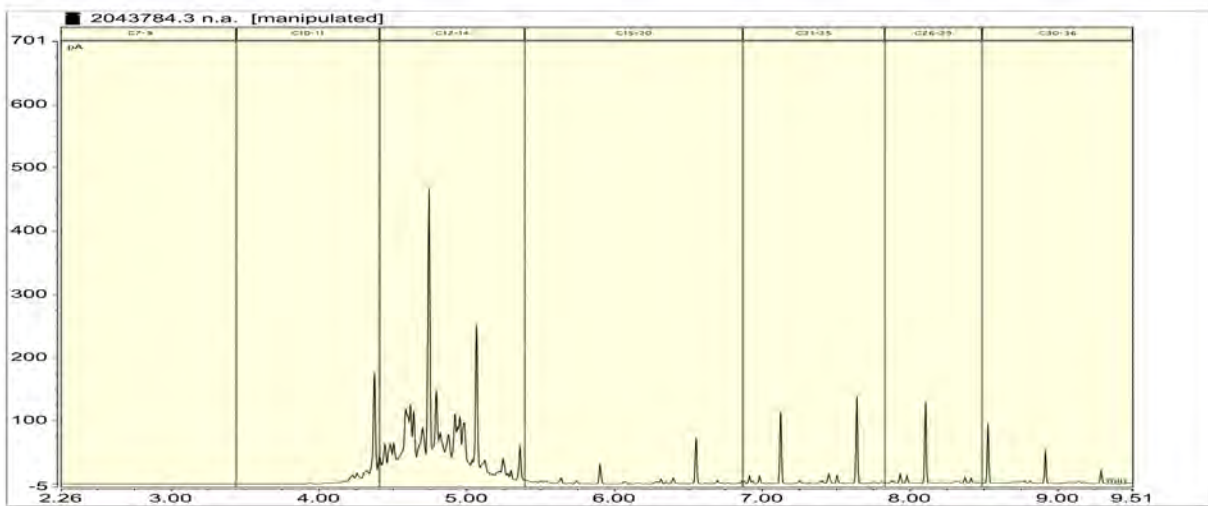
pH*	pH Units	7.7	-	-	-	-
Total Alkalinity*	g/m ³ as CaCO ₃	91	-	-	-	-
Analysis Temperature for Bicarbonate	°C	22	-	-	-	-
Bicarbonate	g/m ³ at Analysis Temperature	137	-	-	-	-
Total Hardness*	g/m ³ as CaCO ₃	110	-	-	-	-
Electrical Conductivity (EC)*	mS/m	228	-	-	-	-
Total Dissolved Solids (TDS)*	g/m ³	2,200	-	-	-	-
Total Barium*	g/m ³	0.27 #1	-	-	-	-
Total Calcium*	g/m ³	23	-	-	-	-
Total Copper*	g/m ³	0.030	-	-	-	-
Total Iron*	g/m ³	22	-	-	-	-
Total Magnesium*	g/m ³	12.7	-	-	-	-
Total Manganese*	g/m ³	0.55	-	-	-	-
Total Mercury*	g/m ³	0.00040	-	-	-	-
Total Nickel*	g/m ³	< 0.03	-	-	-	-
Total Potassium*	g/m ³	22	-	-	-	-
Total Sodium*	g/m ³	73	-	-	-	-
Total Sulphur*	g/m ³	133	-	-	-	-
Total Zinc*	g/m ³	0.144	-	-	-	-
Bromide*	g/m ³	0.21	-	-	-	-
Chloride*	g/m ³	430	-	-	-	-
Nitrite-N	g/m ³	0.0102	-	-	-	-
Nitrate-N	g/m ³	0.58	-	-	-	-
Nitrate*	g/m ³	2.6	-	-	-	-
Nitrate-N + Nitrite-N	g/m ³	0.59	-	-	-	-
Sulphate*	g/m ³	400	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m ³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m ³	< 4	-	-	-	-



Sample Type: Saline

Sample Name:	Composite of GND2643 RF TRC183524 Comp1 & GND2643 RF TRC183524 Comp2					
Lab Number:	2043784.3					
Methanol in Water - Aqueous Solvents						
Methanol*	g/m ³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m ³	0.0032	-	-	-	-
Toluene*	g/m ³	0.0021	-	-	-	-
Ethylbenzene*	g/m ³	< 0.0010	-	-	-	-
m&p-Xylene*	g/m ³	< 0.002	-	-	-	-
o-Xylene*	g/m ³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m ³	< 0.15	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.06	-	-	-	-
C10 - C14*	g/m ³	49	-	-	-	-
C15 - C36*	g/m ³	12.1	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	61	-	-	-	-

2043784.3
Composite of GND2643 RF TRC183524 Comp1 & GND2643 RF TRC183524 Comp2
Client Chromatogram for TPH by FID



Analyst's Comments

#1 It should be noted that the replicate analyses performed on this sample as part of our in-house Quality Assurance procedures showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample. The average of the results of the replicate analyses has been reported.

Appendix No.1 - HCO3 Report 2043784

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m ³	3
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m ³	3
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m ³	3
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m ³	3

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m ³	3
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m ³	3
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	3
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	3
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	3
pH*	Saline water, pH meter. APHA 4500-H ⁺ B 22 nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	3
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m ³ as CaCO ₃	3
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	3
Bicarbonate	Bicarbonate (HCO ₃) 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	3
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22 nd ed. 2012.	1.0 g/m ³ as CaCO ₃	3
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 22 nd ed. 2012.	0.10 mS/m	3
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22 nd ed. 2012.	50 g/m ³	3
Total Barium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.00063 g/m ³	3
Total Calcium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	1.1 g/m ³	3
Total Copper*	Nitric acid digestion, ICP-MS, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0011 g/m ³	3
Total Iron*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0042 g/m ³	3
Total Magnesium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.42 g/m ³	3
Total Manganese*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0011 g/m ³	3
Total Mercury*	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m ³	3
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.007 g/m ³	3
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	1.1 g/m ³	3
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.42 g/m ³	3
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H ₂ S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. APHA 3120 23rd ed. 2017.	0.5 g/m ³	3
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0042 g/m ³	3
Bromide*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 nd ed. 2012.	0.05 g/m ³	3
Chloride*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 nd ed. 2012.	0.5 g/m ³	3
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₃ - I 22nd ed. 2012 (modified).	0.0010 g/m ³	3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. In-House.	0.0010 g/m ³	3
Nitrate*	Calculation from Nitrate-N.	0.010 g/m ³	3
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO ₃ - I 22nd ed. 2012 (modified).	0.0010 g/m ³	3
Total Sulphate*	Calculation: from total sulphur.	2 g/m ³	3

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
C7 - C9	Head Space, GCMS analysis.	0.06 g/m ³	3

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

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

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



ANALYTICAL LABORATORY
 Private Bag 2000, Taupo
 Phone: (07) 374 8211
 Fax: (07) 374 8199
 Email: w.labmanager@gns.cri.nz

CERTIFICATE OF ANALYSIS
ENVSUBGNS_WAIRAKEI 70

Report No: 2018091105

Customer Ref:150671

Ara Heron
 RJ Hill Laboratories (Hamilton)
 Environmental Reports Officers
 Private Bag 3205
 Hamilton

GNS Lot No: 2018091105

GNS Sample No. 2018005894
Collection Date
Site ID 2043784.3
Field ID

pH		7.22	-	-	-
Bicarbonate (Total)	mg/l	137	-	-	-
HCO ₃ Analysis Temperature	°C	22	-	-	-
HCO ₃ Analysis Date		12/09/2018	-	-	-

SUMMARY OF METHODS AND DETECTION LIMITS

The following table gives a brief description of the methods used to conduct the analyses on this report.
 The detection limits given below are those attainable in a relatively clean matrix.

Parameter	Method	*Detection Limit	
Bicarbonate (total)	HCO ₃ Titration Method ASTM Standards D513-82 Vol.11.01 1988	20	mg/l
pH	Electrometric Method - APHA 4500-H+ B 23rd Edition 2017	-	-

*Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Notes: These samples were collected by yourselves (or your agent) and analysed as received at the laboratory. This report must not be reproduced, except in full, without the written consent of the signatory. Samples are held at the laboratory after reporting for a period of 2 to 6 months, dependent on sample type.

M. K. Appleby
 Moya Appleby
 Senior Technician



IANZ
 ACCREDITED LABORATORY

Tests marked with a †
 are not accredited and are
 outside the scope of the
 laboratory's accreditation



Certificate of Analysis

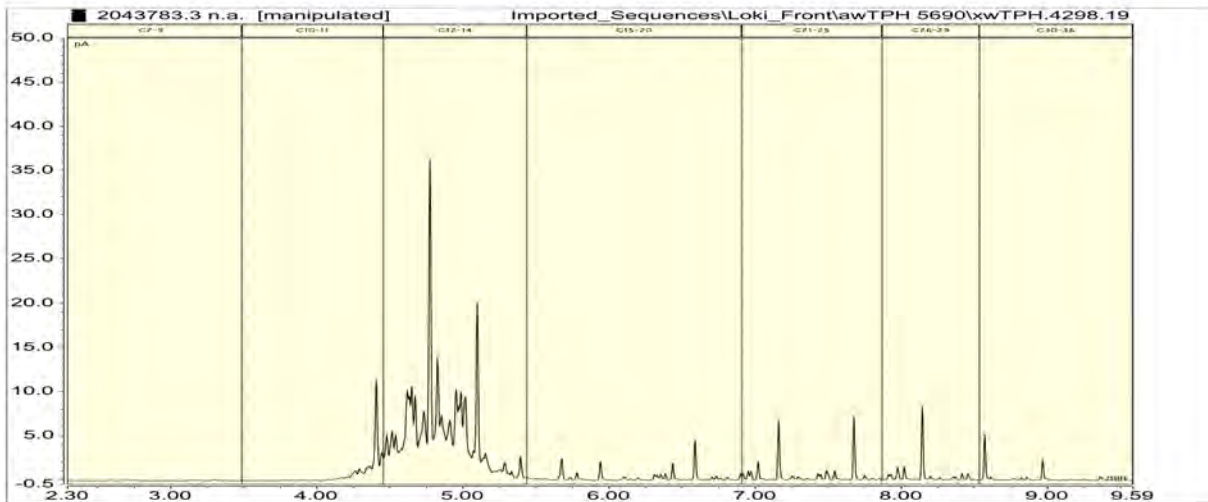
Client:	Taranaki Regional Council	Lab No:	2043783	SPV1
Contact:	Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352	Date Received:	06-Sep-2018	
		Date Reported:	17-Sep-2018	
		Quote No:	50522	
		Order No:	72831	
		Client Reference:	Hydraulic fracturing fluid testing	
		Submitted By:	Sarah Larkin	

Sample Type: Aqueous

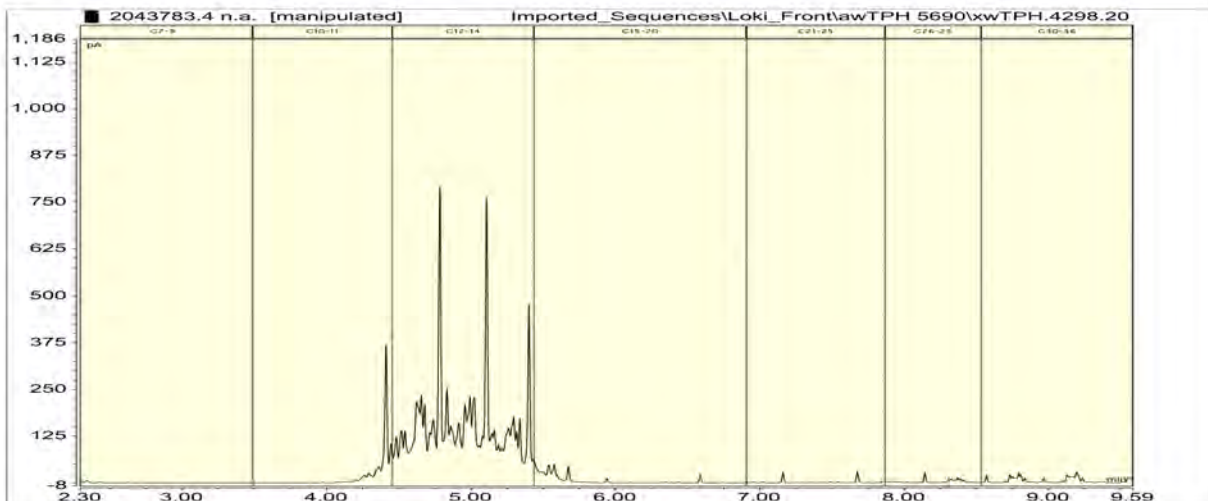
Sample Name:	GND2643 Slickfrac TRC183523 29-Aug-2018 9:30 am	Composite of GND2643 FF TRC183522 Composite 1 & GND2643 FF TRC183522 Composite 2 30-Aug-2018 2:30 pm				
Lab Number:	2043783.3	2043783.4				
Ethylene Glycol in Water						
Ethylene glycol*	g/m ³	< 4	< 4	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m ³	< 4	< 4	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m ³	< 2	< 2	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m ³	< 0.0010	< 0.0010	-	-	-
Toluene	g/m ³	< 0.0010	< 0.0010	-	-	-
Ethylbenzene	g/m ³	0.0101	< 0.0010	-	-	-
m&p-Xylene	g/m ³	< 0.002	< 0.002	-	-	-
o-Xylene	g/m ³	0.0011	< 0.0010	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.06	< 0.06	-	-	-
C10 - C14	g/m ³	23	710	-	-	-
C15 - C36	g/m ³	5	67	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	28	780	-	-	-



2043783.3
 GND2643 Slickfrac TRC183523 29-Aug-2018 9:30 am
 Client Chromatogram for TPH by FID



2043783.4
 Composite of GND2643 FF TRC183522 Composite 1 & GND2643 FF TRC183522 Composite 2 30-Aug-2018 2:30 pm
 Client Chromatogram for TPH by FID



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	3-4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m ³	3-4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m ³	3-4
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m ³	3-4
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m ³	3-4
C7 - C9	Head Space, GCMS analysis.	0.06 g/m ³	3-4

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

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

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

Ara Heron BSc (Tech)
Client Services Manager - Environmental



Certificate of Analysis

Page 1 of 5

Client:	Taranaki Regional Council	Lab No:	2093341	SPV1
Contact:	Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352	Date Received:	07-Dec-2018	
		Date Reported:	09-Jan-2019	
		Quote No:	71307	
		Order No:	72831	
		Client Reference:	#4738 - Kauri E HF Return Fluid Composite	
		Submitted By:	Sarah Larkin	

Sample Type: Saline

Sample Name:	Composite of TRC185079 (GND2643) Start, TRC185079 (GND2643) Middle and TRC185079 (GND2643) End. [water fraction]				
Lab Number:	2093341.6				

Individual Tests

pH*	pH Units	7.4	-	-	-	-
Total Alkalinity*	g/m ³ as CaCO ₃	640	-	-	-	-
Total Hardness*	g/m ³ as CaCO ₃	440	-	-	-	-
Electrical Conductivity (EC)*	mS/m	2,870	-	-	-	-
Total Barium	g/m ³	0.73	-	-	-	-
Total Calcium	g/m ³	110	-	-	-	-
Total Copper	g/m ³	< 0.0053	-	-	-	-
Total Iron	g/m ³	5.6	-	-	-	-
Total Magnesium	g/m ³	39	-	-	-	-
Total Manganese	g/m ³	1.13	-	-	-	-
Total Mercury*	g/m ³	< 0.00008	-	-	-	-
Total Nickel	g/m ³	< 0.032	-	-	-	-
Total Potassium	g/m ³	2,800	-	-	-	-
Total Sodium	g/m ³	4,100	-	-	-	-
Total Sulphur*	g/m ³	19	-	-	-	-
Total Zinc	g/m ³	< 0.021	-	-	-	-
Bromide*	g/m ³	53	-	-	-	-
Chloride*	g/m ³	8,800	-	-	-	-
Nitrite-N	g/m ³	0.0015	-	-	-	-
Nitrate-N	g/m ³	0.0012	-	-	-	-
Nitrate*	g/m ³	< 0.010	-	-	-	-
Nitrate-N + Nitrite-N	g/m ³	0.0028	-	-	-	-
Sulphate*	g/m ³	58	-	-	-	-
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	50	-	-	-	-



Sample Type: Saline

Sample Name:	Composite of TRC185079 (GND2643) Start, TRC185079 (GND2643) Middle and TRC185079 (GND2643) End. [water fraction]				
Lab Number:	2093341.6				

BTEX in Water by Headspace GC-MS

Benzene*	g/m ³	4.4	-	-	-	-
Toluene*	g/m ³	1.79	-	-	-	-
Ethylbenzene*	g/m ³	0.025	-	-	-	-
m&p-Xylene*	g/m ³	1.38	-	-	-	-
o-Xylene*	g/m ³	0.78	-	-	-	-

Formaldehyde in Water by DNPH & LCMSMS

Formaldehyde*	g/m ³	< 0.15	-	-	-	-
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Total Petroleum Hydrocarbons in Water

C7 - C9	g/m ³	8.2	-	-	-	-
C10 - C14*	g/m ³	11.2	-	-	-	-
C15 - C36*	g/m ³	35	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	54	-	-	-	-

Sample Type: Oil

Sample Name:	Composite of TRC185079 (GND2643) Start, TRC185079 (GND2643) Middle and TRC185079 (GND2643) End. [oil fraction]				
Lab Number:	2093341.5				

Individual Tests

Total Barium*	mg/kg as rcvd	3.1	-	-	-	-
Total Calcium*	mg/kg as rcvd	< 130 #1	-	-	-	-
Total Copper*	mg/kg as rcvd	< 1.0	-	-	-	-
Total Iron*	mg/kg as rcvd	160	-	-	-	-
Total Manganese*	mg/kg as rcvd	2.5	-	-	-	-
Total Nickel*	mg/kg as rcvd	< 1.0	-	-	-	-
Total Potassium*	mg/kg as rcvd	430	-	-	-	-
Total Sodium*	mg/kg as rcvd	1,160	-	-	-	-
Total Sulphur*	g/100g as rcvd	0.110	-	-	-	-
Total Zinc*	mg/kg as rcvd	< 5	-	-	-	-
Chloride*	mg/kg as rcvd	2,600	-	-	-	-

Free Product GC Scan by FID

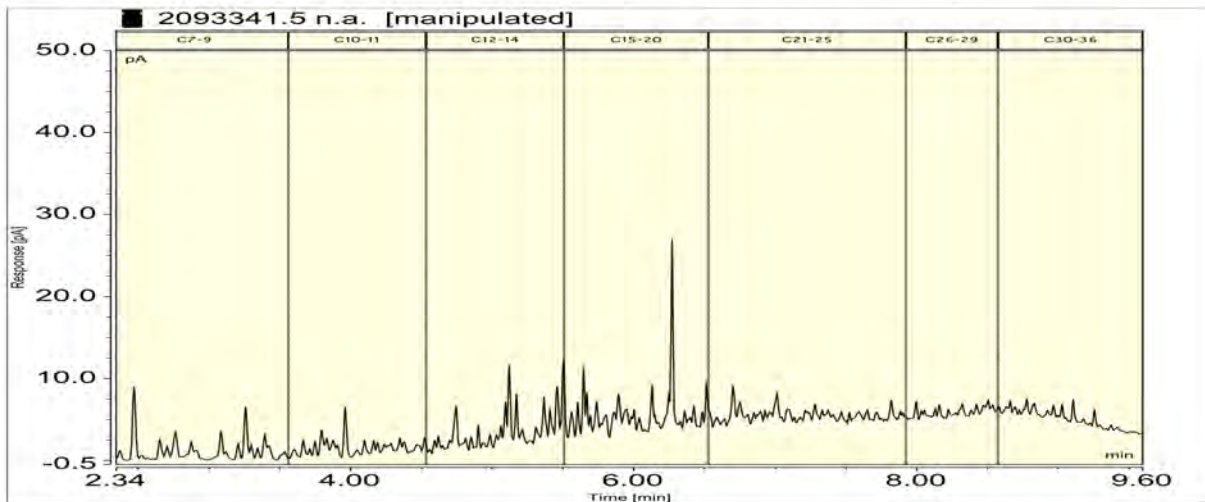
Free Product*	mL/100mL	100	-	-	-	-
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BTEX in Oil by Headspace GC-MS

Benzene*	mg/kg as rcvd	350	-	-	-	-
Toluene*	mg/kg as rcvd	780	-	-	-	-
Ethylbenzene*	mg/kg as rcvd	370	-	-	-	-
m&p-Xylene*	mg/kg as rcvd	1,640	-	-	-	-
o-Xylene*	mg/kg as rcvd	770	-	-	-	-

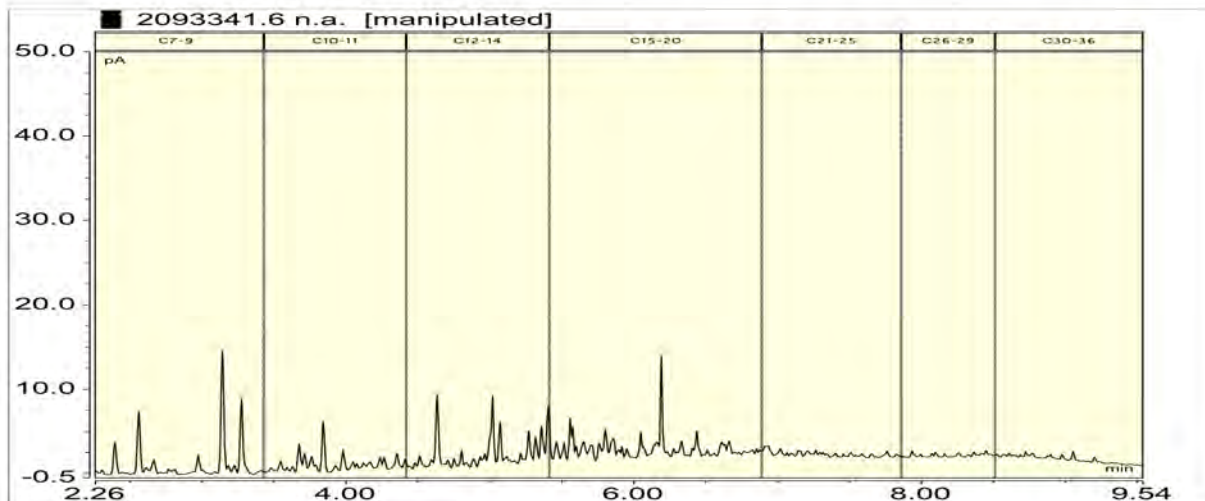
2093341.5

Composite of TRC185079 (GND2643) Start, TRC185079 (GND2643) Middle and TRC185079 (GND2643) End. [oil fraction]
Client Chromatogram for GC Scan



2093341.6

Composite of TRC185079 (GND2643) Start, TRC185079 (GND2643) Middle and TRC185079 (GND2643) End. [water fraction]
Client Chromatogram for TPH by FID



Analyst's Comments

#1 It should be noted that the blank extract contained an elevated level of calcium (109mg/kg c.f. detection limit of 50mg/kg). This has not been corrected for on the sample concentration, and the detection limit has been raised to 130mg/kg because of this.

Appendix No.1 - Sulphur report

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m ³	6
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m ³	6
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m ³	6
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m ³	6
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m ³	6

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m ³	6
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	6
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E (modified) 23 rd ed. 2017.	-	6
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E (modified) 23 rd ed. 2017.	-	6
pH*	Saline water, pH meter. APHA 4500-H ⁺ B 23 rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	6
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m ³ as CaCO ₃	6
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 23 rd ed. 2017.	1.0 g/m ³ as CaCO ₃	6
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 23 rd ed. 2017.	0.10 mS/m	6
Total Barium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017.	0.00063 g/m ³	6
Total Calcium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017.	1.1 g/m ³	6
Total Copper	Nitric acid digestion, ICP-MS, ultratrace. APHA 3125 B 23 rd ed. 2017.	0.0011 g/m ³	6
Total Iron	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017.	0.0042 g/m ³	6
Total Magnesium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017.	0.42 g/m ³	6
Total Manganese	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017.	0.0011 g/m ³	6
Total Mercury*	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m ³	6
Total Nickel	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017.	0.0070 g/m ³	6
Total Potassium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017.	1.1 g/m ³	6
Total Sodium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017.	0.42 g/m ³	6
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H ₂ S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. APHA 3120 B 23 rd ed. 2017.	0.5 g/m ³	6
Total Zinc	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017.	0.0042 g/m ³	6
Bromide*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017.	0.05 g/m ³	6
Chloride*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017.	0.5 g/m ³	6
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I (modified) 23 rd ed. 2017.	0.0010 g/m ³	6
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. In-House.	0.0010 g/m ³	6
Nitrate*	Calculation from Nitrate-N.	0.010 g/m ³	6
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO ₃ ⁻ I (modified) 23 rd ed. 2017.	0.0010 g/m ³	6
Total Sulphate*	Calculation: from total sulphur.	2 g/m ³	6
C7 - C9	Head Space, GCMS analysis.	0.06 g/m ³	6

Sample Type: Oil			
Test	Method Description	Default Detection Limit	Sample No
Client Chromatogram for GC Scan*	.	-	5
Free Product GC Scan by FID*	Dilution of free product in organic solvent	1.0 mL/100mL	5
Volume of Free Product present in TPH Water samples*	Volumes estimated using Measuring Cylinder.	1.0 mL/100mL	5

Sample Type: Oil			
Test	Method Description	Default Detection Limit	Sample No
BTEX in Oil by Headspace GC-MS*	Solvent dilution, Headspace GC-MS analysis [KBIs:5782,26687,3629]	0 mg/kg as rcvd	5
Ashing and Aqua Regia digest	Ashing in Muffle furnace, Aqua Regia (HNO ₃ /HCl) digestion.	-	5
Total Barium*	Aqua Regia Digestion, ICP-MS.	0.2 mg/kg as rcvd	5
Total Calcium*	Aqua Regia Digestion, ICP-MS.	50 mg/kg as rcvd	5
Total Copper*	Aqua Regia Digestion, ICP-MS.	1.0 mg/kg as rcvd	5
Total Iron*	Aqua Regia Digestion, ICP-MS.	20 mg/kg as rcvd	5
Total Manganese*	Aqua Regia Digestion, ICP-MS.	0.5 mg/kg as rcvd	5
Total Nickel*	Aqua Regia Digestion, ICP-MS.	1.0 mg/kg as rcvd	5
Total Potassium*	Aqua Regia Digestion, ICP-MS.	50 mg/kg as rcvd	5
Total Sodium*	Aqua Regia Digestion, ICP-MS.	20 mg/kg as rcvd	5
Total Sulphur (Sub CRL)*	LECO SC-144 Sulphur Determinator, high temperature furnace, infra-red detector. Subcontracted to CRL Energy. ASTM 4239.	0.010 g/100g as rcvd	5
Total Zinc*	Aqua Regia Digestion, ICP-MS.	2 mg/kg as rcvd	5
Chloride in Oil / Water Emulsion*	Extraction of chloride using acid / alcohol mix. Back titration of silver nitrate against potassium thiocyanate. In-House method based on Vogel's Inorganic Analysis.	70 mg/kg as rcvd	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 certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental



REPORT OF ANALYSIS

Customer: Hill Laboratories

Date Received: 19-Dec-18

Description: Samples supplied by client

Order # 151153


Customer Reference: 2093341.5

CRL Energy Ltd Reference: 112/974

Analysis - As Received Basis

Ash (ISO 1171)	w/w %	
Sulphur (ASTM D4239)	w/w %	0.11

Date of Issue: 21-Dec-18

Signature:  _____
Ben Rumsey
Research Officer

THIS REPORT MUST NOT BE QUOTED EXCEPT IN FULL

Distribution:
Hill Laboratories, 1 Clyde Street, Hamilton
CRL Energy Ltd, PO Box 31-244, Lower Hutt