

Greymouth Petroleum Ltd  
Radnor-B Hydraulic Fracturing  
Monitoring Programme  
2018-2019

Technical Report 20-35

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## Executive summary

Greymouth Petroleum Ltd (GPL) operates the Radnor-B hydrocarbon exploration site located on Radnor Road, Midhirst, in the Patea Catchment. This report outlines and discusses the results of the monitoring programme implemented by the Council in relation to hydraulic fracturing activities conducted by GPL at the wellsite over the period 27 April 2018 to 26 September 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 GPL at the Radnor-B wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Radnor-2 well.

### **During the monitoring period, GPL 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. One biomonitoring survey was also carried out on the Piakau Stream prior to commencement of the hydraulic fracturing programme. 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 first monitoring report produced by the Council in relation to the hydraulic fracturing activities at the Radnor-B wellsite.

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

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

For reference, in the 2018-2019 year, consent holders were found to achieve a high level of environmental performance and compliance for 83% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 13% of the consents, a good level of environmental performance and compliance was achieved.

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 Radnor-B wellsite.



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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 Greymouth Petroleum Ltd (GPL) at the Radnor-B wellsite. The report covers the hydraulic fracturing activities undertaken from 27 April 2018 to 26 September 2018 and assesses the Company's level of environmental performance and compliance with the resource consent held in relation to the activity.

The programme of hydraulic fracturing undertaken by GPL at the Radnor-B wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Radnor-2 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, surface water and discharge monitoring components. This is the first monitoring report produced by the Council in relation to hydraulic fracturing activities at the Radnor-B wellsite.

### 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 Radnor-B.

**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 Radnor-B 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 2018-2019 year, consent holders were found to achieve a high level of environmental performance and compliance for 83% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 13% of the consents, a good level of environmental performance and compliance was achieved.<sup>1</sup>

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.

## 1.2 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

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<sup>1</sup> 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

reservoir. The fluid mixture is pumped at a pressure that exceeds the fracture strength of the reservoir rock in order to create fractures. Once fractures have been initiated, pumping continues in order to force the fluid and proppant into the fractures created. The proppant is designed to keep the fractures open when the pumping is stopped. The placement of proppant into the fractures 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.<sup>2</sup>

### 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 (N<sub>2</sub>) 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.<sup>3</sup> 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.<sup>2</sup>

## 1.2.2 The Radnor-B wellsite and hydraulic fracturing activities

The Radnor-B wellsite is located on Radnor Road, Midhirst and lies within the Patea catchment. The Piakau Stream runs west to east, approximately 250 m south of the southern boundary of the Radnor-B wellsite at its closest point. The wellsite lies on the border of the Midhirst Township. The location of the wellsite is illustrated in Figure 1. A summary of the hydraulic fracturing activities carried out by GPL at the Radnor-B wellsite during the period being reported is provided below in Table 1.

Table 1 Summary of hydraulic fracturing details

Well	Bore id.	Date	Interval	Injection zone (m TVDs)	Formation
Radnor-2	GND2596	27/04/18	1	3751.6-3754.6	McKee
		16/05/18	1	3751.6-3754.6, 3768.4-3771.4	
		26/07/18	2	3777.5-3779.5, 3785.3-3788.3	

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

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

Well	Bore id.	Date	Interval	Injection zone (m TVDs)	Formation
		26/09/18	3	3720.1-3723.0	



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 holds one resource consent the details of which are summarised in Table 2 below. 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
10348-1	To discharge water based hydraulic fracturing fluids into land at depths greater than 3,500 m TVDss beneath the Radnor-B wellsite	06/10/2016	June 2021	1/06/2033

## 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 Radnor-B 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 10348-1, GPL 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 included in the monitoring programme for the wellsite.

The survey of existing sites identified one groundwater well (GND1669) within the 1 km radius of the wellsite. The well was deemed unsuitable as it was shallow (6.5 m) and located up-gradient of the wellsite and therefore unlikely to show any impacts from the activity being monitored.

Given the lack of suitable existing groundwater monitoring sites within the survey area, a purpose built monitoring bore (GND2591) was installed at the wellsite to comply with condition 7 of consent 10348-1. GND2591 is the sole groundwater monitoring site included in the monitoring programme. The bore details are summarised in Table 3 and the location of the bore is displayed in Figure 1.

Table 3 Details of groundwater sites included in the monitoring programme

Monitoring site	Easting (NZTM)	Northing (NZTM)	Distance from wellsite (m)	Total depth (m)	Screened/open interval (m)	Aquifer
GND2591	1709290	5649232	Onsite	31	16-31	Volcanics

Samples of groundwater were obtained pre-fracturing to provide a baseline reference of groundwater composition with further rounds of sampling carried out four, eight and 14 months following commencement of the activities.

### 1.4.4.2 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 are comprised of a mixture of hydraulic fracturing fluids and formation fluids produced from the target reservoir, following the completion of the hydraulic fracturing process. The relative concentrations of each contributing fluid type change as the volume of fluid produced from the well increases. Immediately following the opening of the well post-fracturing, a high proportion of the fluid returning to the wellhead is fluid injected during the hydraulic fracturing process. As the volume of fluid produced from the well increases, the proportion of hydraulic fracturing fluid reduces in relation to formation fluids. The 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.

Samples of hydraulic fracturing fluid and return fluid were obtained by GPL during the activity and were sent to Hill Laboratories Ltd for analysis.

### 1.4.5 Surface water quality monitoring

The Piakau Stream runs west to east, approximately 250 m south of the southern boundary of the Radnor-B wellsite at its closest point. A roadside drain runs north-west to south-east along Mountain Road, past the wellsite and joins the Piakau Stream immediately upstream of a road culvert.

Treated site stormwater discharges from the skimmer pit system in the south-east corner of the wellsite, through an underground drain into the roadside drain. Any flow of water then either travels along the western road drain directly into Piakau Stream at the culvert, or potentially is directed through an earlier culvert to the eastern road drain where it would enter an unnamed tributary of the Piakau Stream. This tributary joins the main stream approximately 650 m downstream of where Mountain Road crosses the Piakau Stream.

Details of the three sites selected to monitor downstream of the site and the estimated location of groundwater/subsurface drainage from the discharge area are included in Table 4. The locations are illustrated on Figure 1.

**Table 4** Surface water monitoring site details

Monitoring site	Description	Location	Eastings	Northings
PKS000198	Piakau Stream south	200 m upstream of confluence between road drain and Piakau Stream	1709315	5648794
PKS000203	Piakau Stream south	200 m downstream of confluence between road drain and Piakau Stream	1709741	5648737
PKS000220	Piakau Stream south	450 m downstream of PKS000203	1710199	5648843

#### 1.4.5.1 Biomonitoring surveys

Biomonitoring surveys are undertaken to determine whether stormwater discharges from the wellsite have had any detrimental impacts on the macroinvertebrate communities of the Piakau Stream. Samples are processed to provide number of taxa (richness), MCI and SQMCI<sub>5</sub> scores, and EPT taxa for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects of organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The SQMCI<sub>5</sub> takes into account taxa abundance as well as sensitivity to pollution, and may reveal more subtle changes in communities. It may be the more appropriate index if non-organic impacts are occurring.

Significant differences in either the MCI or the SQMCI<sub>5</sub> between sites indicate the degree of adverse effects (if any) of the discharges being monitored.

One macroinvertebrate survey was carried out on 26 April 2018 at three surface water monitoring sites in the Piakau Stream. A post-fracturing survey could not be undertaken as the necessary flow conditions were not met within the required timeframe<sup>4</sup>.

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<sup>4</sup> A period of up to 10 days is required between rainfall events to meet the necessary flow conditions to enable a robust survey to be undertaken.

## 2 Results

### 2.1 Consent holder submitted data

#### 2.1.1 Radnor-2 post-fracturing discharge report

The conclusions from the Radnor-2 post-fracturing discharge report are summarised as follows:

- A total of three zones were fractured over the period 27 April to 26 September 2018 at depths between 3,720 to 3,785 m TVDss.
- A total of 4,505 bbls (716 m<sup>3</sup>) of liquid was discharged across the three fractured zones. The total proppant weight was 115.9 tonnes (255,458 lbs).
- The Radnor-2 well was opened for flow-back following the completion of fracturing operations. In total 4,696 bbls (747 m<sup>3</sup>) of fluid was returned from the well over the initial flow-back period.
- Zone 1 was fractured twice and returned slightly more fluid than injected with almost all the fluid injected into the zone being returned following the second event. Zone 2 and zone 3 also returned slightly more fluid than injected.
- One screen out occurred while fracturing zone 1 resulting in the under placement of approximately 7.2 tonnes (15,873 lbs) of proppant. All proppant was subsequently recovered with no implications for compliance with consent conditions reported.
- All return fluid from the Radnor-2 fracturing operations was disposed of by deep well injection, at the Kaimiro-G wellsite under consent 9470-1.
- 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 reported by GPL 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 GPL 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 Radnor-B wellsite on 27 April 2018 and continued until 26 September 2018. A pre-fracturing baseline sample was collected on 1 January 2018. Post-fracturing samples were collected three months, eight months and 14 months following commencement of the activities on 1 August 2018, 21 December 2018 and 28 June 2019 respectively.

Trace concentrations of methane were recorded in all groundwater samples collected, and commonly occur as a result of biogenic processes in groundwater across the region. Toluene was also reported at concentrations slightly above the detection limit in the sample collected on 21 December 2018, indicating that peat deposits may be present. Overall, 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 5. The certificates of analysis for the review period are included in Appendix II.

Table 5 Results of groundwater sampling carried out in relation to the Radnor-2 fracturing event

Parameter	Bore id	GND2591			
		29 Jan 2018	01 Aug 2018	21 Dec 2018	28 Jun 2019
Sample date	Unit				
Sample time	-	12:55	10:20	09:10	11:20
Sample id.	-	TRC180538	TRC183129	TRC185301	TRC192540
pH	pH	6.5	6.5	6.3	6.2
Temperature	°C	17.7	12.7	15.5	13.5
Total alkalinity	g/m <sup>3</sup> CaCO <sub>3</sub>	43	41	35	42
Bicarbonate	g/m <sup>3</sup> HCO <sub>3</sub>	52	50	43	51
Total hardness	g/m <sup>3</sup> CaCO <sub>3</sub>	26	28	27	34
Electrical conductivity	mS/m	15.0	15.4	15.6	15.9
Total dissolved solids	g/m <sup>3</sup>	115	107	106	125
Dissolved calcium	g/m <sup>3</sup>	7.8	8.5	8.4	10.4
Chloride	g/m <sup>3</sup>	13.8	12.8	12.2	12.8
Dissolved magnesium	g/m <sup>3</sup>	1.45	1.52	1.49	1.88
Dissolved potassium	g/m <sup>3</sup>	4.8	5.1	5.1	5.4
Dissolved sodium	g/m <sup>3</sup>	8.4	8.0	8.1	8.3
Nitrite nitrogen	g/m <sup>3</sup> N	< 0.2	< 0.002	< 0.02	< 0.002
Nitrate nitrogen	g/m <sup>3</sup> N	< 0.2	< 0.002	0.04	0.002
Nitrate & nitrite nitrogen	g/m <sup>3</sup> N	0.2	< 0.002	0.04	0.003
Sulphate	g/m <sup>3</sup>	8.3	10.0	10.6	10.8
Dissolved barium	mg/kg	0.04	0.043	0.048	0.05
Bromide	g/m <sup>3</sup>	0.07	0.06	0.15	0.14
Dissolved copper	g/m <sup>3</sup>	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved iron	g/m <sup>3</sup>	9.6	9.2	9.9	9.1
Dissolved manganese	g/m <sup>3</sup>	0.193	0.200	0.183	0.194
Dissolved mercury	g/m <sup>3</sup>	< 0.00008	< 0.00008	< 0.00008	< 0.00008
Dissolved Nickel	mg/kg	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved zinc	g/m <sup>3</sup>	0.0041	< 0.0010	0.0025	0.0034
Ethylene glycol	g/m <sup>3</sup>	< 4	< 4	< 4	< 4
Propylene glycol	g/m <sup>3</sup>	< 4	< 4	< 4	< 4
Methanol	g/m <sup>3</sup>	< 2	< 2	< 2	< 2
Benzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m <sup>3</sup>	< 0.0010	< 0.0010	0.002	< 0.0010
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m-Xylene	g/m <sup>3</sup>	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010



Parameter	Bore id	GND2591			
Sample date	Unit	29 Jan 2018	01 Aug 2018	21 Dec 2018	28 Jun 2019
Sample time	-	12:55	10:20	09:10	11:20
Sample id.	-	TRC180538	TRC183129	TRC185301	TRC192540
Formaldehyde	g/m <sup>3</sup>	< 0.02	< 0.02	< 0.02	< 0.02
Ethane	g/m <sup>3</sup>	< 0.003	< 0.003	< 0.003	< 0.003
Ethylene	g/m <sup>3</sup>	< 0.004	< 0.004	< 0.004	< 0.004
Methane	g/m <sup>3</sup>	0.36	0.25	0.32	0.17
C7-C9 hydrocarbons	g/m <sup>3</sup>	< 0.06	< 0.06	< 0.06	< 0.06
C10-C14 hydrocarbons	g/m <sup>3</sup>	< 0.2	< 0.2	< 0.2	< 0.2
C15-C36 hydrocarbons	g/m <sup>3</sup>	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons	g/m <sup>3</sup>	< 0.7	< 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 Radnor-2 well are shown below in Table 6. 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 Radnor-2 well are summarised below in Table 7 and certificates of analysis are included in Appendix III. The results demonstrate the variability of groundwater composition and hydrocarbon concentrations with depth. The relatively high levels of chloride, sodium and hydrocarbons in each sample indicate that the composite samples prepared contained a greater proportion of reservoir fluids than hydraulic fracturing fluids introduced during the fracturing activities, which are comprised predominantly of freshwater.

Table 6 Results of hydraulic fracturing fluid sampling

Parameter	Bore id	GND2596			
-	Unit	Fracturing fluid			
Reference	-	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Sample date	-	27/04/2018	16/05/2018	26/07/2018	26/09/2018
Lab number	Hill	197514.1	1991190.1	2025006.1	2056214.1
Ethylene glycol*	g/m <sup>3</sup>	<4	<20	<20	<20
Propylene glycol*	g/m <sup>3</sup>	<4	<20	<11	<20
Methanol	g/m <sup>3</sup>	<2	<2	<2	3
Benzene	g/m <sup>3</sup>	<0.001	<0.010	<0.010	<0.010
Toluene	g/m <sup>3</sup>	0.0094	<0.010	0.027	0.015
Ethylbenzene	g/m <sup>3</sup>	0.0052	<0.010	0.013	<0.010
m-Xylene	g/m <sup>3</sup>	0.003	<0.02	0.05	<0.02
o-Xylene	g/m <sup>3</sup>	0.0015	<0.010	0.022	<0.010
C7-C9 hydrocarbons	g/m <sup>3</sup>	0.7	<0.6	2.3	1.0

Parameter	Bore id	GND2596			
-	Unit	Fracturing fluid			
Reference	-	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Sample date	-	27/04/2018	16/05/2018	26/07/2018	26/09/2018
Lab number	Hill	197514.1	1991190.1	2025006.1	2056214.1
C10-C14 hydrocarbons	g/m <sup>3</sup>	1,740	2,400	3,000	4,300
C15-C36 hydrocarbons	g/m <sup>3</sup>	85	131	122	196
Total hydrocarbons	g/m <sup>3</sup>	1,820	2,600	3,100	4,500

Note \* Depending on the viscosity of the sample received at the laboratory, samples may require dilution prior to analysis which results in higher detection limits.

Table 7 Results of hydraulic fracturing return fluid sampling

Parameter	Bore id	GND2596		
-	Unit	Return fluid		
Reference	-	Treatment 1 & 2	Treatment 3	Treatment 4
Lab number	Hill	1991189.4	2025036.4	2060275.4
pH	pH	7.5	6.6	7.5
Total alkalinity	g/m <sup>3</sup> CaCO <sub>3</sub>	3,900	790	3,800
Bicarbonate	g/m <sup>3</sup> HCO <sub>3</sub>	22	21	22
Total hardness	g/m <sup>3</sup> CaCO <sub>3</sub>	100	12,100	440
Electrical conductivity	mS/m	1,173	5,440	2,220
Total dissolved solids	g/m <sup>3</sup>	9,200	>25,000	15,500
Total barium	mg/kg	18	158	35
Total bromine	g/m <sup>3</sup>	9.9	33	29
Dissolved calcium	g/m <sup>3</sup>	31	4,800	158
Dissolved copper	g/m <sup>3</sup>	0.016	0.005	0.021
Dissolved iron	g/m <sup>3</sup>	2.9	3.7	2.5
Dissolved magnesium	g/m <sup>3</sup>	5.0	29.0	12.1
Dissolved manganese	g/m <sup>3</sup>	2.2	4.3	1.46
Total Nickel	mg/kg	0.10	0.03	0.16
Total potassium	g/m <sup>3</sup>	230	1360	163
Total sodium	g/m <sup>3</sup>	3,100	6,200	5,100
Total sulphur	g/m <sup>3</sup>	16	22	22
Total zinc	g/m <sup>3</sup>	0.08	0.24	0.07
Chloride	g/m <sup>3</sup>	1,440	22,000	6,000
Nitrite nitrogen	g/m <sup>3</sup> N	0.039	<0.010	<0.10
Nitrate nitrogen	g/m <sup>3</sup> N	0.5	1.4	2.0
Nitrate & nitrite nitrogen	g/m <sup>3</sup> N	0.06	0.31	0.47
Sulphate	g/m <sup>3</sup>	49	65	65
Ethylene glycol*	g/m <sup>3</sup>	<20	19	260
Propylene glycol*	g/m <sup>3</sup>	<20	<2	<20

Parameter	Bore id	GND2596		
-	Unit	Return fluid		
Reference	-	Treatment 1 & 2	Treatment 3	Treatment 4
Lab number	Hill	1991189.4	2025036.4	2060275.4
Methanol*	g/m <sup>3</sup>	<20	<2	<20
Benzene	g/m <sup>3</sup>	35	2.9	70
Toluene	g/m <sup>3</sup>	141	2.3	187
Ethylbenzene	g/m <sup>3</sup>	16.7	0.198	22
m-Xylene	g/m <sup>3</sup>	111	1.27	155
o-Xylene	g/m <sup>3</sup>	33	0.49	49
Formaldehyde*	g/m <sup>3</sup>	<0.15	<8	<1.5
C7-C9 hydrocarbons	g/m <sup>3</sup>	1,040	12	1,660
C10-C14 hydrocarbons	g/m <sup>3</sup>	7,600	520	4,500
C15-C36 hydrocarbons	g/m <sup>3</sup>	7,700	90	4,700
Total hydrocarbons	g/m <sup>3</sup>	16,400	620	10,900

Note \* Depending on the viscosity of the sample received at the laboratory, samples may require dilution prior to analysis which results in higher detection limits.

## 2.3 Biomonitoring surveys

One macroinvertebrate survey was carried out at three sites in the Piakau Stream, near the Radnor-B wellsite following the completion of drilling activities and prior to the commencement of hydraulic fracturing of the Radnor-2 well.

Following completion of hydraulic fracturing at the Radnor-B wellsite the flow conditions that enable a robust survey to be undertaken were not met within the required timeframe. Consequently a post-fracturing survey could not be undertaken.

The results from the pre-hydraulic fracturing survey indicated taxa richness was moderate, with a range from 21 to 23 taxa across the three sites. MCI scores decreased from 121 units at site 1 to 119 units at site 3, while SQMCI scores ranged from 6.3 to 7.0 units. The differences in macroinvertebrate metrics between the three sites were insignificant. All three metrics were not significantly different to the previously recorded medians for sites in similar streams at similar altitude. MCI scores categorised sites 1 and 2 as having 'good' macroinvertebrate community health, while site 3 was categorised as having 'fair' macroinvertebrate community health. However, in this instance all scores were within two MCI units of the other sites and so this change in categorisation is not indicative of an actual change in stream health between the sites.

The macroinvertebrate results recorded indicated that there had been no adverse effects on the macroinvertebrate communities of the Piakau Stream as a result of discharges from the Radnor-B wellsite following drilling activities and prior to the hydraulic fracturing programme at the wellsite.

Although the post-fracturing survey could not be undertaken due to the unsuitable flow conditions, it is considered unlikely that the activity will have resulted in any adverse effects on the macroinvertebrate community of the Piakau Stream.

A copy of the biomonitoring report for the site is available from the Council upon request.

## 2.4 Investigations, interventions, and incidents

The monitoring programme for the year was based on what was considered to be an appropriate level of monitoring, review of data, and liaison with GPL. 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 GPL's conditions in resource consents or provisions in Regional Plans.

## 3 Discussion

### 3.1 Environmental effects of exercise of consents

One well (Radnor-2) was stimulated by hydraulic fracturing at the Radnor-B wellsite during the period 27 April 2018 to 26 September 2018.

The monitoring programme carried out by the Council in relation to the fracturing events undertaken included both groundwater and surface water monitoring components.

The groundwater monitoring component incorporated pre and post-fracturing sampling at one groundwater monitoring site located just inside the perimeter of the Radnor-B 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.

The surface water monitoring component of the programme comprised of one biomonitoring survey of the Piakau Stream pre-fracturing of the Radnor-2 well. Due to unsuitable sampling conditions following the event, post fracturing bio-monitoring was not undertaken. The survey results showed there were no discernible adverse effects in the stream following completion of drilling activities at the site. It is considered unlikely that the activity will have resulted in any adverse effects on the macroinvertebrate community of the Piakau Stream.

In summary, the monitoring carried out by the Council during the period being reported indicated that the hydraulic fracturing activities undertaken by GPL at the Radnor-B wellsite has had no significant adverse effects on local groundwater or surface water 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 and Table 9.

**Table 8 Summary of performance for consent 10348-1**

<b>Purpose: To discharge water based hydraulic fracturing fluids into land at depths greater than 3,500 m TVDss beneath the Radnor-B wellsite</b>		
<b>Condition requirement</b>	<b>Means of monitoring during period under review</b>	<b>Compliance achieved?</b>
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 2028	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

Purpose: To discharge water based hydraulic fracturing fluids into land at depths greater than 3,500 m TVDss beneath the Radnor-B wellsite		
Condition requirement	Means of monitoring during period under review	Compliance achieved?
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
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	Yes
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 post-fracturing report received	Yes
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

Purpose: To discharge water based hydraulic fracturing fluids into land at depths greater than 3,500 m TVDss beneath the Radnor-B wellsite		
Condition requirement	Means of monitoring during period under review	Compliance achieved?
Overall assessment of environmental performance and compliance in respect of this consent		<b>High</b>
Overall assessment of administrative performance and compliance in respect of this consent		<b>High</b>

N/A = not applicable

During the year, GPL 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 air/water discharges in the region, the Council has taken into account:

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

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

It is proposed that the range of monitoring carried out in relation to the hydraulic fracturing activities undertaken by GPL be replicated for any future fracturing events at the Radnor-B 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 10348-1 provides 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 in the year 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 GPL's hydraulic fracturing activities be replicated for any future fracturing events at the Radnor-B 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.
$\text{g}/\text{m}^3$	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.
$\text{mS}/\text{m}$	Millisiemens per metre.
$\text{m}^3$	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.

## Bibliography and references

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- Geology.Com at <http://geology.com/energy/hydraulic-fracturing-fluids/>
- Greymouth Petroleum Ltd (2018) Radnor B wellsite final post-stimulation discharge report October 2018 Frodo Number #2374533.
- Greymouth Petroleum Ltd (2018) Hydraulic fracturing - Radnor-B wellsite water quality monitoring programme April 2018 Frodo Number #1756912.
- Greymouth Petroleum Ltd (2017) Radnor-2 pre-fracturing discharge report November 2017 Frodo Number #1973663.
- Ministry for the Environment. 2018 Guidelines for compliance monitoring and enforcement under the Resource Management Act 1991. Wellington: Ministry for the Environment.
- Stark JD, (1998). SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. New Zealand Journal of Marine and Freshwater Research 32(1): 55-66.
- Taranaki Regional Council (2020) Biomonitoring of the Piakau Stream South in relation to the Radnor-B wellsite, April 2018 Report Number KB088. Frodo Number #515469.

# Appendix I

## Resource consent held by Greymouth Petroleum Ltd

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

### Water abstraction permits

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

### Water discharge permits

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

### Air discharge permits

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

### Discharges of wastes to land

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

### Land use permits

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

### Coastal permits

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

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

Name of  
Consent Holder: Greymouth Petroleum Limited  
PO Box 3394  
New Plymouth 4341

Decision Date: 6 October 2016

Commencement Date: 6 October 2016

**Conditions of Consent**

Consent Granted: To discharge water based hydraulic fracturing fluids into land at depths greater than 3,500 mTVDss beneath the Radnor-B wellsite

Expiry Date: 1 June 2033

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

Site Location: Radnor-B wellsite, Radnor Road, Midhirst  
(Property owner: AB & LH Crofskey)

Grid Reference (NZTM) 1709334E-5649159N

Catchment: Patea

Tributary: Kahouri  
Piakau

*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 3,500 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 2028.
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 10348-1.0

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.

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](mailto: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 10348-1.0

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](mailto:consents@trc.govt.nz) with a reference to the number of this consent.

## Consent 10348-1.0

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 31 December 2021, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.
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 6 October 2016

For and on behalf of  
Taranaki Regional Council

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A D McLay  
**Director - Resource Management**

## Appendix II

### Certificates of analysis (groundwater)





## ANALYSIS REPORT

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1915834	SPV1
<b>Contact:</b>	David Olson C/- Taranaki Regional Council Private Bag 713 Stratford 4352	<b>Date Received:</b>	30-Jan-2018	
		<b>Date Reported:</b>	09-Feb-2018	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>	69429	
		<b>Client Reference:</b>	GPL Radnor B2 PRF-FRAC GW	
		<b>Submitted By:</b>	David Olson	

### Sample Type: Aqueous

<b>Sample Name:</b>	GND2591 29-Jan-2018 1:55 pm				
<b>Lab Number:</b>	1915834.1				

Individual Tests						
Sum of Anions	meq/L	1.43	-	-	-	-
Sum of Cations	meq/L	1.35	-	-	-	-
pH	pH Units	6.5	-	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	43	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	52	-	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	26	-	-	-	-
Electrical Conductivity (EC)	mS/m	15.0	-	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	115	-	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.040	-	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	7.8	-	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Iron	g/m <sup>3</sup>	9.6	-	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	1.45	-	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.193	-	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	4.8	-	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	8.4	-	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.0041	-	-	-	-
Bromide	g/m <sup>3</sup>	0.07	-	-	-	-
Chloride	g/m <sup>3</sup>	13.8	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.2	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	< 0.2	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.2 #1	-	-	-	-
Sulphate	g/m <sup>3</sup>	8.3	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-	-
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-



Sample Type: Aqueous						
<b>Sample Name:</b>	GND2591 29-Jan-2018 1:55 pm					
<b>Lab Number:</b>	1915834.1					
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.004	-	-	-	-
Methane	g/m <sup>3</sup>	0.36	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.06	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	-	-	-	-

### Analyst's Comments

#1 Severe matrix interferences required that a dilution be performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NOxN /NO2N analysis

## 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 <sup>3</sup>	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m <sup>3</sup>	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 <sup>3</sup>	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 <sup>nd</sup> 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 <sup>+</sup> ) also included in calculation if available. APHA 1030 E 22 <sup>nd</sup> ed. 2012.	0.05 meq/L	1
pH	pH meter. APHA 4500-H <sup>+</sup> B 22 <sup>nd</sup> 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.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	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 <sub>2</sub> D 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> 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 <sup>nd</sup> ed. 2012.	10 g/m <sup>3</sup>	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.00010 g/m <sup>3</sup>	1



Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012 (modified).	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012 (modified).	0.002 g/m <sup>3</sup>	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m <sup>3</sup>	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 report 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

Page 1 of 3

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	2025013	SPV1
<b>Contact:</b>	Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352	<b>Date Received:</b>	02-Aug-2018	
		<b>Date Reported:</b>	09-Aug-2018	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>	72831	
		<b>Client Reference:</b>	340300349 Radnor B 3mth GW	
		<b>Submitted By:</b>	Sarah Larkin	

### Sample Type: Aqueous

<b>Sample Name:</b>	GND2591 183129 01-Aug-2018 10:20 am				
<b>Lab Number:</b>	2025013.1				

Individual Tests						
Sum of Anions	meq/L	1.40	-	-	-	-
Sum of Cations	meq/L	1.37	-	-	-	-
pH	pH Units	6.5	-	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	41	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	50	-	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	28	-	-	-	-
Electrical Conductivity (EC)	mS/m	15.4	-	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	107	-	-	-	-
Sample Temperature*	°C	12.7	-	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.043	-	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	8.5	-	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Iron	g/m <sup>3</sup>	9.2	-	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	1.52	-	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.20	-	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	5.1	-	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	8.0	-	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Bromide	g/m <sup>3</sup>	0.06	-	-	-	-
Chloride	g/m <sup>3</sup>	12.8	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	< 0.002	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-	-
Sulphate	g/m <sup>3</sup>	10.0	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-



Sample Type: Aqueous						
<b>Sample Name:</b>	GND2591 183129					
	01-Aug-2018					
	10:20 am					
<b>Lab Number:</b>	2025013.1					
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-	-
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.004	-	-	-	-
Methane	g/m <sup>3</sup>	0.25	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.06	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 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 <sup>3</sup>	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m <sup>3</sup>	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 <sup>3</sup>	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 <sup>nd</sup> 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 <sup>+</sup> ) also included in calculation if available. APHA 1030 E 22 <sup>nd</sup> ed. 2012.	0.05 meq/L	1
pH	pH meter. APHA 4500-H <sup>+</sup> B 22 <sup>nd</sup> 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 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	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 <sub>2</sub> D 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.	0.1 mS/m	1

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
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 <sup>nd</sup> ed. 2012.	10 g/m <sup>3</sup>	1
Sample Temperature*	Supplied by customer, otherwise 20°C.	0.1 °C	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.005 g/m <sup>3</sup>	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012 (modified).	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012 (modified).	0.002 g/m <sup>3</sup>	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m <sup>3</sup>	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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Graham Corban MSc Tech (Hons)  
Client Services Manager - Environmental





## Certificate of Analysis

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	2101935	SPV1
<b>Contact:</b>	Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352	<b>Date Received:</b>	22-Dec-2018	
		<b>Date Reported:</b>	08-Jan-2019	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>	72831	
		<b>Client Reference:</b>	#4771- Radnor B 3 Month Post Frac GW	
		<b>Submitted By:</b>	Sarah Larkin	

### Sample Type: Aqueous

<b>Sample Name:</b>	TRC185301 (GND2591) 21-Dec-2018 9:10 am				
<b>Lab Number:</b>	2101935.1				

### Individual Tests

Sum of Anions	meq/L	1.27	-	-	-	-
Sum of Cations	meq/L	1.39	-	-	-	-
pH	pH Units	6.3	-	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	35	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	43	-	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	27	-	-	-	-
Electrical Conductivity (EC)	mS/m	15.6	-	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	106	-	-	-	-
Sample Temperature*	°C	15.5	-	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.048	-	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	8.4	-	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Iron	g/m <sup>3</sup>	9.9	-	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	1.49	-	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.183	-	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	5.1	-	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	8.1	-	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.0025	-	-	-	-
Bromide	g/m <sup>3</sup>	0.15	-	-	-	-
Chloride	g/m <sup>3</sup>	12.2	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.02 #1	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	0.04	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.04 #1	-	-	-	-
Sulphate	g/m <sup>3</sup>	10.6	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-



**Sample Type: Aqueous**

<b>Sample Name:</b>	TRC185301 (GND2591) 21-Dec-2018 9:10 am				
<b>Lab Number:</b>	2101935.1				
<b>BTEX in Water by Headspace GC-MS</b>					
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-
Toluene	g/m <sup>3</sup>	0.0020	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-
<b>Formaldehyde in Water by DNPH &amp; LCMSMS</b>					
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-
<b>Gases in groundwater</b>					
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.004	-	-	-
Methane	g/m <sup>3</sup>	0.32	-	-	-
<b>Total Petroleum Hydrocarbons in Water</b>					
C7 - C9	g/m <sup>3</sup>	< 0.06	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	-	-	-

**Analyst's Comments**

#1 Severe matrix interferences required that a dilution be performed prior to analysis of this sample, resulting in a detection limit higher than that normally achieved for the NO<sub>2</sub>N, NO<sub>3</sub>N and NO<sub>x</sub>N analysis.

**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.

<b>Sample Type: Aqueous</b>			
<b>Test</b>	<b>Method Description</b>	<b>Default Detection Limit</b>	<b>Sample No</b>
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m <sup>3</sup>	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 <sup>3</sup>	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 <sup>rd</sup> 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 <sup>+</sup> ) also included in calculation if available. APHA 1030 E 23 <sup>rd</sup> ed. 2017.	0.05 meq/L	1
pH	pH meter. APHA 4500-H+ B 23 <sup>rd</sup> 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 <sup>rd</sup> ed. 2017.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1



Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
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 <sub>2</sub> D 23 <sup>rd</sup> ed. 2017.	1.0 g/m <sup>3</sup> at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23 <sup>rd</sup> ed. 2017.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23 <sup>rd</sup> 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 <sup>rd</sup> ed. 2017.	10 g/m <sup>3</sup>	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 <sup>rd</sup> ed. 2017.	0.005 g/m <sup>3</sup>	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.05 g/m <sup>3</sup>	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.0005 g/m <sup>3</sup>	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.02 g/m <sup>3</sup>	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.02 g/m <sup>3</sup>	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.0005 g/m <sup>3</sup>	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.0005 g/m <sup>3</sup>	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.05 g/m <sup>3</sup>	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.02 g/m <sup>3</sup>	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.0010 g/m <sup>3</sup>	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 <sup>rd</sup> ed. 2017.	0.05 g/m <sup>3</sup>	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 <sup>rd</sup> ed. 2017.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I (modified) 23 <sup>rd</sup> ed. 2017.	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I (modified) 23 <sup>rd</sup> ed. 2017.	0.002 g/m <sup>3</sup>	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 <sup>rd</sup> ed. 2017.	0.5 g/m <sup>3</sup>	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m <sup>3</sup>	1

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Ara Heron BSc (Tech)  
Client Services Manager - Environmental





## Certificate of Analysis

Page 1 of 3

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	2200714	SPV1
<b>Contact:</b>	Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352	<b>Date Received:</b>	29-Jun-2019	
		<b>Date Reported:</b>	15-Jul-2019	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>	72831	
		<b>Client Reference:</b>	#5152 - Radnor B 1 year Post Frac GW	
		<b>Submitted By:</b>	Sarah Larkin	

### Sample Type: Aqueous

<b>Sample Name:</b>	TRC192540 (GND2591) 28-Jun-2019 11:20 am				
<b>Lab Number:</b>	2200714.1				

#### Individual Tests

Sum of Anions	meq/L	1.43	-	-	-	-
Sum of Cations	meq/L	1.51	-	-	-	-
pH	pH Units	6.2	-	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	42	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	51	-	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	34	-	-	-	-
Electrical Conductivity (EC)	mS/m	15.9	-	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	125	-	-	-	-
Sample Temperature*	°C	13.5	-	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.050	-	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	10.4	-	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Iron	g/m <sup>3</sup>	9.1	-	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	1.88	-	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.194	-	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	5.4	-	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	8.3	-	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.0034	-	-	-	-
Bromide	g/m <sup>3</sup>	0.14	-	-	-	-
Chloride	g/m <sup>3</sup>	12.8	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	0.002	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.003	-	-	-	-
Sulphate	g/m <sup>3</sup>	10.8	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-



Sample Type: Aqueous						
<b>Sample Name:</b>	TRC192540 (GND2591) 28-Jun-2019 11:20 am					
<b>Lab Number:</b>	2200714.1					
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-	-
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.004	-	-	-	-
Methane	g/m <sup>3</sup>	0.173	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.06	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 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 <sup>3</sup>	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m <sup>3</sup>	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 <sup>3</sup>	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 <sup>rd</sup> 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 <sup>+</sup> ) also included in calculation if available. APHA 1030 E 23 <sup>rd</sup> ed. 2017.	0.05 meq/L	1
pH	pH meter. APHA 4500-H <sup>+</sup> B 23 <sup>rd</sup> 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 <sup>rd</sup> ed. 2017.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	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 <sub>2</sub> D 23 <sup>rd</sup> ed. 2017.	1.0 g/m <sup>3</sup> 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 <sup>rd</sup> ed. 2017.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23 <sup>rd</sup> 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 <sup>rd</sup> ed. 2017.	10 g/m <sup>3</sup>	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 <sup>rd</sup> ed. 2017.	0.005 g/m <sup>3</sup>	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.05 g/m <sup>3</sup>	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.0005 g/m <sup>3</sup>	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.02 g/m <sup>3</sup>	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.02 g/m <sup>3</sup>	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.0005 g/m <sup>3</sup>	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.0005 g/m <sup>3</sup>	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.05 g/m <sup>3</sup>	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.02 g/m <sup>3</sup>	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23 <sup>rd</sup> ed. 2017.	0.0010 g/m <sup>3</sup>	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 <sup>rd</sup> ed. 2017.	0.05 g/m <sup>3</sup>	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 <sup>rd</sup> ed. 2017.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I (modified) 23 <sup>rd</sup> ed. 2017.	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I (modified) 23 <sup>rd</sup> ed. 2017.	0.002 g/m <sup>3</sup>	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 <sup>rd</sup> ed. 2017.	0.5 g/m <sup>3</sup>	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m <sup>3</sup>	1

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



## Appendix III

Certificates of analysis  
(hydraulic fracturing fluids)







## Certificate of Analysis

<b>Client:</b>	Greymouth Petroleum Limited	<b>Lab No:</b>	1975414	SPV1
<b>Contact:</b>	Skye Loveridge-Easter C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	<b>Date Received:</b>	04-May-2018	
		<b>Date Reported:</b>	16-May-2018	
		<b>Quote No:</b>	85159	
		<b>Order No:</b>	242248	
		<b>Client Reference:</b>	Hydraulic fracturing fluid testing	
		<b>Submitted By:</b>	Skye Loveridge-Easter	

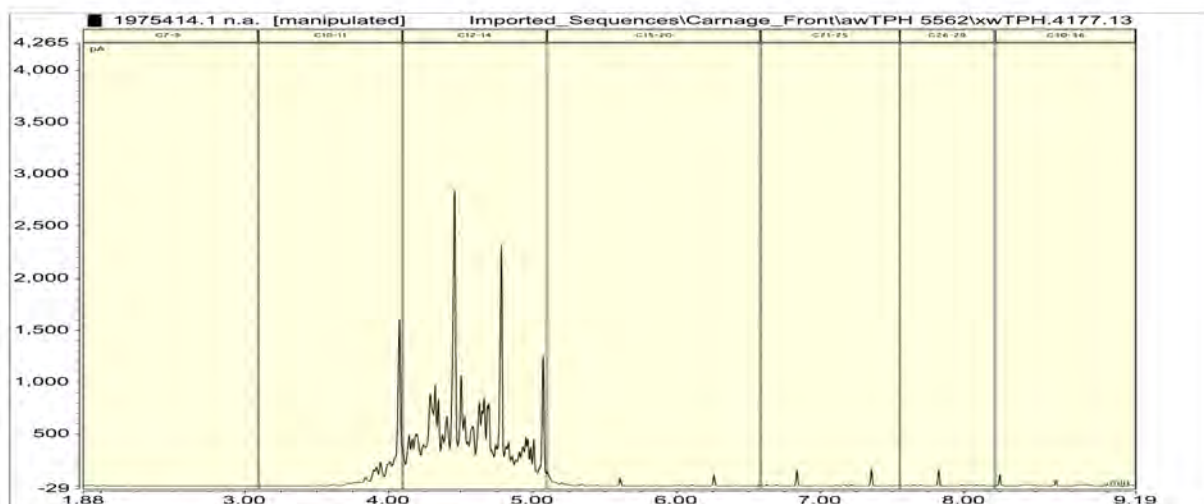
### Sample Type: Aqueous

<b>Sample Name:</b>	Radnor Prepumped Sample 27-Apr-2018					
<b>Lab Number:</b>	1975414.1					
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	0.094	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	0.0052	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	0.003	-	-	-	-
o-Xylene	g/m <sup>3</sup>	0.0015	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	0.71	-	-	-	-
C10 - C14	g/m <sup>3</sup>	1,740	-	-	-	-
C15 - C36	g/m <sup>3</sup>	85	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	1,820	-	-	-	-

1975414.1

Radnor Prepumped Sample 27-Apr-2018

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 <sup>3</sup>	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	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 <sup>3</sup>	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m <sup>3</sup>	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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Client Services Manager - Environmental



## Certificate of Analysis

<b>Client:</b>	Greymouth Petroleum Limited	<b>Lab No:</b>	1991189	SPV1
<b>Contact:</b>	Skye Loveridge-Easter C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	<b>Date Received:</b>	30-May-2018	
		<b>Date Reported:</b>	12-Jun-2018	
		<b>Quote No:</b>	81870	
		<b>Order No:</b>	242440	
		<b>Client Reference:</b>	Return Fluid Composite	
		<b>Submitted By:</b>	Skye Loveridge-Easter	

### Sample Type: Saline

<b>Sample Name:</b>	Composite of Radnor Frac 2 'Start', Radnor Frac 2 'Middle' & Radnor Frac 2 'End'				
<b>Lab Number:</b>	1991189.4				

### Individual Tests

pH*	pH Units	7.5	-	-	-	-
Total Alkalinity*	g/m <sup>3</sup> as CaCO <sub>3</sub>	3,900	-	-	-	-
Analysis Temperature for Bicarbonate	°C	22	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at Analysis Temperature	3,670	-	-	-	-
Total Hardness*	g/m <sup>3</sup> as CaCO <sub>3</sub>	100	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,173	-	-	-	-
Total Dissolved Solids (TDS)*	g/m <sup>3</sup>	9,200	-	-	-	-
Dissolved Barium*	g/m <sup>3</sup>	18.0	-	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	9.9	-	-	-	-
Dissolved Calcium*	g/m <sup>3</sup>	31	-	-	-	-
Dissolved Copper*	g/m <sup>3</sup>	0.016	-	-	-	-
Dissolved Iron*	g/m <sup>3</sup>	2.9	-	-	-	-
Dissolved Magnesium*	g/m <sup>3</sup>	5	-	-	-	-
Dissolved Manganese*	g/m <sup>3</sup>	2.2	-	-	-	-
Total Nickel*	g/m <sup>3</sup>	0.10	-	-	-	-
Total Potassium*	g/m <sup>3</sup>	230	-	-	-	-
Total Sodium*	g/m <sup>3</sup>	3,100	-	-	-	-
Total Sulphur*	g/m <sup>3</sup>	16	-	-	-	-
Total Zinc*	g/m <sup>3</sup>	0.080	-	-	-	-
Chloride*	g/m <sup>3</sup>	1,440	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	0.039	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	0.121	-	-	-	-
Nitrate*	g/m <sup>3</sup>	0.54	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.160	-	-	-	-
Sulphate*	g/m <sup>3</sup>	49	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 20	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 20	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 20	-	-	-	-



**Sample Type: Saline**

<b>Sample Name:</b>	Composite of Radnor Frac 2 'Start', Radnor Frac 2 'Middle' & Radnor Frac 2 'End'				
<b>Lab Number:</b>	1991189.4				

**BTEX in Water by Headspace GC-MS**

Benzene*	g/m <sup>3</sup>	35	-	-	-	-
Toluene*	g/m <sup>3</sup>	141	-	-	-	-
Ethylbenzene*	g/m <sup>3</sup>	16.7	-	-	-	-
m&p-Xylene*	g/m <sup>3</sup>	111	-	-	-	-
o-Xylene*	g/m <sup>3</sup>	33	-	-	-	-

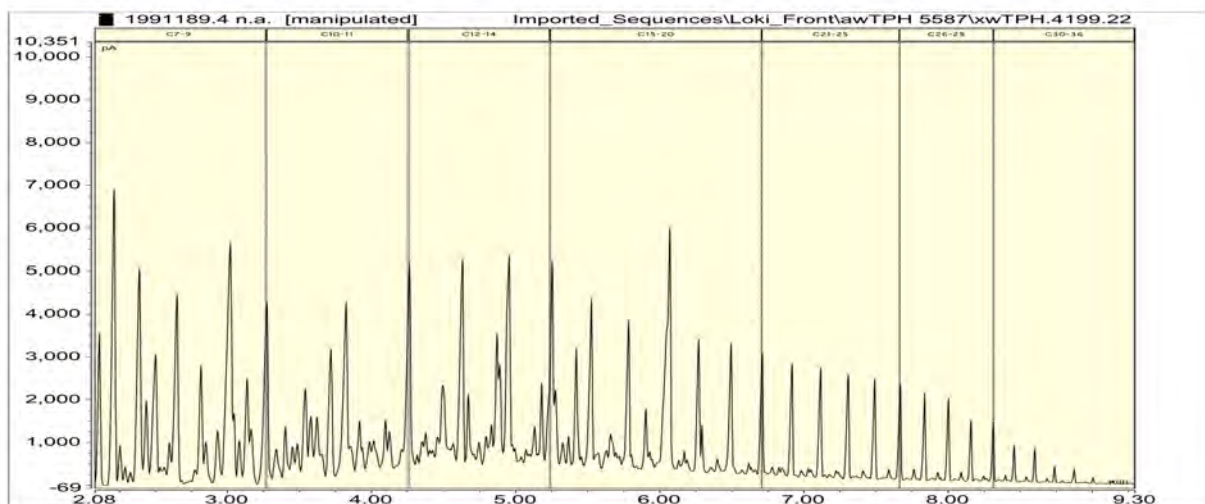
**Formaldehyde in Water by DNPH & LCMSMS**

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

C7 - C9	g/m <sup>3</sup>	1,040	-	-	-	-
C10 - C14*	g/m <sup>3</sup>	7,600	-	-	-	-
C15 - C36*	g/m <sup>3</sup>	7,700	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	16,400	-	-	-	-

1991189.4  
 Composite of Radnor Frac 2 'Start', Radnor Frac 2 'Middle' & Radnor Frac 2 'End'  
 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: Saline**

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	4
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	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 <sup>3</sup>	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	4
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
pH*	pH meter. APHA 4500-H <sup>+</sup> B 22 <sup>nd</sup> 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	4
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO <sub>3</sub> ) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m <sup>3</sup> at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	4
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.	0.1 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22 <sup>nd</sup> ed. 2012.	50 g/m <sup>3</sup>	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22 <sup>nd</sup> ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0006 g/m <sup>3</sup>	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.10 g/m <sup>3</sup>	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup>	4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.004 g/m <sup>3</sup>	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.4 g/m <sup>3</sup>	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.007 g/m <sup>3</sup>	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	1.1 g/m <sup>3</sup>	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.42 g/m <sup>3</sup>	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H <sub>2</sub> 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 <sup>3</sup>	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0042 g/m <sup>3</sup>	4
Chloride*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>3</sub> - I 22 <sup>nd</sup> ed. 2012 (modified).	0.0010 g/m <sup>3</sup>	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m <sup>3</sup>	4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO <sub>3</sub> - I 22 <sup>nd</sup> ed. 2012 (modified).	0.0010 g/m <sup>3</sup>	4
Total Sulphate*	Calculation: from total sulphur.	2 g/m <sup>3</sup>	4
C7 - C9	Head Space, GCMS analysis.	0.06 g/m <sup>3</sup>	4

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

Ara Heron BSc (Tech)  
Client Services Manager - Environmental



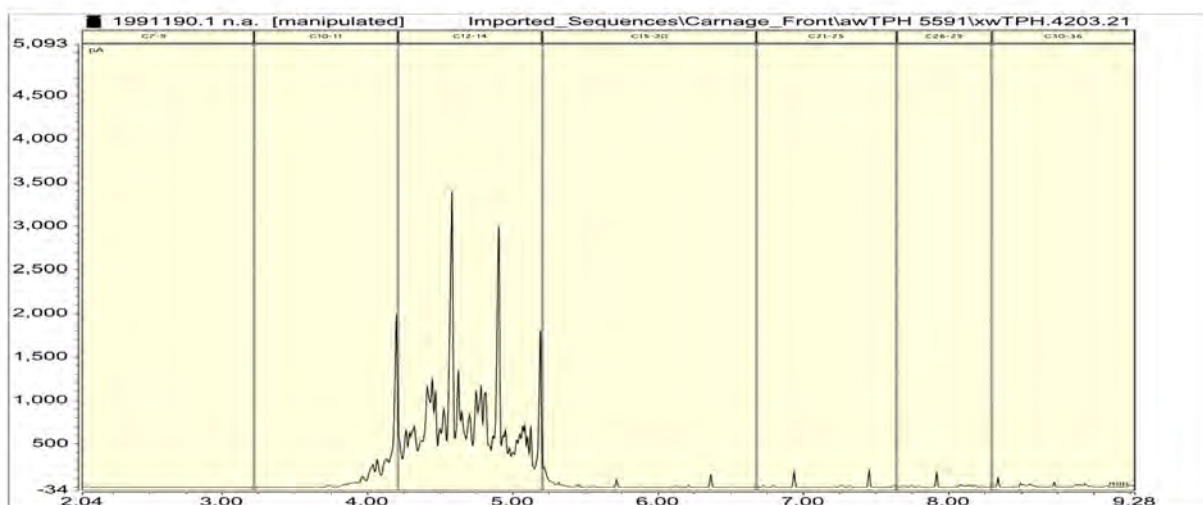
## Certificate of Analysis

<b>Client:</b>	Greymouth Petroleum Limited	<b>Lab No:</b>	1991190	SPV1
<b>Contact:</b>	Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	<b>Date Received:</b>	30-May-2018	
		<b>Date Reported:</b>	13-Jun-2018	
		<b>Quote No:</b>	85159	
		<b>Order No:</b>	242437	
		<b>Client Reference:</b>	Hydraulic fracturing fluid testing	
		<b>Submitted By:</b>	Skye Loveridge-Easther	

### Sample Type: Aqueous

<b>Sample Name:</b>	Radnor Frac 2 Prepump HF Fluid 16-May-2018				
<b>Lab Number:</b>	1991190.1				
Ethylene Glycol in Water					
Ethylene glycol*	g/m <sup>3</sup>	< 20	-	-	-
Propylene Glycol in Water					
Propylene glycol*	g/m <sup>3</sup>	< 20	-	-	-
Methanol in Water - Aqueous Solvents					
Methanol*	g/m <sup>3</sup>	< 2	-	-	-
BTEX in Water by Headspace GC-MS					
Benzene	g/m <sup>3</sup>	< 0.010	-	-	-
Toluene	g/m <sup>3</sup>	< 0.010	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.010	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.02	-	-	-
o-Xylene	g/m <sup>3</sup>	< 0.010	-	-	-
Total Petroleum Hydrocarbons in Water					
C7 - C9	g/m <sup>3</sup>	< 0.6	-	-	-
C10 - C14	g/m <sup>3</sup>	2,400	-	-	-
C15 - C36	g/m <sup>3</sup>	131	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	2,600	-	-	-

1991190.1  
Radnor Frac 2 Prepump HF Fluid 16-May-2018  
Client Chromatogram for TPH by FID



This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised. The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked \*, which are not accredited.

## 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 <sup>3</sup>	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	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 <sup>3</sup>	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m <sup>3</sup>	1

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

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

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Ara Heron BSc (Tech)  
Client Services Manager - Environmental





## Certificate of Analysis

<b>Client:</b>	Greymouth Petroleum Limited	<b>Lab No:</b>	2025036	SPV1
<b>Contact:</b>	Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	<b>Date Received:</b>	02-Aug-2018	
		<b>Date Reported:</b>	15-Aug-2018	
		<b>Quote No:</b>	81870	
		<b>Order No:</b>	242998	
		<b>Client Reference:</b>	Return Fluid Composite	
		<b>Submitted By:</b>	Skye Loveridge-Easther	

### Sample Type: Saline

<b>Sample Name:</b>	Composite of Radnor Stim 3 Return Fluid Start, Radnor Stim 3 Return Fluid Middle and Radnor Stim 3 Return Fluid End				
<b>Lab Number:</b>	2025036.4				

### Individual Tests

pH*	pH Units	6.6	-	-	-	-
Total Alkalinity*	g/m <sup>3</sup> as CaCO <sub>3</sub>	790	-	-	-	-
Analysis Temperature for Bicarbonate	°C	21	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at Analysis Temperature	952	-	-	-	-
Total Hardness*	g/m <sup>3</sup> as CaCO <sub>3</sub>	12,100	-	-	-	-
Electrical Conductivity (EC)*	mS/m	5,440	-	-	-	-
Total Dissolved Solids (TDS)*	g/m <sup>3</sup>	> 25,000	-	-	-	-
Dissolved Barium*	g/m <sup>3</sup>	158	-	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	33	-	-	-	-
Dissolved Calcium*	g/m <sup>3</sup>	4,800	-	-	-	-
Dissolved Copper*	g/m <sup>3</sup>	0.005	-	-	-	-
Dissolved Iron*	g/m <sup>3</sup>	3.7	-	-	-	-
Dissolved Magnesium*	g/m <sup>3</sup>	29	-	-	-	-
Dissolved Manganese*	g/m <sup>3</sup>	4.3	-	-	-	-
Total Nickel*	g/m <sup>3</sup>	0.03 #1	-	-	-	-
Total Potassium*	g/m <sup>3</sup>	1,360	-	-	-	-
Total Sodium*	g/m <sup>3</sup>	6,200	-	-	-	-
Total Sulphur*	g/m <sup>3</sup>	22	-	-	-	-
Total Zinc*	g/m <sup>3</sup>	0.24	-	-	-	-
Chloride*	g/m <sup>3</sup>	22,000	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.010 #2	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	0.30	-	-	-	-
Nitrate*	g/m <sup>3</sup>	1.35	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.31	-	-	-	-
Sulphate*	g/m <sup>3</sup>	65	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	19	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-



**Sample Type: Saline**

<b>Sample Name:</b>	Composite of Radnor Stim 3 Return Fluid Start, Radnor Stim 3 Return Fluid Middle and Radnor Stim 3 Return Fluid End				
<b>Lab Number:</b>	2025036.4				

**Methanol in Water - Aqueous Solvents**

Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
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**BTEX in Water by Headspace GC-MS**

Benzene*	g/m <sup>3</sup>	2.9	-	-	-	-
Toluene*	g/m <sup>3</sup>	2.3	-	-	-	-
Ethylbenzene*	g/m <sup>3</sup>	0.198	-	-	-	-
m&p-Xylene*	g/m <sup>3</sup>	1.27	-	-	-	-
o-Xylene*	g/m <sup>3</sup>	0.49	-	-	-	-

**Formaldehyde in Water by DNPH & LCMSMS**

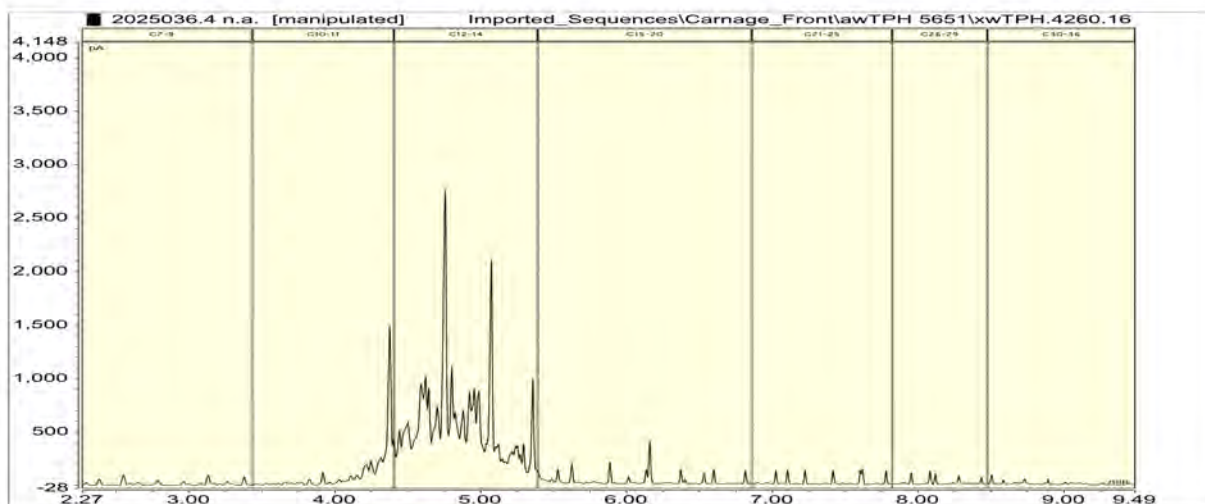
Formaldehyde*	g/m <sup>3</sup>	< 8	-	-	-	-
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**Total Petroleum Hydrocarbons in Water**

C7 - C9	g/m <sup>3</sup>	12.1	-	-	-	-
C10 - C14*	g/m <sup>3</sup>	520	-	-	-	-
C15 - C36*	g/m <sup>3</sup>	90	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	620	-	-	-	-

2025036.4

Composite of Radnor Stim 3 Return Fluid Start, Radnor Stim 3 Return Fluid Middle and Radnor Stim 3 Return Fluid End  
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.

#2 Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NO2Nsal analysis.

Appendix No.1 - HCO3 Report 2025036

**Summary of Methods**

The following table(s) give 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.

<b>Sample Type: Saline</b>			
Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	4

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	4
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	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 <sup>3</sup>	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	4
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
pH*	Saline water, pH meter. APHA 4500-H <sup>+</sup> B 22 <sup>nd</sup> 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	4
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO <sub>3</sub> ) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m <sup>3</sup> at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	4
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.	0.10 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22 <sup>nd</sup> ed. 2012.	50 g/m <sup>3</sup>	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22 <sup>nd</sup> ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0006 g/m <sup>3</sup>	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.10 g/m <sup>3</sup>	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup>	4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.004 g/m <sup>3</sup>	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.4 g/m <sup>3</sup>	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.007 g/m <sup>3</sup>	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	1.1 g/m <sup>3</sup>	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.42 g/m <sup>3</sup>	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H <sub>2</sub> 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 <sup>3</sup>	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0042 g/m <sup>3</sup>	4
Chloride*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>3</sub> - I 22nd ed. 2012 (modified).	0.0010 g/m <sup>3</sup>	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m <sup>3</sup>	4

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m <sup>3</sup>	4
Total Sulphate*	Calculation: from total sulphur.	2 g/m <sup>3</sup>	4
C7 - C9	Head Space, GCMS analysis.	0.06 g/m <sup>3</sup>	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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Martin Cowell - BSc  
Client Services Manager - Environmental



**CERTIFICATE OF ANALYSIS**  
**ENVSUBGNS\_WAIRAKEI 67**

Report No: 2018080802

Customer Ref:150527

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

**GNS Lot No: 2018080802**

**GNS Sample No.** 2018005195  
**Collection Date**  
**Site ID** 2025036.4  
**Field ID**

pH	6.99	-	-	-
Bicarbonate (Total) mg/l	952	-	-	-
HCO <sub>3</sub> Analysis Temperature °C	21	-	-	-
HCO <sub>3</sub> Analysis Date	8/08/2018	-	-	-

**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 <sub>3</sub> 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.

Moya Appleby  
Senior Technician



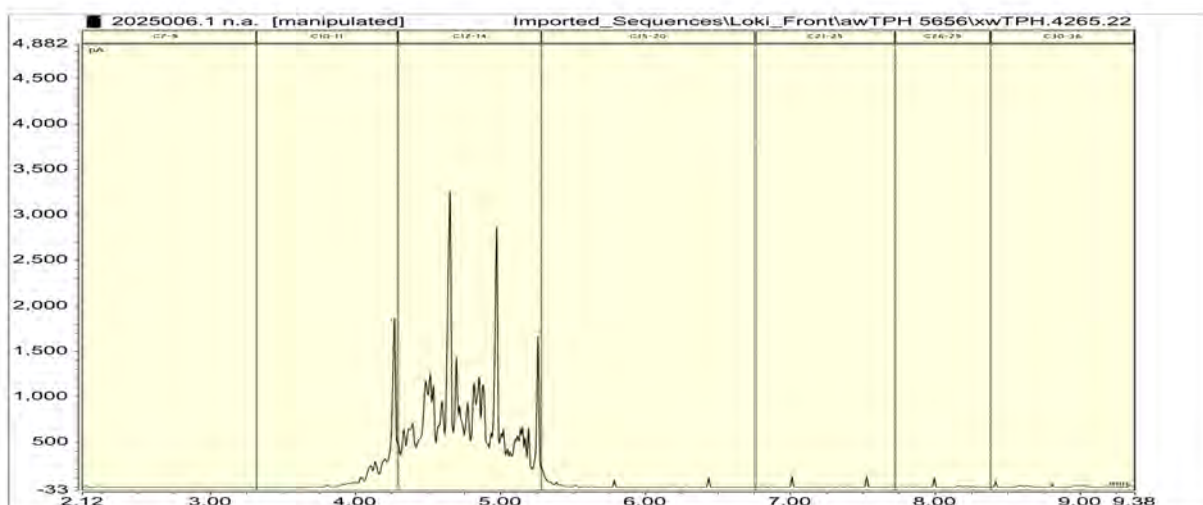


## Certificate of Analysis

<b>Client:</b>	Greymouth Petroleum Limited	<b>Lab No:</b>	2025006	SPV1
<b>Contact:</b>	Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	<b>Date Received:</b>	02-Aug-2018	
		<b>Date Reported:</b>	15-Aug-2018	
		<b>Quote No:</b>	85159	
		<b>Order No:</b>	242997	
		<b>Client Reference:</b>	Hydraulic fracturing fluid testing	
		<b>Submitted By:</b>	Skye Loveridge-Easther	

Sample Type: Aqueous						
Sample Name:		Radnor Stim 3 Prepumped HF Fluid 26-Jul-2018				
Lab Number:		2025006.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 20	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 11	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.010	-	-	-	-
Toluene	g/m <sup>3</sup>	0.027	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	0.013	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	0.05	-	-	-	-
o-Xylene	g/m <sup>3</sup>	0.022	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	2.3	-	-	-	-
C10 - C14	g/m <sup>3</sup>	3,000	-	-	-	-
C15 - C36	g/m <sup>3</sup>	122	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	3,100	-	-	-	-

2025006.1  
Radnor Stim 3 Prepumped HF Fluid 26-Jul-2018  
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 <sup>3</sup>	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	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 <sup>3</sup>	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m <sup>3</sup>	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

<b>Client:</b>	Greymouth Petroleum Limited	<b>Lab No:</b>	2060275	SPV2
<b>Contact:</b>	Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	<b>Date Received:</b>	05-Oct-2018	
		<b>Date Reported:</b>	24-Oct-2018	
		<b>Quote No:</b>	81870	
		<b>Order No:</b>	PO243639	
		<b>Client Reference:</b>	Return Fluid Composite	
		<b>Submitted By:</b>	Skye Loveridge-Easther	

### Sample Type: Saline

<b>Sample Name:</b>	Composite of Radnor Stim 4 Return Fluid Start, Radnor Stim 4 Return Fluid Middle and Radnor Stim 4 Return Fluid End				
<b>Lab Number:</b>	2060275.4				

### Individual Tests

pH*	pH Units	7.5	-	-	-	-
Total Alkalinity*	g/m <sup>3</sup> as CaCO <sub>3</sub>	3,800	-	-	-	-
Analysis Temperature for Bicarbonate	°C	22	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at Analysis Temperature	3,550	-	-	-	-
Total Hardness*	g/m <sup>3</sup> as CaCO <sub>3</sub>	440	-	-	-	-
Electrical Conductivity (EC)*	mS/m	2,220	-	-	-	-
Total Dissolved Solids (TDS)*	g/m <sup>3</sup>	15,500	-	-	-	-
Dissolved Barium*	g/m <sup>3</sup>	35	-	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	29	-	-	-	-
Dissolved Calcium*	g/m <sup>3</sup>	158	-	-	-	-
Dissolved Copper*	g/m <sup>3</sup>	0.021	-	-	-	-
Dissolved Iron*	g/m <sup>3</sup>	2.5	-	-	-	-
Dissolved Magnesium*	g/m <sup>3</sup>	12.1	-	-	-	-
Dissolved Manganese*	g/m <sup>3</sup>	1.46	-	-	-	-
Total Nickel*	g/m <sup>3</sup>	0.16	-	-	-	-
Total Potassium*	g/m <sup>3</sup>	163	-	-	-	-
Total Sodium*	g/m <sup>3</sup>	5,100	-	-	-	-
Total Sulphur*	g/m <sup>3</sup>	22	-	-	-	-
Total Zinc*	g/m <sup>3</sup>	0.071	-	-	-	-
Chloride*	g/m <sup>3</sup>	6,000	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.10 #1	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	0.44	-	-	-	-
Nitrate*	g/m <sup>3</sup>	2.0	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.47 #1	-	-	-	-
Sulphate*	g/m <sup>3</sup>	65	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	260	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-

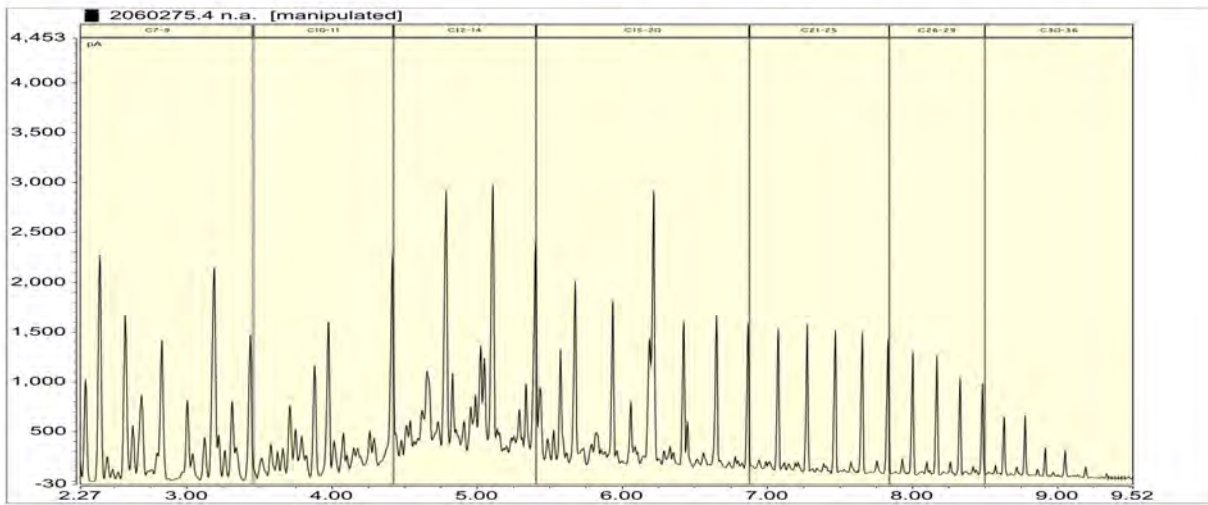


**Sample Type: Saline**

<b>Sample Name:</b>	Composite of Radnor Stim 4 Return Fluid Start, Radnor Stim 4 Return Fluid Middle and Radnor Stim 4 Return Fluid End				
<b>Lab Number:</b>	2060275.4				

Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m <sup>3</sup>	70	-	-	-	-
Toluene*	g/m <sup>3</sup>	187	-	-	-	-
Ethylbenzene*	g/m <sup>3</sup>	22	-	-	-	-
m&p-Xylene*	g/m <sup>3</sup>	155	-	-	-	-
o-Xylene*	g/m <sup>3</sup>	49	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m <sup>3</sup>	< 1.5	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	1,660	-	-	-	-
C10 - C14*	g/m <sup>3</sup>	4,500	-	-	-	-
C15 - C36*	g/m <sup>3</sup>	4,700	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	10,900	-	-	-	-

2060275.4  
 Composite of Radnor Stim 4 Return Fluid Start, Radnor Stim 4 Return Fluid Middle and Radnor Stim 4 Return Fluid End  
 Client Chromatogram for TPH by FID



**Analyst's Comments**

#1 Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NO<sub>2</sub>N, NO<sub>3</sub>N and NO<sub>x</sub>N analysis.

Appendix No.1 - GNS 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 <sup>3</sup>	4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	4

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	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 <sup>3</sup>	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	4
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
pH*	pH meter. APHA 4500-H+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	4
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO <sub>3</sub> ) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m <sup>3</sup> at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	4
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	50 g/m <sup>3</sup>	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m <sup>3</sup>	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m <sup>3</sup>	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m <sup>3</sup>	4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m <sup>3</sup>	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m <sup>3</sup>	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m <sup>3</sup>	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m <sup>3</sup>	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m <sup>3</sup>	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.1 g/m <sup>3</sup>	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.42 g/m <sup>3</sup>	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H <sub>2</sub> 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 <sup>3</sup>	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m <sup>3</sup>	4
Chloride*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m <sup>3</sup>	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>3</sub> - I 22nd ed. 2012 (modified).	0.0010 g/m <sup>3</sup>	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m <sup>3</sup>	4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO <sub>3</sub> - I 22nd ed. 2012 (modified).	0.0010 g/m <sup>3</sup>	4

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
Total Sulphate*	Calculation: from total sulphur.	2 g/m <sup>3</sup>	4
C7 - C9	Head Space, GCMS analysis.	0.06 g/m <sup>3</sup>	4

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

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

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



Helena Bertram BSc  
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 71**

Report No: 2018100906

Customer Ref:150786

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

**GNS Lot No: 2018100906**

**GNS Sample No.** 2018006543  
**Collection Date**  
**Site ID** 2060275.4  
**Field ID**

pH		7.70	-	-	-
Bicarbonate (Total)	mg/l	3548	-	-	-
HCO <sub>3</sub> Analysis Temperature	°C	22	-	-	-
HCO <sub>3</sub> Analysis Date		10/10/2018	-	-	-

**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 <sub>3</sub> 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.

Ann Noddings  
 Senior Technician





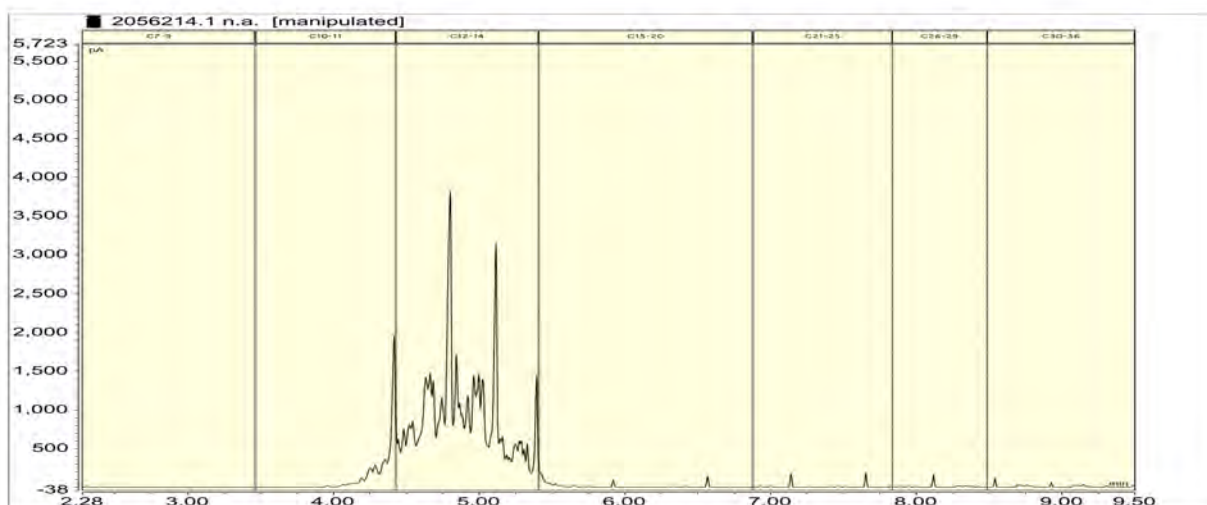
## Certificate of Analysis

<b>Client:</b>	Greymouth Petroleum Limited	<b>Lab No:</b>	2056214	SPV1
<b>Contact:</b>	Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	<b>Date Received:</b>	28-Sep-2018	
		<b>Date Reported:</b>	05-Oct-2018	
		<b>Quote No:</b>	85159	
		<b>Order No:</b>	PO 243640	
		<b>Client Reference:</b>	Hydraulic fracturing fluid testing	
		<b>Submitted By:</b>	Skye Loveridge-Easther	

### Sample Type: Aqueous

<b>Sample Name:</b>	Radnor Stim 4 Prepumped HF Fluid 26-Sep-2018					
<b>Lab Number:</b>	2056214.1					
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 20	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 20	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	3	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.010	-	-	-	-
Toluene	g/m <sup>3</sup>	0.015	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.02	-	-	-	-
o-Xylene	g/m <sup>3</sup>	< 0.010	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	1.0	-	-	-	-
C10 - C14	g/m <sup>3</sup>	4,300	-	-	-	-
C15 - C36	g/m <sup>3</sup>	196	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	4,500	-	-	-	-

2056214.1  
Radnor Stim 4 Prepumped HF Fluid 26-Sep-2018  
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. 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 <sup>3</sup>	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	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 <sup>3</sup>	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m <sup>3</sup>	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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