

Petrochem Ltd  
Kowhai-A Hydraulic Fracturing  
Monitoring Programme  
2017-2018

Technical Report 19-05

ISSN: 1178-1467 (Online)  
Document: 2202275 (Word)  
Document: 2231231 (Pdf)

Taranaki Regional Council  
Private Bag 713  
STRATFORD  
June 2019



## Executive summary

Petrochem Ltd (Petrochem) a subsidiary of Greymouth Petroleum Ltd operates the Kowhai-A hydrocarbon exploration site located on Ngatimaru Road, in the Waiau catchment. This report for the period July 2017 to June 2019 describes the monitoring programme implemented by the Taranaki Regional Council (the Council) to assess the Company's environmental and consent compliance performance during the period under review. The report also details the results of the monitoring undertaken and assesses the environmental effects of the Company's activities.

This report outlines and discusses the results of the monitoring programme implemented by the Council in relation to hydraulic fracturing activities conducted by Petrochem at the Kowhai-A wellsite over the period 25 February 2018 to 5 June 2018.

The programme of hydraulic fracturing undertaken by Petrochem at the Kowhai-A wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Kowhai-A1R well.

### **During the monitoring period, Petrochem 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. Biomonitoring surveys were also carried out to assess the impact of any site discharges during the fracturing programme on an unnamed tributary of the Waiau Stream. 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 Kowhai-A wellsite.

The monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by Petrochem 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 Petrochem in relation to these activities or provisions in regional plans, during the period under review.

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

For reference, in the 2017-2018 year, consent holders were found to achieve a high level of environmental performance and compliance for 76% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 20% 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 Kowhai-A wellsite.



## Table of contents

|         | Page   |    |
|---------|--|----|
| 1       | Introduction   | 1  |
| 1.1     | Compliance monitoring programme reports and the Resource Management Act 1991 | 1  |
| 1.1.1   | Introduction   | 1  |
| 1.1.2   | Structure of this report   | 1  |
| 1.1.3   | The Resource Management Act 1991 and monitoring                              | 1  |
| 1.1.4   | Evaluation of environmental and administrative performance                   | 2  |
| 1.2     | Process description  | 3  |
| 1.2.1   | Hydraulic fracturing   | 3  |
| 1.2.1.1 | Gel fracturing   | 3  |
| 1.2.1.2 | Slick water fracturing   | 4  |
| 1.2.1.3 | Nitrogen gas fracturing  | 4  |
| 1.2.2   | The Kowhai-A wellsite and hydraulic fracturing activities                    | 4  |
| 1.3     | Resource consents  | 6  |
| 1.3.1   | Discharges of wastes to land   | 6  |
| 1.4     | Monitoring programme   | 7  |
| 1.4.1   | Introduction   | 7  |
| 1.4.2   | Programme liaison and management   | 7  |
| 1.4.3   | Assessment of data submitted by the consent holder                           | 7  |
| 1.4.4   | Physiochemical sampling  | 7  |
| 1.4.4.1 | Groundwater  | 7  |
| 1.4.4.2 | Hydraulic fracturing and return fluids                                       | 8  |
| 1.4.5   | Surface water quality monitoring   | 8  |
| 1.4.5.1 | Biomonitoring surveys  | 9  |
| 2       | Results  | 10 |
| 2.1     | Consent holder submitted data  | 10 |
| 2.1.1   | Kowhai-A1R post-fracturing discharge report                                  | 10 |
| 2.2     | Physiochemical sampling  | 10 |
| 2.2.1   | Groundwater  | 10 |
| 2.2.2   | Hydraulic fracturing and return fluids                                       | 12 |
| 2.3     | Biomonitoring surveys  | 14 |
| 2.4     | Investigations, interventions, and incidents                                 | 14 |
| 3       | Discussion   | 16 |

|     |  |    |
|-----|--|----|
| 3.1 | Environmental effects of exercise of consents                              | 16 |
| 3.2 | Evaluation of performance  | 16 |
| 3.3 | Alterations to monitoring programmes of future hydraulic fracturing events | 18 |
| 3.4 | Exercise of optional review of consent                                     | 18 |
| 4   | Recommendations  | 20 |
|     | Glossary of common terms and abbreviations                                 | 21 |
|     | Bibliography and references  | 23 |
|     | Appendix I Resource consent held by Petrochem Ltd                          |    |
|     | Appendix II Certificates of analysis (groundwater)                         |    |
|     | Appendix III Certificates of analysis (hydraulic fracturing fluids)        |    |
|     | Appendix IV Biomonitoring Reports  |    |

## List of tables

|         |  |    |
|---------|--|----|
| Table 1 | Summary of hydraulic fracturing details  | 4  |
| Table 2 | Details of groundwater sites included in the monitoring programme                          | 8  |
| Table 3 | Surface water monitoring site details  | 8  |
| Table 4 | Results of groundwater sampling carried out in relation to the Kowhai-A1R fracturing event | 11 |
| Table 5 | Results of hydraulic fracturing fluid sampling   | 13 |
| Table 6 | Results of hydraulic fracturing return fluid sampling                                      | 13 |
| Table 7 | Summary of performance for consent 10356-1   | 16 |

## List of figures

|          |              |   |
|----------|--------------|---|
| Figure 1 | Location map | 5 |
|----------|--------------|---|

# 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 Petrochem Ltd (Petrochem) at the Kowhai-A wellsite, over the period 25 February 2018 to 5 June 2018. The report also 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 Petrochem at the Kowhai-A wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Kowhai-A1R 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 Kowhai-A 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 Kowhai-A.

**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 Kowhai-A 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 consent holder, 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 consent holder'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 significant environmental impacts and was not obliged to issue any abatement notices or infringement notices in relation to such impacts.

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

For example:

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

**Improvement required:** Likely or actual adverse effects of activities on the receiving environment were more than minor, but not substantial. There were some issues noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent



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

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

### Administrative 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 2017-2018 year, consent holders were found to achieve a high level of environmental performance and compliance for 76% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 20% 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 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) or turbulent flow (slick-water fracturing).

#### 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>1</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<sup>2</sup>) 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>2</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 Kowhai-A wellsite and hydraulic fracturing activities

The Kowhai-A wellsite is located on Ngatimaru Road and lies within the Waiau Catchment. An ephemeral drainage channel is located to the north east of the wellsite. The channel drains into an unnamed tributary of the Waiau Stream located around 200 m to the east of the site.

The area surrounding the site is rural in nature and farming and forestry activities co-exist with active petroleum exploration and production operations. The location of the wellsite is illustrated in Figure 1. A summary of the hydraulic fracturing activities carried out by Petrochem at the Kowhai-A wellsite during the period being reported is provided below in Table 1.

Table 1 Summary of hydraulic fracturing details

| Well       | Bore id. | Fracturing date | Interval | Injection zone (m TVDss) | Formation |
|------------|----------|-----------------|----------|--------------------------|-----------|
| Kowhai-A1R | GND2765  | 25/02/18        | 1        | 4,088.5-4,103.5          | Mangahewa |
|            |          | 13/04/18        | 1        | 4,088.5-4,103.5          |           |
|            |          | 24/04/18        | 2        | 3,811.9-3,814.9          |           |
|            |          | 13/05/18        | 3        | 3,711.9-3,714.9          |           |
|            |          | 22/05/18        | 4        | 3,657.1-3,660.1          |           |
|            |          | 5/06/18         | 5        | 3,592.1-3,595.1          |           |

<sup>1</sup> <http://geology.com/energy/hydraulic-fracturing-fluids>

<sup>2</sup> <http://frackwire.com/nitrogen-gas-fracking>

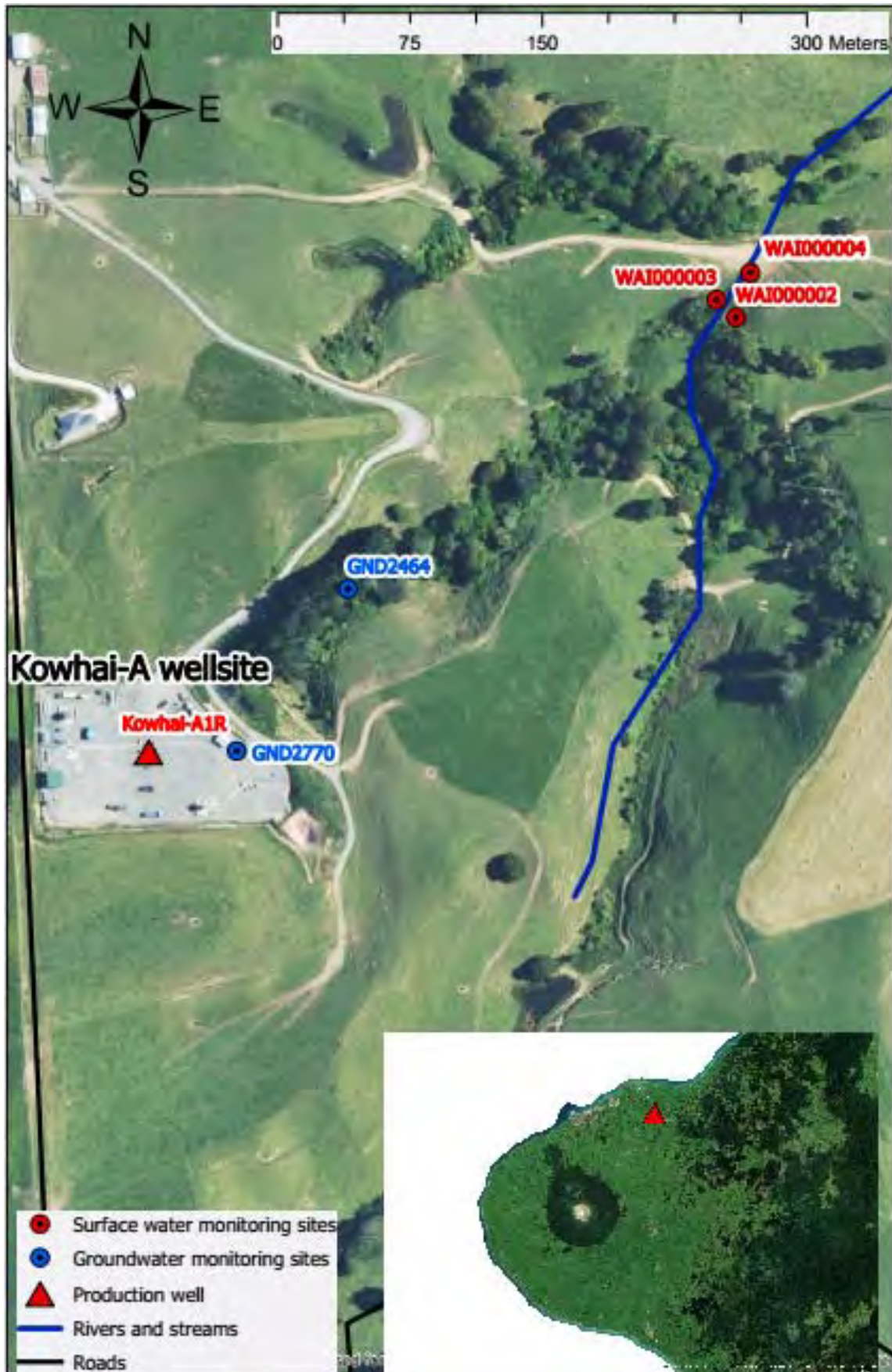


Figure 1 Location map

## 1.3 Resource consents

### 1.3.1 Discharges of wastes to land

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

Petrochem was granted resource consent **10356-1** on 10 November 2016. The consent permits the discharge of contaminants in association with hydraulic fracturing activities at the Kowhai-A wellsite, Ngatimaru Road, Tikorangi. The consent was issued by the Council under Section 87(e) of the RMA. The consent requires the injection of fracturing fluids to occur below a depth of 3,300 m TVDss. The consent is due to expire 1 June 2033.

Consent 10356-1 has 20 special conditions, as summarised below:

- Condition 1 stipulates the minimum depth below which the injection of hydraulic fracturing fluids must occur;
- Condition 2 requires that no further hydraulic fracturing be undertaken after 1 June 2028;
- Condition 3 sets out the requirements the consent holder must take should the Geonet seismic monitoring network record a seismic event higher than magnitude 3 within 5 km of the discharge;
- Condition 4 stipulates the reporting requirements following any seismic event described in condition 3;
- Condition 5 requires the consent holder to ensure that the exercising of the consent does not result in any contaminants reaching any useable freshwater (ground or surface water);
- Conditions 6, 7, 8 and 9 relate to freshwater monitoring requirements, to allow compliance with condition 5 to be assessed;
- Condition 10 requires the consent holder to carry out pressure testing of equipment prior to discharging;
- Condition 11 requires the consent holder to submit a pre-fracturing discharge report prior to any discharge occurring;
- Condition 12 is a notification requirement;
- Condition 13 requires the consent holder to submit a post-fracturing discharge report after the completion of the hydraulic fracturing programme for each well;
- Condition 14 stipulates the requirements for interim post-fracturing reports;
- Condition 15 stipulates how the reports required by conditions 11, 13 and 14 are to be submitted;
- Condition 16 requires the consent holder to allow the Council access to a location where samples of hydraulic fracturing and return fluids can be obtained;
- Condition 17 requires the consent holder to adopt best practicable options;
- Condition 18 relates to the composition of the fracturing fluid;
- Condition 19 is a lapse clause; and
- Condition 20 is a review provision.

This summary of consent conditions may not reflect the full requirements of each condition. The consent conditions in full can be found in the resource consent appended to this report (Appendix I).

## 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 Kowhai-A 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 10356-1, Petrochem 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 (area of review) of a hydraulic fracturing activity are assessed for their suitability for sampling (or otherwise) and included in the monitoring programme for the wellsite.

During the survey, one groundwater bore (GND2706) and one groundwater spring (GND2464) were found within the 1 km area of review. The spring is located in the base of a gully approximately 90 m to the north east of the wellsite. Although the spring is located close to and down-gradient of the wellsite the flow is seasonal and therefore likely receives a mixture of both shallow groundwater and surface water drainage, making it unsuitable for ongoing monitoring. The bore GND2706 was also unsuitable as it is located approximately 700 m away and up-gradient of the wellsite within a different catchment.

Given the lack of suitable existing groundwater sites for monitoring within the survey area, a purpose built monitoring bore (GND2770) was drilled by Petrochem in order to comply with condition 7 of consent 10356-1. The bore details are summarised in Table 1. The location of the bore is displayed in Figure 1. GND2770 is the only groundwater monitoring site included in the monitoring programme.



Table 2 Details of groundwater sites included in the monitoring programme

| Monitoring site | Eastings (NZTM) | Northings (NZTM) | Distance from wellsite (m) | Total depth (m) | Screened/open interval (m) | Aquifer                        |
|-----------------|-----------------|------------------|----------------------------|-----------------|----------------------------|--------------------------------|
| GND2770         | 1710982         | 5676289          | Onsite                     | 38              | 26-38                      | Volcanics and marine sediments |

Samples of groundwater were obtained pre-fracturing to provide a baseline reference of groundwater composition, with further rounds of sampling carried out three months and one year after the cessation of 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 for each well 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 were obtained by Petrochem during the activity and were sent to Hill Laboratories Ltd for analysis.

#### 1.4.5 Surface water quality monitoring

A tributary of the Waiau Stream is located approximately 200 m to the east of the wellsite and an ephemeral spring (GND2464), that discharges into the tributary, is located approximately 100 m to the north-east of the wellsite.

Stormwater and treated site water are discharged onto land and into the unnamed tributary of the Waiau Stream under consent 10169-1 at the Kowhai-A wellsite. 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 3. The locations are illustrated on Figure 1.

Table 3 Surface water monitoring site details

| Monitoring site | Description                                 | Location   | Eastings | Northings |
|-----------------|---|--|----------|-----------|
| WAI000002       | Waiau Stream: unnamed tributary             | 10 m upstream of confluence with receiving tributary | 1711265  | 5676535   |
| WAI000003       | Waiau Stream: unnamed tributary (ephemeral) | 10 m upstream of confluence (receiving tributary)    | 1711254  | 5676545   |

| Monitoring site | Description                        | Location  | Eastings | Northings |
|-----------------|------------------------------------|---|----------|-----------|
| WAI000004       | Waiau Stream:<br>unnamed tributary | 15 m downstream of confluence of receiving tributary/ 5 m upstream of culvert | 1711272  | 5672562   |

#### 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 unnamed tributary of the Waiau Stream. Samples are processed to provide number of taxa (richness), MCI and SQMCI<sub>s</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>s</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>s</sub> between sites indicate the degree of adverse effects (if any) of the discharges being monitored.

Two macroinvertebrate surveys were carried out at two of the established surface water monitoring sites in the unnamed tributary of the Waiau Stream closest to the wellsite (WAI000003 and WAI000004). The third site (WAI000002) could not be sampled on either occasion due to the presence of livestock preventing safe access to the sampling location.

The pre-hydraulic fracturing survey was undertaken on 18 December 2017 and the post-hydraulic fracturing survey was undertaken on 10 September 2018.

## 2 Results

### 2.1 Consent holder submitted data

#### 2.1.1 Kowhai-A1R post-fracturing discharge report

The conclusions from the Kowhai-A1R post-fracturing discharge report are summarised as follows:

- A total of five zones were fractured over the period 25 February to 5 June 2018 at depths between 3,592 to 4,104 m TVDss.
- A total of 10,665 bbls (1,696 m<sup>3</sup>) of liquid was discharged across the five fractured zones. The total proppant weight was 307.5 tonnes (677,945 lbs).
- The Kowhai-A1R well was opened for flow-back following the completion of fracturing operations. In total 11,855 bbls (1,885 m<sup>3</sup>) of fluid was returned from the well over the initial flow-back period.
- Zone 1 was fractured twice and returned less fluid than injected on both occasions. Zone 3 and zone 6 also returned slightly less fluid than injected. The remaining zones returned a greater volume than injected.
- Nitrogen was used to assist in flowing back zones 1, 2, 4 and 5.
- One screen out occurred while fracturing zone 3 resulting in the under placement of approximately 1.93 tonnes (4,273 lbs) of proppant. All proppant was subsequently recovered with no implications for compliance with consent conditions reported.
- All return fluid from the Kowhai-A1R 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.
- It is considered that the mitigation measures implemented by Petrochem were effective in ensuring there were no adverse environmental effects associated with fracturing operations.

### 2.2 Physiochemical sampling

#### 2.2.1 Groundwater

Hydraulic fracturing activities commenced at the Kowhai-A wellsite on 25 February 2018 and continued until 5 June 2018. A pre-fracturing baseline sample was collected on 29 November 2017. Post-fracturing samples were collected three months and one year following commencement of the activities on 25 May 2018 and 19 February 2019 respectively.

All samples demonstrate relatively narrow ranges between analyte concentrations over time. The subtle variation in analyte concentrations at each site are a result of natural seasonal fluctuation and sampling variability. The results of the laboratory analysis indicate there have been no significant changes in groundwater composition over the period monitored.

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



Table 4 Results of groundwater sampling carried out in relation to the Kowhai-A1R fracturing event

| Parameter                  | Bore id                            | GND2770                   |                 |                  |
|----------------------------|------------------------------------|---------------------------|-----------------|------------------|
|                            | Unit                               | Pre-fracturing (baseline) | 3 mth post-frac | 1 year post-frac |
| Sample date                | -                                  | 29/11/2017                | 25/05/2018      | 19/02/2019       |
| Lab number (Hill)          | -                                  | 1886541                   | 1989659         | 2127462          |
| pH                         | pH                                 | 6.8                       | 6.2             | 6.3              |
| Total alkalinity           | g/m <sup>3</sup> CaCO <sub>3</sub> | 51                        | 19.8            | 25               |
| Bicarbonate                | g/m <sup>3</sup> HCO <sub>3</sub>  | 62                        | 24              | 30               |
| Total hardness             | g/m <sup>3</sup> CaCO <sub>3</sub> | 59                        | 70              | 75               |
| Electrical conductivity    | mS/m                               | 18.9                      | 31.6            | 27.2             |
| Total dissolved solids     | g/m <sup>3</sup>                   | 138                       | 210             | 220              |
| Dissolved calcium          | g/m <sup>3</sup>                   | 12.4                      | 14.2            | 15.7             |
| Chloride                   | g/m <sup>3</sup>                   | 21                        | 73              | 54               |
| Dissolved magnesium        | g/m <sup>3</sup>                   | 6.8                       | 8.5             | 8.6              |
| Dissolved potassium        | g/m <sup>3</sup>                   | 1.54                      | 2.3             | 1.68             |
| Dissolved sodium           | g/m <sup>3</sup>                   | 13.3                      | 31              | 16.3             |
| Nitrite nitrogen           | g/m <sup>3</sup> N                 | 0.02                      | <0.002          | <0.002           |
| Nitrate nitrogen           | g/m <sup>3</sup> N                 | 1.92                      | 1.3             | 1.69             |
| Nitrate & nitrite nitrogen | g/m <sup>3</sup> N                 | 1.94                      | 1.3             | 1.69             |
| Sulphate                   | g/m <sup>3</sup>                   | 2.3                       | 1.4             | 2.0              |
| Dissolved barium           | mg/kg                              | 0.0088                    | 0.0192          | 0.013            |
| Bromide                    | g/m <sup>3</sup>                   | 0.1                       | 0.29            | 0.23             |
| Dissolved copper           | g/m <sup>3</sup>                   | <0.0005                   | <0.0005         | <0.0005          |
| Dissolved iron             | g/m <sup>3</sup>                   | 0.05                      | <0.02           | <0.02            |
| Dissolved manganese        | g/m <sup>3</sup>                   | 0.036                     | 0.026           | 0.0051           |
| Dissolved mercury          | g/m <sup>3</sup>                   | <0.00008                  | <0.00008        | <0.00008         |
| Dissolved Nickel           | mg/kg                              | 0.0018                    | <0.0005         | <0.0005          |
| Dissolved zinc             | g/m <sup>3</sup>                   | 0.0164                    | 0.0181          | 0.0153           |
| Ethylene glycol            | g/m <sup>3</sup>                   | <4                        | <4              | <4               |
| Propylene glycol           | g/m <sup>3</sup>                   | <4                        | <4              | <4               |
| Methanol                   | g/m <sup>3</sup>                   | <2                        | <2              | <5               |
| Benzene                    | g/m <sup>3</sup>                   | <0.0010                   | <0.0010         | <0.0010          |
| Toluene                    | g/m <sup>3</sup>                   | <0.0010                   | <0.0010         | <0.0010          |
| Ethylbenzene               | g/m <sup>3</sup>                   | <0.0010                   | <0.0010         | <0.0010          |
| m-Xylene                   | g/m <sup>3</sup>                   | <0.002                    | <0.002          | <0.002           |
| o-Xylene                   | g/m <sup>3</sup>                   | <0.0010                   | <0.0010         | <0.0010          |
| Formaldehyde               | g/m <sup>3</sup>                   | <0.02                     | <0.02           | <0.02            |
| Ethane                     | g/m <sup>3</sup>                   | <0.003                    | <0.003          | <0.003           |
| Ethylene                   | g/m <sup>3</sup>                   | <0.004                    | <0.004          | <0.004           |
| Methane                    | g/m <sup>3</sup>                   | 0.014                     | <0.002          | <0.002           |
| C7-C9                      | g/m <sup>3</sup>                   | <0.06                     | <0.06           | <0.06            |
| C10-C14                    | g/m <sup>3</sup>                   | <0.2                      | <0.2            | <0.2             |
| C15-C36                    | g/m <sup>3</sup>                   | <0.4                      | <0.4            | <0.4             |
| Total hydrocarbons         | g/m <sup>3</sup>                   | <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 Kowhai-A1R well are shown below in Table 5. The certificates of analysis are included in Appendix III.

Depending on the viscosity of the sample received at the laboratory, samples may require dilution prior to analysis which results in the higher detection limited (<200 and <400 g/m<sup>3</sup>) seen for some of the parameters reported in Treatment 1.

The results of the analyses carried out on the return fluid samples obtained following the hydraulic fracturing of the Kowhai-A1R well are summarised below in Table 6 and certificates of analysis are included in Appendix III. Return fluids collected demonstrate the variability of groundwater quality 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 5 Results of hydraulic fracturing fluid sampling

| Parameter          | Well id          | Kowhai-A1R (GND2765) |          |          |          |          |          |
|--------------------|------------------|----------------------|----------|----------|----------|----------|----------|
| Reference          | Unit             | Zone 1               | Zone 1   | Zone 2   | Zone 3   | Zone 4   | Zone 5   |
| Treatment          | -                | 1                    | 2        | 3        | 4        | 5        | 6        |
| Date               | -                | 25/02/18             | 13/04/18 | 24/04/18 | 13/05/18 | 22/05/18 | 05/06/18 |
| Lab number         | Hill             | 1940128              | 1966864  | 1976223  | 1988608  | 2011654  | 1997054  |
| Ethylene glycol*   | g/m <sup>3</sup> | <400                 | <4       | <20      | <20      | <4       | <20      |
| Propylene glycol*  | g/m <sup>3</sup> | <400                 | <4       | <20      | <20      | <4       | <20      |
| Methanol*          | g/m <sup>3</sup> | <200                 | <2       | <2       | <20      | 3        | <20      |
| Benzene            | g/m <sup>3</sup> | <0.0010              | <0.010   | <0.0010  | <0.010   | <0.010   | 0.002    |
| Toluene            | g/m <sup>3</sup> | <0.0010              | <0.010   | <0.0010  | 0.056    | <0.010   | 0.0023   |
| Ethylbenzene       | g/m <sup>3</sup> | 0.0012               | <0.010   | <0.0010  | <0.010   | <0.010   | 0.0019   |
| m-Xylene           | g/m <sup>3</sup> | 0.002                | <0.02    | <0.002   | <0.02    | <0.02    | 0.006    |
| o-Xylene           | g/m <sup>3</sup> | 0.0015               | <0.010   | <0.0010  | <0.010   | <0.010   | 0.0024   |
| C7-C9              | g/m <sup>3</sup> | 0.11                 | <0.6     | <0.06    | 1        | <0.06    | 0.68     |
| C10-C14            | g/m <sup>3</sup> | 18.7                 | 189      | 113      | 2,100    | 1,780    | 210      |
| C15-C36            | g/m <sup>3</sup> | 46                   | 37       | 46       | 130      | 106      | 65       |
| Total hydrocarbons | g/m <sup>3</sup> | 65                   | 230      | 159      | 2,300    | 1,880    | 280      |

\* Some samples required dilution in the lab due to high viscosity which has resulted in a range of detection limits for some parameters

Table 6 Results of hydraulic fracturing return fluid sampling

| Parameter               | Bore id                            | Kowhai-A1R (GND2765) |          |          |          |          |         |
|-------------------------|------------------------------------|----------------------|----------|----------|----------|----------|---------|
| Reference               | Unit                               | Zone 1               | Zone 1   | Zone 2   | Zone 3   | Zone 4   | Zone 5  |
| Sample date             | -                                  | 25/02/18             | 13/04/18 | 24/04/18 | 13/05/18 | 22/05/18 | 5/06/18 |
| Lab number              | Hill                               | 1952930              | 1966863  | 1975423  | 1988609  | 2011708  | 2002229 |
| pH                      | pH                                 | 7.1                  | 6        | 6.5      | 7.2      | 6.9      | 6.8     |
| Total alkalinity        | g/m <sup>3</sup> CaCO <sub>3</sub> | 690                  | 43       | 600      | 1,980    | 780      | 1,250   |
| Bicarbonate             | g/m <sup>3</sup> HCO <sub>3</sub>  | 481                  | 23       | 540      | 1,812    | 719      | 1,016   |
| Total hardness          | g/m <sup>3</sup> CaCO <sub>3</sub> | 156                  | 79       | 640      | 200      | 146      | 147     |
| Electrical conductivity | mS/m                               | 969                  | 96       | 2,510    | 1,908    | 1,135    | 1,406   |
| Total dissolved solids  | g/m <sup>3</sup>                   | 7,300                | 3,100    | 16,500   | 12,200   | 9,400    | 10,400  |
| Dissolved barium        | mg/kg                              | 17                   | 0.37     | 110      | 29       | 20       | 23      |
| Dissolved bromine       | g/m <sup>3</sup>                   | 24                   | <0.5     | 16.7     | 14.4     | 7        | 11.6    |
| Dissolved calcium       | g/m <sup>3</sup>                   | 53                   | 24       | 230      | 61       | 46       | 46      |
| Dissolved copper        | g/m <sup>3</sup>                   | 0.06                 | 0.017    | 0.023    | 0.013    | 0.011    | 0.008   |
| Dissolved iron          | g/m <sup>3</sup>                   | 2.1                  | 2.7      | 7.5      | 2.9      | 3.3      | 1.63    |
| Dissolved magnesium     | g/m <sup>3</sup>                   | 6                    | 4        | 18       | 11       | 8        | 8       |
| Dissolved manganese     | g/m <sup>3</sup>                   | 0.71                 | 0.36     | 2.4      | 4.5      | 1.87     | 3.7     |
| Total Nickel            | mg/kg                              | 0.05                 | 0.053    | 0.03     | 0.21     | 0.09     | 0.03    |
| Total potassium         | g/m <sup>3</sup>                   | 300                  | 68       | 260      | 189      | 120      | 155     |
| Total sodium            | g/m <sup>3</sup>                   | 1,860                | 38       | 5,200    | 5,100    | 2,200    | 3,000   |
| Total sulphur           | g/m <sup>3</sup>                   | <6                   | 53       | 31       | 17       | 28       | 310     |
| Total zinc              | g/m <sup>3</sup>                   | 0.96                 | 0.099    | 0.094    | <0.015   | 3        | 0.28    |

| Parameter                  | Bore id            | Kowhai-A1R (GND2765) |          |          |          |          |         |
|----------------------------|--------------------|----------------------|----------|----------|----------|----------|---------|
| Reference                  | Unit               | Zone 1               | Zone 1   | Zone 2   | Zone 3   | Zone 4   | Zone 5  |
| Sample date                | -                  | 25/02/18             | 13/04/18 | 24/04/18 | 13/05/18 | 22/05/18 | 5/06/18 |
| Lab number                 | Hill               | 1952930              | 1966863  | 1975423  | 1988609  | 2011708  | 2002229 |
| Chloride                   | g/m <sup>3</sup>   | 2,700                | 210      | 8,300    | 3,800    | 6,500    | 5,000   |
| Nitrite nitrogen           | g/m <sup>3</sup> N | 0.011                | 0.137    | 0.039    | 0.041    | 0.12     | 0.3     |
| Nitrate nitrogen           | g/m <sup>3</sup> N | 0.072                | 0.25     | 0.015    | <0.010   | <0.10    | <0.10   |
| Nitrate & nitrite nitrogen | g/m <sup>3</sup> N | 0.027                | 0.193    | 0.054    | 0.038    | <0.5     | <0.5    |
| Sulphate                   | g/m <sup>3</sup>   | <16                  | 158      | 92       | 52       | 84       | 920     |
| Ethylene glycol            | g/m <sup>3</sup>   | <400                 | <40      | <4       | <20      | 690      | 73      |
| Propylene glycol           | g/m <sup>3</sup>   | <400                 | <40      | <4       | <20      | <4       | <20     |
| Methanol                   | g/m <sup>3</sup>   | <200                 | <2       | <2       | <2       | 540      | 57      |
| Benzene                    | g/m <sup>3</sup>   | 0.44                 | 0.039    | 3.1      | 18.1     | 31       | 6.8     |
| Toluene                    | g/m <sup>3</sup>   | 1.05                 | 0.065    | 1.93     | 49       | 71       | 11.7    |
| Ethylbenzene               | g/m <sup>3</sup>   | 0.186                | <0.010   | 0.129    | 6.7      | 8.7      | 1.48    |
| m-Xylene                   | g/m <sup>3</sup>   | 1.2                  | 0.71     | 0.69     | 49       | 58       | 8.9     |
| o-Xylene                   | g/m <sup>3</sup>   | 0.41                 | 0.21     | 0.29     | 14.1     | 18.2     | 3.1     |
| Formaldehyde               | g/m <sup>3</sup>   | <1.5                 | <0.15    | <0.15    | <0.15    | <0.15    | <0.15   |
| C7-C9                      | g/m <sup>3</sup>   | 13.5                 | 4.4      | 5.2      | 260      | 350      | 52      |
| C10-C14                    | g/m <sup>3</sup>   | 670                  | 1,220    | 340      | 1,120    | 4,800    | 490     |
| C15-C36                    | g/m <sup>3</sup>   | 930                  | 138      | 40       | 1,210    | 3,200    | 96      |
| Total hydrocarbons         | g/m <sup>3</sup>   | 1,610                | 1,360    | 380      | 2,600    | 8,300    | 640     |

## 2.3 Biomonitoring surveys

Two macroinvertebrate surveys were carried out at two sites in an unnamed tributary of the Waiau Stream, near the Kowhai-A wellsite prior to and following hydraulic fracturing activities, to determine if stormwater discharges from the wellsite had significant adverse effects on the stream macroinvertebrate communities. These surveys recorded high MCI and SQMCI scores for lowland coastal streams at similar altitude. MCI scores were similar between the two sites and surveys, while SQMCI scores were lower at WAI000003 than WAI000004. WAI000003 also showed a significant decrease in SQMCI between the two surveys, which was not apparent at WAI000004. Taxa richness was the same at both sites in the pre-hydraulic fracturing survey, but was higher at WAI000004 in the post-HF survey. WAI000004 also showed an increase in taxa richness between the two surveys, while WAI000003 remained similar. Overall, the macroinvertebrate communities reflected habitat differences between the two sites. There was no evidence that the stormwater discharges from the Kowhai-A wellsite had caused any recent significant detrimental impacts on the macroinvertebrate communities of the unnamed tributary of the Waiau Stream.

The biomonitoring full report is appended to this report as Appendix IV.

## 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 Petrochem. 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 Petrochem's conditions in resource consents or provisions in Regional Plans.

## 3 Discussion

### 3.1 Environmental effects of exercise of consents

One well (Kowhai-A1R) was stimulated by hydraulic fracturing at the Kowhai-A wellsite during the period 25 February 2018 to 5 June 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 outside the perimeter of the Kowhai-A wellsite. The results of post fracturing groundwater sampling carried out showed only very minor variations in water composition in comparison to baseline results. Methane and traces of ethane were recorded in all the groundwater samples collected and are not interpreted to be a result of hydraulic fracturing activities at the Kowhai-A1R wellsite. The minor variations in most analytes are a result of natural variations in water composition.

The surface water monitoring component of the programme comprised of two biomonitoring surveys of two unnamed tributaries in Waiau Catchment pre and post-fracturing of the Kowhai-A1R well. The results of the biomonitoring surveys undertaken in relation to the Kowhai-A fracturing event indicate that site activities had no adverse effects on the invertebrate communities within the stream.

In summary, the monitoring carried out by the Council during the period being reported indicates that the hydraulic fracturing activities undertaken by Petrochem at the Kowhai-A 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 7 and Table 8.

Table 7 Summary of performance for consent 10356-1

| <b>Purpose To discharge water based hydraulic fracturing fluids into land at depths greater than 3,300 mTVDss beneath the Kowhai-A wellsite at or about (NZTM) 1710930E-5676255N</b> |   |                             |
|--|---|-----------------------------|
| <b>Condition requirement</b>   | <b>Means of monitoring during period under review</b>   | <b>Compliance achieved?</b> |
| 1. Any discharge shall occur below 3,300 mTVDss  | 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 3,300 mTVDss beneath the Kowhai-A wellsite at or about (NZTM) 1710930E-5676255N**

| 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 7 and 9 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 3,300 mTVDss beneath the Kowhai-A wellsite at or about (NZTM) 1710930E-5676255N**

| 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, Petrochem 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 Petrochem be replicated for any future fracturing events at the Kowhai-A 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 10356-1 provides for an optional review of the consent in June 2019. 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 Petrochem's hydraulic fracturing activities be replicated for any future fracturing events at the Kowhai-A 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 2019, 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).  |
| EPT               | Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) which are macroinvertebrates sensitive to pollution.  |
| Fresh             | Elevated flow in a stream, such as after heavy rainfall.  |
| g/m <sup>3</sup>  | Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.  |
| Incident          | An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred. |
| Intervention      | Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.  |
| Investigation     | Action taken by Council to establish the circumstances/events surrounding an incident including any allegations of an incident.   |
| L/s               | Litres per second.  |
| Macroinvertebrate | An invertebrate that is large enough to be seen without the use of a microscope.  |
| masl              | Metres above sea level.   |
| MCI               | Macroinvertebrate community index; a numerical indication of the state of biological life in a stream that takes into account the sensitivity of the taxa present to organic pollution in stony habitats.   |
| mS/m              | Millisiemens per metre.   |
| m <sup>3</sup>    | 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.  |

Workover                    The repair or stimulation of an existing production well for the purpose of restoring, prolonging or enhancing the production of hydrocarbons.

## Bibliography and references

Baker Hughes at <http://blogs.bakerhughes.com/reservoir/2012/02/20/hydraulic-fracturing-an-environmentally-responsible-technology-for-ensuring-our-energy-future-part-iii-of-iii>

Geology.Com at <http://geology.com/energy/hydraulic-fracturing-fluids/>

Greymouth Petroleum Ltd (2017) Kowhai-A1R Pre-Fracturing Discharge Report December 2017 Frodo Number #1979762

Greymouth Petroleum Ltd (2017) Kowhai-A Wellsite Water Quality Monitoring Programme Report December 2017 Frodo Number #1965839

Greymouth Petroleum Ltd (2017) Kowhai-A1R Interim Post-Fracturing Discharge Report May 2018 Frodo Number #2059372

Greymouth Petroleum Ltd (2017) Kowhai-A1R Final Post-Fracturing Discharge Report July 2018 Frodo Number #2092339

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.



# Appendix I

## Resource consent held by Petrochem Ltd

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





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

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

Decision Date: 10 November 2016

Commencement Date: 10 November 2016

**Conditions of Consent**

Consent Granted: To discharge water based hydraulic fracturing fluids into land at depths greater than 3,300 mTVDss beneath the Kowhai-A wellsite

Expiry Date: 1 June 2033

Review Date(s): June Annually

Site Location: Kowhai-A wellsite, 547 Ngatimaru Road, Tikorangi

Grid Reference (NZTM) 1710930E-5676255N

Catchment: Waiau

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

### General condition

- a. The consent holder shall pay to the Taranaki Regional Council all the administration, monitoring and supervision costs of this consent, fixed in accordance with section 36 of the Resource Management Act 1991.

### Special conditions

1. The discharge point shall be deeper than 3,300 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 10356-1.0

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 10356-1.0

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.
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.

## Consent 10356-1.0

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 10 November 2016

For and on behalf of  
Taranaki Regional Council

---

A D McLay  
**Director - Resource Management**

## Appendix II

### Certificates of analysis (groundwater)







## ANALYSIS REPORT

|                 |   |                          |                                      |      |
|-----------------|---|--------------------------|--------------------------------------|------|
| <b>Client:</b>  | Taranaki Regional Council   | <b>Lab No:</b>           | 1886541                              | SPV1 |
| <b>Contact:</b> | David Olson<br>C/- Taranaki Regional Council<br>Private Bag 713<br>Stratford 4352 | <b>Date Received:</b>    | 30-Nov-2017                          |      |
|                 |   | <b>Date Reported:</b>    | 12-Dec-2017                          |      |
|                 |   | <b>Quote No:</b>         | 47915                                |      |
|                 |   | <b>Order No:</b>         | 68504                                |      |
|                 |   | <b>Client Reference:</b> | GPL Kowhai A IR Pre-Erac GW Nov 2017 |      |
|                 |   | <b>Submitted By:</b>     | David Olson                          |      |

### Sample Type: Aqueous

|                     |                                   |  |  |  |  |
|---------------------|-----------------------------------|--|--|--|--|
| <b>Sample Name:</b> | GND2770<br>29-Nov-2017 2:55<br>pm |  |  |  |  |
| <b>Lab Number:</b>  | 1886541.1                         |  |  |  |  |

| Individual Tests                     |                                       |           |   |   |   |   |
|--------------------------------------|---------------------------------------|-----------|---|---|---|---|
| Sum of Anions                        | meq/L                                 | 1.79      | - | - | - | - |
| Sum of Cations                       | meq/L                                 | 1.80      | - | - | - | - |
| pH                                   | pH Units                              | 6.8       | - | - | - | - |
| Total Alkalinity                     | g/m <sup>3</sup> as CaCO <sub>3</sub> | 51        | - | - | - | - |
| Bicarbonate                          | g/m <sup>3</sup> at 25°C              | 62        | - | - | - | - |
| Total Hardness                       | g/m <sup>3</sup> as CaCO <sub>3</sub> | 59        | - | - | - | - |
| Electrical Conductivity (EC)         | mS/m                                  | 18.9      | - | - | - | - |
| Total Dissolved Solids (TDS)         | g/m <sup>3</sup>                      | 138       | - | - | - | - |
| Dissolved Barium                     | g/m <sup>3</sup>                      | 0.0088    | - | - | - | - |
| Dissolved Calcium                    | g/m <sup>3</sup>                      | 12.4      | - | - | - | - |
| Dissolved Copper                     | g/m <sup>3</sup>                      | < 0.0005  | - | - | - | - |
| Dissolved Iron                       | g/m <sup>3</sup>                      | 0.05      | - | - | - | - |
| Dissolved Magnesium                  | g/m <sup>3</sup>                      | 6.8       | - | - | - | - |
| Dissolved Manganese                  | g/m <sup>3</sup>                      | 0.036     | - | - | - | - |
| Dissolved Mercury                    | g/m <sup>3</sup>                      | < 0.00008 | - | - | - | - |
| Dissolved Nickel                     | g/m <sup>3</sup>                      | 0.0018    | - | - | - | - |
| Dissolved Potassium                  | g/m <sup>3</sup>                      | 1.54      | - | - | - | - |
| Dissolved Sodium                     | g/m <sup>3</sup>                      | 13.3      | - | - | - | - |
| Dissolved Zinc                       | g/m <sup>3</sup>                      | 0.0164    | - | - | - | - |
| Bromide                              | g/m <sup>3</sup>                      | 0.10      | - | - | - | - |
| Chloride                             | g/m <sup>3</sup>                      | 21        | - | - | - | - |
| Nitrite-N                            | g/m <sup>3</sup>                      | 0.020     | - | - | - | - |
| Nitrate-N                            | g/m <sup>3</sup>                      | 1.92      | - | - | - | - |
| Nitrate-N + Nitrite-N                | g/m <sup>3</sup>                      | 1.94      | - | - | - | - |
| Sulphate                             | g/m <sup>3</sup>                      | 2.3       | - | - | - | - |
| 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>                    | GND2770<br>29-Nov-2017 2:55<br>pm |         |   |   |   |   |
| <b>Lab Number:</b>                     | 1886541.1                         |         |   |   |   |   |
| 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>                  | 0.014   | - | - | - | - |
| 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<br>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.<br>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.<br>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         |
| 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         |

| Sample Type: Aqueous  |   |                          |           |
|-----------------------|---|--------------------------|-----------|
| Test                  | Method Description  | Default Detection Limit  | Sample No |
| 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

|                 |  |                          |              |      |
|-----------------|--|--------------------------|--------------|------|
| <b>Client:</b>  | Taranaki Regional Council  | <b>Lab No:</b>           | 1989656      | SPV1 |
| <b>Contact:</b> | Sarah Larkin<br>C/- Taranaki Regional Council<br>Private Bag 713<br>Stratford 4352 | <b>Date Received:</b>    | 26-May-2018  |      |
|                 |  | <b>Date Reported:</b>    | 07-Jun-2018  |      |
|                 |  | <b>Quote No:</b>         | 47915        |      |
|                 |  | <b>Order No:</b>         | Kowhai A     |      |
|                 |  | <b>Client Reference:</b> | HFGW 3mth    |      |
|                 |  | <b>Submitted By:</b>     | Sarah Larkin |      |

### Sample Type: Aqueous

|                     |                                       |  |  |  |  |
|---------------------|---------------------------------------|--|--|--|--|
| <b>Sample Name:</b> | GND2770 HF<br>25-May-2018<br>12:10 pm |  |  |  |  |
| <b>Lab Number:</b>  | 1989656.1                             |  |  |  |  |

| Individual Tests                     |                                       |           |   |   |   |   |
|--------------------------------------|---------------------------------------|-----------|---|---|---|---|
| Sum of Anions                        | meq/L                                 | 2.6       | - | - | - | - |
| Sum of Cations                       | meq/L                                 | 2.8       | - | - | - | - |
| pH                                   | pH Units                              | 6.2       | - | - | - | - |
| Total Alkalinity                     | g/m <sup>3</sup> as CaCO <sub>3</sub> | 19.8      | - | - | - | - |
| Bicarbonate                          | g/m <sup>3</sup> at 25°C              | 24        | - | - | - | - |
| Total Hardness                       | g/m <sup>3</sup> as CaCO <sub>3</sub> | 70        | - | - | - | - |
| Electrical Conductivity (EC)         | mS/m                                  | 31.6      | - | - | - | - |
| Total Dissolved Solids (TDS)         | g/m <sup>3</sup>                      | 210       | - | - | - | - |
| Dissolved Barium                     | g/m <sup>3</sup>                      | 0.0192    | - | - | - | - |
| Dissolved Calcium                    | g/m <sup>3</sup>                      | 14.2      | - | - | - | - |
| Dissolved Copper                     | g/m <sup>3</sup>                      | < 0.0005  | - | - | - | - |
| Dissolved Iron                       | g/m <sup>3</sup>                      | < 0.02    | - | - | - | - |
| Dissolved Magnesium                  | g/m <sup>3</sup>                      | 8.5       | - | - | - | - |
| Dissolved Manganese                  | g/m <sup>3</sup>                      | 0.026     | - | - | - | - |
| 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>                      | 2.3       | - | - | - | - |
| Dissolved Sodium                     | g/m <sup>3</sup>                      | 31        | - | - | - | - |
| Dissolved Zinc                       | g/m <sup>3</sup>                      | 0.0181    | - | - | - | - |
| Bromide                              | g/m <sup>3</sup>                      | 0.29      | - | - | - | - |
| Chloride                             | g/m <sup>3</sup>                      | 73        | - | - | - | - |
| Nitrite-N                            | g/m <sup>3</sup>                      | < 0.002   | - | - | - | - |
| Nitrate-N                            | g/m <sup>3</sup>                      | 1.30      | - | - | - | - |
| Nitrate-N + Nitrite-N                | g/m <sup>3</sup>                      | 1.30      | - | - | - | - |
| Sulphate                             | g/m <sup>3</sup>                      | 1.4       | - | - | - | - |
| 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>                    | GND2770 HF<br>25-May-2018<br>12:10 pm |         |   |   |   |   |
| <b>Lab Number:</b>                     | 1989656.1                             |         |   |   |   |   |
| 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>                      | < 0.002 | - | - | - | - |
| 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<br>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         |
| 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         |
| 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         |

| Sample Type: Aqueous  |   |                          |           |
|-----------------------|---|--------------------------|-----------|
| Test                  | Method Description  | Default Detection Limit  | Sample No |
| 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.

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

Ara Heron BSc (Tech)  
Client Services Manager - Environmental

## Appendix III

Certificates of analysis  
(hydraulic fracturing fluids)







## Certificate of Analysis

|                 |   |                          |                                    |      |
|-----------------|---|--------------------------|------------------------------------|------|
| <b>Client:</b>  | Greymouth Petroleum Limited   | <b>Lab No:</b>           | 1988608                            | SPV1 |
| <b>Contact:</b> | Skye Loveridge-Easter<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 25-May-2018                        |      |
|                 |   | <b>Date Reported:</b>    | 07-Jun-2018                        |      |
|                 |   | <b>Quote No:</b>         | 85159                              |      |
|                 |   | <b>Order No:</b>         | 242441                             |      |
|                 |   | <b>Client Reference:</b> | Hydraulic fracturing fluid testing |      |
|                 |   | <b>Submitted By:</b>     | Skye Loveridge-Easter              |      |

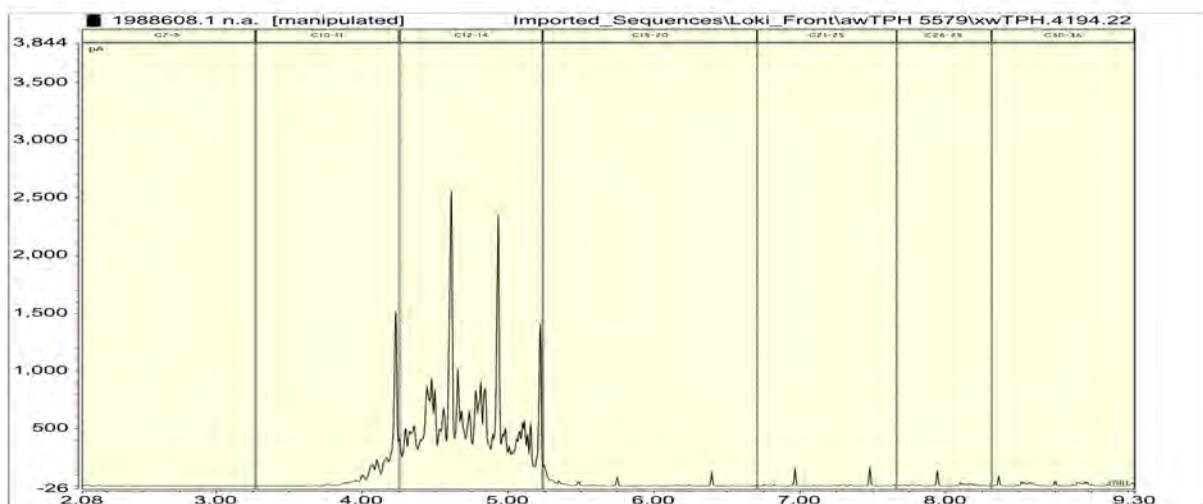
### Sample Type: Aqueous

|                                       |   |         |   |   |   |
|---------------------------------------|---|---------|---|---|---|
| <b>Sample Name:</b>                   | Kowhai A Frac 4<br>Prepumped HF<br>Fluid<br>13-May-2018 |         |   |   |   |
| <b>Lab Number:</b>                    | 1988608.1   |         |   |   |   |
| 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>  | < 20    | - | - | - |
| BTEX in Water by Headspace GC-MS      |   |         |   |   |   |
| Benzene                               | g/m <sup>3</sup>  | < 0.010 | - | - | - |
| Toluene                               | g/m <sup>3</sup>  | 0.056   | - | - | - |
| 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>  | 2,100   | - | - | - |
| C15 - C36                             | g/m <sup>3</sup>  | 130     | - | - | - |
| Total hydrocarbons (C7 - C36)         | g/m <sup>3</sup>  | 2,300   | - | - | - |

1988608.1

Kowhai A Frac 4 Prepumped HF Fluid 13-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<br>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



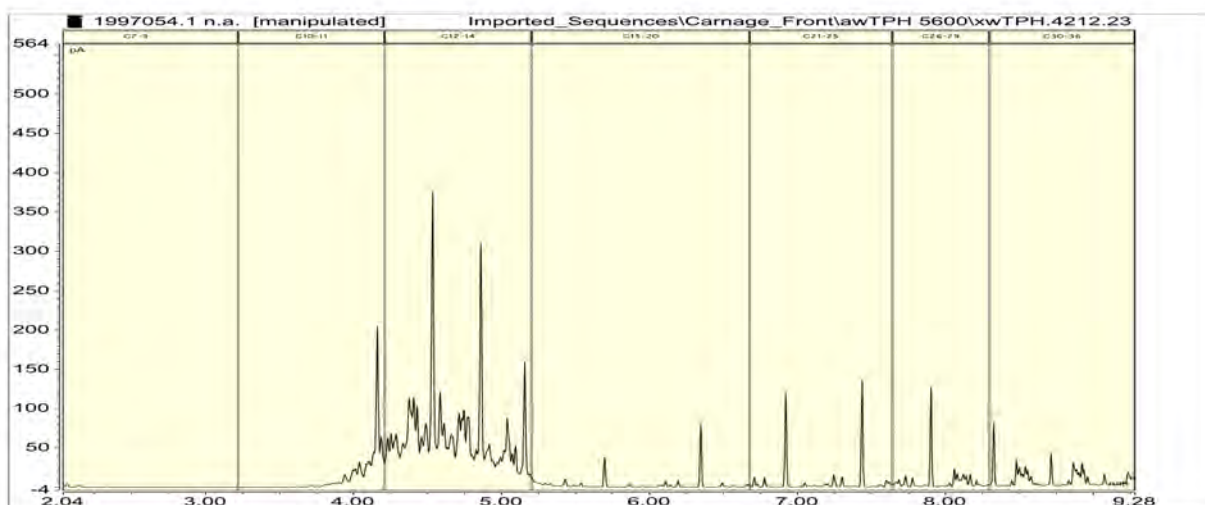
## Certificate of Analysis

|                 |  |                          |                                    |           |
|-----------------|--|--------------------------|------------------------------------|-----------|
| <b>Client:</b>  | Greymouth Petroleum Limited  | <b>Lab No:</b>           | 1997054                            | SPv2      |
| <b>Contact:</b> | Skye Loveridge-Easther<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 09-Jun-2018                        |           |
|                 |  | <b>Date Reported:</b>    | 04-Jul-2018                        | (Amended) |
|                 |  | <b>Quote No:</b>         | 85159                              |           |
|                 |  | <b>Order No:</b>         | 242443                             |           |
|                 |  | <b>Client Reference:</b> | Hydraulic fracturing fluid testing |           |
|                 |  | <b>Submitted By:</b>     | Skye Loveridge-Easther             |           |

### Sample Type: Aqueous

|                                       |  |        |   |   |   |
|---------------------------------------|--|--------|---|---|---|
| <b>Sample Name:</b>                   | Kowhai A Frac 6<br>Prepumped HF<br>Fluid 05-Jun-2018 |        |   |   |   |
| <b>Lab Number:</b>                    | 1997054.1  |        |   |   |   |
| 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>                                     | < 20   | - | - | - |
| BTEX in Water by Headspace GC-MS      |  |        |   |   |   |
| Benzene                               | g/m <sup>3</sup>                                     | 0.0020 | - | - | - |
| Toluene                               | g/m <sup>3</sup>                                     | 0.0023 | - | - | - |
| Ethylbenzene                          | g/m <sup>3</sup>                                     | 0.0019 | - | - | - |
| m&p-Xylene                            | g/m <sup>3</sup>                                     | 0.006  | - | - | - |
| o-Xylene                              | g/m <sup>3</sup>                                     | 0.0024 | - | - | - |
| Total Petroleum Hydrocarbons in Water |  |        |   |   |   |
| C7 - C9                               | g/m <sup>3</sup>                                     | 0.68   | - | - | - |
| C10 - C14                             | g/m <sup>3</sup>                                     | 210    | - | - | - |
| C15 - C36                             | g/m <sup>3</sup>                                     | 65     | - | - | - |
| Total hydrocarbons (C7 - C36)         | g/m <sup>3</sup>                                     | 280    | - | - | - |

1997054.1  
Kowhai A Frac 6 Prepumped HF Fluid 05-Jun-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.

## Analyst's Comments

**Amended Report:** This certificate of analysis replaces an earlier certificate issued on 20 Jun 2018 at 2:05 pm  
Reason for amendment: The Sample Name has been amended as requested.

## 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<br>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.



Carole Rodgers-Carroll BA, NZCS  
Client Services Manager - Environmental



## Certificate of Analysis

|                 |   |                          |                        |           |
|-----------------|---|--------------------------|------------------------|-----------|
| <b>Client:</b>  | Greymouth Petroleum Limited   | <b>Lab No:</b>           | 2002229                | SPv2      |
| <b>Contact:</b> | Skye Loveridge-Easter<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 20-Jun-2018            |           |
|                 |   | <b>Date Reported:</b>    | 04-Jul-2018            | (Amended) |
|                 |   | <b>Quote No:</b>         | 81870                  |           |
|                 |   | <b>Order No:</b>         | PO 242444              |           |
|                 |   | <b>Client Reference:</b> | Return Fluid Composite |           |
|                 |   | <b>Submitted By:</b>     | Skye Loveridge-Easter  |           |

### Sample Type: Saline

|                     |   |  |  |  |  |
|---------------------|---|--|--|--|--|
| <b>Sample Name:</b> | Composite of Kow A -Frac 6 Return Fluid Start, Kow A -Frac 6 Return Fluid Middle & Kow A -Frac 6 Return Fluid End |  |  |  |  |
| <b>Lab Number:</b>  | 2002229.4   |  |  |  |  |

### Individual Tests

|                                      |  |        |   |   |   |   |
|--------------------------------------|--|--------|---|---|---|---|
| pH*                                  | pH Units                                 | 6.8    | - | - | - | - |
| Total Alkalinity*                    | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 1,250  | - | - | - | - |
| Analysis Temperature for Bicarbonate | °C                                       | 22     | - | - | - | - |
| Bicarbonate                          | g/m <sup>3</sup> at Analysis Temperature | 1,016  | - | - | - | - |
| Total Hardness*                      | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 147    | - | - | - | - |
| Electrical Conductivity (EC)*        | mS/m                                     | 1,406  | - | - | - | - |
| Total Dissolved Solids (TDS)*        | g/m <sup>3</sup>                         | 10,400 | - | - | - | - |
| Dissolved Barium*                    | g/m <sup>3</sup>                         | 23     | - | - | - | - |
| Dissolved Bromine*                   | g/m <sup>3</sup>                         | 11.6   | - | - | - | - |
| Dissolved Calcium*                   | g/m <sup>3</sup>                         | 46     | - | - | - | - |
| Dissolved Copper*                    | g/m <sup>3</sup>                         | 0.008  | - | - | - | - |
| Dissolved Iron*                      | g/m <sup>3</sup>                         | 1.63   | - | - | - | - |
| Dissolved Magnesium*                 | g/m <sup>3</sup>                         | 8      | - | - | - | - |
| Dissolved Manganese*                 | g/m <sup>3</sup>                         | 3.7    | - | - | - | - |
| Total Nickel*                        | g/m <sup>3</sup>                         | 0.03   | - | - | - | - |
| Total Potassium*                     | g/m <sup>3</sup>                         | 155    | - | - | - | - |
| Total Sodium*                        | g/m <sup>3</sup>                         | 3,000  | - | - | - | - |
| Total Sulphur*                       | g/m <sup>3</sup>                         | 310    | - | - | - | - |
| Total Zinc*                          | g/m <sup>3</sup>                         | 0.28   | - | - | - | - |
| Chloride*                            | g/m <sup>3</sup>                         | 5,000  | - | - | - | - |
| Nitrite-N                            | g/m <sup>3</sup>                         | 0.30   | - | - | - | - |
| Nitrate-N                            | g/m <sup>3</sup>                         | < 0.10 | - | - | - | - |
| Nitrate*                             | g/m <sup>3</sup>                         | < 0.5  | - | - | - | - |
| Nitrate-N + Nitrite-N                | g/m <sup>3</sup>                         | 0.30   | - | - | - | - |
| Sulphate*                            | g/m <sup>3</sup>                         | 920    | - | - | - | - |
| Ethylene Glycol in Water             |  |        |   |   |   |   |
| Ethylene glycol*                     | g/m <sup>3</sup>                         | 73     | - | - | - | - |
| Propylene Glycol in Water            |  |        |   |   |   |   |
| Propylene glycol*                    | g/m <sup>3</sup>                         | < 20   | - | - | - | - |



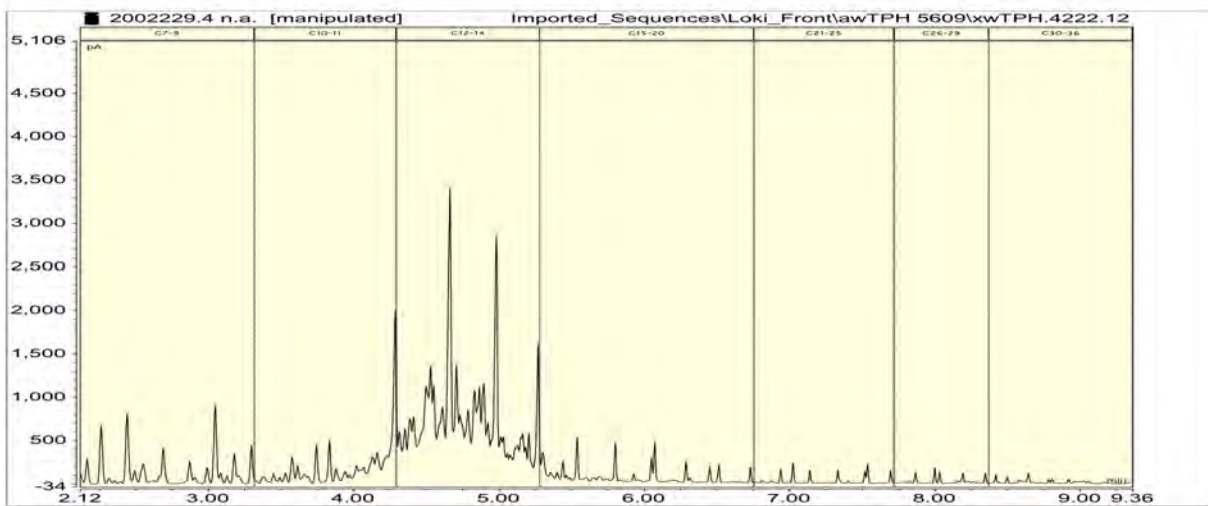
**Sample Type: Saline**

|                     |   |  |  |  |  |
|---------------------|---|--|--|--|--|
| <b>Sample Name:</b> | Composite of Kow A -Frac 6 Return Fluid Start, Kow A -Frac 6 Return Fluid Middle & Kow A -Frac 6 Return Fluid End |  |  |  |  |
| <b>Lab Number:</b>  | 2002229.4   |  |  |  |  |

|  |                  |        |   |   |   |   |
|--|------------------|--------|---|---|---|---|
| Methanol in Water - Aqueous Solvents   |                  |        |   |   |   |   |
| Methanol*                              | g/m <sup>3</sup> | 57     | - | - | - | - |
| BTEX in Water by Headspace GC-MS       |                  |        |   |   |   |   |
| Benzene*                               | g/m <sup>3</sup> | 6.8    | - | - | - | - |
| Toluene*                               | g/m <sup>3</sup> | 11.7   | - | - | - | - |
| Ethylbenzene*                          | g/m <sup>3</sup> | 1.48   | - | - | - | - |
| m&p-Xylene*                            | g/m <sup>3</sup> | 8.9    | - | - | - | - |
| o-Xylene*                              | g/m <sup>3</sup> | 3.1    | - | - | - | - |
| Formaldehyde in Water by DNPH & LCMSMS |                  |        |   |   |   |   |
| Formaldehyde*                          | g/m <sup>3</sup> | < 0.15 | - | - | - | - |
| Total Petroleum Hydrocarbons in Water  |                  |        |   |   |   |   |
| C7 - C9                                | g/m <sup>3</sup> | 52     | - | - | - | - |
| C10 - C14*                             | g/m <sup>3</sup> | 490    | - | - | - | - |
| C15 - C36*                             | g/m <sup>3</sup> | 96     | - | - | - | - |
| Total hydrocarbons (C7 - C36)          | g/m <sup>3</sup> | 640    | - | - | - | - |

2002229.4

Composite of Kow A -Frac 6 Return Fluid Start, Kow A -Frac 6 Return Fluid Middle & Kow A -Frac 6 Return Fluid End  
Client Chromatogram for TPH by FID



**Analyst's Comments**

**Amended Report:** This certificate of analysis replaces an earlier certificate issued on 03 Jul 2018 at 3:34 pm  
Reason for amendment: The Sample Names have been amended as requested.

**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         |

| Sample Type: Saline                       |  |   |           |
|---|--|---|-----------|
| Test                                      | Method Description   | Default Detection Limit                     | Sample No |
| Total Petroleum Hydrocarbons in Water*    | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis<br>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         |
| 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.



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





## Certificate of Analysis

|                 |   |                          |                                    |      |
|-----------------|---|--------------------------|------------------------------------|------|
| <b>Client:</b>  | Greymouth Petroleum Limited   | <b>Lab No:</b>           | 1940128                            | SPV1 |
| <b>Contact:</b> | Skye Loveridge-Easter<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 09-Mar-2018                        |      |
|                 |   | <b>Date Reported:</b>    | 16-Mar-2018                        |      |
|                 |   | <b>Quote No:</b>         | 85159                              |      |
|                 |   | <b>Order No:</b>         | 241668                             |      |
|                 |   | <b>Client Reference:</b> | Hydraulic fracturing fluid testing |      |
|                 |   | <b>Submitted By:</b>     | Skye Loveridge-Easter              |      |

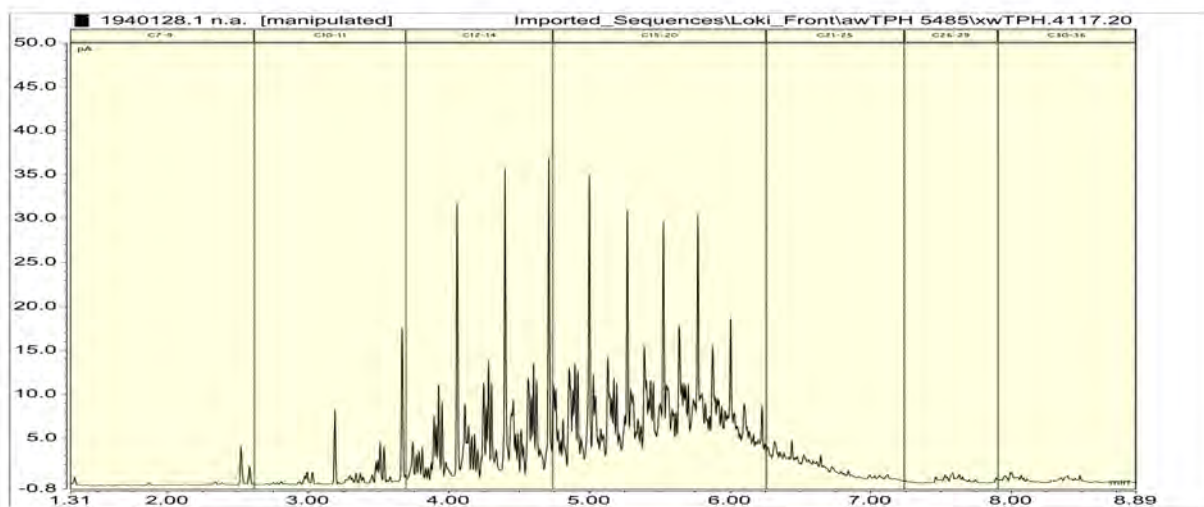
### Sample Type: Aqueous

|                                       |   |          |   |   |   |
|---------------------------------------|---|----------|---|---|---|
| <b>Sample Name:</b>                   | Kowhai A Frac 1<br>Prepumped HF<br>Fluid<br>25-Feb-2018 |          |   |   |   |
| <b>Lab Number:</b>                    | 1940128.1   |          |   |   |   |
| Ethylene Glycol in Water              |   |          |   |   |   |
| Ethylene glycol*                      | g/m <sup>3</sup>  | < 400    | - | - | - |
| Propylene Glycol in Water             |   |          |   |   |   |
| Propylene glycol*                     | g/m <sup>3</sup>  | < 400    | - | - | - |
| Methanol in Water - Aqueous Solvents  |   |          |   |   |   |
| Methanol*                             | g/m <sup>3</sup>  | < 200    | - | - | - |
| 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>  | 0.0012   | - | - | - |
| m&p-Xylene                            | g/m <sup>3</sup>  | 0.002    | - | - | - |
| o-Xylene                              | g/m <sup>3</sup>  | 0.0015   | - | - | - |
| Total Petroleum Hydrocarbons in Water |   |          |   |   |   |
| C7 - C9                               | g/m <sup>3</sup>  | 0.11     | - | - | - |
| C10 - C14                             | g/m <sup>3</sup>  | 18.7     | - | - | - |
| C15 - C36                             | g/m <sup>3</sup>  | 46       | - | - | - |
| Total hydrocarbons (C7 - C36)         | g/m <sup>3</sup>  | 65       | - | - | - |

1940128.1

Kowhai A Frac 1 Prepumped HF Fluid 25-Feb-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<br>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 report must not be reproduced, except in full, without the written consent of the signatory.



Martin Cowell - BSc  
Client Services Manager - Environmental



## Certificate of Analysis

|                 |  |                          |                        |      |
|-----------------|--|--------------------------|------------------------|------|
| <b>Client:</b>  | Greymouth Petroleum Limited  | <b>Lab No:</b>           | 1952930                | SPv2 |
| <b>Contact:</b> | Skye Loveridge-Easther<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 28-Mar-2018            |      |
|                 |  | <b>Date Reported:</b>    | 24-Apr-2018            |      |
|                 |  | <b>Quote No:</b>         | 81870                  |      |
|                 |  | <b>Order No:</b>         | 241669                 |      |
|                 |  | <b>Client Reference:</b> | Return Fluid Composite |      |
|                 |  | <b>Submitted By:</b>     | Skye Loveridge-Easther |      |

### Sample Type: Saline

|                     |   |  |  |  |  |
|---------------------|---|--|--|--|--|
| <b>Sample Name:</b> | Composite of<br>Kowhai A Frac 1<br>Start, Kowhai A<br>Frac 1 Middle and<br>Kowhai A Frac 1<br>End |  |  |  |  |
| <b>Lab Number:</b>  | 1952930.4   |  |  |  |  |

### Individual Tests

|                                      |  |       |   |   |   |   |
|--------------------------------------|--|-------|---|---|---|---|
| pH*                                  | pH Units                                 | 7.1   | - | - | - | - |
| Total Alkalinity*                    | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 690   | - | - | - | - |
| Analysis Temperature for Bicarbonate | °C                                       | 21    | - | - | - | - |
| Bicarbonate                          | g/m <sup>3</sup> at Analysis Temperature | 481   | - | - | - | - |
| Total Hardness*                      | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 156   | - | - | - | - |
| Electrical Conductivity (EC)*        | mS/m                                     | 969   | - | - | - | - |
| Total Dissolved Solids (TDS)*        | g/m <sup>3</sup>                         | 7,300 | - | - | - | - |
| Dissolved Barium*                    | g/m <sup>3</sup>                         | 17.0  | - | - | - | - |
| Dissolved Bromine*                   | g/m <sup>3</sup>                         | 24    | - | - | - | - |
| Dissolved Calcium*                   | g/m <sup>3</sup>                         | 53    | - | - | - | - |
| Dissolved Copper*                    | g/m <sup>3</sup>                         | 0.060 | - | - | - | - |
| Dissolved Iron*                      | g/m <sup>3</sup>                         | 2.1   | - | - | - | - |
| Dissolved Magnesium*                 | g/m <sup>3</sup>                         | 6     | - | - | - | - |
| Dissolved Manganese*                 | g/m <sup>3</sup>                         | 0.71  | - | - | - | - |
| Total Nickel*                        | g/m <sup>3</sup>                         | 0.05  | - | - | - | - |
| Total Potassium*                     | g/m <sup>3</sup>                         | 300   | - | - | - | - |
| Total Sodium*                        | g/m <sup>3</sup>                         | 1,860 | - | - | - | - |
| Total Sulphur*                       | g/m <sup>3</sup>                         | < 6   | - | - | - | - |
| Total Zinc*                          | g/m <sup>3</sup>                         | 0.96  | - | - | - | - |
| Chloride*                            | g/m <sup>3</sup>                         | 2,700 | - | - | - | - |
| Nitrite-N                            | g/m <sup>3</sup>                         | 0.011 | - | - | - | - |
| Nitrate-N                            | g/m <sup>3</sup>                         | 0.016 | - | - | - | - |
| Nitrate*                             | g/m <sup>3</sup>                         | 0.072 | - | - | - | - |
| Nitrate-N + Nitrite-N                | g/m <sup>3</sup>                         | 0.027 | - | - | - | - |
| Sulphate*                            | g/m <sup>3</sup>                         | < 16  | - | - | - | - |
| Ethylene Glycol in Water             |  |       |   |   |   |   |
| Ethylene glycol*                     | g/m <sup>3</sup>                         | < 400 | - | - | - | - |
| Propylene Glycol in Water            |  |       |   |   |   |   |
| Propylene glycol*                    | g/m <sup>3</sup>                         | < 400 | - | - | - | - |
| Methanol in Water - Aqueous Solvents |  |       |   |   |   |   |
| Methanol*                            | g/m <sup>3</sup>                         | < 200 | - | - | - | - |



**Sample Type: Saline**

|                     |  |  |  |  |  |
|---------------------|--|--|--|--|--|
| <b>Sample Name:</b> | Composite of Kowhai A Frac 1 Start, Kowhai A Frac 1 Middle and Kowhai A Frac 1 End |  |  |  |  |
| <b>Lab Number:</b>  | 1952930.4  |  |  |  |  |

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

|               |                  |       |   |   |   |   |
|---------------|------------------|-------|---|---|---|---|
| Benzene*      | g/m <sup>3</sup> | 0.44  | - | - | - | - |
| Toluene*      | g/m <sup>3</sup> | 1.05  | - | - | - | - |
| Ethylbenzene* | g/m <sup>3</sup> | 0.186 | - | - | - | - |
| m&p-Xylene*   | g/m <sup>3</sup> | 1.20  | - | - | - | - |
| o-Xylene*     | g/m <sup>3</sup> | 0.41  | - | - | - | - |

**Formaldehyde in Water by DNPH & LCMSMS**

|               |                  |       |   |   |   |   |
|---------------|------------------|-------|---|---|---|---|
| Formaldehyde* | g/m <sup>3</sup> | < 1.5 | - | - | - | - |
|---------------|------------------|-------|---|---|---|---|

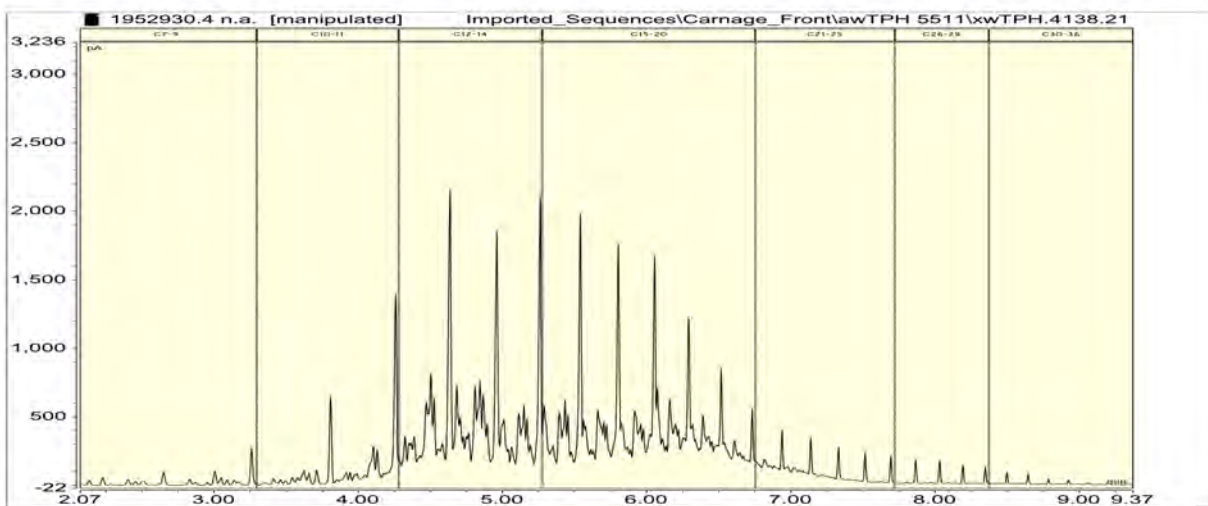
**Total Petroleum Hydrocarbons in Water**

|                               |                  |       |   |   |   |   |
|-------------------------------|------------------|-------|---|---|---|---|
| C7 - C9                       | g/m <sup>3</sup> | 13.5  | - | - | - | - |
| C10 - C14*                    | g/m <sup>3</sup> | 670   | - | - | - | - |
| C15 - C36*                    | g/m <sup>3</sup> | 930   | - | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m <sup>3</sup> | 1,610 | - | - | - | - |

1952930.4

Composite of Kowhai A Frac 1 Start, Kowhai A Frac 1 Middle and Kowhai A Frac 1 End

Client Chromatogram for TPH by FID



**Analyst's Comments**

Due to instrumental breakdown, the analysis for Formaldehyde could not be carried out within the recommended holding time and therefore may be underestimated. This should be kept in mind when interpreting this result.

**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<br>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         |

| Sample Type: Saline                       |  |   |           |
|---|--|---|-----------|
| Test                                      | Method Description   | Default Detection Limit                     | Sample No |
| 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         |
| 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         |
| 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.



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



## Certificate of Analysis

|                 |  |                          |                        |      |
|-----------------|--|--------------------------|------------------------|------|
| <b>Client:</b>  | Greymouth Petroleum Limited  | <b>Lab No:</b>           | 1966863                | SPV1 |
| <b>Contact:</b> | Skye Loveridge-Easther<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 20-Apr-2018            |      |
|                 |  | <b>Date Reported:</b>    | 07-May-2018            |      |
|                 |  | <b>Quote No:</b>         | 81870                  |      |
|                 |  | <b>Order No:</b>         | 241697                 |      |
|                 |  | <b>Client Reference:</b> | Return Fluid Composite |      |
|                 |  | <b>Submitted By:</b>     | Skye Loveridge-Easther |      |

### Sample Type: Saline

|                     |  |  |  |  |  |
|---------------------|--|--|--|--|--|
| <b>Sample Name:</b> | Kowhai A Frac 2<br>Return Fluid<br>13-Apr-2018 |  |  |  |  |
| <b>Lab Number:</b>  | 1966863.1                                      |  |  |  |  |

| Individual Tests                     |  |          |   |   |   |   |
|--------------------------------------|--|----------|---|---|---|---|
| pH*                                  | pH Units                                 | 6.0      | - | - | - | - |
| Total Alkalinity*                    | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 43       | - | - | - | - |
| Analysis Temperature for Bicarbonate | °C                                       | 21       | - | - | - | - |
| Bicarbonate                          | g/m <sup>3</sup> at Analysis Temperature | 23       | - | - | - | - |
| Total Hardness*                      | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 79       | - | - | - | - |
| Electrical Conductivity (EC)*        | mS/m                                     | 95.6     | - | - | - | - |
| Total Dissolved Solids (TDS)*        | g/m <sup>3</sup>                         | 3,100    | - | - | - | - |
| Dissolved Barium*                    | g/m <sup>3</sup>                         | 0.37     | - | - | - | - |
| Dissolved Bromine*                   | g/m <sup>3</sup>                         | < 0.5    | - | - | - | - |
| Dissolved Calcium*                   | g/m <sup>3</sup>                         | 24       | - | - | - | - |
| Dissolved Copper*                    | g/m <sup>3</sup>                         | 0.017    | - | - | - | - |
| Dissolved Iron*                      | g/m <sup>3</sup>                         | 2.7      | - | - | - | - |
| Dissolved Magnesium*                 | g/m <sup>3</sup>                         | 4        | - | - | - | - |
| Dissolved Manganese*                 | g/m <sup>3</sup>                         | 0.36     | - | - | - | - |
| Total Nickel*                        | g/m <sup>3</sup>                         | 0.053 #2 | - | - | - | - |
| Total Potassium*                     | g/m <sup>3</sup>                         | 68       | - | - | - | - |
| Total Sodium*                        | g/m <sup>3</sup>                         | 38       | - | - | - | - |
| Total Sulphur*                       | g/m <sup>3</sup>                         | 53       | - | - | - | - |
| Total Zinc*                          | g/m <sup>3</sup>                         | 0.099    | - | - | - | - |
| Chloride*                            | g/m <sup>3</sup>                         | 210      | - | - | - | - |
| Nitrite-N                            | g/m <sup>3</sup>                         | 0.137    | - | - | - | - |
| Nitrate-N                            | g/m <sup>3</sup>                         | 0.056    | - | - | - | - |
| Nitrate*                             | g/m <sup>3</sup>                         | 0.25     | - | - | - | - |
| Nitrate-N + Nitrite-N                | g/m <sup>3</sup>                         | 0.193    | - | - | - | - |
| Sulphate*                            | g/m <sup>3</sup>                         | 158      | - | - | - | - |
| Ethylene Glycol in Water             |  |          |   |   |   |   |
| Ethylene glycol*                     | g/m <sup>3</sup>                         | < 40 #1  | - | - | - | - |
| 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>                         | 0.039    | - | - | - | - |
| Toluene*                             | g/m <sup>3</sup>                         | 0.065    | - | - | - | - |
| Ethylbenzene*                        | g/m <sup>3</sup>                         | < 0.010  | - | - | - | - |
| m&p-Xylene*                          | g/m <sup>3</sup>                         | 0.71     | - | - | - | - |
| o-Xylene*                            | g/m <sup>3</sup>                         | 0.21     | - | - | - | - |

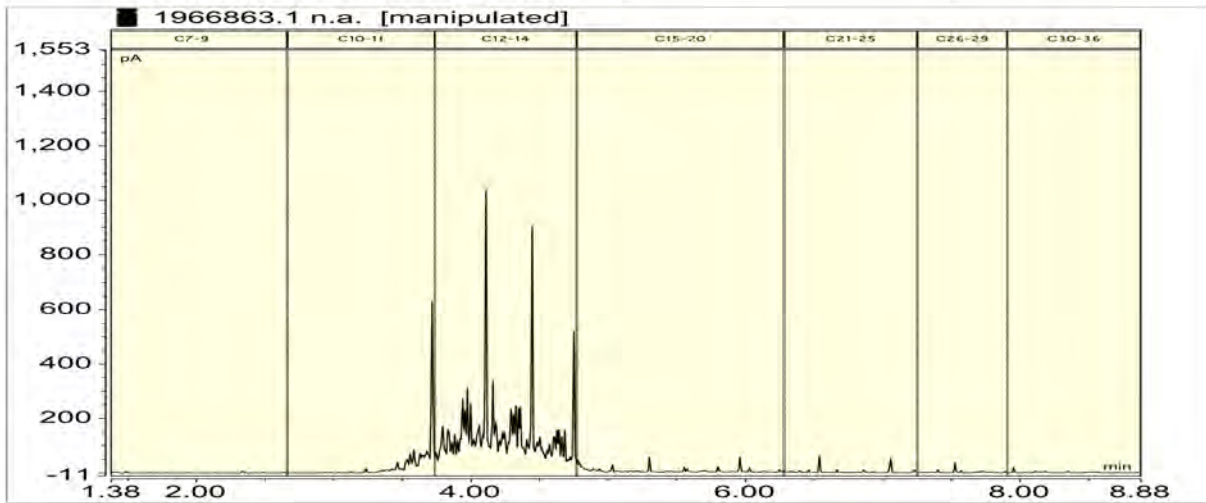




**Sample Type: Saline**

|  |  |        |   |   |   |   |
|--|--|--------|---|---|---|---|
| <b>Sample Name:</b>                    | Kowhai A Frac 2<br>Return Fluid<br>13-Apr-2018 |        |   |   |   |   |
| <b>Lab Number:</b>                     | 1966863.1                                      |        |   |   |   |   |
| Formaldehyde in Water by DNPH & LCMSMS |  |        |   |   |   |   |
| Formaldehyde*                          | g/m <sup>3</sup>                               | < 0.15 | - | - | - | - |
| Total Petroleum Hydrocarbons in Water  |  |        |   |   |   |   |
| C7 - C9                                | g/m <sup>3</sup>                               | 4.4    | - | - | - | - |
| C10 - C14*                             | g/m <sup>3</sup>                               | 1,220  | - | - | - | - |
| C15 - C36*                             | g/m <sup>3</sup>                               | 138    | - | - | - | - |
| Total hydrocarbons (C7 - C36)          | g/m <sup>3</sup>                               | 1,360  | - | - | - | - |

1966863.1  
Kowhai A Frac 2 Return Fluid 13-Apr-2018  
Client Chromatogram for TPH by FID



**Analyst's Comments**

#1 Due to some interference found in the chromatography for Ethylene glycol in the Glycol analysis on sample 1966863.1, the sample was diluted and re-analysed. Hence the higher detection limit reported.

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

Appendix No.1 - HCO3 Report 1966863

**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>              | 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         |
| Total Petroleum Hydrocarbons in Water*  | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis<br>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 Digestion*                        | Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).   | -                               | 1         |
| Total Digestion of Saline Samples*      | Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).   | -                               | 1         |



| Sample Type: Saline                       |  |   |           |
|---|--|---|-----------|
| Test                                      | Method Description   | Default Detection Limit                     | Sample No |
| 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                                | 1         |
| Total Alkalinity*                         | Saline water, Titration to pH 4.5.   | 1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>   | 1         |
| Analysis Temperature for Bicarbonate      | Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.   | 1.0 °C                                      | 1         |
| Bicarbonate                               | Bicarbonate (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 | 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)*             | Saline water, Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.   | 0.10 mS/m                                   | 1         |
| Total Dissolved Solids (TDS)*             | Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22 <sup>nd</sup> ed. 2012.   | 50 g/m <sup>3</sup>                         | 1         |
| 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.   | -   | 1         |
| Dissolved Barium*                         | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.  | 0.0006 g/m <sup>3</sup>                     | 1         |
| Dissolved Bromine*                        | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.  | 0.10 g/m <sup>3</sup>                       | 1         |
| Dissolved Calcium*                        | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.  | 1.0 g/m <sup>3</sup>                        | 1         |
| Dissolved Copper*                         | Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.  | 0.0010 g/m <sup>3</sup>                     | 1         |
| 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>                      | 1         |
| Dissolved Magnesium*                      | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.  | 0.4 g/m <sup>3</sup>                        | 1         |
| 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>                     | 1         |
| 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>                      | 1         |
| 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>                        | 1         |
| 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>                       | 1         |
| 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 23 <sup>rd</sup> ed. 2017.   | 0.5 g/m <sup>3</sup>                        | 1         |
| 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>                     | 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                                 | 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>                     | 1         |
| Nitrate-N                                 | Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.  | 0.0010 g/m <sup>3</sup>                     | 1         |
| Nitrate*                                  | Calculation from Nitrate-N.  | 0.010 g/m <sup>3</sup>                      | 1         |
| 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>                     | 1         |
| Total Sulphate*                           | Calculation: from total sulphur.   | 2 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.



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



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

**CERTIFICATE OF ANALYSIS**  
**ENVSUBGNS\_WAIRAKEI 53**

Report No: 2018042705

Customer Ref:149928

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

**GNS Lot No: 2018042705**

**GNS Sample No.** 2018002996  
**Collection Date**  
**Site ID** 1966863.1  
**Field ID**

|  |            |   |   |   |
|--|------------|---|---|---|
| pH                                       | 5.55       | - | - | - |
| Bicarbonate (Total) mg/l                 | 23         | - | - | - |
| HCO <sub>3</sub> Analysis Temperature °C | 21         | - | - | - |
| HCO <sub>3</sub> Analysis Date           | 27/04/2018 | - | - | - |

**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 22nd Edition 2012                 | -                | -    |

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

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

*M. K. Appleby*  
 Moya Appleby  
 Senior Technician



**IANZ**  
 ACCREDITED LABORATORY

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



## Certificate of Analysis

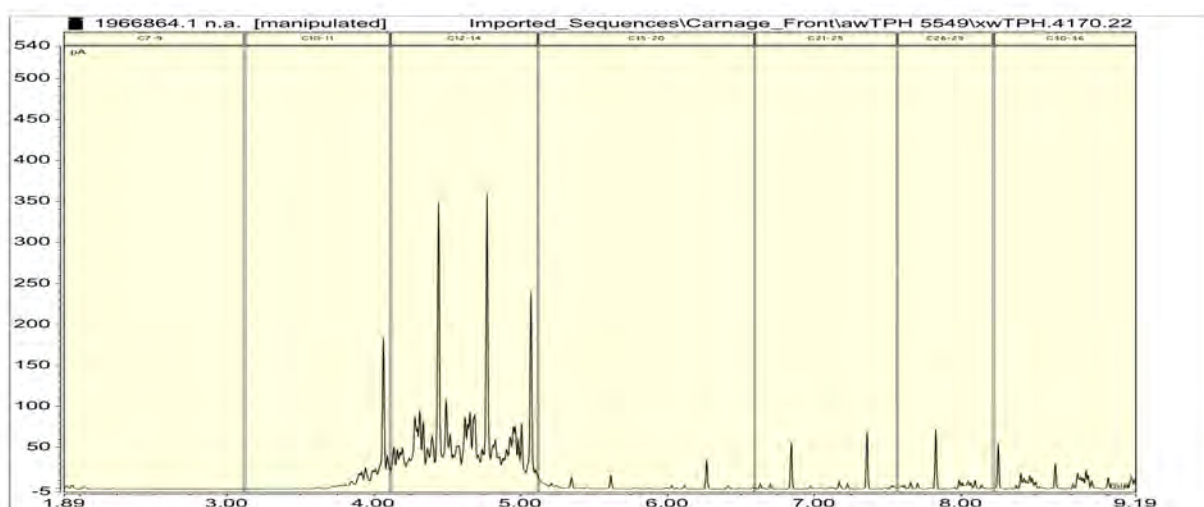
|                 |   |                          |                                    |      |
|-----------------|---|--------------------------|------------------------------------|------|
| <b>Client:</b>  | Greymouth Petroleum Limited   | <b>Lab No:</b>           | 1966864                            | SPV1 |
| <b>Contact:</b> | Skye Loveridge-Easter<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 20-Apr-2018                        |      |
|                 |   | <b>Date Reported:</b>    | 08-May-2018                        |      |
|                 |   | <b>Quote No:</b>         | 85159                              |      |
|                 |   | <b>Order No:</b>         | 241696                             |      |
|                 |   | <b>Client Reference:</b> | Hydraulic fracturing fluid testing |      |
|                 |   | <b>Submitted By:</b>     | Skye Loveridge-Easter              |      |

### Sample Type: Aqueous

|                     |   |  |  |  |  |
|---------------------|---|--|--|--|--|
| <b>Sample Name:</b> | Kowhai A FRAC 2<br>PRE PUMPED<br>FLUID<br>13-Apr-2018 |  |  |  |  |
| <b>Lab Number:</b>  | 1966864.1   |  |  |  |  |

|                                       |                  |         |   |   |   |
|---------------------------------------|------------------|---------|---|---|---|
| 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> | < 0.010 | - | - | - |
| 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> | 189     | - | - | - |
| C15 - C36                             | g/m <sup>3</sup> | 37      | - | - | - |
| Total hydrocarbons (C7 - C36)         | g/m <sup>3</sup> | 230     | - | - | - |

1966864.1  
Kowhai A FRAC 2 PRE PUMPED FLUID 13-Apr-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<br>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.



Kim Harrison MSc  
Client Services Manager - Environmental



## Certificate of Analysis

|                 |  |                          |                                    |      |
|-----------------|--|--------------------------|------------------------------------|------|
| <b>Client:</b>  | Greymouth Petroleum Limited  | <b>Lab No:</b>           | 1976223                            | SPv2 |
| <b>Contact:</b> | Skye Loveridge-Easther<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 04-May-2018                        |      |
|                 |  | <b>Date Reported:</b>    | 22-May-2018                        |      |
|                 |  | <b>Quote No:</b>         | 85159                              |      |
|                 |  | <b>Order No:</b>         | 242108                             |      |
|                 |  | <b>Client Reference:</b> | Hydraulic fracturing fluid testing |      |
|                 |  | <b>Submitted By:</b>     | Skye Loveridge-Easther             |      |

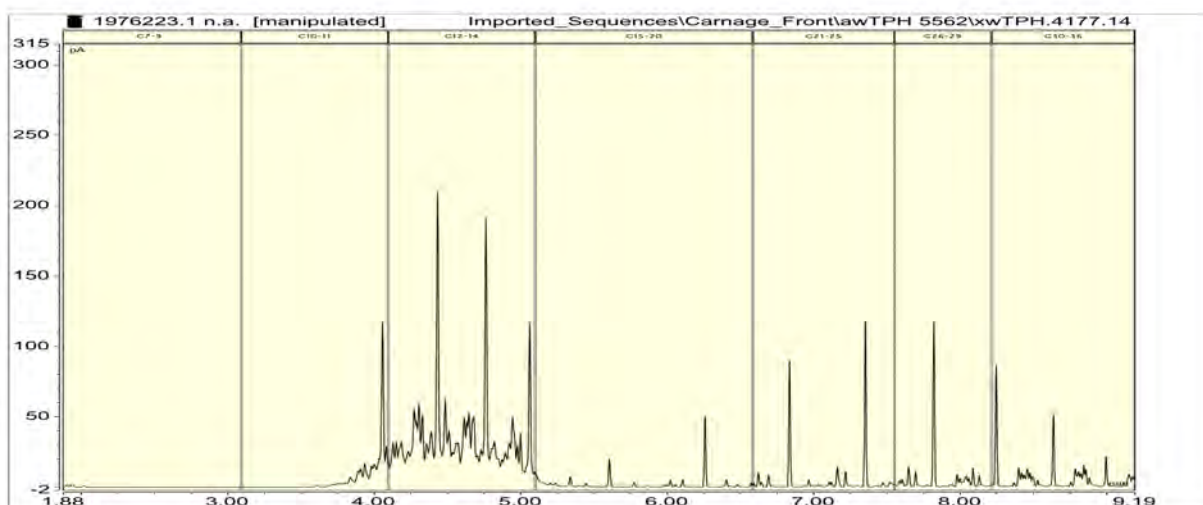
### Sample Type: Aqueous

|                                       |   |          |   |   |   |
|---------------------------------------|---|----------|---|---|---|
| <b>Sample Name:</b>                   | Kowhai: A Frac 3<br>Prepumped HF<br>Fluid 24-Apr-2018 |          |   |   |   |
| <b>Lab Number:</b>                    | 1976223.1   |          |   |   |   |
| 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>                                      | < 0.0010 | - | - | - |
| 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 | - | - | - |
| Total Petroleum Hydrocarbons in Water |   |          |   |   |   |
| C7 - C9                               | g/m <sup>3</sup>                                      | < 0.06   | - | - | - |
| C10 - C14                             | g/m <sup>3</sup>                                      | 113      | - | - | - |
| C15 - C36                             | g/m <sup>3</sup>                                      | 46       | - | - | - |
| Total hydrocarbons (C7 - C36)         | g/m <sup>3</sup>                                      | 159      | - | - | - |

1976223.1

Kowhai: A Frac 3 Prepumped HF Fluid 24-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<br>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.



Carole Rodgers-Carroll BA, NZCS  
Client Services Manager - Environmental



## Certificate of Analysis

|                 |  |                          |                        |      |
|-----------------|--|--------------------------|------------------------|------|
| <b>Client:</b>  | Greymouth Petroleum Limited  | <b>Lab No:</b>           | 1975423                | SPV1 |
| <b>Contact:</b> | Skye Loveridge-Easther<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 04-May-2018            |      |
|                 |  | <b>Date Reported:</b>    | 16-May-2018            |      |
|                 |  | <b>Quote No:</b>         | 81870                  |      |
|                 |  | <b>Order No:</b>         | 242101                 |      |
|                 |  | <b>Client Reference:</b> | Return Fluid Composite |      |
|                 |  | <b>Submitted By:</b>     | Skye Loveridge-Easther |      |

### Sample Type: Saline

|                     |  |  |  |  |  |
|---------------------|--|--|--|--|--|
| <b>Sample Name:</b> | Composite of<br>Kowhai A Frac 3<br>Return Fluid Start,<br>Kowhai A Frac 3<br>Return Fluid<br>Middle and<br>Kowhai A Frac 3<br>Return Fluid End |  |  |  |  |
| <b>Lab Number:</b>  | 1975423.4  |  |  |  |  |

### Individual Tests

|                                      |  |        |   |   |   |   |
|--------------------------------------|--|--------|---|---|---|---|
| pH*                                  | pH Units                                 | 6.5    | - | - | - | - |
| Total Alkalinity*                    | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 600    | - | - | - | - |
| Analysis Temperature for Bicarbonate | °C                                       | 22     | - | - | - | - |
| Bicarbonate                          | g/m <sup>3</sup> at Analysis Temperature | 540    | - | - | - | - |
| Total Hardness*                      | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 640    | - | - | - | - |
| Electrical Conductivity (EC)*        | mS/m                                     | 2,510  | - | - | - | - |
| Total Dissolved Solids (TDS)*        | g/m <sup>3</sup>                         | 16,500 | - | - | - | - |
| Dissolved Barium*                    | g/m <sup>3</sup>                         | 110    | - | - | - | - |
| Dissolved Bromine*                   | g/m <sup>3</sup>                         | 16.7   | - | - | - | - |
| Dissolved Calcium*                   | g/m <sup>3</sup>                         | 230    | - | - | - | - |
| Dissolved Copper*                    | g/m <sup>3</sup>                         | 0.023  | - | - | - | - |
| Dissolved Iron*                      | g/m <sup>3</sup>                         | 7.5    | - | - | - | - |
| Dissolved Magnesium*                 | g/m <sup>3</sup>                         | 18     | - | - | - | - |
| Dissolved Manganese*                 | g/m <sup>3</sup>                         | 2.4    | - | - | - | - |
| Total Nickel*                        | g/m <sup>3</sup>                         | 0.03   | - | - | - | - |
| Total Potassium*                     | g/m <sup>3</sup>                         | 260    | - | - | - | - |
| Total Sodium*                        | g/m <sup>3</sup>                         | 5,200  | - | - | - | - |
| Total Sulphur*                       | g/m <sup>3</sup>                         | 31     | - | - | - | - |
| Total Zinc*                          | g/m <sup>3</sup>                         | 0.094  | - | - | - | - |
| Chloride*                            | g/m <sup>3</sup>                         | 8,300  | - | - | - | - |
| Nitrite-N                            | g/m <sup>3</sup>                         | 0.039  | - | - | - | - |
| Nitrate-N                            | g/m <sup>3</sup>                         | 0.015  | - | - | - | - |
| Nitrate*                             | g/m <sup>3</sup>                         | 0.07   | - | - | - | - |
| Nitrate-N + Nitrite-N                | g/m <sup>3</sup>                         | 0.054  | - | - | - | - |
| Sulphate*                            | g/m <sup>3</sup>                         | 92     | - | - | - | - |
| Ethylene Glycol in Water             |  |        |   |   |   |   |
| Ethylene glycol*                     | g/m <sup>3</sup>                         | < 4    | - | - | - | - |
| Propylene Glycol in Water            |  |        |   |   |   |   |
| Propylene glycol*                    | g/m <sup>3</sup>                         | < 4    | - | - | - | - |



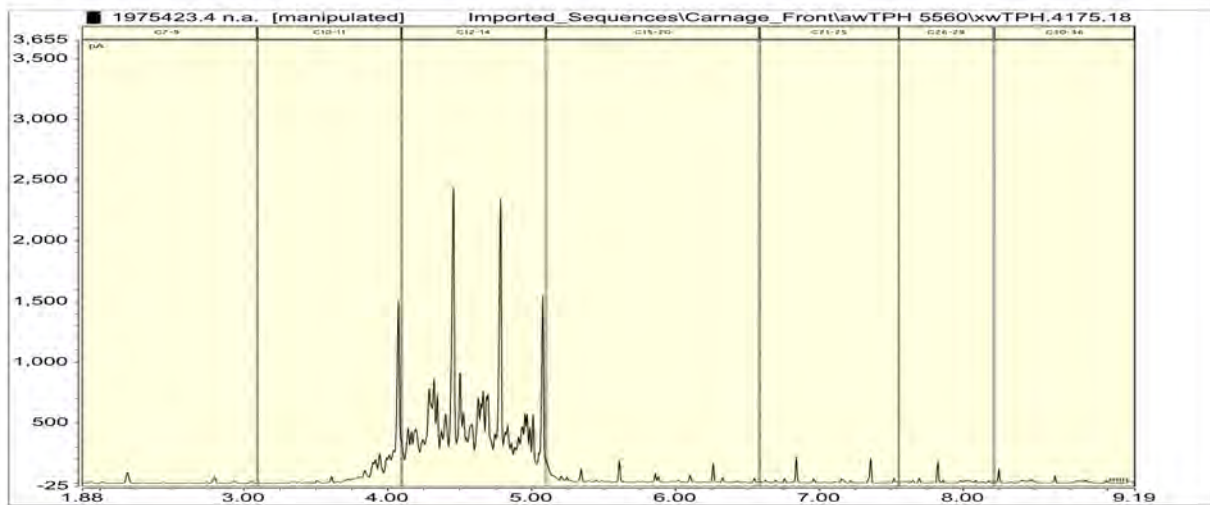


**Sample Type: Saline**

|                     |   |  |  |  |  |
|---------------------|---|--|--|--|--|
| <b>Sample Name:</b> | Composite of Kowhai A Frac 3 Return Fluid Start, Kowhai A Frac 3 Return Fluid Middle and Kowhai A Frac 3 Return Fluid End |  |  |  |  |
| <b>Lab Number:</b>  | 1975423.4   |  |  |  |  |

|  |                  |        |   |   |   |   |
|--|------------------|--------|---|---|---|---|
| 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> | 3.1    | - | - | - | - |
| Toluene*                               | g/m <sup>3</sup> | 1.93   | - | - | - | - |
| Ethylbenzene*                          | g/m <sup>3</sup> | 0.129  | - | - | - | - |
| m&p-Xylene*                            | g/m <sup>3</sup> | 0.69   | - | - | - | - |
| o-Xylene*                              | g/m <sup>3</sup> | 0.29   | - | - | - | - |
| Formaldehyde in Water by DNPH & LCMSMS |                  |        |   |   |   |   |
| Formaldehyde*                          | g/m <sup>3</sup> | < 0.15 | - | - | - | - |
| Total Petroleum Hydrocarbons in Water  |                  |        |   |   |   |   |
| C7 - C9                                | g/m <sup>3</sup> | 5.2    | - | - | - | - |
| C10 - C14*                             | g/m <sup>3</sup> | 340    | - | - | - | - |
| C15 - C36*                             | g/m <sup>3</sup> | 40     | - | - | - | - |
| Total hydrocarbons (C7 - C36)          | g/m <sup>3</sup> | 380    | - | - | - | - |

1975423.4  
 Composite of Kowhai A Frac 3 Return Fluid Start, Kowhai A Frac 3 Return Fluid Middle and Kowhai A Frac 3 Return Fluid 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<br>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         |

| Sample Type: Saline                       |  |   |           |
|---|--|---|-----------|
| Test                                      | Method Description   | Default Detection Limit                     | Sample No |
| 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         |
| 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         |
| 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.



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



## Certificate of Analysis

|                 |  |                          |                        |      |
|-----------------|--|--------------------------|------------------------|------|
| <b>Client:</b>  | Greymouth Petroleum Limited  | <b>Lab No:</b>           | 2011708                | SPv2 |
| <b>Contact:</b> | Skye Loveridge-Easther<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 06-Jul-2018            |      |
|                 |  | <b>Date Reported:</b>    | 20-Jul-2018            |      |
|                 |  | <b>Quote No:</b>         | 81870                  |      |
|                 |  | <b>Order No:</b>         | 242802                 |      |
|                 |  | <b>Client Reference:</b> | Return Fluid Composite |      |
|                 |  | <b>Submitted By:</b>     | Skye Loveridge-Easther |      |

### Sample Type: Saline

|                     |   |  |  |  |  |
|---------------------|---|--|--|--|--|
| <b>Sample Name:</b> | Composite of Kow A - Frac 5 Start, Kow A - Frac 5 Middle and Kow A - Frac 5 End |  |  |  |  |
| <b>Lab Number:</b>  | 2011708.4   |  |  |  |  |

### Individual Tests

|                                      |  |         |   |   |   |   |
|--------------------------------------|--|---------|---|---|---|---|
| pH*                                  | pH Units                                 | 6.9     | - | - | - | - |
| Total Alkalinity*                    | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 780     | - | - | - | - |
| Analysis Temperature for Bicarbonate | °C                                       | 22      | - | - | - | - |
| Bicarbonate                          | g/m <sup>3</sup> at Analysis Temperature | 719     | - | - | - | - |
| Total Hardness*                      | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 146     | - | - | - | - |
| Electrical Conductivity (EC)*        | mS/m                                     | 1,135   | - | - | - | - |
| Total Dissolved Solids (TDS)*        | g/m <sup>3</sup>                         | 9,400   | - | - | - | - |
| Dissolved Barium*                    | g/m <sup>3</sup>                         | 20      | - | - | - | - |
| Dissolved Bromine*                   | g/m <sup>3</sup>                         | 7.0     | - | - | - | - |
| Dissolved Calcium*                   | g/m <sup>3</sup>                         | 46      | - | - | - | - |
| Dissolved Copper*                    | g/m <sup>3</sup>                         | 0.011   | - | - | - | - |
| Dissolved Iron*                      | g/m <sup>3</sup>                         | 3.3     | - | - | - | - |
| Dissolved Magnesium*                 | g/m <sup>3</sup>                         | 8       | - | - | - | - |
| Dissolved Manganese*                 | g/m <sup>3</sup>                         | 1.87    | - | - | - | - |
| Total Nickel*                        | g/m <sup>3</sup>                         | 0.09    | - | - | - | - |
| Total Potassium*                     | g/m <sup>3</sup>                         | 120     | - | - | - | - |
| Total Sodium*                        | g/m <sup>3</sup>                         | 2,200   | - | - | - | - |
| Total Sulphur*                       | g/m <sup>3</sup>                         | 28      | - | - | - | - |
| Total Zinc*                          | g/m <sup>3</sup>                         | 3.0     | - | - | - | - |
| Chloride*                            | g/m <sup>3</sup>                         | 3,500   | - | - | - | - |
| Nitrite-N                            | g/m <sup>3</sup>                         | 0.12 #1 | - | - | - | - |
| Nitrate-N                            | g/m <sup>3</sup>                         | < 0.10  | - | - | - | - |
| Nitrate*                             | g/m <sup>3</sup>                         | < 0.5   | - | - | - | - |
| Nitrate-N + Nitrite-N                | g/m <sup>3</sup>                         | 0.16 #1 | - | - | - | - |
| Sulphate*                            | g/m <sup>3</sup>                         | 84      | - | - | - | - |
| Ethylene Glycol in Water             |  |         |   |   |   |   |
| Ethylene glycol*                     | g/m <sup>3</sup>                         | 690     | - | - | - | - |
| Propylene Glycol in Water            |  |         |   |   |   |   |
| Propylene glycol*                    | g/m <sup>3</sup>                         | < 4     | - | - | - | - |
| Methanol in Water - Aqueous Solvents |  |         |   |   |   |   |
| Methanol*                            | g/m <sup>3</sup>                         | 540     | - | - | - | - |



**Sample Type: Saline**

**Sample Name:** Composite of Kow A - Frac 5 Start, Kow A - Frac 5 Middle and Kow A - Frac 5 End  
**Lab Number:** 2011708.4

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

|               |                  |      |   |   |   |   |
|---------------|------------------|------|---|---|---|---|
| Benzene*      | g/m <sup>3</sup> | 31   | - | - | - | - |
| Toluene*      | g/m <sup>3</sup> | 71   | - | - | - | - |
| Ethylbenzene* | g/m <sup>3</sup> | 8.7  | - | - | - | - |
| m&p-Xylene*   | g/m <sup>3</sup> | 58   | - | - | - | - |
| o-Xylene*     | g/m <sup>3</sup> | 18.2 | - | - | - | - |

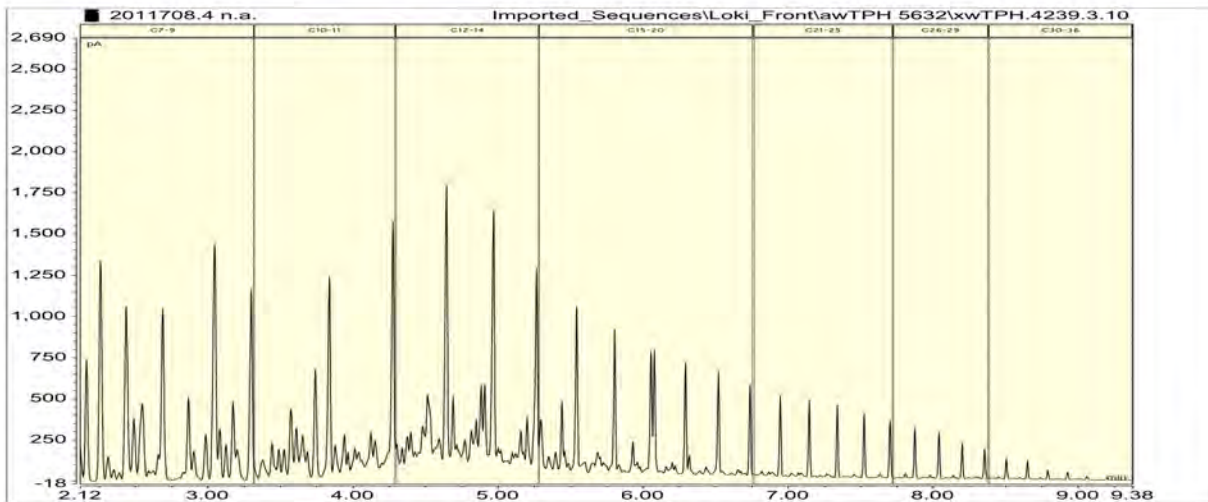
**Formaldehyde in Water by DNPH & LCMSMS**

|               |                  |        |   |   |   |   |
|---------------|------------------|--------|---|---|---|---|
| Formaldehyde* | g/m <sup>3</sup> | < 0.15 | - | - | - | - |
|---------------|------------------|--------|---|---|---|---|

**Total Petroleum Hydrocarbons in Water**

|                               |                  |       |   |   |   |   |
|-------------------------------|------------------|-------|---|---|---|---|
| C7 - C9                       | g/m <sup>3</sup> | 350   | - | - | - | - |
| C10 - C14*                    | g/m <sup>3</sup> | 4,800 | - | - | - | - |
| C15 - C36*                    | g/m <sup>3</sup> | 3,200 | - | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m <sup>3</sup> | 8,300 | - | - | - | - |

2011708.4  
 Composite of Kow A - Frac 5 Start, Kow A - Frac 5 Middle and Kow A - Frac 5 End  
 Client Chromatogram for TPH by FID



**Analyst's Comments**

It has been noted that the duplicate analyses for the BTEX analysis on sample 2011708/4 showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample. Therefore the results should be treated as indicative only.

#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.

**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         |

| Sample Type: Saline                       |  |   |           |
|---|--|---|-----------|
| Test                                      | Method Description   | Default Detection Limit                     | Sample No |
| Total Petroleum Hydrocarbons in Water*    | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis<br>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         |
| 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.

A handwritten signature in blue ink, consisting of a large capital 'K' followed by the name 'Harrison' in a cursive script.

Kim Harrison MSc  
Client Services Manager - Environmental





## Certificate of Analysis

|                 |  |                          |                                    |      |
|-----------------|--|--------------------------|------------------------------------|------|
| <b>Client:</b>  | Greymouth Petroleum Limited  | <b>Lab No:</b>           | 2011654                            | SPV1 |
| <b>Contact:</b> | Skye Loveridge-Easther<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 06-Jul-2018                        |      |
|                 |  | <b>Date Reported:</b>    | 11-Jul-2018                        |      |
|                 |  | <b>Quote No:</b>         | 85159                              |      |
|                 |  | <b>Order No:</b>         | 242803                             |      |
|                 |  | <b>Client Reference:</b> | Hydraulic fracturing fluid testing |      |
|                 |  | <b>Submitted By:</b>     | Skye Loveridge-Easther             |      |

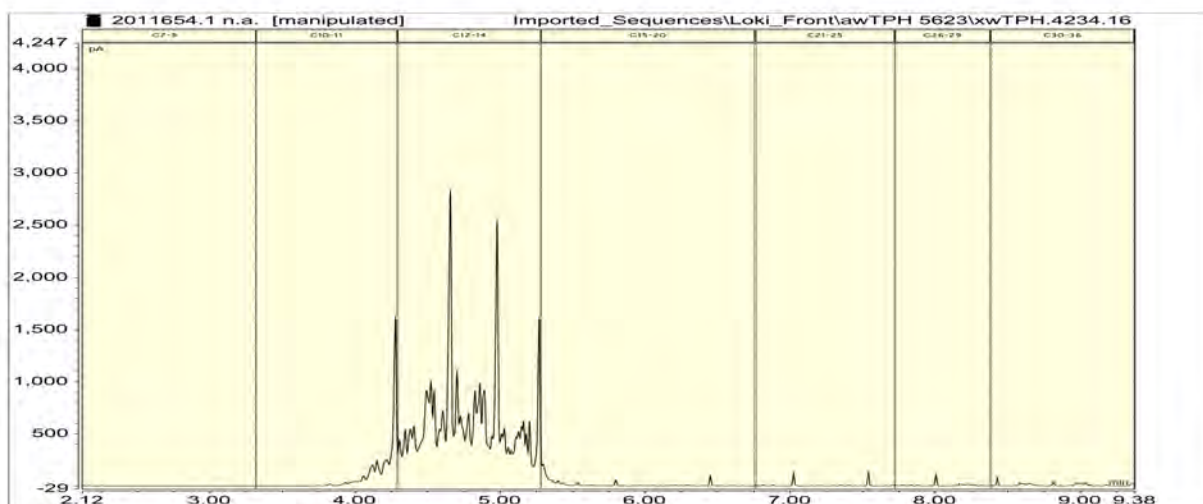
### Sample Type: Aqueous

|                                       |   |         |   |   |   |
|---------------------------------------|---|---------|---|---|---|
| <b>Sample Name:</b>                   | Kowhai A Frac 5 PrePumped HF Fluid<br>22-May-2018 |         |   |   |   |
| <b>Lab Number:</b>                    | 2011654.1   |         |   |   |   |
| 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>                                  | 3       | - | - | - |
| 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>                                  | 1,780   | - | - | - |
| C15 - C36                             | g/m <sup>3</sup>                                  | 106     | - | - | - |
| Total hydrocarbons (C7 - C36)         | g/m <sup>3</sup>                                  | 1,880   | - | - | - |

2011654.1

Kowhai A Frac 5 PrePumped HF Fluid 22-May-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<br>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.



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



## Certificate of Analysis

|                 |  |                          |                        |      |
|-----------------|--|--------------------------|------------------------|------|
| <b>Client:</b>  | Greymouth Petroleum Limited  | <b>Lab No:</b>           | 1988609                | SPV1 |
| <b>Contact:</b> | Skye Loveridge-Easther<br>C/- Greymouth Petroleum Limited<br>14 Connett Road West<br>Bell Block<br>New Plymouth 4312 | <b>Date Received:</b>    | 25-May-2018            |      |
|                 |  | <b>Date Reported:</b>    | 13-Jun-2018            |      |
|                 |  | <b>Quote No:</b>         | 81870                  |      |
|                 |  | <b>Order No:</b>         | 242442                 |      |
|                 |  | <b>Client Reference:</b> | Return Fluid Composite |      |
|                 |  | <b>Submitted By:</b>     | Skye Loveridge-Easther |      |

### Sample Type: Saline

|                     |  |  |  |  |  |
|---------------------|--|--|--|--|--|
| <b>Sample Name:</b> | Kowhai A Frac 4 composite return fluid |  |  |  |  |
| <b>Lab Number:</b>  | 1988609.1                              |  |  |  |  |

### Individual Tests

|                                      |  |          |   |   |   |   |
|--------------------------------------|--|----------|---|---|---|---|
| pH*                                  | pH Units                                 | 7.2      | - | - | - | - |
| Total Alkalinity*                    | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 1,980    | - | - | - | - |
| Analysis Temperature for Bicarbonate | °C                                       | 21       | - | - | - | - |
| Bicarbonate                          | g/m <sup>3</sup> at Analysis Temperature | 1,812    | - | - | - | - |
| Total Hardness*                      | g/m <sup>3</sup> as CaCO <sub>3</sub>    | 200      | - | - | - | - |
| Electrical Conductivity (EC)*        | mS/m                                     | 1,908    | - | - | - | - |
| Total Dissolved Solids (TDS)*        | g/m <sup>3</sup>                         | 12,200   | - | - | - | - |
| Dissolved Barium*                    | g/m <sup>3</sup>                         | 29       | - | - | - | - |
| Dissolved Bromine*                   | g/m <sup>3</sup>                         | 14.4     | - | - | - | - |
| Dissolved Calcium*                   | g/m <sup>3</sup>                         | 61       | - | - | - | - |
| Dissolved Copper*                    | g/m <sup>3</sup>                         | 0.013    | - | - | - | - |
| Dissolved Iron*                      | g/m <sup>3</sup>                         | 2.9      | - | - | - | - |
| Dissolved Magnesium*                 | g/m <sup>3</sup>                         | 11       | - | - | - | - |
| Dissolved Manganese*                 | g/m <sup>3</sup>                         | 4.5      | - | - | - | - |
| Total Nickel*                        | g/m <sup>3</sup>                         | 0.21     | - | - | - | - |
| Total Potassium*                     | g/m <sup>3</sup>                         | 189      | - | - | - | - |
| Total Sodium*                        | g/m <sup>3</sup>                         | 5,100    | - | - | - | - |
| Total Sulphur*                       | g/m <sup>3</sup>                         | 17       | - | - | - | - |
| Total Zinc*                          | g/m <sup>3</sup>                         | < 0.015  | - | - | - | - |
| Chloride*                            | g/m <sup>3</sup>                         | 3,800    | - | - | - | - |
| Nitrite-N                            | g/m <sup>3</sup>                         | 0.041 #1 | - | - | - | - |
| Nitrate-N                            | g/m <sup>3</sup>                         | < 0.010  | - | - | - | - |
| Nitrate*                             | g/m <sup>3</sup>                         | < 0.05   | - | - | - | - |
| Nitrate-N + Nitrite-N                | g/m <sup>3</sup>                         | 0.038 #1 | - | - | - | - |
| Sulphate*                            | g/m <sup>3</sup>                         | 52       | - | - | - | - |
| 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>                         | 18.1     | - | - | - | - |
| Toluene*                             | g/m <sup>3</sup>                         | 49       | - | - | - | - |
| Ethylbenzene*                        | g/m <sup>3</sup>                         | 6.7      | - | - | - | - |
| m&p-Xylene*                          | g/m <sup>3</sup>                         | 49       | - | - | - | - |
| o-Xylene*                            | g/m <sup>3</sup>                         | 14.1     | - | - | - | - |

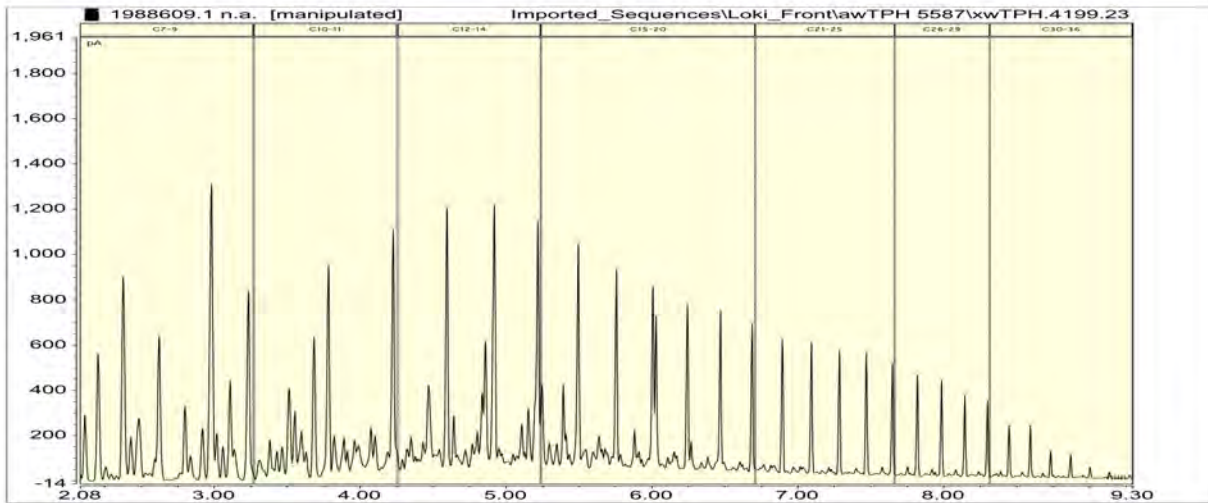


**Sample Type: Saline**

|                     |  |  |  |  |  |
|---------------------|--|--|--|--|--|
| <b>Sample Name:</b> | Kowhai A Frac 4 composite return fluid |  |  |  |  |
| <b>Lab Number:</b>  | 1988609.1                              |  |  |  |  |

|  |                  |        |   |   |   |   |
|--|------------------|--------|---|---|---|---|
| Formaldehyde in Water by DNPH & LCMSMS |                  |        |   |   |   |   |
| Formaldehyde*                          | g/m <sup>3</sup> | < 0.15 | - | - | - | - |
| Total Petroleum Hydrocarbons in Water  |                  |        |   |   |   |   |
| C7 - C9                                | g/m <sup>3</sup> | 260    | - | - | - | - |
| C10 - C14*                             | g/m <sup>3</sup> | 1,120  | - | - | - | - |
| C15 - C36*                             | g/m <sup>3</sup> | 1,210  | - | - | - | - |
| Total hydrocarbons (C7 - C36)          | g/m <sup>3</sup> | 2,600  | - | - | - | - |

1988609.1  
 Kowhai A Frac 4 composite return fluid  
 Client Chromatogram for TPH by FID



**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 NO2Nsal, NO3Nsal and NOxNsal analysis.

Appendix No.1 - Bicarbonate Report - 1988609

**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 |
|--|--|---------------------------------|-----------|
| Sample preparation by Non Routine section* | Sample preparation as per test requirement.  | -                               | 1         |
| 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         |
| Total Petroleum Hydrocarbons in Water*     | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis<br>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 Digestion*                           | Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).   | -                               | 1         |
| Total Digestion of Saline Samples*         | Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).   | -                               | 1         |

| 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                                | 1         |
| Total Alkalinity*                         | Saline water, Titration to pH 4.5.   | 1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>   | 1         |
| Analysis Temperature for Bicarbonate      | Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.   | 1.0 °C                                      | 1         |
| Bicarbonate                               | Bicarbonate (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 | 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.   | 50 g/m <sup>3</sup>                         | 1         |
| 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.   | -   | 1         |
| Dissolved Barium*                         | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.  | 0.0006 g/m <sup>3</sup>                     | 1         |
| Dissolved Bromine*                        | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.  | 0.10 g/m <sup>3</sup>                       | 1         |
| Dissolved Calcium*                        | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.  | 1.0 g/m <sup>3</sup>                        | 1         |
| Dissolved Copper*                         | Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.  | 0.0010 g/m <sup>3</sup>                     | 1         |
| 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>                      | 1         |
| Dissolved Magnesium*                      | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.  | 0.4 g/m <sup>3</sup>                        | 1         |
| 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>                     | 1         |
| 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>                      | 1         |
| 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>                        | 1         |
| 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>                       | 1         |
| 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>                        | 1         |
| 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>                     | 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                                 | 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>                     | 1         |
| Nitrate-N                                 | Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.  | 0.0010 g/m <sup>3</sup>                     | 1         |
| Nitrate*                                  | Calculation from Nitrate-N.  | 0.010 g/m <sup>3</sup>                      | 1         |
| 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>                     | 1         |
| Total Sulphate*                           | Calculation: from total sulphur.   | 2 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.

A handwritten signature in blue ink, consisting of several overlapping, stylized lines that form a unique, somewhat abstract shape.

Ara Heron BSc (Tech)  
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 57**

Report No: 2018060102

Customer Ref:150138

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

**GNS Lot No: 2018060102**

**GNS Sample No.** 2018003589  
**Collection Date**  
**Site ID** 1988609.1  
**Field ID**

|                                       |      |           |   |   |   |
|---------------------------------------|------|-----------|---|---|---|
| pH                                    |      | 7.40      | - | - | - |
| Bicarbonate (Total)                   | mg/l | 1812      | - | - | - |
| HCO <sub>3</sub> Analysis Temperature | °C   | 21        | - | - | - |
| HCO <sub>3</sub> Analysis Date        |      | 5/06/2018 | - | - | - |

**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.

*M. K. Appleby*  
 Moya Appleby  
 Senior Technician



**IANZ**  
 ACCREDITED LABORATORY

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



## Certificate of Analysis

|                 |   |                          |                                      |      |
|-----------------|---|--------------------------|--------------------------------------|------|
| <b>Client:</b>  | Taranaki Regional Council   | <b>Lab No:</b>           | 2127462                              | SPV1 |
| <b>Contact:</b> | Jane Harvey<br>C/- Taranaki Regional Council<br>Private Bag 713<br>Stratford 4352 | <b>Date Received:</b>    | 20-Feb-2019                          |      |
|                 |   | <b>Date Reported:</b>    | 27-Feb-2019                          |      |
|                 |   | <b>Quote No:</b>         | 47915                                |      |
|                 |   | <b>Order No:</b>         | 72831                                |      |
|                 |   | <b>Client Reference:</b> | #4884 - Kowhai A 1 Year Post Frac GW |      |
|                 |   | <b>Submitted By:</b>     | Sarah Larkin                         |      |

### Sample Type: Aqueous

|                     |  |  |  |  |  |
|---------------------|--|--|--|--|--|
| <b>Sample Name:</b> | TRC190808<br>(GND2770)<br>19-Feb-2019 9:50<br>am |  |  |  |  |
| <b>Lab Number:</b>  | 2127462.1  |  |  |  |  |

#### Individual Tests

|                                      |                                       |           |   |   |   |   |
|--------------------------------------|---------------------------------------|-----------|---|---|---|---|
| Sum of Anions                        | meq/L                                 | 2.2       | - | - | - | - |
| Sum of Cations                       | meq/L                                 | 2.2       | - | - | - | - |
| pH                                   | pH Units                              | 6.3       | - | - | - | - |
| Total Alkalinity                     | g/m <sup>3</sup> as CaCO <sub>3</sub> | 25        | - | - | - | - |
| Bicarbonate                          | g/m <sup>3</sup> at 25°C              | 30        | - | - | - | - |
| Total Hardness                       | g/m <sup>3</sup> as CaCO <sub>3</sub> | 75        | - | - | - | - |
| Electrical Conductivity (EC)         | mS/m                                  | 27.2      | - | - | - | - |
| Total Dissolved Solids (TDS)         | g/m <sup>3</sup>                      | 220       | - | - | - | - |
| Sample Temperature*                  | °C                                    | 18.7      | - | - | - | - |
| Dissolved Barium                     | g/m <sup>3</sup>                      | 0.013     | - | - | - | - |
| Dissolved Calcium                    | g/m <sup>3</sup>                      | 15.7      | - | - | - | - |
| Dissolved Copper                     | g/m <sup>3</sup>                      | < 0.0005  | - | - | - | - |
| Dissolved Iron                       | g/m <sup>3</sup>                      | < 0.02    | - | - | - | - |
| Dissolved Magnesium                  | g/m <sup>3</sup>                      | 8.6       | - | - | - | - |
| Dissolved Manganese                  | g/m <sup>3</sup>                      | 0.0051    | - | - | - | - |
| 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>                      | 1.68      | - | - | - | - |
| Dissolved Sodium                     | g/m <sup>3</sup>                      | 16.3      | - | - | - | - |
| Dissolved Zinc                       | g/m <sup>3</sup>                      | 0.0153    | - | - | - | - |
| Bromide                              | g/m <sup>3</sup>                      | 0.23      | - | - | - | - |
| Chloride                             | g/m <sup>3</sup>                      | 54        | - | - | - | - |
| Nitrite-N                            | g/m <sup>3</sup>                      | < 0.002   | - | - | - | - |
| Nitrate-N                            | g/m <sup>3</sup>                      | 1.69      | - | - | - | - |
| Nitrate-N + Nitrite-N                | g/m <sup>3</sup>                      | 1.69      | - | - | - | - |
| Sulphate                             | g/m <sup>3</sup>                      | 2.0       | - | - | - | - |
| 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>                      | < 5       | - | - | - | - |



| Sample Type: Aqueous                   |  |          |   |   |   |   |
|--|--|----------|---|---|---|---|
| <b>Sample Name:</b>                    | TRC190808<br>(GND2770)<br>19-Feb-2019 9:50<br>am |          |   |   |   |   |
| <b>Lab Number:</b>                     | 2127462.1  |          |   |   |   |   |
| 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>                                 | < 0.002  | - | - | - | - |
| 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<br>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.<br>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.<br>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         |

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

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

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

Ara Heron BSc (Tech)  
Client Services Manager - Environmental



## Appendix IV

### Biomonitoring Reports



To Job Manager, Jane Harvey  
 From Environmental Scientist, Katie Blakemore  
 Report No KB070  
 Document 2134743  
 Date 5 October 2018

## Biomonitoring of unnamed tributaries of the Waiau Stream in relation to hydraulic fracturing at the Kowhai-A wellsite

### Introduction

Macroinvertebrate surveys were carried out in two unnamed tributaries of the Waiau Stream in the vicinity of the Kowhai-A wellsite prior to the commencement of hydraulic fracturing (HF) activities, and again following the completion of HF. This provided data to assess whether discharges relating to the HF activities had caused detrimental effects upon the macroinvertebrate communities of the unnamed tributaries.

### Methods

A pre-HF survey was undertaken on 8 December 2017 at two sites which were established at the time of sampling (Table 1, Figure 1). A post HF survey was undertaken at the same sites on 10 September 2018.

Table 1 Biomonitoring sites in unnamed tributaries of the Waiau Stream sampled in relation to the Kowhai-A wellsite

| Site number | Site code | Grid reference (NZTM) | Location                                | Altitude (masl) |
|-------------|-----------|-----------------------|---|-----------------|
| 1           | WAI000003 | E1711254 N5676545     | Receiving tributary, 10m U/S confluence | 80              |
| 2           | WAI000004 | E1711272 N5676562     | 5m U/S culvert                          | 80              |

The standard 'vegetation sweep' technique was used to collect streambed macroinvertebrates at sites 1 and 2 in the pre-HF and post-HF surveys. The 'vegetation sweep' technique is very similar to Protocol C2 (soft-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate sampling in wadeable streams (Stark et al. 2001).

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using Protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001). Macroinvertebrate taxa in each sample were recorded based on the abundance categories in Table 2.

Table 2 Macroinvertebrate abundance categories

| Abundance category      | Number of individuals |
|-------------------------|-----------------------|
| R (rare)                | 1-4                   |
| C (common)              | 5-19                  |
| A (abundant)            | 20-99                 |
| VA (very abundant)      | 100-499               |
| XA (extremely abundant) | >499                  |

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scores 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience. By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. However, other physical variables such as sedimentation, temperatures, water velocity and dissolved oxygen levels may also affect the MCI scores because the taxa that are able to tolerate extremes in these variables generally have lower sensitivity scores. More 'sensitive' communities inhabit less polluted waterways. A gradation of biological water quality conditions based upon MCI ranges has been adapted for Taranaki streams and rivers (TRC, 2013) from Stark's classification (Stark 1985; Boothroyd & Stark 2001) is shown in Table 3. A difference of eleven or more MCI units is considered statistically significant (Stark 1998).

**Table 3** Macroinvertebrate community health based on MCI ranges adapted for Taranaki streams and rivers (TRC, 2013) from Stark's classification (Stark, 1985; Boothroyd and Stark, 2000)

| Grading   | MCI     |
|-----------|---------|
| Excellent | > 140   |
| Very Good | 120-140 |
| Good      | 100-119 |
| Fair      | 80-99   |
| Poor      | 60-79   |
| Very Poor | <60     |

A semi-quantitative MCI value (SQMCI<sub>s</sub>) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the SQMCI<sub>s</sub> is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

## Results

The pre-HF survey was undertaken 30 days after a fresh greater than both 3x and 7x median flow. The water temperature was 16.6 °C and 18.9 °C at sites 1 and 2 respectively. Site 1 had substrate comprised entirely of silt, while site 2 was dominated by hard clay and fine gravel with small amounts of silt and sand present. Both sites had abundant macrophytes on the streambed, and no periphyton was present at either site. Leaves were patchy on the streambed at site 1 only. Site 1 was completely shaded, while site 2 had partial shading from overhanging grasses.

The post-HF survey was undertaken seven days after a fresh of 3x median flow and 20 days after a fresh of 7x median flow. The water temperature was 11.7 °C at both sites 1 and 2. Site 1 had substrate dominated by silt, with some hard clay. Site 2 had substrate dominated by sand, with some silt, gravels and hard clay present. Both sites had abundant macrophytes on the streambed, and no periphyton was present at either site. Leaves were widespread at site 1 only. Site 1 was completely shaded, while site 2 had partial shading from overhanging grasses.

## Macroinvertebrate communities

Macroinvertebrate metrics recorded at sites in Taranaki lowland coastal streams at similar altitude are provided for comparative purposes in Table 4. Full macroinvertebrate fauna recorded in the pre-HF and post-HF surveys are provided in Table 5 and Table 6 respectively.

Table 4 Range and median taxa richness, MCI and SQMCI scores for lowland coastal streams at altitudes of 80-124 masl

| Metric        | Number of samples | Range   | Median |
|---------------|-------------------|---------|--------|
| Taxa richness | 5                 | 13-25   | 16     |
| MCI           | 5                 | 75-82   | 80     |
| SQMCI         | 2                 | 2.0-2.4 | 2.2    |

Table 5 Macroinvertebrate fauna of unnamed tributaries of the Waiau Stream Sampled on 8 December 2017

| Taxa List                 | Site Number                      | MCI score                   | 1         | 2                       |
|---------------------------|----------------------------------|-----------------------------|-----------|-------------------------|
|                           | Site Code                        |                             | WAI000003 | WAI000004               |
|                           | Sample Number                    |                             | FWB17458  | FWB17457                |
| NEMATODA                  | Nematoda                         | 3                           | R         | -                       |
| ANNELIDA (WORMS)          | Oligochaeta                      | 1                           | A         | C                       |
| MOLLUSCA                  | <i>Potamopyrgus</i>              | 4                           | VA        | A                       |
|                           | Sphaeriidae                      | 3                           | C         | -                       |
| CRUSTACEA                 | Ostracoda                        | 1                           | VA        | R                       |
|                           | Paraleptamphopidae               | 5                           | XA        | XA                      |
|                           | <i>Paranephrops</i>              | 5                           | R         | -                       |
| EPHEMEROPTERA (MAYFLIES)  | <i>Zephlebia group</i>           | 7                           | R         | VA                      |
| COLEOPTERA (BEETLES)      | Ptilodactylidae                  | 8                           | R         | -                       |
| TRICHOPTERA (CADDISFLIES) | <i>Hydropsyche (Orthopsyche)</i> | 9                           | -         | R                       |
|                           | Oeconesidae                      | 5                           | C         | R                       |
|                           | <i>Triplectides</i>              | 5                           | -         | R                       |
| DIPTERA (TRUE FLIES)      | <i>Paralimnophila</i>            | 6                           | R         | -                       |
|                           | <i>Zelandotipula</i>             | 6                           | R         | -                       |
|                           | Orthocladiinae                   | 2                           | -         | R                       |
|                           | <i>Polypedilum</i>               | 3                           | R         | C                       |
|                           | Tanypodinae                      | 5                           | -         | R                       |
|                           | <i>Paradixa</i>                  | 4                           | -         | R                       |
|                           | Empididae                        | 3                           | -         | R                       |
| No of taxa                |                                  |                             | 13        | 13                      |
| MCI                       |                                  |                             | 88        | 83                      |
| SQMCI                     |                                  |                             | 4.2       | 5.2                     |
| EPT (taxa)                |                                  |                             | 2         | 4                       |
| %EPT (taxa)               |                                  |                             | 15        | 31                      |
| 'Tolerant' taxa           |                                  | 'Moderately sensitive' taxa |           | 'Highly sensitive' taxa |

R = Rare    C = Common    A = Abundant    VA = Very Abundant    XA = Extremely Abundant

Table 6 Macroinvertebrate fauna of unnamed tributaries of the Waiau Stream Sampled on 10 September 2018

| Taxa List                   | Site Number                      | MCI score                   | 1                       | 2         |
|-----------------------------|----------------------------------|-----------------------------|-------------------------|-----------|
|                             | Site Code                        |                             | WAI000003               | WAI000004 |
|                             | Sample Number                    |                             | FWB18240                | FWB18241  |
| PLATYHELMINTHES (FLATWORMS) | <i>Cura</i>                      | 3                           | -                       | R         |
| NEMATODA                    | Nematoda                         | 3                           | R                       | -         |
| ANNELIDA (WORMS)            | Oligochaeta                      | 1                           | VA                      | C         |
| MOLLUSCA                    | <i>Potamopyrgus</i>              | 4                           | A                       | A         |
|                             | Sphaeriidae                      | 3                           | A                       | R         |
| CRUSTACEA                   | Ostracoda                        | 1                           | A                       | C         |
|                             | Isopoda                          | 5                           | R                       | -         |
|                             | Paraleptamphopidae               | 5                           | R                       | VA        |
| EPHEMEROPTERA (MAYFLIES)    | <i>Zephlebia group</i>           | 7                           | -                       | VA        |
| PLECOPTERA (STONEFLIES)     | <i>Acroperla</i>                 | 5                           | -                       | C         |
| COLEOPTERA (BEETLES)        | Hydrophilidae                    | 5                           | -                       | R         |
|                             | Scirtidae                        | 8                           | R                       | -         |
| TRICHOPTERA (CADDISFLIES)   | <i>Hydropsyche (Orthopsyche)</i> | 9                           | -                       | R         |
|                             | <i>Psilochorema</i>              | 6                           | -                       | R         |
| DIPTERA (TRUE FLIES)        | Eriopterini                      | 5                           | R                       | -         |
|                             | Hexatomini                       | 5                           | -                       | R         |
|                             | <i>Paralimnophila</i>            | 6                           | R                       | -         |
|                             | Orthoclaadiinae                  | 2                           | -                       | R         |
|                             | <i>Polypedilum</i>               | 3                           | -                       | R         |
|                             | Tanypodinae                      | 5                           | -                       | C         |
|                             | Empididae                        | 3                           | -                       | R         |
| ACARINA (MITES)             | Acarina                          | 5                           | C                       | R         |
|                             |                                  | No of taxa                  | 11                      | 17        |
|                             |                                  | MCI                         | 84                      | 85        |
|                             |                                  | SQMCI                       | 1.9                     | 5.5       |
|                             |                                  | EPT (taxa)                  | 0                       | 4         |
|                             |                                  | %EPT (taxa)                 | 0                       | 24        |
| 'Tolerant' taxa             |                                  | 'Moderately sensitive' taxa | 'Highly sensitive' taxa |           |

R = Rare    C = Common    A = Abundant    VA = Very Abundant    XA = Extremely Abundant

## Site 1

A macroinvertebrate community richness of 13 taxa was recorded in the pre-HF survey, while 11 taxa were recorded in the post-HF survey. These results are respectively equal to and two taxa less than the lowest richness recorded in lowland coastal streams at similar altitude (although this is based on only five previous samples).

A MCI score of 88 units was recorded in the pre-HF survey and 84 units was recorded in the post-HF survey, categorising the community as having 'fair' macroinvertebrate community health on both occasions (Table 3). These scores are not significantly different from one another (Stark, 1998) or from the median score for lowland coastal streams at similar altitude.

SQMCI scores of 4.2 and 1.9 units were recorded in the pre-HF and post-HF surveys respectively. This is statistically significant decline between the two surveys (Stark, 1998), which was caused primarily by a decrease in abundance of the 'moderately sensitive' Paraleptamphopidae amphipods and *Zephlebia* mayflies, together with an increase in the 'tolerant' Oligochaete worms.

## Site 2

A macroinvertebrate community richness of 13 taxa was recorded in the pre-HF survey, while 17 taxa was recorded in the post-HF survey. These results are respectively three taxa less and one taxon more than the median score for lowland coastal stream at similar altitude.



MCI scores of 83 and 85 units were recorded in the pre-HF and post-HF surveys respectively, categorising the site as having 'fair' macroinvertebrate community health on both occasions. These scores were not significantly different from one another (Stark, 1998) or from the median score for Taranaki lowland coastal streams at similar altitude (Table 4).

SQMCI scores of 5.2 and 5.5 units were recorded in the pre-HF and post-HF surveys respectively. These scores are not significantly different from one another, although they are significantly higher than the two SMQCI scores previously recorded in lowland coastal streams at similar altitude (Table 4) (Stark, 1998).

## Discussion and conclusions

The Council's 'vegetation sweep' sampling technique was used to collect samples from two sites in the two unnamed tributaries of the Waiau Stream on two occasions. This has provided data to assess the impact of the stormwater discharge to land and water from the Kowhai-A wellsite on the macroinvertebrate communities of the tributaries. Samples were processed to provide taxa richness, MCI and SQMCI scores for each site.

Taxa richness is a valuable macroinvertebrate community metric when determining whether a community has been exposed to a toxic discharge, as macroinvertebrates will either drift downstream to avoid the discharge or may be killed. This would result in reduced taxa richness at the downstream sites. In contrast, the MCI and SQMCI scores are a measure of community tolerance to organic pollution, although they can also provide an indication of more subtle influences caused by a poor quality discharge. As the SQMCI score takes into account relative abundances of the taxa found in the sample, it provides additional insight to that provided by the MCI score. However, it is also easily influenced by the 'patchiness' of invertebrates on the streambed, and as such must be considered in the context of all three metrics.

Taxa richnesses in at both sites in the pre-HF survey were moderately low, and did not change between the two sites. In the post-HF survey, the taxa richness at site 1 was similar to that recorded in the pre-HF survey, while site 2 recorded a substantially higher taxa richness than in the pre-HF survey and when compared to site 1 in the post-HF survey.

MCI scores at both sites in the pre-HF and post-HF surveys were similar, and categorised the sites as having 'fair' macroinvertebrate community health. These scores were higher than any MCI scores previously recorded in Taranaki lowland coastal streams at similar altitude, although this difference was relatively minor and most likely reflects the limited dataset available for these streams. This is supported by the median score for these streams, which is not significantly different from any score in the pre-HF or post-HF surveys.

SQMCI scores were significantly lower at site 1 than at site 2 in both surveys. Site 1 showed a significant decrease between the two surveys, while site 2 remained similar over the same period. The change at site 1 was largely due to substantial changes in abundance of three taxa (*Paraleptamphopidae* amphipods, *Zephlebia* mayflies and oligochaete worms). This also reflects the patchiness of the macroinvertebrate community, as the taxa richness and MCI score did not show this same pattern. All scores except site 1 in the post-HF survey recorded scores which were substantially higher than the previously recorded scores for lowland coastal streams at similar altitude. Overall, the macroinvertebrate communities reflected the wetland-type habitat at site 1, and the macrophyte dominated habitat at site 2.

Overall, the results of these two surveys show that these two unnamed tributaries of the Waiau Stream have macroinvertebrate community health similar to or slightly better than expected when compared with other lowland coastal streams at similar altitude. When the results of the two surveys are taken together, the macroinvertebrate metrics do not indicate that stormwater discharges from the Kowhai-A wellsite had caused any recent detrimental impacts on the macroinvertebrate communities of these two unnamed tributaries of the Waiau Stream.

## Summary

Two macroinvertebrate surveys were carried out at two sites in two unnamed tributaries of the Waiau Stream, near the Kowhai-A wellsite prior to and following hydraulic fracturing activities, to determine if stormwater discharges from the wellsite had significant adverse effects on the stream macroinvertebrate communities. These surveys recorded high MCI and SQMCI scores for lowland coastal streams at similar altitude.

MCI scores were similar between sites and surveys, while SQMCI scores were lower at site 1 than site 2. Site 1 also showed a significant decrease in SQMCI between the two surveys, which was not apparent at site 2. Taxa richness was the same at both sites in the pre-HF survey, but was higher at site 2 in the post-HF survey. Site 2 also showed an increase in taxa richness between the two surveys, while site 1 remained similar. Overall, the macroinvertebrate communities reflected habitat differences between the two sites. There was no evidence that the stormwater discharges from the Kowhai-A wellsite had caused any recent significant detrimental impacts on the macroinvertebrate communities of these two unnamed tributaries of the Waiau Stream.

## References

- Stark JD, 1985: A macroinvertebrate community index of water quality for stony streams. Water and Soil Miscellaneous Publication No. 87.
- 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.
- Stark JD, Boothroyd IKG, Harding JS, Maxted JR, Scarsbrook MR, 2001: Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103. 57p.
- TRC, 2017: Some statistics from the Taranaki Regional Council database (Esam) of freshwater macroinvertebrate surveys performed during the period from January 1980 to 30 September 2017 (SEM reference report).
- Winterbourn MJ, Gregson KLD, Dolphin CH, 2006. Guide to the aquatic insects of New Zealand. [4th edition]. Bulletin of the Entomological Society of New Zealand 14, 108p.