Todd Petroleum Mining Company Limited KA1/7/19/20 Hydraulic Fracturing Monitoring Programme Biennial Report 2016-2018

Technical Report 2018-14

ISSN: 1178-1467 (Online)
Document: 2053852 (Word)
Document: 2080938 (Pdf)

Taranaki Regional Council
Private Bag 713
STRATFORD

August 2018

Executive summary

This report for the activities over the period November to December 2016 outlines and discusses the results of the monitoring programme implemented by the Taranaki Regional Council (the Council) in relation to hydraulic fracturing activities conducted by Shell Todd Ltd (STOS) at the KA1/7/19/20/wellsite. The wellsite and associated consents were transferred to Todd Petroleum Mining Company Ltd (Todd) in November 2017, prior to the completion of the monitoring programme.

The programme of hydraulic fracturing undertaken by STOS at the KA1/7/19/20 wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the KA20 well.

During the monitoring period STOS 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 2016-2017 and 2017-2018 monitoring years. Monitoring included a mixture of groundwater, surface water and discharge monitoring components. This is the third monitoring report produced by the Council in relation to the hydraulic fracturing activities at the KA20 wellsite. The two previous reports covered hydraulic fracturing activities spanning July 2012 to June 2016.

The programme of monitoring implemented by the Council during the period being reported 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 the Kapuni 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.

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

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

During the monitoring period, STOS and Todd demonstrated a high level of environmental and administrative performance with the resource consent.

For reference, in the 2016-2017 year, consent holders were found to achieve a high level of environmental performance and compliance for 74% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 21% of the consents, a good level of environmental performance and compliance was achieved.

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.

In terms of overall environmental and compliance performance by the consent holder over the last several years, this report shows that the consent holder's performance remains at a high level.

This report includes recommendations for the future monitoring of any hydraulic fracturing activities at the KA20 wellsite.

Table of contents

List of tables

List of figures

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 Shell Todd Ltd (STOS) at the KA1/7/19/20 wellsite, over the period November to December 2016. The report also assesses the Company's level of environmental performance and compliance with the resource consent held in relation to the activity. The wellsite and all associated consents were transferred to Todd Petroleum Mining Company Ltd (Todd) in November 2017, prior to the completion of the monitoring programme.

The programme of hydraulic fracturing undertaken by STOS at the KA1/7/19/20 wellsite included the hydraulic fracturing of one well. The well targeted for stimulation, during November to December 2016, was the KA20 well.

The programme of monitoring implemented by the Council in relation to these hydraulic fracturing activities spanned the 2016-2017 and 2017-2018 monitoring years. Monitoring included a mixture of groundwater, surface water and discharge monitoring components. This is the third monitoring report produced by the Council in relation to the hydraulic fracturing activities at the KA1/7/19/20 wellsite. The two previous reports covered previous hydraulic fracturing activities spanning July 2012 to June 2016.

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 KA1/7/19/20.

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 KA1/7/19/20 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 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 2016-2017 year, consent holders were found to achieve a high level of environmental performance and compliance for 74% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 21% of the consents, a good level of environmental performance and compliance was achieved.

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 fracking) or turbulent flow (slick-water fracking).

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. [1]

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^2) is a gas at room temperature, it can be maintained in a liquid state through cooling and pressurisation. Nitrogen assisted fracking 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. [2] More indirectly, a reduction in the volume of water used also reduces the total concentration of chemical additives required and the volume of water returning to the surface that requires subsequent disposal[2].

1.2.2 The KA1/7/19/20 wellsite and hydraulic fracturing activities

The KA1/7/19/20 wellsite is located at 360 Palmer Road and lies within the Kapuni Catchment approximately 50 m to the west of the Kapuni Stream. 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 STOS at the KA1/7/19/20 wellsite during the period being reported is provided below in Table 1.

Table 1 Summary of hydraulic fracturing details

Well	Bore id.	Fracturing date		Injection zone (m TVss)	Formation
		Start	End		
KA20	GND2594	29/11/16	13/12/16	3,211 to 3,433	Kapuni Group

[1] *http://geology.com/energy/hydraulic-fracturing-fluids/*

[2] *http://frackwire.com/nitrogen-gas-fracking*

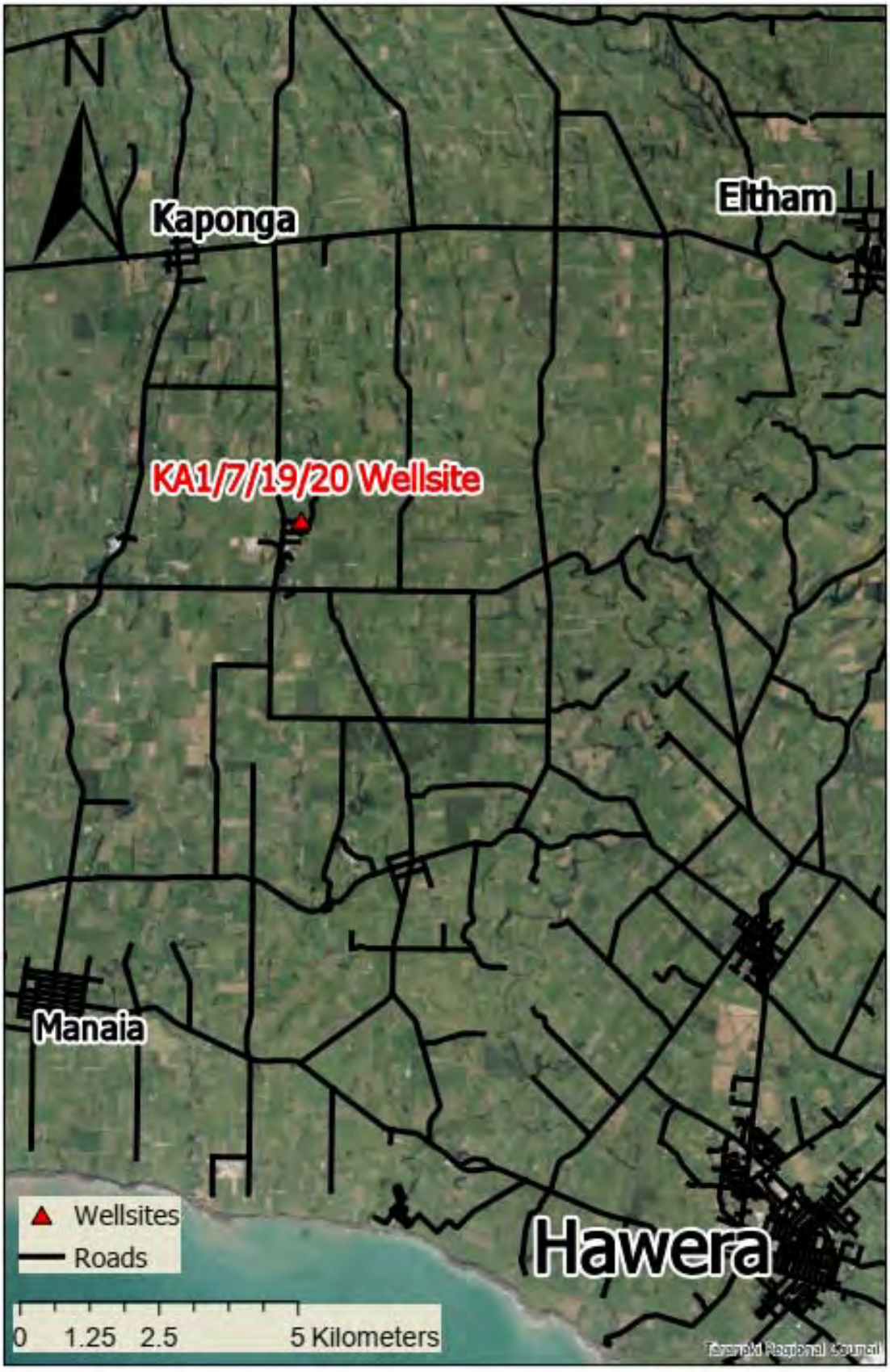


Figure 1 Location map

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.

At the start of the monitoring period and during the hydraulic fracturing activities STOS held discharge permit **7995-1** to cover hydraulic fracturing activities at the KA1/7/19/20 wellsite. This permit was issued by the Council on 28 March 2012 under Section 87(e) of the RMA and expired on 1 June 2017. The wellsite was transferred to Todd during the consent renewal process and consent **7995-2** was issued to Todd on 14 November 2017 and is due to expire 1 June 2028.

Consent **7995-1** had 14 special conditions, as summarised below:

- Condition 1 stipulates the minimum depth below which the injection of hydraulic fracturing fluids must occur;
- Condition 2 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 3, 4 and 5 relate to freshwater monitoring requirements, to allow compliance with condition 2 to be assessed;
- Condition 6 requires the consent holder to carry out pressure testing of equipment prior to discharging;
- Condition 7 requires the consent holder to submit a pre-fracturing discharge report prior to any discharge occurring;
- Condition 8 is a notification requirement;
- Condition 9 requires the consent holder to submit a post-fracturing discharge report after the completion of the hydraulic fracturing programme for each well;
- Condition 10 stipulates how the reports required by conditions 7 and 9 are to be submitted;
- Condition 11 requires the consent holder to allow the Council access to a location where samples of hydraulic fracturing and return fluids can be obtained;
- Condition 12 requires the consent holder to adopt best practicable options;
- Condition 13 relates to the composition of the fracturing fluid; and
- Condition 14 is a review provision.

Consent **7995-2** has 23 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 discharge occur after 1 June 2022;
- Condition 3, 4 and 5 relate to seismic monitoring requirements and reporting;
- Condition 6 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 7, 8 and 9 relate to freshwater monitoring requirements, to allow compliance with condition 6 to be assessed;
- Condition 10 requires all monitoring to be undertaken in accordance with a sampling and analysis plan;

- Condition 11 requires the consent holder to carry out pressure testing of equipment prior to discharging;
- Condition 12 requires the consent holder to submit a pre-fracturing discharge report prior to any discharge occurring;
- Condition 13 is a notification requirement;
- Condition 14 and 15 requires the consent holder to submit a post-fracturing discharge reports after each hydraulic fracturing programme for each well;
- Condition 16 stipulates how a report required by condition 3 is to be submitted;
- Condition 17 stipulates how the reports required by conditions 12,14 and 15 are to be submitted;
- Condition 18 requires the consent holder to allow the Council access to a location where samples of hydraulic fracturing and return fluids can be obtained;
- Condition 19 requires the consent holder to adopt best practicable options;
- Condition 20 relates to the composition of the fracturing fluid;
- Condition 21 is a notification requirement;
- Condition 22 is a lapse provision; and
- Condition 23 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 consents which are 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 KA1/7/19/20 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 7995-1, STOS submitted pre and post-fracturing discharge reports to the Council for the wells fractured during the period under review. Pre-fracturing discharge reports provide an outline of the proposed fracturing operations in relation to 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

In order to select suitable sites for sampling, a well survey was carried out in the vicinity of the KA1/7/19/20 wellsite to identify any existing groundwater abstractions in the area within a one km radius of the site. A total of six groundwater abstraction sites were identified and considered for inclusion in the monitoring programme. Two of the six bores were removed as they were both shallow and up-gradient of the potential water flow path. A summary of the bore details for the remaining four bores is included in Table 2. The site selection is designed to provide a sample set representative of groundwater abstractions in the area surrounding the site.

Table 2 Details of groundwater sites included in the monitoring programme

Monitoring site	Distance from wellsite (m)	Total depth (m)	Screened/open interval (m)	Aquifer
GND0093	753	55	25-55	Volcanics
GND2357	960	430	386-430	Matemateonga
GND2348	911	49	24-49	Volcanics
GND2021	986	35	24-35	Volcanics

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 from storage tanks on-site.

All samples were transported to RJ Hill Laboratories Ltd for analysis following standard chain of custody procedures.

1.4.5 Surface water quality monitoring

1.4.5.1 Biomonitoring surveys

Macroinvertebrate surveys were carried out on 22 November 2016 and 9 January 2017 at the KA1/7/19/20 wellsite to determine whether discharges relating to hydraulic fracturing activities undertaken during the reporting period at the wellsite had caused a detrimental effect upon the macroinvertebrate communities of two unnamed tributaries of the Kapuni Stream. The wellsite treated stormwater and uncontaminated site water were discharged from a skimmer pit onto land where they enter the shallow groundwater system and eventually drain into the Kapuni Stream (Figure 3).

Table 3 Biomonitoring site details

Site number	Site code	Eastings (NZTM)	Northings (NZTM)	Location	Altitude (masl)
1	KPN000279	1701343	5630194	Off the Hawera water treatment plant track, upstream (u/s) of the pipeline bridge (u/s of discharge)	70
2	KPN000280	1701263	5630047	250m u/s of water treatment plant (downstream (d/s) of discharge)	70
3	KPN000281	1701216	5629958	150m u/s of the water treatment plant (d/s of discharge)	70

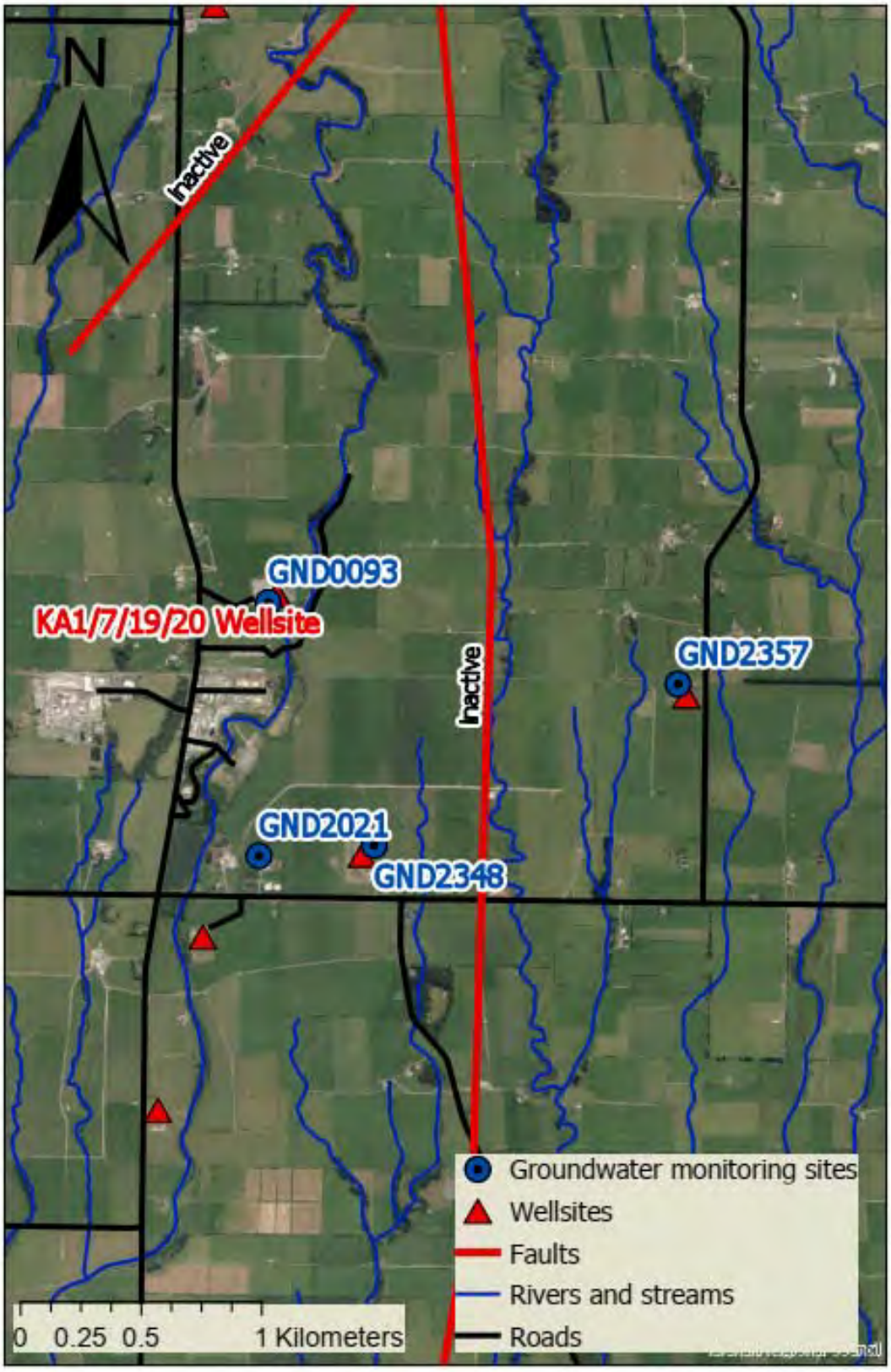


Figure 2 Groundwater monitoring sites

Figure 3 Surface water monitoring sites

2 Results

2.1 Consent holder submitted data

2.1.1 KA20 post-fracturing discharge report

The conclusions from the KA20 post-fracturing discharge report are summarised as follows:

- A total of four zones were fractured over the period 29 November to 13 December 2016 at depths between 3,211 to 3,433 m TVss.
- A total of 10,124 bbls (1,610 m^3) of liquid was discharged across the four fractured zones. The total proppant weight was 188 tonnes (414,981 lbs).
- The KA20 well was opened for flow-back following the completion of fracturing operations. In total, 1,644 bbls (261 m^3) of fluid was returned from the well over the initial flow-back period.
- The volume of fluid remaining in the formation after initial flow-back was 8,480 bbls (1,343 m^3) or 84% of the total fluid discharged.
- During subsequent fishing operations a further 2,006 bbls (319 m^3) was discharged into the formation, of this 223 bbls (36 m^3) was returned leaving 1,782 bbls (283 m^3) or 89% of the fluid discharged within the formation.
- Approximately 182 tonnes (401,440 lbs) or 97 % of proppant and 10,262 bbls or 86% of the total fluids discharged remained within the formation after the completion of the 50 day flow back.
- All return fluid from the KA20 fracturing operations was disposed of by deep well injection, via the KW2 injection well under consent 9970-1.
- No screen outs occurred while fracturing.
- The injection well integrity was continuously monitored via fibre optic cable technology during the hydraulic fracturing event.
- The fibre optic sensor, located along the well completion indicated four leak points along the reservoir section. Any fluid leaked remained below the 3,000 m TVDS as required by the consent.
- During fracture of zone four the fibre optic cable broke and fracture zones five and six were cancelled to avoid any potential impact on the integrity of the well.
- Pressure testing undertaken on 22 December confirmed the on-going integrity of the well.
- It is considered that the mitigation measures implemented by STOS were effective in ensuring there were no adverse environmental effects associated with fracturing operations.
- The well was shut in due to no viable commercial production and is not expected to recover any additional fluids or solids in the midterm.

2.2 Physiochemical sampling

2.2.1 Groundwater

The hydraulic fracturing activities commenced at the KA1/7/19/20 wellsite on 29 November 2016 and continued until 13 December 2016. Pre-fracturing sampling was undertaken on 15 and 16 November 2016. A three month post-fracturing sample was undertaken on 20 March 2017 and a one year post-fracturing sampling was undertaken on 22 November 2017.

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

Trace benzene at concentrations significantly lower than the maximum acceptable value of 0.01 mg/L for determinands in the drinking water standards of New Zealand, were recorded in the baseline sample and the pre-fracturing and one year post fracturing samples taken at GND2348, which is located on the KA5/10 wellsite. Trace values can be attributable to lab margins of error and when not accompanied by other hydrocarbons or increased chloride concentrations are generally of little or no concern.

Concentrations in several parameters including alkalinity, calcium, potassium, chloride, sodium, magnesium, dissolved iron and methane at GND2357 indicate gradually increasing trends over time. In contrast, sulphate and dissolved oxygen have both reduced significantly over time in this bore.

Further investigation and an assessment of the historical water quality data, bore construction and other activities undertaken at this site indicate that the changes in water quality observed in GND2357 may be due to the shallow aquifer becoming oxygenated following site remediation work, undertaken between May and August 2013. In total 1,123 tonnes of material was removed from the site likely resulting in exposure of the water table to the atmosphere, leading to more oxygenated recharge waters entering the aquifer and an increase in hydraulic conductivity due to the remediated soil. Subsequent sampling supports this theory and indicates that the changes in water quality are likely a consequence of the aquifer returning to its original oxidation state and do not indicate any impacts attributable to hydraulic fracturing activities.

Methane was detected in all monitoring sites at varying concentrations during the reporting period. When concentrations exceeded 1 mg/L, samples were sent to GNS for further analysis. Isotopic analysis of the dissolved methane within the samples analysed by GNS indicates the methane gas at all sites is biogenic in nature and concentrations from the samples analysed were all within the expected ranges for shallow groundwater across Taranaki.

All samples, with a few minor exceptions discussed above, 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.

A summary of the results for groundwater samples taken in relation to the hydraulic fracturing activities compared to baseline is included in Table 4 and Table 5. 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 KA20 fracturing event compared to baseline

Parameter	Bore id	GND2357					GND2348				
	Unit	Range 2013-2015		Pre-frac	3 mth post-frac	1 year post-frac	Range 2013-2015		Pre-frac	3 mth post-frac	1 year post-frac
Sample date	-	Min	Max	15/11/2016	20/03/2017	21/11/2017	Min	Max	15/11/2016	21/03/2017	21/11/2017
Lab number	TRC			TRC164404	TRC171269	TRC174125			TRC164402	TRC171267	TRC174126
pH	pH	6.8	8.7	7.5	6.9	6.8	6.6	6.8	6.9	6.7	6.5
Conductivity	mS/m	17.0	63.7	61.3	83.8	86.9	38.7	45.2	48.0	39.7	37.9
Total dissolved solids	g/m^3	151	330	310	450	420	250	330	330	260	280
Total alkalinity	g/m^3 CaCO3	75	310	280	380	410	49	53	58	53	53
Bicarbonate	g/m^3 HCO_3	87	370	340	470	500	60	64	71	65	65
Total hardness	g/m^3 $CaCO_3$	25	154	140	193	194	76	90	90	80	70
Calcium	g/m^3	6	29	25	34	37	17	19	20	17	16
Chloride	g/m^3	13	26	28	37	36	83	99	99	88	79
Magnesium	g/m^3	3	20	19	26	25	8	11	10	9	7
Potassium	g/m^3	4	16	15	21	22	8	10	9	9	9
Sodium	g/m^3	23	49	46	54	55	27	33	32	29	26
Barium	mg/kg	0.020	0.085	0.068	0.083	0.091	0.056	0.066	0.069	0.058	0.051
Bromide	g/m^3	<0.05	<0.05	-	-	0.19	0.30	0.30	-	-	0.28
Dissolved bromine	g/m^3	0.042	0.134	0.115	0.170	-	0.300	0.320	0.320	0.230	-
Dissolved copper	g/m^3	<0.0010	0.0149	< 0.0005	< 0.0005	0.0006	<0.0005	0.0005	< 0.0005	< 0.0005	0.0005
Dissolved iron	g/m^3	0.9	11.0	10.4	69.0	79.0	27.0	34.0	32.0	27.0	25.0

Parameter	Bore id	GND2357					GND2348				
	Unit	Range 2013-2015		Pre-frac	3 mth post-frac	1 year post-frac	Range 2013-2015		Pre-frac	3 mth post-frac	1 year post-frac
Sample date	-	Min	Max	15/11/2016	20/03/2017	21/11/2017	Min	Max	15/11/2016	21/03/2017	21/11/2017
Lab number	TRC			TRC164404	TRC171269	TRC174125			TRC164402	TRC171267	TRC174126
Dissolved manganese	g/m^3	0.05	0.27	0.19	0.32	0.32	0.53	0.63	0.62	0.59	0.48
Dissolved mercury	g/m^3	<0.00008	<0.00008	0.0002	0.00025	< 0.00008	<0.00008	<0.00008	0.00011	0.00032	< 0.00008
Dissolved Nickel	mg/kg	0.0006	0.0014	< 0.0005	< 0.0005	< 0.0005	0.0007	0.002	0.0007	< 0.0005	0.0015
Dissolved zinc	g/m^3	5.700	20.000	5.600	0.700	0.860	0.470	0.710	0.870	0.270	0.410
Nitrate & nitrite nitrogen	g/m^3 N	<0.002	0.007	< 0.002	< 0.02	0.02	<0.2	<0.2	< 0.02	< 0.02	< 0.02
Nitrite nitrogen	g/m^3 N	<0.002	<0.002	< 0.002	< 0.02	< 0.02	<0.02	<0.2	< 0.02	< 0.02	< 0.02
Nitrate nitrogen	g/m^3 N	0.005	0.005	< 0.002	< 0.02	< 0.02	<0.02	<0.2	< 0.02	< 0.02	< 0.02
Sulphate	g/m^3	<0.5	18.1	< 0.5	< 0.5	< 0.5	<0.5	25.0	< 0.5	< 0.5	< 0.5
Ethane	g/m^3	<0.003	<0.003	< 0.003	< 0.003	< 0.007	<0.003	<0.003	< 0.003	< 0.003	< 0.003
Methane	g/m^3	3.7	16.1	24.0	38.0	47.0	0.7	1.2	1.1	0.9	0.9
Formaldehyde	g/m^3	0.02	0.02	0.03	0.05	0.05	<0.02	<0.02	< 0.02	< 0.02	< 0.02
Ethylene	g/m^3	<0.003	<0.003	< 0.003	< 0.003	< 0.009	<0.003	<0.003	< 0.003	< 0.003	< 0.003
Ethylbenzene	g/m^3	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylene glycol	g/m^3	< 4	< 4	< 4	< 4	< 4	<4	<4	< 4	< 4	< 4
Propylene glycol	g/m^3	<4	<4	< 4	< 4	< 4	<4	<4	< 4	< 4	< 4
Methanol	g/m^3	<2	<2	< 2	< 2	< 2	<2	2	< 2	< 2	< 2
Benzene	g/m^3	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010	<0.0010	0.0019	0.0019	< 0.0010	0.0014
Toluene	g/m^3	<0.0010	0.0018	0.0011	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010
o-Xylene	g/m^3	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010
m-Xylene	g/m^3	<0.002	<0.002	< 0.002	< 0.002	< 0.002	<0.002	<0.002	< 0.002	< 0.002	< 0.002
Total hydrocarbons	g/m^3	<0.7	11.8	< 0.7	< 0.7	< 0.7	<0.7	<0.7	< 0.7	< 0.7	< 0.7
δ13C value*	‰ (-)	54.7	54.7	59.6	65.9	64.2	-	-	88.5	-	-

Table 5 Results of groundwater sampling carried out in relation to the KA20 fracturing event compared to baseline

Parameter	Bore id	GND2021					GND0093				
	Unit	Range 2013-2015		Pre-frac	3 mth post-frac	1 year post-frac	Range 2013-2015		Pre-frac	3 mth post-frac	1 year post-frac
Sample date	-	Min	Max	16/11/2016	21/03/2017	21/11/2017	Min	Max	15/11/2016	20/03/2017	21/11/2017
Lab number	TRC			TRC164405	TRC171270	TRC174127			TRC164403	TRC171268	TRC174124
pH	pH	8.1	8.2	8.3	8.1	8.1	6.4	7.9	7.8	7.2	7.2
Conductivity	mS/m	22.4	31.6	31.8	31.8	32.0	23.2	25.4	15.9	14.9	14.3
Total dissolved solids	g/m^3	156	210	220	200	164	112	162	94	84	83
Total alkalinity	g/m^3 CaCO3	97	147	146	145	147	53	79	47	43	43
Bicarbonate	g/m^3 HCO_3	117	178	174	175	177	65	97	57	52	52
Total hardness	g/m^3 $CaCO_3$	60	92	80	82	80	34	47	24	22	23
Calcium	g/m^3	15	24	21	21	22	9	11	6	5	5
Chloride	g/m^3	12	15	14	13	14	30	34	20	19	18
Magnesium	g/m^3	5	8	7	8	6	3	5	3	2	3
Potassium	g/m^3	4	5	4	5	5	9	10	5	6	6
Sodium	g/m^3	24	34	35	34	29	23	28	19	17	14
Barium	mg/kg	0.004	0.009	0.004	0.003	0.003	0.031	0.116	0.015	0.014	0.014
Bromide	g/m^3	-	-	-	-	0.08	-	-	-	-	0.16
Dissolved bromine	g/m^3	0.041	0.050	0.047	0.043	-	0.150	0.181	0.128	0.123	-
Dissolved copper	g/m^3	<0.0005	0.0005	< 0.0005	< 0.0005	< 0.0005	<0.0005	<0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved iron	g/m^3	0.0	0.1	0.0	0.1	0.1	0.5	12.8	1.3	1.8	1.5

Parameter	Bore id	GND2021					GND0093				
	Unit	Range 2013-2015		Pre-frac	3 mth post-frac	1 year post-frac	Range 2013-2015		Pre-frac	3 mth post-frac	1 year post-frac
Sample date	-	Min	Max	16/11/2016	21/03/2017	21/11/2017	Min	Max	15/11/2016	20/03/2017	21/11/2017
Lab number	TRC			TRC164405	TRC171270	TRC174127			TRC164403	TRC171268	TRC174124
Dissolved manganese	g/m^3	0.01	0.03	0.02	0.02	0.02	0.15	0.34	0.08	0.09	0.08
Dissolved mercury	g/m^3	<0.00008	<0.00008	< 0.00008	< 0.00008	< 0.00008	<0.00008	<0.00008	0.00021	0.00044	< 0.00008
Dissolved Nickel	mg/kg	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0006	0.0006	< 0.0005	< 0.0005	< 0.0005
Dissolved zinc	g/m^3	0.003	0.027	0.005	0.005	0.003	0.042	4.900	0.650	0.240	0.200
Nitrate & nitrite nitrogen	g/m^3 N	<0.002	0.25	< 0.002	< 0.002	< 0.002	<0.002	0.008	< 0.002	< 0.002	< 0.002
Nitrite nitrogen	g/m^3 N	<0.002	<0.002	< 0.002	< 0.002	< 0.002	<0.002	<0.002	< 0.002	< 0.002	< 0.002
Nitrate nitrogen	g/m^3 N	<0.002	0.25	< 0.002	< 0.002	< 0.002	<0.002	0.007	< 0.002	< 0.002	< 0.002
Sulphate	g/m^3	<0.5	2.3	< 0.5	< 0.5	< 0.5	<0.5	14.3	< 0.5	< 0.5	< 0.5
Ethane	g/m^3	<0.003	<0.003	< 0.003	< 0.003	< 0.003	<0.003	<0.003	< 0.003	< 0.003	< 0.003
Methane	g/m^3	1.5	3.6	2.7	4.2	3.8	2.1	3.1	3.8	3.7	2.2
Formaldehyde	g/m^3	<0.02	<0.02	< 0.02	< 0.02	< 0.02	<0.02	<0.02	< 0.02	< 0.02	< 0.02
Ethylene	g/m^3	<0.003	<0.003	< 0.003	< 0.003	< 0.003	<0.003	<0.003	< 0.003	< 0.003	< 0.003
Ethylbenzene	g/m^3	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylene glycol	g/m^3	<4	<4	< 4	< 4	< 4	<4	<4	< 4	< 4	< 4
Propylene glycol	g/m^3	<4	<4	< 4	< 4	< 4	<4	<4	< 4	< 4	< 4
Methanol	g/m^3	<2	<2	< 2	< 2	< 2	<2	<2	< 2	< 2	< 2
Benzene	g/m^3	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m^3	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010
o-Xylene	g/m^3	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010

Parameter	Bore id	GND2021					GND0093				
	Unit	Range 2013-2015		Pre-frac	3 mth post-frac	1 year post-frac	Range 2013-2015		Pre-frac	3 mth post-frac	1 year post-frac
Sample date	-	Min	Max	16/11/2016	21/03/2017	21/11/2017	Min	Max	15/11/2016	20/03/2017	21/11/2017
Lab number	TRC			TRC164405	TRC171270	TRC174127			TRC164403	TRC171268	TRC174124
m-Xylene	g/m^3	<0.002	<0.002	< 0.002	< 0.002	< 0.002	<0.002	<0.002	< 0.002	< 0.002	< 0.002
Total hydrocarbons	g/m^3	<0.7	<0.7	< 0.7	< 0.7	< 0.7	<0.7	<0.7	< 0.7	< 0.7	< 0.7
δ13C value*	‰ (-)	-	-	84.7	89.4	86.3	-	-	66.3	69.3	64.5

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 KA20 well are shown below in Table 6. The certificates of analysis are included in Appendix III.

Table 6 Results of hydraulic fracturing fluid sampling

Parameter	Unit	GND2594
Injection well	-	**KA20**
Lab number	-	**TRC171821**
Sample date	-	**13-Dec-16**
Methanol	g/m^3	<2
Benzene	g/m^3	0.0024
Ethylbenzene	g/m^3	<0.0010
Ethylene glycol	g/m^3	16
Toluene	g/m^3	0.0062
M & p-Xylene	g/m^3	0.003
o-Xylene	g/m^3	<0.0010
C7 - C9	g/m^3	2.2
C10 - C14	g/m^3	260
C15 - C36	g/m^3	480
Total hydrocarbons	g/m^3	740
Propylene glycol	g/m^3	116

The results of the analyses carried out on the return fluid samples obtained following the hydraulic fracturing of the KA20 well are summarised below in Table 7 and certificates of analysis are included in Appendix III. Return fluid samples generally contain a composite of samples collected at different intervals during the flow back period. 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 fluids introduced during fracturing activities (comprised predominantly of freshwater).

Table 7 Results of hydraulic fracturing return fluid sampling

Parameter	GND2594				
Location	KA20 well				
Sample	TRC171820		Sample	TRC171820	
Collected	Unit	27-Dec-16	Collected	Unit	27-Dec-16
Conductivity	g/m^3	1,421	Total copper	g/m^3	0.039
pH	pH units	7.2	Total iron	g/m^3	47
Total alkalinity	g/m^3 $CaCO_3$	6,600	Total manganese	g/m^3	13.5
Total hardness	g/m^3 $CaCO_3$	168	Total mercury	g/m^3	<0.00008
Bicarbonate	g/m^3 HCO_3	6,900	Total nickel	g/m^3	0.09
Calcium	g/m^3	48	Total zinc	g/m^3	0.144
Dissolved calcium	g/m^3	46	Formaldehyde	g/m^3	<1.5
Chloride	g/m^3	1,060	Methanol	g/m^3	51
Dissolved magnesium	g/m^3	13	Ethylene glycol	g/m^3	171
Total potassium	g/m^3	390	Propylene glycol	g/m^3	<4
Total sodium	g/m^3	4,000	C7-C9	g/m^3	8.1
Total dissolved solids	g/m^3	13,200	C10 - C14	g/m^3	29
Nitrate & nitrite nitrogen	g/m^3	34	C15-C36	g/m^3	66
Nitrite nitrogen	g/m^3	32	Total hydrocarbons	g/m^3	104
Nitrate nitrogen	g/m^3	2.3	Benzene	g/m^3	1.65
Sulphate	g/m^3	154	Toluene	g/m^3	1.58
Total sulphur	g/m^3	51	Ethylbenzene	g/m^3	0.102
Total barium	g/m^3	2.8	M & p-Xylene	g/m^3	0.68
Total bromine	g/m^3	8	o-Xylene	g/m^3	0.31

2.3 Biomonitoring surveys

The Council's standard 'kick-sampling' technique was used at three established sites to collect streambed macroinvertebrates from the Kapuni Stream on two occasions, one pre-fracturing and one post-fracturing of the KA20 well. Surveys are undertaken to determine whether stormwater discharges from the wellsite have had any detrimental impacts on the macroinvertebrate communities of the Kapuni Stream. Samples were processed to provide number of taxa (richness), (MCI and $SQMCI_S$ 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 $SQMCI_S$ 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 $SQMCI_S$ between sites indicate the degree of adverse effects (if any) of the discharges being monitored.

Moderate to moderately low taxonomic richnesses were observed, while MCI scores and $SQMCI_s$ scores were significantly higher than the median scores for sites at similar altitude in ring plain streams rising outside the National Park. This indicates that the macroinvertebrate communities at these sites are healthy.

Overall, there was no evidence that the stormwater discharges from the KA1/7/19/20 wellsite have caused any recent significant adverse effects on the macroinvertebrate communities of the Kapuni 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 STOs and Todd. 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 the STOS or Todd's conditions in resource consents or provisions in Regional Plans.

3 Discussion

3.1 Environmental effects of exercise of consents

One well (KA20) was stimulated by hydraulic fracturing at the KA1/7/19/20 wellsite during November and December 2016.

STOS monitored the integrity of the well using fibre optic technology, which allows for detailed real time continuous monitoring. The results of the monitoring indicated a number of small leaks along the wellbore. All leaks occurred below 3,000 m TVss and all fluid remained below the consented depth. Pressure testing undertaken on 22 December confirmed the integrity of the well and it is considered that the mitigation measures implemented by STOS were effective in ensuring there were no adverse environmental effects associated with the fracturing operations.

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 four groundwater monitoring sites in the vicinity of the KA/1/7/19/20 wellsite.

The results of post fracturing groundwater sampling carried out showed only very minor variations in water composition in comparison to baseline results, with the exception of results in GND2357. Changes in the water quality seen in this bore although anomalous are not interpreted to be a result of hydraulic fracturing activities at the KA20 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 the Kapuni Stream pre and post-fracturing of the wells.

The results of the biomonitoring surveys undertaken in relation to the KA1/7/19/20 fracturing event indicate that site activities had no adverse effects on local surface water resources.

In summary, the monitoring carried out by the Council during the period being reported indicates that the hydraulic fracturing activities undertaken by STOS at the KA1/7/19/20 wellsite has had no significant adverse effects on local groundwater or surface water resources.

3.2 Evaluation of performance

A tabular summary of the consent holder's compliance record for the year under review is set out in Table 8 and Table 9. An evaluation of environmental performance since 2012 is included in Table 10.

Table 8 Summary of performance for consent 7995-1

Purpose: *To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3,000 metres true vertical depth subsea (TVDss) beneath the KA1/7/19/20 wellsite at or about (NZTM) 1701152E-5630141N*		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
1. Any discharge shall occur below 3,000 mTVDss	Assessment of consent holder submitted data	Yes
2. Exercise of consent shall not result in any contaminants reaching any useable freshwater	Results of groundwater monitoring	Yes
3. Consent holder shall undertake sampling programme	Development and certification of a monitoring programme	Yes
4. 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
5. All sampling to be carried out in accordance with a certified Sampling and Analysis Plan	Development and certification of a Sampling and Analysis Plan	Yes
6. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing	Assessment of consent holder submitted data	Yes
7. A pre-fracturing discharge report is to be provided to the Council 14 days prior to discharge	Pre-fracturing discharge report received	Yes
8. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	Yes
9. A post-fracturing discharge report is to be provided to the Council within 90 days of any commencement	Post-fracturing discharge report received	Yes
10. The reports outlined in conditions 7 and 9 must be emailed to consents@trc.govt.nz	Reports received via email	Yes

Purpose: *To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3,000 metres true vertical depth subsea (TVDss) beneath the KA1/7/19/20 wellsite at or about (NZTM) 1701152E-5630141N*		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
11. 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
12. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
13. Fracture fluid composition no less than 95 % water and proppant by volume	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes
14. Notice of Council to review consent	No provision for review during period	N/A
Overall assessment of environmental performance and compliance in respect of this consent		**High**
Overall assessment of administrative performance and compliance in respect of this consent		**High**

N/A = not applicable

Table 9 Summary of performance for consent 7995-2

Purpose: *To discharge water based hydraulic fracturing fluids into land at depths greater than 2,900 metres true vertical depth subsea (TVDss) beneath the KA1/7/19/20 wellsite*		
Condition requirement	**Means of monitoring during period under review**	**Compliance * achieved?**
1. Any discharge shall occur below 2,900 mTVDss	Assessment of consent holder submitted data	N/A
2. No discharge shall occur after 1 June 2022	Assessment of consent holder submitted data	N/A
3. Micro-seismic monitoring if activities occur within one km of a fault	Pre-fracturing and post fracturing reports	N/A
4. Seismic monitoring to be carried out	Post fracturing report	N/A
5. Reporting requirement for conditions 3 and 4	Report received	N/A
6. Exercise of consent shall not result in any contaminants reaching any useable freshwater	Results of groundwater monitoring	N/A
7. 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 2,900 metres true vertical depth subsea (TVDss) beneath the KA1/7/19/20 wellsite*		
Condition requirement	**Means of monitoring during period under review**	**Compliance * achieved?**
8. Monitoring programme to include installation and sampling of at least one suitable monitoring bore	Consultation and installation of a bore	N/A
9. 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
10. 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
11. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing	Assessment of consent holder submitted data	N/A
12. A pre-fracturing discharge report is to be provided to the Council 14 days prior to discharge	Pre-fracturing discharge report received	N/A
13. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	N/A
14. A post-fracturing discharge report is to be provided to the Council within 90 days of any commencement	Post-fracturing discharge report received	N/A
15. The requirement for interim reports to meet the 90 day deadline	Interim post-fracturing discharge report received	N/A
16. Provision of any reporting required by condition 3	Reports received	N/A
17. The reports outlined in conditions 12,14 and 15 must be emailed to consents@trc.govt.nz	Reports received via email	N/A
18. 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	N/A
19. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	N/A

Purpose: *To discharge water based hydraulic fracturing fluids into land at depths greater than 2,900 metres true vertical depth subsea (TVDss) beneath the KA1/7/19/20 wellsite*		
Condition requirement	**Means of monitoring during period under review**	**Compliance * achieved?**
20. Fracture fluid composition no less than 95 % water and proppant by volume	Assessment of consent holder submitted data and sampling of fracturing fluid	N/A
21. Notification clause regarding any impacts to the Hawera water supply	Notification received	N/A
22. Lapse clause	Receive notice of exercise of consent	N/A
23. Notice of Council to review consent	No provision for review during period	N/A
Overall assessment of environmental performance and compliance in respect of this consent		**N/A**
Overall assessment of administrative performance and compliance in respect of this consent		**N/A**

**Note- To date no hydraulic fracturing events have been undertaken by Todd under this version of the consent.*

Table 10 Evaluation of environmental performance over time

Period	Operator	Consent no	High	Good	Improvement required	Poor
2012-2014	STOS	7995-1	1			
2014-2015	STOS	7995-1	1			
2016-2018	STOS/Todd	7995-1/2	1			
Totals			3			

During the year, STOS and Todd demonstrated a high level of environmental and high level of administrative performance with the resource consent as defined in Section 1.1.4. Since 2011 the environmental performance in relation to Consent 7995-1 and 7995-2 has remained at a high level.

3.3 Recommendations from the previous compliance report

In the previous compliance report, it was recommended:

1. THAT the range of monitoring carried out during the reporting period in relation to the Company's hydraulic fracturing activities be replicated for any future fracturing events at the KA1/7/19/20 wellsite.
2. THAT the Council notes there is no requirement at this time for a consent review to be pursued or grounds to exercise the review options.

These recommendations were implemented.

3.4 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 STOS be replicated for any future fracturing events at the KA1/7/19/20 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.

3.5 Exercise of optional review of consent

Resource consent 7995-2 provides for an optional review of the consent in June 2019. Condition 23 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 19; 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, and in previous years as set out in earlier compliance monitoring reports, 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 STOS/Todd's hydraulic fracturing activities be replicated for any future fracturing events at the KA1/7/19/20 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 23 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).
Fresh	Elevated flow in a stream, such as after heavy rainfall.
g/m3	Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.
Incident	An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred.
Intervention	Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.
Investigation	Action taken by Council to establish the circumstances/events surrounding an incident including any allegations of an incident.
L/s	Litres per second.
Macroinvertebrate	An invertebrate that is large enough to be seen without the use of a microscope.
masl	Metres above sea level.
MCI	Macroinvertebrate community index; a numerical indication of the state of biological life in a stream that takes into account the sensitivity of the taxa present to organic pollution in stony habitats.
mS/m	Millisiemens per metre.
m^3	Cubic metre (1,000 litres).
NZTM	New Zealand Transverse Mercator coordinates.
pH	A numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline.
Physicochemical	Measurement of both physical properties (e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment.
Resource consent	Refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15).
RMA	Resource Management Act 1991 and including all subsequent amendments.
Screen Out	A condition that occurs when the solids carried in a treatment fluid, such as proppant in a fracture fluid, create a bridge across the perforations or similar restricted flow area. This creates a sudden and significant restriction to fluid flow that causes a rapid rise in pump pressure.
SQMCI	Semi quantitative macroinvertebrate community index.
TVDss	True vertical depth sub-sea.
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

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.

Shell Todd Oil Services Ltd (STOS) 2017 Kapuni KA20 Phase 2 K1707 (NZ201702007) Post-Fracturing Report 2017. Frodo id #1846527.

Shell Todd Oil Services Ltd (STOS) 2016 Kapuni KA20 Pre-fracturing Report, STOS Report 3889. Frodo id #1773341.

Taranaki Regional Council (2017) Biomonitoring of the Kapuni Stream in relation to hydraulic fracturing at the KA1/7/19/20 wellsite, November 2016 and January 2017. Technical Report KB027 Frodo id. #1994330.

Taranaki Regional Council (2015) Shell Todd Oil Services Ltd Kapuni Wellsites Hydraulic Fracturing Monitoring Programme Report 2014-2015. Technical Report 2015-43 Frodo id #1566838.

Taranaki Regional Council (2015) Shell Todd Oil Services Ltd Kapuni Wellsites Hydraulic Fracturing Monitoring Programme Report 2012-2014. Technical Report 2014-95. Frodo id#1427591.

Taranaki Regional Council (2015): Shell Todd Oil Services Ltd Maui and Kapuni Production Stations Monitoring Programmes Annual Report 2012-2014. Technical Report 2014-41.

Taranaki Regional Council (2014): Shell Todd Oil Services Ltd KA1/7/19/20 Wellsite Monitoring Report 2011-2012. Technical Report 2014-03.

Taranaki Regional Council (2013): Guide to Regulating Oil and Gas Exploration and Development Activities Under the Resource Management Act.

Taranaki Regional Council (2013): Shell Todd Oil Services Ltd Maui and Kapuni Production Stations Monitoring Programmes Annual Report 2011-2012. Technical Report 2012-35.

Appendix I

Resource consent held by Todd Petroleum Mining Company Limited

(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:	Shell Todd Oil Services Ltd Private Bag 2035 NEW PLYMOUTH 4342
Decision Date:	28 March 2012
Commencement Date:	28 March 2012

Conditions of Consent

Consent Granted:	To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3000 mTVDss beneath the KA-1/7/19/20 wellsite at or about (NZTM) 1701152E-5630141N
Expiry Date:	1 June 2017
Review Date(s):	June 2012, June 2013, June 2014, June 2015, June 2016
Site Location:	KA-1/7/19/20 wellsite, 360 Palmer Road, Kapuni
Legal Description:	Lot 2 DP 11138 Blk XVI Kaupokonui SD (Discharge source & site)
Catchment:	Kapuni

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 3000 mTVDss.

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

2. The consent holder shall ensure that the exercise of this consent does not result in contaminants reaching any useable fresh water (groundwater or surface water). Usable fresh groundwater is defined as any groundwater having a Total Dissolved Solids concentration of less than 1000 mg/l.

3. The consent holder shall undertake a programme of sampling and testing that monitors the effects of the exercise of this consent on fresh water resources to assess compliance with condition 2 (the 'Monitoring Programme'). The Monitoring Programme shall be certified by the Chief Executive, Taranaki Regional Council ('the Chief Executive'), before this consent is exercised, and shall include:

   (a) the location of the discharge point(s);
   (b) the location of sampling sites; and
   (c) sampling frequency with reference to a hydraulic fracturing programme.

4. All water samples taken for monitoring purposes shall be taken in accordance with recognised field procedures and analysed for:

   (a) pH;
   (b) conductivity;
   (c) total dissolved solids;
   (d) major ions (Ca, Mg, K, Na, total alkalinity, bromide, chloride, nitrate-nitrogen, and sulphate);
   (e) trace metals (barium, copper, iron, manganese, nickel, and zinc);
   (f) total petroleum hydrocarbons;
   (g) formaldehyde;
   (h) dissolved methane and ethane gas;
   (i) methanol;
   (j) glycols;
   (k) benzene, toluene, ethylbenzene, and xylenes (BTEX); and
   (l) carbon-13 composition of any dissolved methane gas discovered ($^{13}C\text{-}CH_4$).

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

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

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

6. The consent holder shall undertake well and equipment pressure testing prior to any hydraulic fracture programme on a given well to ensure any discharge will not affect the integrity of the well and hydraulic fracturing equipment.

7. Any hydraulic fracture discharge shall only occur after the consent holder has provided a comprehensive 'Pre-fracturing discharge report' to the Chief Executive. The report shall be provided at least 14 days before the discharge is proposed to commence and shall detail the hydraulic fracturing programme proposed, including as a minimum:

   (a) the specific well in which each discharge is to occur and the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment);
   (b) the number of discharges proposed and the geographical position (i.e. depth and lateral position) of each intended discharge point;
   (c) the total volume of fracture fluid planned to be pumped down the well and its intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
   (d) the results of the reviews required by condition 12;
   (e) results of modelling showing an assessment of the likely extent and dimensions of the fractures that will be generated by the discharge;
   (f) the preventative and mitigation measures to be in place to ensure the discharge does not cause adverse environmental effects and complies with condition 2;
   (g) the extent and permeability characteristics of the geology above the discharge point to the surface;
   (h) any identified faults within the modeled fracture length plus a margin of 50%, and the potential for adverse environmental effects due to the presence of the identified faults;
   (i) the burst pressure of the well and the anticipated maximum well and discharge pressures and the duration of the pressures; and
   (j) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal.

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

8. The consent holder shall notify the Taranaki Regional Council of each discharge by emailing worknotification@trc.govt.nz. Notification shall include the date that the discharge is to occur and identify the 'Pre-fracturing discharge report', required by condition 7, which details the discharge. Where practicable and reasonable notice shall be given between 3 days and 14 days before the discharge occurs, but in any event 24 hours notice shall be given.

9. At the conclusion of a hydraulic fracturing programme on a given well, the consent holder shall submit a comprehensive 'Post-fracturing discharge report' to the Chief Executive. The report shall be provided within 60 days after the programme is completed and, as a minimum, shall contain:

   (a) confirmation of the interval(s) where fracturing occurred for that programme, and the geographical position (i.e. depth and lateral position) of the discharge point for each fracture interval;
   (b) the contaminant volumes and compositions discharged into each fracture interval;
   (c) the volume of return fluids from each fracture interval;
   (d) an analysis for the constituents set out in conditions 4(a) to 4(k), in a return fluid sample taken within the first two hours of flow back, for each fracture interval if flowed back individually, or for the well if flowed back with all intervals comingled;
   (e) an estimate of the volume of fluids (and proppant) remaining underground;
   (f) the volume of water produced with the hydrocarbons (produced water) over the period beginning at the start of the hydraulic fracturing programme and ending 50 days after the programme is completed;
   (g) an assessment of the extent and dimensions of the fractures that were generated by the discharge, based on modelling undertaken after the discharge has occurred and other diagnostic techniques, including production analysis, available to determine fracture length, height and containment;
   (h) the results of pressure testing required by condition 6, and the well and discharge pressure durations and the maximum pressure reached during the hydraulic fracture discharge;
   (i) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal;
   (j) details of any incidents where hydraulic fracture fluid is unable to pass through the well perforations (screen outs) that occurred, their likely cause and implications for compliance with conditions 1 and 2; and
   (k) an assessment of the effectiveness of the mitigation measures in place with specific reference to those described in the application for this consent.

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

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

12. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimize any actual or likely adverse effect of the activity on the environment by, as a minimum, ensuring that:

    (a) the discharge is contained within the fracture interval;
    (b) regular reviews are undertaken of the preventative and mitigation measures adopted to ensure the discharge does not cause adverse environmental effects; and
    (c) regular reviews of the chemicals used are undertaken with a view to reducing the toxicity of the chemicals used.

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

14. The Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review during the month of June each year, for the purposes of:

    (a) ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or

    (b) further specifying the best practicable option as required by condition 12; and/or

    (c) ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Signed at Stratford on 28 March 2012

For and on behalf of
Taranaki Regional Council

_____

Director-Resource Management

Discharge Permit

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

Name of Consent Holder:	Todd Petroleum Mining Company Limited PO Box 802 New Plymouth 4340
Decision Date:	14 November 2017
Commencement Date:	14 November 2017

Conditions of Consent

Consent Granted:	To discharge water based hydraulic fracturing fluids into land at depths greater than 2,900 mTVDss beneath the KA-1/7/19/20 wellsite
Expiry Date:	1 June 2028
Review Date(s):	June annually and in accordance with special condition 23
Site Location:	KA-1/7/19/20 wellsite, 360 Palmer Road, Kapuni
Grid Reference (NZTM)	1701152E-5630141N
Catchment:	Kapuni

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

General condition

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

Special conditions

1. The discharge point shall be deeper than 2,900 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 2022.

3. The consent holder shall undertake micro-seismic monitoring during any hydraulic fracturing activities occurring within 1,000 metres of the subsurface mapped position of nearby faults. If the micro-seismic monitoring records a seismic event higher than a Modified Mercalli intensity of magnitude 1, hydraulic fracturing shall cease.

4. 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.

5. Following the occurrence of any seismic event described in special condition 3 or 4 the consent holder shall investigate and report to the Chief Executive, Taranaki Regional Council (the 'Chief Executive') 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 has considered the report and concluded that the environmental risk of recommencing hydraulic fracturing is acceptable and has advised the consent holder accordingly.

6. 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.

7. 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 6 (the 'Monitoring Programme'). The Monitoring Programme shall be certified by the Chief Executive, 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 1,000 metres of the wellsite;
   (c) confirmation of the bores and wells identified in 7(b) above that will be sampled and the reasons they were, or weren't, chosen;
   (d) the location of sampling sites; and
   (e) sampling frequency with reference to a hydraulic fracturing programme.

8. The Monitoring Programme shall 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 and installed in accordance with NZS 4411:2001.

9. 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}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.*

10. All sampling and analysis shall be undertaken in accordance with a *Sampling and Analysis Plan*, which shall be submitted to the Chief Executive for review and certification before the first sampling is undertaken. The plan shall specify the use of standard protocols recognised to constitute good professional practice including quality control and assurance. An International Accreditation New Zealand (IANZ) accredited laboratory shall be used for all sample analysis. Results shall be provided to the Chief Executive within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 6.

    Note: *The Sampling and Analysis Plan may be combined with the Monitoring Programme required by condition 7.*

11. 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.

12. Any hydraulic fracture discharge shall only occur after the consent holder has provided a comprehensive 'Pre-fracturing Discharge Report' to the Chief Executive. The report shall be provided at least 14 days before the discharge is proposed to commence and shall detail the hydraulic fracturing programme proposed, including as a minimum:

    (a) the specific well in which each discharge is to occur, the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment), and the duration of the hydraulic fracturing programme;
    (b) the number of discharges proposed and the geographical position (i.e. depth and lateral position) of each intended discharge point;
    (c) the total volume of fracture fluid planned to be pumped down the well, including mini-fracture treatments, and their intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
    (d) the monitoring techniques to be used to determine the fate of discharged material;

(e) the results of the reviews required by condition 19;
(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 6;
(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; and
(k) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal; and
(l) details why the contaminants in the discharge and the monitoring techniques used comply with condition 19.

13. The consent holder shall notify the Taranaki Regional Council of the date that each discharge is intended to commence by emailing worknotification@trc.govt.nz. Notification also shall identify the 'Pre-fracturing Discharge Report', required by condition 12, 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.

14. Subject to condition 15, within 90 days of any commencement date as advised under condition 13, the consent holder shall submit a comprehensive 'Post-fracturing Discharge Report' to the Chief Executive. The report shall, as a minimum, contain:

(a) date and time of discharge;
(b) confirmation of the interval(s) where fracturing occurred for that programme, and the geographical position (i.e., depth and lateral position) of the discharge point for each fracture interval;
(c) the contaminant volumes and composition of fluid discharged into each fracture interval;
(d) the volume of return fluids from each fracture interval;
(e) an analysis for the constituents set out in conditions 9(a) to 9(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 11 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 6; and
(l) results of the monitoring referred to in condition 9(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.

15. For programs including multiple hydraulic fracturing discharges, more than one 'Post-fracturing discharge report' may be required in order to meet the 90-day deadline from each commencement date. In these situations the consent holder shall submit a subsequent 'Post-fracturing Discharge Report', to the Chief Executive within 90 days of the previous report being submitted.

16. Within 6 months of any commencement date as advised under condition 13, the consent holder shall submit a review of the GeoNet seismic monitoring network data and any monitoring undertaken in accordance with condition 3 on the likelihood of any seismic events occurring as the result of the exercise of this consent, extending for a period of 3 months past the last hydraulic fracture.

17. The reports described in conditions 12, 14 and 15 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.

18. 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.

19. 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.

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

21. If, as a consequence of the activity authorised by this consent, an event occurs that may have a significant adverse effect on water quality at the registered drinking water supply abstraction point for the Hawera Water Supply, the consent holder shall, as soon as reasonably practicable, phone the Taranaki Regional Council and the South Taranaki District Council and notify them of the event.

22. This consent shall lapse on 31 December 2022, 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.

23. 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 5 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 19; 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 14 November 2017

For and on behalf of
Taranaki Regional Council

_____

A D McLay
Director - Resource Management

Appendix II

Certificates of analysis (groundwater)

Hill Laboratories
BETTER TESTING BETTER RESULTS

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

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1681426 SPv1
Contact:	Regan Phipps	**Date Received:**	17-Nov-2016
	C/- Taranaki Regional Council	**Date Reported:**	05-Dec-2016
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	
		Client Reference:	ST05 KA 1/7/19/20 Pre Frac GW
		Submitted By:	David Olson

Sample Type: Aqueous

Sample Name:		GND0093 15-Nov-2016 12:00 pm	GND2348 15-Nov-2016 3:32 pm	GND2357 15-Nov-2016 5:33 pm	GND2021 15-Nov-2016 11:04 am	
Lab Number:		1681426.1	1681426.2	1681426.3	1681426.4	
Individual Tests						
Sum of Anions	meq/L	1.49	3.9	6.4	3.3	-
Sum of Cations	meq/L	1.51	4.6	5.7	3.2	-
pH	pH Units	7.8	6.9	7.5	8.3	-
Total Alkalinity	g/m³ as $CaCO_3$	47	58	280	146	-
Bicarbonate	g/m³ at 25°C	57	71	340	174	-
Total Hardness	g/m³ as $CaCO_3$	24	90	140	80	-
Electrical Conductivity (EC)	mS/m	15.9	48.0	61.3	31.8	-
Total Dissolved Solids (TDS)	g/m³	94	330	310	220	-
Dissolved Barium	g/m³	0.0149	0.069	0.068	0.0038	-
Dissolved Bromine*	g/m³	0.128	0.32	0.115	0.047	-
Dissolved Calcium	g/m³	5.5	19.7	25	21	-
Dissolved Copper	g/m³	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-
Dissolved Iron	g/m³	1.28	32	10.4	0.04	-
Dissolved Magnesium	g/m³	2.6	9.9	18.6	6.8	-
Dissolved Manganese	g/m³	0.082	0.62	0.191	0.0180	-
Dissolved Mercury	g/m³	0.00021	0.00011	0.00020	< 0.00008	-
Dissolved Nickel	g/m³	< 0.0005	0.0007	< 0.0005	< 0.0005	-
Dissolved Potassium	g/m³	5.4	8.7	15.2	4.1	-
Dissolved Sodium	g/m³	18.7	32	46	35	-
Dissolved Zinc	g/m³	0.65	0.87	5.6	0.0051	-
Chloride	g/m³	19.7	99	28	13.7	-
Nitrite-N	g/m³	< 0.002	< 0.02	< 0.002	< 0.002	-
Nitrate-N	g/m³	< 0.002	< 0.02	< 0.002	< 0.002	-
Nitrate-N + Nitrite-N	g/m³	< 0.002	< 0.02 #1	< 0.002	< 0.002	-
Sulphate	g/m³	< 0.5	< 0.5	< 0.5	< 0.5	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 4	< 4	< 4	< 4	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	< 4	< 4	< 4	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	< 2	< 2	< 2	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	0.0019	< 0.0010	< 0.0010	-
Toluene	g/m³	< 0.0010	< 0.0010	0.0011	< 0.0010	-
Ethylbenzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
m&p-Xylene	g/m³	< 0.002	< 0.002	< 0.002	< 0.002	-

Sample Type: Aqueous						
Sample Name:		GND0093 15-Nov-2016 12:00 pm	GND2348 15-Nov-2016 3:32 pm	GND2357 15-Nov-2016 5:33 pm	GND2021 15-Nov-2016 11:04 am	
Lab Number:		1681426.1	1681426.2	1681426.3	1681426.4	
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	< 0.02	0.03	< 0.02	-
Gases in groundwater						
Ethane	g/m³	< 0.003	< 0.003	< 0.003	< 0.003	-
Ethylene	g/m³	< 0.003	< 0.003	< 0.003	< 0.003	-
Methane	g/m³	3.8	1.13	24	2.7	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	< 0.10	< 0.10	< 0.10	-
C10 - C14	g/m³	< 0.2	< 0.2	< 0.2	< 0.2	-
C15 - C36	g/m³	< 0.4	< 0.4	< 0.4	< 0.4	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	< 0.7	< 0.7	< 0.7	-

Analyst's Comments

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

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1-4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1-4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	1-4
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	1-4
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	1-4
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m³	1-4
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m³	1-4
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-4
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L 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 22nd ed. 2012.	0.07 meq/L	1-4
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1-4
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.	0.1 pH Units	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-4
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m³ at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-4
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	10 g/m³	1-4

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m³	1-4
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m³	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1-4
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1-4
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m³	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1-4
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m³	1-4

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

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

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
1 Clyde Street Hamilton 3216
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1744282 SPv1
Contact:	Regan Phipps	**Date Received:**	22-Mar-2017
	C/- Taranaki Regional Council	**Date Reported:**	30-Mar-2017
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	
		Client Reference:	STO5 KA20 3 month Post Frac
		Submitted By:	David Olson

Sample Type: Aqueous

Sample Name:		GND 2357 20-Mar-2017 12:53 pm	GND 2348 21-Mar-2017 10:46 am	GND2021 21-Mar-2017 11:40 am	GND0093 20-Mar-2017 10:18 am	
Lab Number:		1744282.1	1744282.2	1744282.3	1744282.4	
Individual Tests						
Sum of Anions	meq/L	8.7	3.5	3.3	1.38	-
Sum of Cations	meq/L	9.2	4.1	3.2	1.41	-
pH	pH Units	6.9	6.7	8.1	7.2	-
Total Alkalinity	g/m³ as $CaCO_3$	380	53	145	43	-
Bicarbonate	g/m³ at 25°C	470	65	175	52	-
Total Hardness	g/m³ as $CaCO_3$	193	80	82	22	-
Electrical Conductivity (EC)	mS/m	83.8	39.7	31.8	14.9	-
Total Dissolved Solids (TDS)	g/m³	450	260	200	84	-
Dissolved Barium	g/m³	0.083	0.058	0.0029	0.0144	-
Dissolved Bromine*	g/m³	0.17	0.23	0.043	0.123	-
Dissolved Calcium	g/m³	34	16.9	21	4.7	-
Dissolved Copper	g/m³	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-
Dissolved Iron	g/m³	69	27	0.06	1.83	-
Dissolved Magnesium	g/m³	26	9.2	7.5	2.4	-
Dissolved Manganese	g/m³	0.32	0.59	0.0184	0.087	-
Dissolved Mercury	g/m³	0.00025	0.00032	< 0.00008	0.00044	-
Dissolved Nickel	g/m³	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-
Dissolved Potassium	g/m³	21	9.2	4.6	5.7	-
Dissolved Sodium	g/m³	54	29	34	17.4	-
Dissolved Zinc	g/m³	0.70	0.27	0.0046	0.24	-
Chloride	g/m³	37	88	13.2	18.8	-
Nitrite-N	g/m³	< 0.02 #1	< 0.02 #1	< 0.002	< 0.002	-
Nitrate-N	g/m³	< 0.02	< 0.02	< 0.002	< 0.002	-
Nitrate-N + Nitrite-N	g/m³	< 0.02 #1	< 0.02 #1	< 0.002	< 0.002	-
Sulphate	g/m³	< 0.5	< 0.5	< 0.5	< 0.5	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 4	< 4	< 4	< 4	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	< 4	< 4	< 4	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	< 2	< 2	< 2	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Toluene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Ethylbenzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
m&p-Xylene	g/m³	< 0.002	< 0.002	< 0.002	< 0.002	-
o-Xylene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-

Sample Type: Aqueous						
Sample Name:		GND 2357 20-Mar-2017 12:53 pm	GND 2348 21-Mar-2017 10:46 am	GND2021 21-Mar-2017 11:40 am	GND0093 20-Mar-2017 10:18 am	
Lab Number:		1744282.1	1744282.2	1744282.3	1744282.4	
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	0.05	< 0.02	< 0.02	< 0.02	-
Gases in groundwater						
Ethane	g/m³	< 0.003	< 0.003	< 0.003	< 0.003	-
Ethylene	g/m³	< 0.003	< 0.003	< 0.003	< 0.003	-
Methane	g/m³	38	0.94	4.2	3.7	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	< 0.10	< 0.10	< 0.10	-
C10 - C14	g/m³	< 0.2	< 0.2	< 0.2	< 0.2	-
C15 - C36	g/m³	< 0.4	< 0.4	< 0.4	< 0.4	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	< 0.7	< 0.7	< 0.7	-

Analyst's Comments

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

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1-4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1-4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	1-4
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	1-4
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	1-4
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m³	1-4
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m³	1-4
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-4
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L 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 22nd ed. 2012.	0.07 meq/L	1-4
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1-4
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.	0.1 pH Units	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-4
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m³ at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-4
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	10 g/m³	1-4
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m³	1-4

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m³	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1-4
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1-4
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m³	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1-4
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m³	1-4

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

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

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

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1882120 SPv1
Contact:	David Olson	**Date Received:**	23-Nov-2017
	C/- Taranaki Regional Council	**Date Reported:**	04-Dec-2017
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	68238
		Client Reference:	STOS KA20 1 Year Post Frac GW Nov 17
		Submitted By:	David Olson

Sample Type: Aqueous

Sample Name:		GND0093 21-Nov-2017	GND2357 21-Nov-2017 10:20 am	GND2348 21-Nov-2017 12:35 pm	GND2021 21-Nov-2017 1:30 pm	
Lab Number:		1882120.1	1882120.2	1882120.3	1882120.4	
Individual Tests						
Sum of Anions	meq/L	1.37	9.2	3.3	3.3	-
Sum of Cations	meq/L	1.28	9.7	3.7	3.0	-
pH	pH Units	7.2	6.8	6.5	8.1	-
Total Alkalinity	g/m³ as $CaCO_3$	43	410	53	147	-
Bicarbonate	g/m³ at 25°C	52	500	65	177	-
Total Hardness	g/m³ as $CaCO_3$	23	194	70	80	-
Electrical Conductivity (EC)	mS/m	14.3	86.9	37.9	32.0	-
Total Dissolved Solids (TDS)	g/m³	83	420	280	164	-
Dissolved Barium	g/m³	0.0144	0.091	0.051	0.0031	-
Dissolved Calcium	g/m³	5.0	37	16.0	22	-
Dissolved Copper	g/m³	< 0.0005	0.0006	0.0005	< 0.0005	-
Dissolved Iron	g/m³	1.54	79	25	0.07	-
Dissolved Magnesium	g/m³	2.5	25	7.2	6.3	-
Dissolved Manganese	g/m³	0.080	0.32	0.48	0.0195	-
Dissolved Mercury	g/m³	< 0.00008	< 0.00008	< 0.00008	< 0.00008	-
Dissolved Nickel	g/m³	< 0.0005	< 0.0005	0.0015	< 0.0005	-
Dissolved Potassium	g/m³	5.5	22	8.9	4.6	-
Dissolved Sodium	g/m³	14.1	55	26	29	-
Dissolved Zinc	g/m³	0.20	0.86	0.41	0.0033	-
Bromide	g/m³	0.16	0.19	0.28	0.08	-
Chloride	g/m³	17.6	36	79	13.8	-
Nitrite-N	g/m³	< 0.002	< 0.02 #1	< 0.02 #1	< 0.002	-
Nitrate-N	g/m³	< 0.002	< 0.02	< 0.02	< 0.002	-
Nitrate-N + Nitrite-N	g/m³	< 0.002	0.02 #1	< 0.02 #1	< 0.002	-
Sulphate	g/m³	< 0.5	< 0.5	< 0.5	< 0.5	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 4	< 4	< 4	< 4	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	< 4	< 4	< 4	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	< 2	< 2	< 2	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	< 0.0010	0.0014	< 0.0010	-
Toluene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Ethylbenzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
m&p-Xylene	g/m³	< 0.002	< 0.002	< 0.002	< 0.002	-
o-Xylene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-

Sample Type: Aqueous						
Sample Name:		GND0093 21-Nov-2017	GND2357 21-Nov-2017 10:20 am	GND2348 21-Nov-2017 12:35 pm	GND2021 21-Nov-2017 1:30 pm	
Lab Number:		1882120.1	1882120.2	1882120.3	1882120.4	
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	0.05	< 0.02	< 0.02	-
Gases in groundwater						
Ethane	g/m³	< 0.003	< 0.007	< 0.003	< 0.003	-
Ethylene	g/m³	< 0.003	< 0.009	< 0.003	< 0.003	-
Methane	g/m³	2.2	47	0.90	3.8	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.06	< 0.06	< 0.06	< 0.06	-
C10 - C14	g/m³	< 0.2	< 0.2	< 0.2	< 0.2	-
C15 - C36	g/m³	< 0.4	< 0.4	< 0.4	< 0.4	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	< 0.7	< 0.7	< 0.7	-

Analyst's Comments

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

SUMMARY OF METHODS

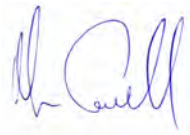
The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix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

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1-4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1-4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	1-4
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	1-4
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	1-4
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m³	1-4
Total Petroleum Hydrocarbons in Water	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m³	1-4
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-4
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L 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 22nd ed. 2012.	0.07 meq/L	1-4
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1-4
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.	0.1 pH Units	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-4
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m³ at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-4
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	10 g/m³	1-4
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m³	1-4

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1-4
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1-4
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.05 g/m³	1-4
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m³	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1-4
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m³	1-4
C7 - C9	Head Space, GCMS analysis.	0.06 g/m³	1-4

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

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



Martin Cowell - BSc
Client Services Manager - Environmental

Appendix III

Certificates of analysis (hydraulic fracturing fluids and return flow fluids)

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
1 Clyde Street Hamilton 3216
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

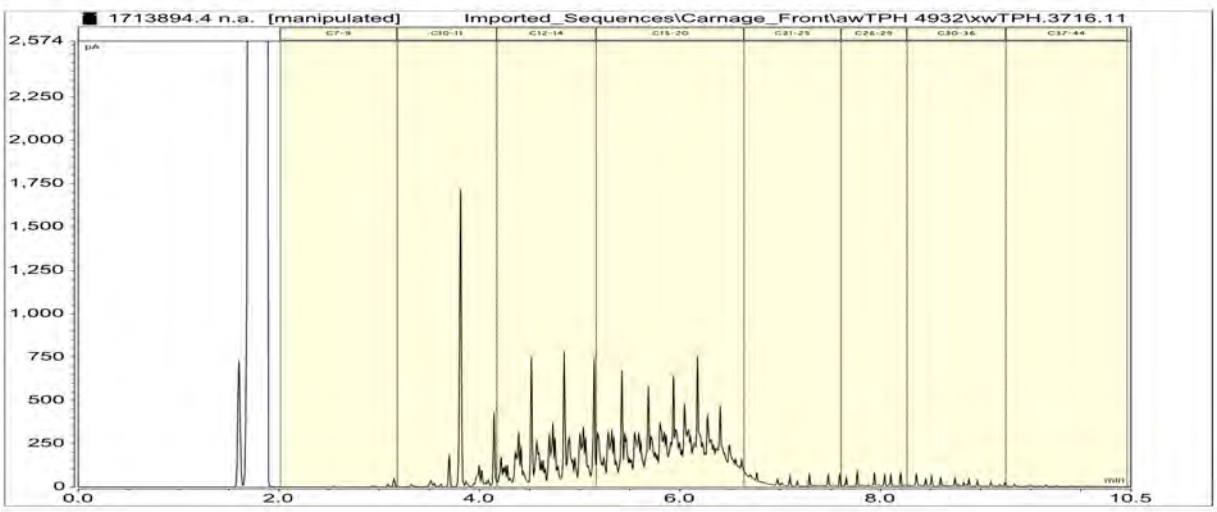
ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1713894 SPv1
Contact:	Regan Phipps	**Date Received:**	26-Jan-2017
	C/- Taranaki Regional Council	**Date Reported:**	13-Feb-2017
	Private Bag 713	**Quote No:**	50522
	Stratford 4352	**Order No:**	62358
		Client Reference:	STOS KA20 Frac Fluid
		Submitted By:	David Olson

Sample Type: Aqueous

Sample Name:		GND2594 FF - Composite of GND2594 2, GND2594 5 and GND2594 9				
Lab Number:		1713894.4				
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	16	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	116	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	0.0024	-	-	-	-
Toluene	g/m³	0.0062	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	0.003	-	-	-	-
o-Xylene	g/m³	< 0.0010	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	2.2	-	-	-	-
C10 - C14	g/m³	260	-	-	-	-
C15 - C36	g/m³	480	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	740	-	-	-	-

1713894.4
GND2594 FF - Composite of GND2594 2, GND2594 5 and GND2594 9
Client Chromatogram for TPH by FID



SUMMARY OF METHODS

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

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

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

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
1 Clyde Street Hamilton 3216
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

ANALYSIS REPORT

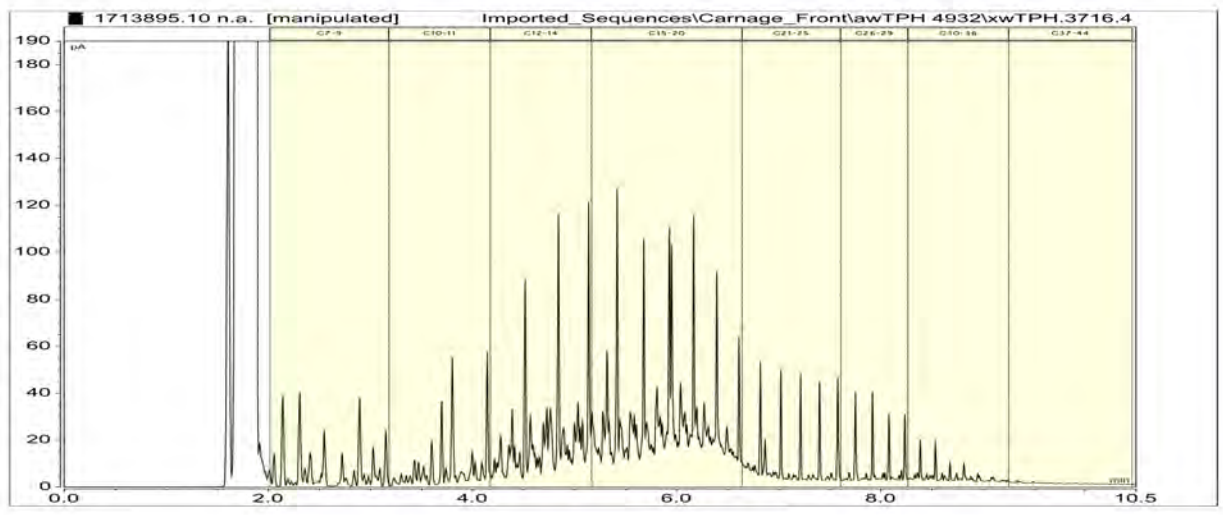
Client:	Taranaki Regional Council	**Lab No:**	1713895 SPv1
Contact:	Regan Phipps	**Date Received:**	26-Jan-2017
	C/- Taranaki Regional Council	**Date Reported:**	14-Feb-2017
	Private Bag 713	**Quote No:**	71307
	Stratford 4352	**Order No:**	62358
		Client Reference:	STOS KA20 Return Fluid
		Submitted By:	David Olson

Sample Type: Saline

Sample Name:		GND2594 RF - Composite of KA20 - 15, KA20 - 21, KA20 - 27, KA20 - 29, KA20 - 32, KA20 - 34, KA20 - 35, KA20 - 38 & KA20 - 42				
Lab Number:		1713895.10				
Individual Tests						
pH*	pH Units	7.2	-	-	-	-
Total Alkalinity*	g/m³ as $CaCO_3$	6,600	-	-	-	-
Analysis Temperature for Bicarbonate	°C	23	-	-	-	-
Bicarbonate	g/m³ at Analysis Temperature	6,900	-	-	-	-
Total Hardness*	g/m³ as $CaCO_3$	168	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,421	-	-	-	-
Total Dissolved Solids (TDS)*	g/m³	13,200	-	-	-	-
Total Barium*	g/m³	2.8	-	-	-	-
Total Bromine*	g/m³	8.0	-	-	-	-
Dissolved Calcium*	g/m³	46	-	-	-	-
Total Calcium*	g/m³	48	-	-	-	-
Total Copper*	g/m³	0.039	-	-	-	-
Total Iron*	g/m³	47	-	-	-	-
Dissolved Magnesium*	g/m³	13	-	-	-	-
Total Magnesium*	g/m³	13.5	-	-	-	-
Total Manganese*	g/m³	1.92	-	-	-	-
Total Mercury*	g/m³	< 0.00008	-	-	-	-
Total Nickel*	g/m³	0.090	-	-	-	-
Total Potassium*	g/m³	390	-	-	-	-
Total Sodium*	g/m³	4,000	-	-	-	-
Total Sulphur*	g/m³	51	-	-	-	-
Total Zinc*	g/m³	0.144	-	-	-	-
Chloride*	g/m³	1,060	-	-	-	-
Nitrite-N	g/m³	32	-	-	-	-
Nitrate-N	g/m³	2.3	-	-	-	-
Nitrate*	g/m³	10.2	-	-	-	-
Nitrate-N + Nitrite-N	g/m³	34	-	-	-	-
Sulphate*	g/m³	154	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	171	-	-	-	-

Sample Type: Saline						
Sample Name:	GND2594 RF - Composite of KA20 - 15, KA20 - 21, KA20 - 27, KA20 - 29, KA20 - 32, KA20 - 34, KA20 - 35, KA20 - 38 & KA20 - 42					
Lab Number:	1713895.10					
Propylene Glycol in Water						
Propylene glycol* g/m³	< 4	-	-	-	-	
Methanol in Water - Aqueous Solvents						
Methanol* g/m³	51	-	-	-	-	
BTEX in Water by Headspace GC-MS						
Benzene* g/m³	1.65	-	-	-	-	
Toluene* g/m³	1.58	-	-	-	-	
Ethylbenzene* g/m³	0.102	-	-	-	-	
m&p-Xylene* g/m³	0.68	-	-	-	-	
o-Xylene* g/m³	0.31	-	-	-	-	
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde* g/m³	< 1.5	-	-	-	-	
Total Petroleum Hydrocarbons in Water						
C7 - C9* g/m³	8.1	-	-	-	-	
C10 - C14* g/m³	29	-	-	-	-	
C15 - C36* g/m³	66	-	-	-	-	
Total hydrocarbons (C7 - C36)* g/m³	104	-	-	-	-	

1713895.10
GND2594 RF - Composite of KA20 - 15, KA20 - 21, KA20 - 27, KA20 - 29, KA20 - 32, KA20 - 34, KA20 - 35, KA20 - 38 & KA20 - 42
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/m³	10
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	10
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	10
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	10
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	10
Total Petroleum Hydrocarbons in Water*	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m³	10

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	10
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	10
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	10
pH*	Saline water, 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.	0.1 pH Units	10
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m³ as $CaCO_3$	10
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	10
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m³ at Analysis Temperature	10
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	10
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.10 mS/m	10
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/m³	10
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	10
Total Barium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.00063 g/m³	10
Total Bromine*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.11 g/m³	10
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m³	10
Total Calcium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.1 g/m³	10
Total Copper*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0011 g/m³	10
Total Iron*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m³	10
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m³	10
Total Magnesium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.42 g/m³	10
Total Manganese*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0011 g/m³	10
Total Mercury*	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	10
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0011 g/m³	10
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.1 g/m³	10
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.42 g/m³	10
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method.	0.5 g/m³	10
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m³	10
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m³	10
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	10
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	10
Nitrate*	Calculation from Nitrate-N.	0.010 g/m³	10
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	10
Total Sulphate*	Calculation: from total sulphur.	2 g/m³	10

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.

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

Appendix IV

Biomonitoring reports

To	Job Manager, Jane Harvey
From	Environmental Scientist, Katie Blakemore
Report No	KB027
Document	1994330
Date	19 Jan 2018

Biomonitoring of the Kapuni Stream in relation to hydraulic fracturing at the KA-1/7/19/20 wellsite, November 2016 and January 2017

Introduction

A pre-hydraulic fracturing (HF) biological survey was carried out near the KA-1/7/19/20 wellsite, to provide baseline data on the health of the macroinvertebrate communities of the Kapuni Stream prior to the commencement of HF activities. A further survey was undertaken following the completion of hydraulic fracturing to determine whether stormwater discharges onto land and water have caused significant adverse effects on the macroinvertebrate communities of the Kapuni Stream.

Methods

The standard '400 ml kick-sampling' technique was used to collect streambed macroinvertebrates from riffle habitats at three established sites (sites 1, 2 and 3) in the Kapuni Stream (Table 1, Figure 1) on 22 November 2016 and 9 January 2017. This 'kick-sampling' technique is very similar to Protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark et al, 2001).

Table 1 Biomonitoring sites in the Kapuni Stream, sampled in relation to discharges from the KA-1/7/19/20 wellsite

Site number	Site code	Grid reference (NZTM)	Location	Altitude (masl)
1	KPN000279	E1701343 N5630194	Immediately upstream of pipebridge	180
2	KPN000280	E1701263 N5630047	150m downstream of pipebridge	180
3	KPN000281	E1701216 N5629958	40m upstream of old Kapuni water treatment plant access bridge	180

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 found 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

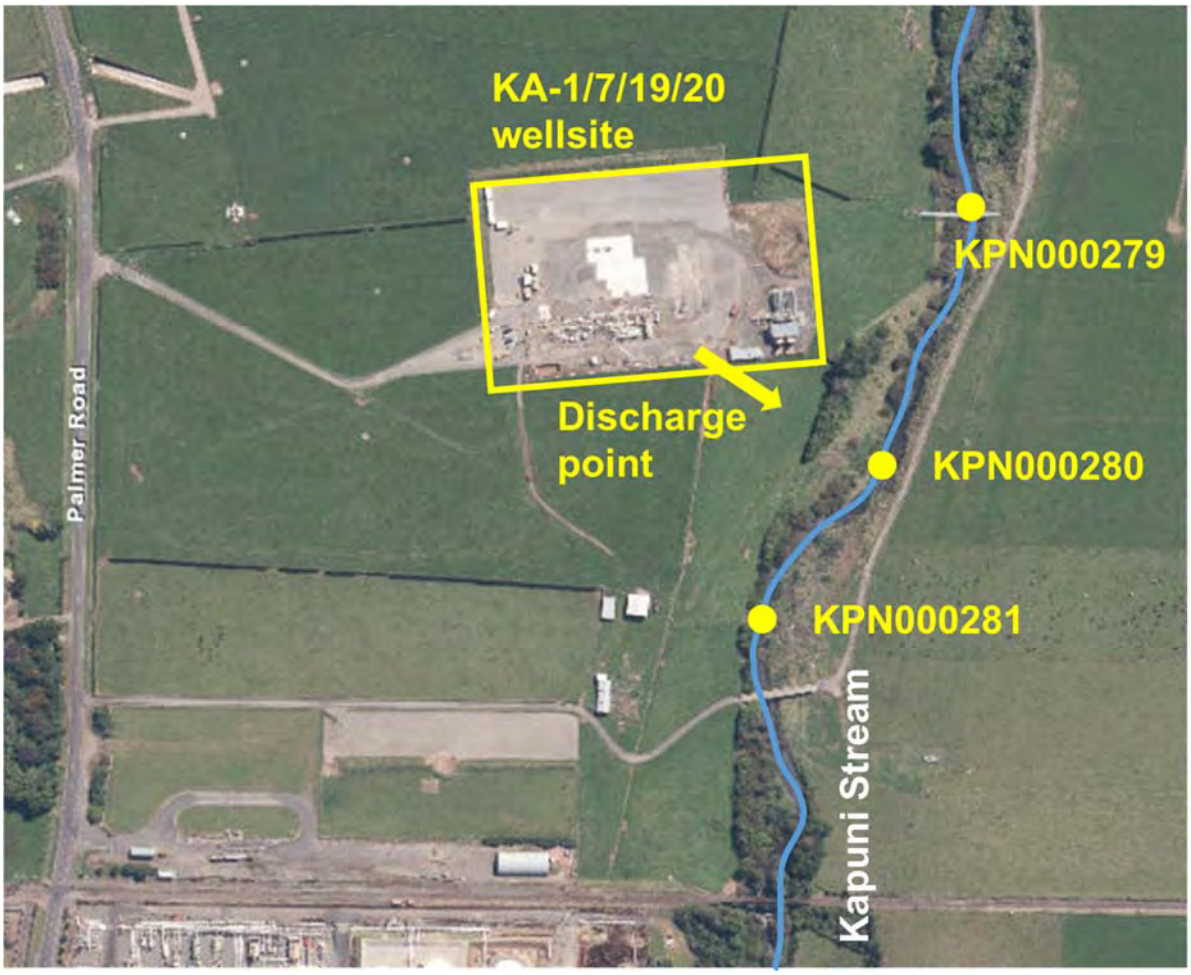


Figure 1 Biomonitoring sites in the Kapuni Stream, sampled in relation to discharges from the KA-1/7/19/20 wellsite

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 scored 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. More 'sensitive' communities inhabit less polluted waterways. A difference of 11 or more MCI units is considered significantly different (Stark 1998). A gradation of biological water quality conditions based upon MCI ranges which has been adapted for Taranaki streams and rivers (TRC, 2013) from Stark's classification (Stark, 1985; Boothroyd and Stark, 2000) (Table 3).

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

TRC Grading	MCI	$SQMCI_s$	Stark's classification
Excellent	>140	>7.00	Excellent
Very Good	120-140	6.00-7.00	
Good	100-119	5.00-5.99	Good
Fair	80-99	4.00-4.99	Fair
Poor	60-79	3.00-3.99	Poor
Very Poor	<60	<3.00	

A semi-quantitative MCI value (SQMCIs) 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 SQMCIs 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 carried out 6 days after a fresh of 3x median flow and 7 days after a fresh of 7x median flow (based on the flow recorder on the Kapuni Stream at Normanby Rd). There was a moderate, swift, clear grey flow at all three sites. Water temperatures ranged from 13.1°C- 13.8°C at the three sites. Substrate composition was similar at the three sites, comprising a mixture of sand, fine and coarse gravels, cobble and boulder. Cobble was the dominant substrate type at all three sites.

Periphyton mats were recorded as slippery, and filamentous periphyton was absent at all three sites. Moss and macrophytes were absent from the streambed at all three sites, while wood was patchy at site 2 but absent at sites 1 and 3, and leaves were patchy at site 3 but absent at sites 1 and 2.

The post-HF survey was carried out 42 days after a fresh of 3x median flow and 54 days after a fresh of 7x median flow (based on the flow recorder on the Kapuni Stream at Normanby Rd). There was a low, swift, clear and uncoloured flow at all three sites. There had been only one fresh of greater than 3x median flow since the preceding survey. Substrate composition was almost identical to that recorded in the pre –HF survey.

Periphyton mats were recorded as slippery at all three sites, and filamentous periphyton was absent at sites 1 and 2. Site 3 had small patches of short green filamentous algae present. Moss, wood and macrophytes were absent from the streambed at all three sites, while patchy leaves were present at sites 1 and 2, but were absent at site 3.

Macroinvertebrate communities

Previous macroinvertebrate surveys have been undertaken at all three sites. At sites 1 and 3, two previous surveys have been carried out in relation to the KA-1/7/19/20 wellsite, while site 2 was sampled relation to the old Kapuni water treatment plant and as such has a more extensive sample history. Data from previous surveys is provided in Table 4, together with the results of the current surveys. Median scores have been calculated for site 2 only, due to the greater amount of data available for this site.

Table 4 Summary of previously recorded number of taxa, MCI values and SQMCIs values together with results from the pre-HF and post-HF surveys

Site	Number of previous surveys	Numbers of taxa			MCI values			Number of previous surveys	$SQMCI_s$ values		
		Range (Median)	Pre-HF	Post-HF	Range (Median)	Pre-HF	Post-HF		Range (Median)	Pre-HF	Post-HF
1	2	20-24	18	24	116-120	129	119	2	7.3-7.5	7.2	7.1
2	22	10-34 (25)	13	21	96-124 (106)	128	123	10	4.8-7.1 (6.4)	7.2	7.7
3	2	17-20	12	16	119-122	135	119	2	7.4-7.8	7.7	7.6

Table 5 gives scores from previously collected sampled for ringplain streams rising in the National Park at similar altitude (TRC 2016).

Table 5 Macroinvertebrate statistics for control sites in Taranaki ringplain streams rising inside the National Park at altitude 155-199 masl

Metric	Number of samples	Range	Median
Taxa richness	416	1-38	21
MCI	416	64-160	108
$SQMCI_s$	313	1.9-8.0	6.0

The full results of the pre-HF survey are presented in Table 5 and the results of the post-HF survey are in Table 7.

Table 6 Macroinvertebrate communities of the Kapuni Stream sampled in relation to discharges from the KA-1/7/19/20 on 22 November 2016

Taxa List	Site Number	MCI score	1	2	3
	Site Code		KPN000279	KPN000280	KPN000281
	Sample Number		FWB16259	FWB16260	FWB16261
EPHEMEROPTERA (MAYFLIES)	*Ameletopsis*	10	-	R	-
	Austroclima	7	R	-	-
	Coloburiscus	7	A	R	C
	Deleatidium	8	VA	A	VA
	Nesameletus	9	R	-	-
PLECOPTERA (STONEFLIES)	*Megaleptoperla*	9	C	-	-
	Zelandobius	5	R	-	-
	Zelandoperla	8	R	-	R
COLEOPTERA (BEETLES)	Elmidae	6	C	C	C
MEGALOPTERA (DOBSONFLIES)	*Archichauliodes*	7	C	R	R
TRICHOPTERA (CADDISFLIES)	*Hydropsyche (Aoteapsyche)*	4	C	R	-
	Costachorema	7	C	R	-
	Hydrobiosis	5	R	-	R
	Beraeoptera	8	C	R	C
	Helicopsyche	10	-	-	R
	Olinga	9	C	R	R
	Pycnocentrodes	5	A	R	C
DIPTERA (TRUE FLIES)	*Aphrophila*	5	R	R	-
	Eriopterini	5	R	R	R
	Orthocladiinae	2	C	R	-
	Tabanidae	3	-	-	R
	No of taxa		18	13	12
	MCI		129	128	135
	SQMCIs		7.2	7.2	7.7
	EPT (taxa)		13	8	8
	%EPT (taxa)		72	62	67

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

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

Table 7 Macroinvertebrate communities of the Kapuni Stream sampled in relation to discharges from the KA-1/7/19/20 on 9 January 2017

Taxa List	Site Number	MCI score	1	2	3
	Site Code		KPN000279	KPN000280	KPN000281
	Sample Number		FWB17006	FWB17007	FWB17008
NEMATOMORPHA	*Gordius*	7	R	-	-
ANNELIDA (WORMS)	Oligochaeta	1	R	-	-
EPHEMEROPTERA (MAYFLIES)	*Austroclima*	7	-	R	-
	Coloburiscus	7	A	C	C
	Deleatidium	8	XA	XA	XA
	Nesameletus	9	C	C	-
PLECOPTERA (STONEFLIES)	*Megaleptoperla*	9	R	-	-
	Stenoperla	10	R	-	-
	Zelandobius	5	-	R	-
	Zelandoperla	8	R	R	R
COLEOPTERA (BEETLES)	Elmidae	6	A	C	C
	Hydraenidae	8	R	R	R
MEGALOPTERA (DOBSONFLIES)	*Archichauliodes*	7	A	R	R
TRICHOPTERA (CADDISFLIES)	*Hydropsyche (Aoteapsyche)*	4	VA	C	A
	Costachorema	7	C	R	C
	Hydrobiosis	5	A	C	C
	Plectrocnemia	8	-	R	-
	Beraeoptera	8	A	C	R
	Olinga	9	A	C	R
	Pycnocentrodes	5	A	A	C
DIPTERA (TRUE FLIES)	*Aphrophila*	5	C	R	C
	Eriopterini	5	C	-	-
	Maoridiamesa	3	-	-	C
	Orthocladiinae	2	C	C	C
	Tanypodinae	5	-	R	-
	Tanytarsini	3	R	R	-
	Austrosimulium	3	R	C	R
	Tabanidae	3	R	-	-
	Tanyderidae	4	R	-	-
		No of taxa	24	21	16
		MCI	119	123	119
		SQMCIs	7.1	7.7	7.6
		EPT (taxa)	12	13	9
		%EPT (taxa)	50	62	56
'Tolerant' taxa	'Moderately sensitive' taxa	'Highly sensitive' taxa			

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

Site 1

Taxa richnesses of 18 and 24 were recorded in the pre-HF and post-HF surveys respectively. The macroinvertebrate community in the pre-HF survey was characterised by three taxa, one 'highly sensitive' taxon [mayfly (*Deleatidium*)], and two ' moderately sensitive' taxa [mayfly (*Coloburiscus*) and caddisfly (*Pyncnocentrodes*)]. At the time of the post-HF survey, the macroinvertebrate community was characterised by these same three and six additional taxa, two of which are 'highly sensitive' [caddisflies (*Beraeoptera* and *Olinga*)], three 'moderately sensitive' [beetle (*Elmidaae*), dobsonfly (Archicauliodes) and caddisfly (*Hydrobiosis*)] and one 'tolerant' [caddisfly (*Hydropsyche* - formerly *Aoteapsyche*)].

MCI scores of 129 were recorded in the pre-HF survey, and 119 in the post-HF survey. These scores categorise the site as having 'very good' and 'good' macroinvertebrate community health respectively (Table 3). This shows a non-significant decline in MCI score between the two surveys (Stark 1998). Both recorded scores are significantly higher than the median MCI score for sites at similar altitude in ringplain streams rising inside the National Park (Table 5).

$SQMCI_s$ scores of 7.2 and 7.7 were recorded in the pre-HF and post-HF surveys respectively. These scores are not significantly different from each other, although both are significantly higher than the median $SQMCI_s$ score for sites ringplain streams rising in the National Park at similar altitude (Table 5).

Site 2

Taxa richnesses of 13 and 21 taxa were recorded in the pre-HF and post-HF surveys respectively, showing a substantial increase of eight taxa between the two surveys. These richnesses are within the previously recorded range for this site, although both are lower than the median richness for this site (Table 4). The macroinvertebrate community in the pre-HF survey was characterised by only one taxon ['highly sensitive' mayfly (*Deleatidium*)]. The community in the post-HF survey was characterised by the same taxon, and one additional taxon ['moderately sensitive' caddisfly (*Pyncnocentrodes*)].

MCI scores of 128 and 123 were recorded in the pre-HF and post-HF surveys respectively, categorising the site as having 'very good' macroinvertebrate community health on both occasions. These scores are not significantly different from one another (Stark 1998), and both are significantly higher than the median score for this site (Table 4) as well as the median score for sites at similar altitude in ringplain streams rising in the National Park (Table 5). The pre-HF score of 128 is the highest MCI score recorded at this site to date (Table 4).

$SQMCI_s$ scores of 7.2 and 7.7 were recorded in the pre-HF and post-HF surveys respectively. These scores are not significantly different to one another (Stark 1998). Both scores are significantly higher than the median score for this site (Table 4) as well as the median score for sites at similar altitude in ringplain streams rising in the National Park (Table 5). Both scores are also higher than any $SQMCI_s$ score previously recorded at this site (Table 4).

Site 3

Moderately low taxa richnesses of 12 and 16 were recorded at this site in the pre-HF and post-HF surveys. The macroinvertebrate community in the pre-HF survey was characterised by only one taxon ['highly sensitive' mayfly (*Deleatidium*)]. The community in the post-HF survey was characterised by the same taxon, and one additional taxon ['tolerant' caddisfly (*Hydropsyche* -formerly *Aoteapsyche*)].

MCI scores of 135 and 119 were recorded in the pre-HF and post-HF surveys respectively. These scores categorise the site as having 'very good' and 'good' macroinvertebrate community health respectively (Table 3). This shows a significant decrease in MCI score between the two surveys (Stark 1998).

$SQMCI_s$ scores of 7.7 and 7.6 were recorded in the pre-HF and post-HF surveys respectively. These scores are not significantly different from each other, although both are significantly higher than the median $SQMCI_s$ score for sites ringplain streams rising in the National Park at similar altitude (Table 5).

Discussion and conclusions

The Council's 'kick-sampling' technique was used at three sites to collect benthic macroinvertebrates from the Kapuni Stream in relation to discharges to land from the KA-1/7/19/20 wellsite. This has provided data to assess any potential impacts the consented discharges have had on the macroinvertebrate communities of the stream. Samples were processed to provide number of taxa (taxa richness), MCI and $SQMCI_s$ scores for each site.

Taxa richness is the most robust index when determining whether a macroinvertebrate community has been exposed to toxic discharges. Macroinvertebrates when exposed to toxic discharges may die and be swept downstream or may deliberately drift downstream as an avoidance mechanism (catastrophic drift). The MCI is a measure of the overall sensitivity of the macroinvertebrate community to organic pollution in

stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The $SQMCI_s$ takes into account relative abundances of taxa as well as sensitivity to pollution. Significant differences in taxa richness, MCI or $SQMCI_s$ between sites may indicate the degree of adverse effects (if any) of the discharge being monitored.

Taxa richnesses increased between the surveys at all three sites, and decreased in a downstream direction in both surveys. The change between surveys is most likely related to flow conditions at the time of the surveys, with the pre-HF survey being carried out towards the end of a very wet winter and spring period. In contrast, the flows had remained relatively stable in the time between the two surveys, with only one fresh of greater than 3x median flow and no fresh greater than 7x median flow occurring during this time. It should also be noted that due to the wet weather conditions the pre-HF survey was carried out only 7 days after a fresh of 7x median flow. This could potentially result in flood-affected results by collecting samples before macroinvertebrates have had a chance to recolonise the survey reach.

MCI scores decreased between the two surveys at all three sites, although this difference was significant only for site 3. This difference was caused by the presence of an additional three 'tolerant' taxa in post-HF survey. There were no significant differences in score between the three sites in either the pre-HF survey or the post-HF survey. All recorded scores in both surveys were significantly higher than the median score for sites at similar altitude in ringplain streams rising inside the National Park. Further, the scores categorised the sites as having 'good' or 'very good' macroinvertebrate community health on both occasions. It is also worth noting that the two samples which were categorised as having 'good' macroinvertebrate community health were on the category boundary, with an increase in MCI score of only 1 unit needed to categorise these communities as 'very good'.

All $SQMCI_s$ scores were similar across sites and across surveys, with a recorded range of 7.1-7.7. All recorded scores in both surveys were significantly higher than the median score for sites at similar altitude in ringplain streams rising inside the National Park. Furthermore, $SQMCI_s$ scores of 7.0 or greater categorise the site as having 'excellent' macroinvertebrate community health. These results reflect the numerical dominance of sensitive taxa in the macroinvertebrate communities, with the 'highly sensitive' mayfly *Deleatidium* (MCI score 8) being the dominant taxon across the sites and surveys.

It is not uncommon to observe decreasing MCI scores as taxonomic richness increases, especially when the MCI scores are towards the higher end of the range. This pattern is caused by an increased proportion of lower scoring taxa which may be caused by a slight change in conditions, which causes higher scoring taxa to be less able to outcompete lower scoring taxa for resources, thus allowing a greater range of species to co-exist. In this case, it also likely to be due to the more stable flows allowing colonisation by a greater range of macroinvertebrate taxa. Finally, more algae was observed in the post-HF survey, which tends to be associated with more 'tolerant' taxa. When combined with the lack of change in $SQMCI_s$ scores between the two surveys, the results suggest that although changes in the macroinvertebrate community are occurring, this is caused by an increased number of lower scoring 'rare' taxa while more 'sensitive' taxa continue to dominate the macroinvertebrate communities.

Overall, there is no evidence that discharges from the KA-1/7/19/20 wellsite had had any detrimental impacts on the macroinvertebrate communities of the Kapuni Stream. Taxa richnesses increased, and MCI scores decreased between the two surveys, although this change was significant only for site 3. $SQMCI_s$ scores remained stable between the two surveys, and between sites. MCI scores and $SQMCI_s$ scores were significantly higher than the median score for sites at similar altitude in ringplain streams rising inside the National Park in all cases, indicating that the macroinvertebrate communities of the Kapuni Stream were in good biological health.

Summary

Two macroinvertebrate surveys were carried out at three sites in the Kapuni Stream near the KA-1/7/19/20 wellsite prior to and following hydraulic fracturing activities, to determine whether stormwater discharges from the wellsite had caused any detrimental impacts on the macroinvertebrate communities of the Kapuni Stream. Moderate to moderately low taxonomic richnesses were observed, while MCI scores and $SQMCI_s$ scores were significantly higher than the median scores for sites at similar altitude in ringplain streams rising outside the National Park. This indicates that the macroinvertebrate communities at these sites are healthy. Overall, there was no evidence that the stormwater discharges from the KA-1/7/19/20 wellsite have caused any recent significant adverse effects on the macroinvertebrate communities of the Kapuni 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, 1999: An evaluation of Taranaki Regional Council's SQMCI biomonitoring index. Cawthron Institute, Nelson. Cawthron Report No. 472.

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.

Sutherland DS 2015. Biomonitoring of the Kapuni Stream and tributaries of the Inaha Stream and Waiokura Stream pre and post hydraulic fracturing by Shell Todd Oil Services Ltd at wellsites KA1/7/19/20, KA4/14 and KA6/11/17, November 2013, June 2013 and July - August 2013. TRC Report DS003.

TRC, 2016: Some statistics from the Taranaki Regional Council database (Esam) of freshwater macroinvertebrate surveys performed during the period from January 1980 to 30 September 2016 (SEM reference report). Technical Report 2014-15.

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.