Shell Todd Oil Services Limited (STOS)
Kapuni Wellsites Hydraulic Fracturing
Monitoring Programme
Annual Report
2014-2015

Technical Report 2015-43

ISSN: 1178-1467 (Online)
Document: 1566838 (Word)
Document: 1570052 (Pdf)

Taranaki Regional Council
Private Bag 713
STRATFORD

November 2015

Executive summary

Shell Todd Oil Services Limited (STOS) operate the KA1/7/19/20 wellsite, located at 360 Palmer Road, the KA4/14 wellsite, located at 598 Palmer Road and the KA6/11/17 wellsite, located at 849 Ahipaipa Road. The wellsites lie within the Kapuni, Waiokura and the Inaha catchments, respectively. Each wellsite contains a number of hydrocarbon producing wells and associated infrastructure.

STOS hold resource consents 7995-1, 7996-1 and 7998-1, authorising the discharge of contaminants into land at the KA1/7/19/20, KA4/14 and KA6/11/17 wellsites, respectively. The consents were issued by the Taranaki Regional Council (the Council) on 28 March 2012 (7995-1 and 7996-1) and 5 April 2012 (7998-1). Each consent contains a total of 14 special conditions which set out the requirements that STOS must satisfy.

The following report for the period April 2014 to March 2015 outlines and discusses the results of the monitoring programme implemented by the Council in relation to the programme of hydraulic fracturing undertaken by STOS within their Kapuni gas field over the period June 2013 to December 2013. The programme of hydraulic fracturing undertaken by STOS included the fracturing of three wells, at three separate Kapuni wellsites. The wells targeted for stimulation included KA-14, located at the KA4/14 wellsite; KA-17, located at the KA6/11/17 wellsite; and KA-19, located at the KA1/7/19/20 wellsite. The report also assesses STOS's level of environmental performance and compliance with the resource consents held in relation to the activity. No further hydraulic fracturing stimulations have been carried out in the Kapuni Field post December 2013.

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

The programme of monitoring implemented by the Council in relation to hydraulic fracturing activities described above commenced in the 2012-2013 monitoring year. The results of monitoring undertaken between April 2013 and March 2014 were presented in the 2012-2014 biennial report (Taranaki Regional Council, 2015). The results of the monitoring undertaken between April 2014 and March 2015 are presented in this report. Monitoring included analysis of samples taken from nine existing groundwater supplies surrounding the wellsites.

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

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

For reference, in the 2014-2015 year, 75% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level o f environmental performance and compliance with their consents, while another 22% demonstrated a good level of environmental performance and compliance with their consents.

This report includes recommendations for the 2015-2016 year.

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

The following report outlines and discusses the results of the monitoring programme implemented by the Taranaki Regional Council (the Council) in relation to the programme of hydraulic fracturing undertaken by Shell Todd Oil Services Limited (STOS), within their Kapuni gas field over the period June to December 2013.

The programme of hydraulic fracturing undertaken by STOS included the fracturing of three wells, at three separate Kapuni wellsites. The wells targeted for stimulation were KA-14, located at the KA4/14 wellsite, 598 Palmer Road; KA-17, located at the KA6/11/17 wellsite, 849 Ahipaipa Road; and KA-19, located at the KA1/7/19/20 wellsite, 360 Palmer Road. The wellsites are located in the Waiokura, Inaha and Kapuni catchments, respectively.

A report was completed in March 2015 which outlined and discussed the results of the monitoring carried out during the 2012-2013 and 2013-2014 monitoring periods. The following report provides an update on the results of further monitoring carried out since the initial report was completed and includes monitoring undertaken in the 2014-2015 monitoring period.

1.1.2 Structure of this report

Section 1 of this report is a background section. It sets out general information about compliance monitoring under the *Resource Management Act 1991* (RMA) and the Council's obligations and general approach to monitoring sites though annual programmes, the resource consents held by STOS in the Waiokura, Inaha and Kapuni catchments, the nature of the monitoring programme in place for the period under review, and a description of the activities and operations conducted in Stos's site/catchment.

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

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

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

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

1.1.3 The Resource Management Act 1991 and monitoring

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

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

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

1.1.4 Evaluation of environmental and administrative performance

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

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

Events that were beyond the control of the consent holder and unforeseeable (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 2014-2015 year, 75% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level o f environmental performance and compliance with their consents, while another 22% demonstrated a good level of environmental performance and compliance with their consents.

1.2 Process description

1.2.1 Hydraulic fracturing

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

The process of hydraulic fracturing involves the pumping of fluids (consisting of freshwater and a small volume of chemicals) and a proppant (medium-grained sand or small ceramic pellets) down a well, through a perforated section of the well casing, and into the target reservoir. The fluid mixture is pumped at a pressure that exceeds the fracture strength of the reservoir rock in order to create fractures. Once fractures have been initiated, pumping continues in order to force the fluid and proppant into the fractures created. The proppant is designed to keep the fractures open when the pumping is stopped. The placement of proppant into the fractures is assisted by the use of cross-linked gels. These are solutions, which are liquid at the surface but, when mixed, form long-chain polymer bonds and thus become gels that transport the proppant into the formation. Once in the formation these gels 'break' back with time and temperature to a liquid state and are flowed back to surface without disturbing the proppant wedge. With continued flow, fluids pumped as part of hydraulic fracturing process, formation fluids and hydrocarbons are drawn to the surface.

1.2.2 Kapuni 'Tight Gas' programme

STOS's Kapuni field has been in production since 1969 and is the oldest producing gas and condensate field in New Zealand. The objective of the Kapuni 'Tight Gas' programme is to improve hydrocarbon production rates from the field, thus extending

its economic life. The programme includes the workovers of existing production wells, the drilling of new wells and well stimulation by hydraulic fracturing.

The initial phase of the programme included the hydraulic fracturing of the existing KA-14 and KA-17 wells, and the drilling and hydraulic fracturing of the KA-19 well. The wells are located at the KA4/14, KA6/11/17 and KA1/7/19/20 wellsites, respectively. The location of each wellsite is illustrated in Figure 1. Well construction and geological stratigraphy schematics for each well are included in Appendix I.

A summary of all hydraulic fracturing activities carried out by STOS during the period being reported is provided below in Table 1.

Table 1 Summary of hydraulic fracturing activity (2012-2014)

Well	Wellsite	Consent	Date		Injection zone (m TVDss)	Formation
			Start	End		
KA-14	KA4/14	7996-1	12/06/13	22/06/13	3,073 to 3,450	Kapuni Group
KA-17	KA6/11/17	7998-1	28/07/13	06/08/13	3,036 to 3,360	Kapuni Group
KA-19	KA1/7/19/20	7995-1	14/11/13	10/12/13	3,065 to 3,419	Kapuni Group

A report was completed in March 2015 (Taranaki Regional Council), which outlined and discussed the results of the monitoring carried out during the 2012-2013 and 2013-2014 monitoring periods. The report presented herein provides an update on the results of further monitoring carried out since the March 2015 report was compiled.

1.3 Resource consents

1.3.1 Discharges onto and into land

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

STOS hold resource consents **7995-1, 7996-1** and **7998-1**, authorising the discharge of contaminants into land at the KA1/7/19/20, KA4/14 and KA6/11/17 wellsites, respectively. The consents were issued by the Council on 28 March 2012 (7995-1 and 7996-1) and 5 April 2012 (7998-1), under Section 87(e) of the RMA. Each consent contains a total of 14 special conditions which set out the requirements that STOS must satisfy.

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 fresh water 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 use best practicable options.

Condition 13 relates to the composition of the fracturing fluid.

Condition 14 is a review provision.

Copies of each permit are included in Appendix II.

Figure 1 Locations of Kapuni wellsites where hydraulic fracturing occurred

1.4 Monitoring programme

1.4.1 Introduction

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

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

The monitoring programme implemented in relation to the hydraulic fracturing of the KA-14, KA-17 and KA-19 wells consisted of three primary components.

1.4.2 Programme liaison and management

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

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

1.4.3 Review of consent holder submitted data

As required by the conditions of consents 7995-1, 7996-1 and 7998-1, STOS submitted pre and post-fracturing discharge reports to the Council for each well fractured during the period under review. Pre-fracturing discharge reports provide an outline of the proposed fracturing operations in relation to each well, while post-fracturing reports confirm details of what actually occurred. The specific range of information required in each report is stipulated in the conditions of the resource consents. The post-fracturing discharge reports are discussed in detail in the 2012-2014 biennial report (Taranaki Regional Council, 2015).

1.4.4 Chemical sampling

The groundwater monitoring programme over the period in question included the sampling of nine existing groundwater supply wells located in the vicinity of the wellsites at which hydraulic fracturing took place, and the analysis of the results.

The details of each site are included in Table 2 and their proximity to the relevant hydraulically fractured well is illustrated in Figures 2, 3 and 4.

Table 2 Details of groundwater sites included in the monitoring programme

Hydraulically fractured well	Wellsite	Monitoring site	Distance from bottom hole location (m)	Total depth (m)	Screened interval (m)	Aquifer
KA-14 (GND1693)	KA4/14	GND1689	1,320*	31	19.5 to 31	Volcanics
		GND2333	1,000	10	0 to 10	Volcanics
KA-19 (GND2431)	KA1/7/19/20	GND0093	753	55	25 to 55	Volcanics
		GND2011	960	430	386 to 430	Matemateaonga
		GND2348	911	49	24 to 49	Volcanics
		GND2357	986	35	24 to 35	Volcanics
KA-17 (GND2366)	KA6/11/17	GND2342	958	18	NR**	Volcanics
		GND2349	768	40	23 to 40	Volcanics
		GND2352	978	27	24 to 27	Volcanics

* Outside of defined area of review but included in assessment due to lack of suitable alternative monitoring sites.
** Bore not accessible to obatin measurments.

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

Two rounds of groundwater sampling occurred between April 2013 and March 2014. The results of these sampling rounds are outlined in the 2012-2014 biennial report (Taranaki Regional Council, 2015).

Sampling was undertaken between December 2014 and March 2015 to monitor potential residual effects of the hydraulic fracturing of the KA-14, KA-17 and KA-19 wells on local groundwater resources. Where access to the bore was available, samples were obtained using a pneumatic bladder or peristaltic pump, using a low-flow sampling methodology. Where access to the bore was not available, samples were obtained at a point in the water distribution network as close to the wellhead as practicable. All samples were transported to Hill Laboratories Limited for analysis following standard chain of custody procedures.

Figure 2 Location of groundwater sampling sites in relation to KA-14 well (GND1693)

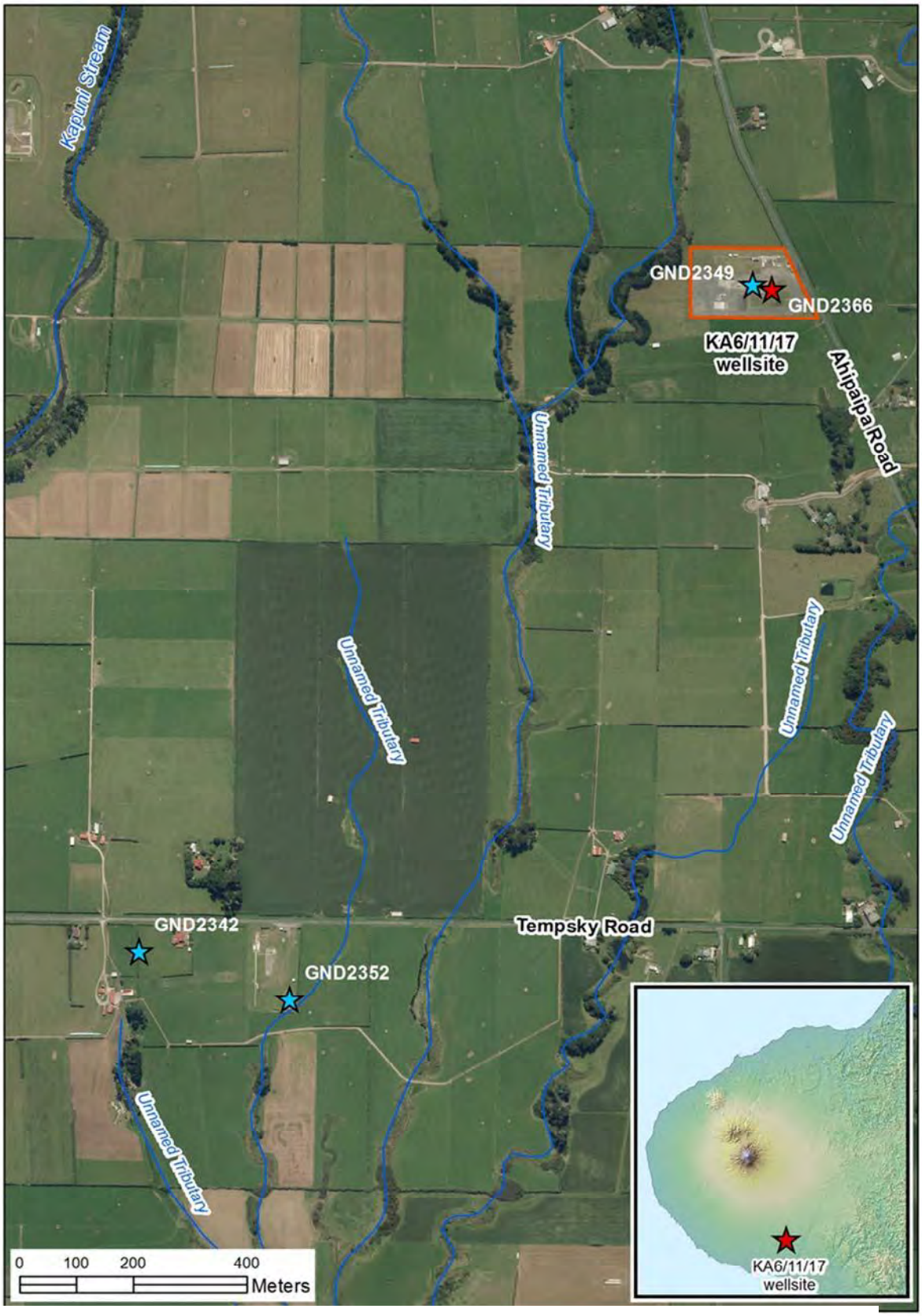

Figure 3 Location of groundwater sampling sites in relation to KA-17 well (GND2366)

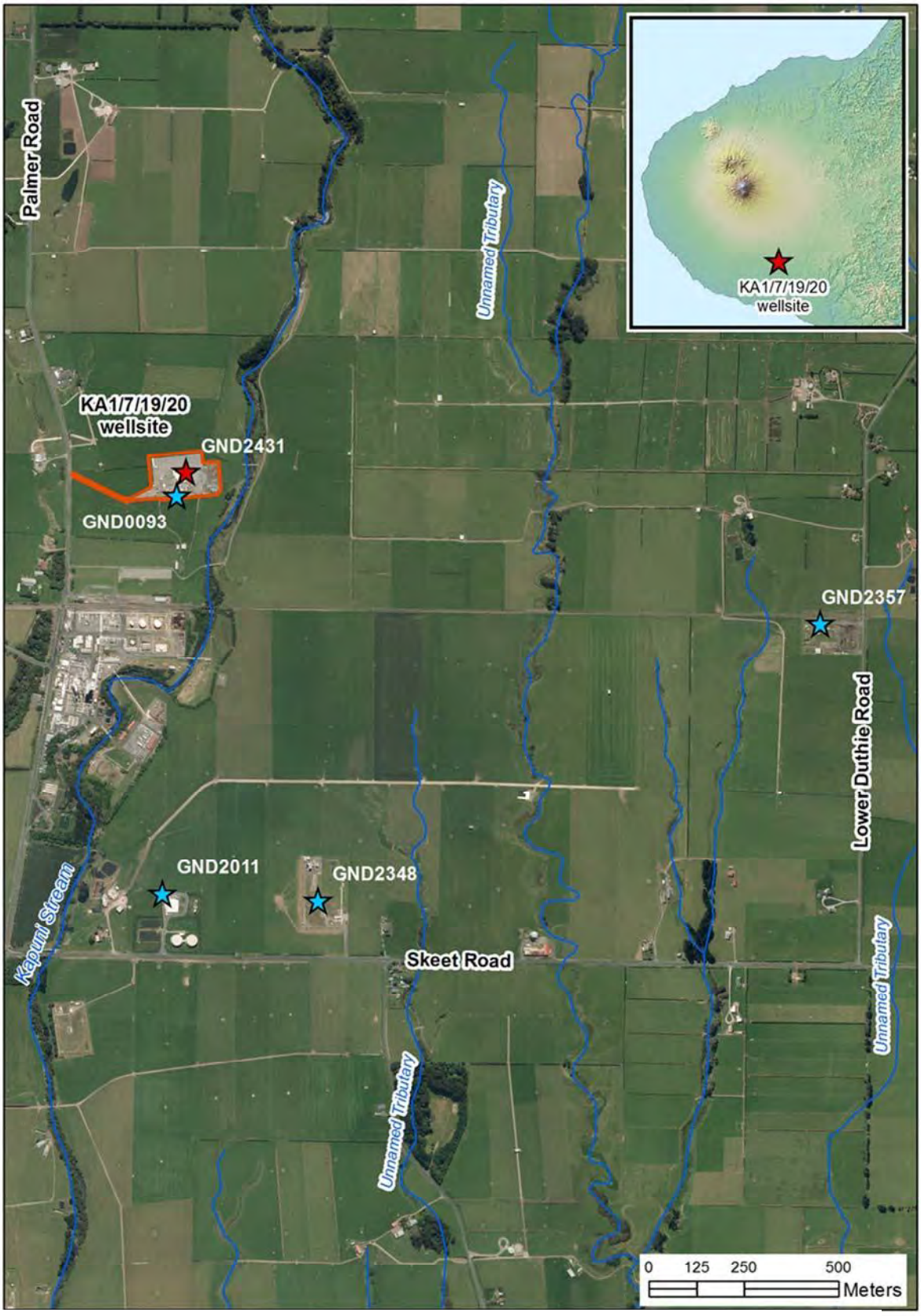

Figure 4 Location of groundwater sampling sites in relation to KA-19 well (GND2431)

2. Results

2.1 Groundwater sampling

Between December 2013 and March 2015, groundwater samples were collected from eight wells across the three sites. Key indicator parameters pH, electrical conductivity, chloride and total dissolved solids are plotted against time (Figures 3-14). If the concentration of these parameters changed it could indicate the migration of deep formation water, which is highly saline in composition, via fractures or conduits created by the hydraulic fracturing process, leakage from the wellbore due to integrity issues, or the mishandling of fluids at the surface.

2.1.1 KA-14 groundwater sampling survey

pH concentrations increased during the December 2013 sampling event in GND1689 but returned to pre-fracturing levels in December 2014. GND2333 did not show a substantial increase in pH during the December 2013 sampling event, and remained relatively consistent throughout monitoring. GND1689 exhibited a slight decrease in electrical conductivity, total dissolved solids and chloride between August and December 2013 sampling events, before reverting to pre-fracturing levels before the December 2014 sampling event.

The changes in concentration of these four analytes are a result of natural variations in water composition and are unrelated to fracturing activities.

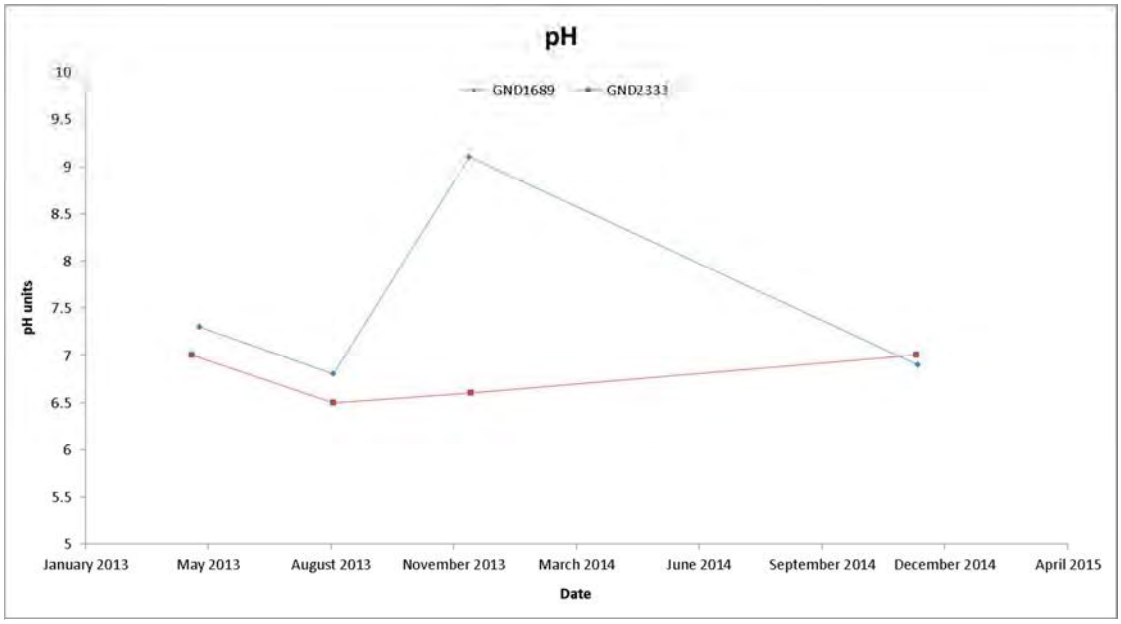

Figure 5 Results of pH analysis

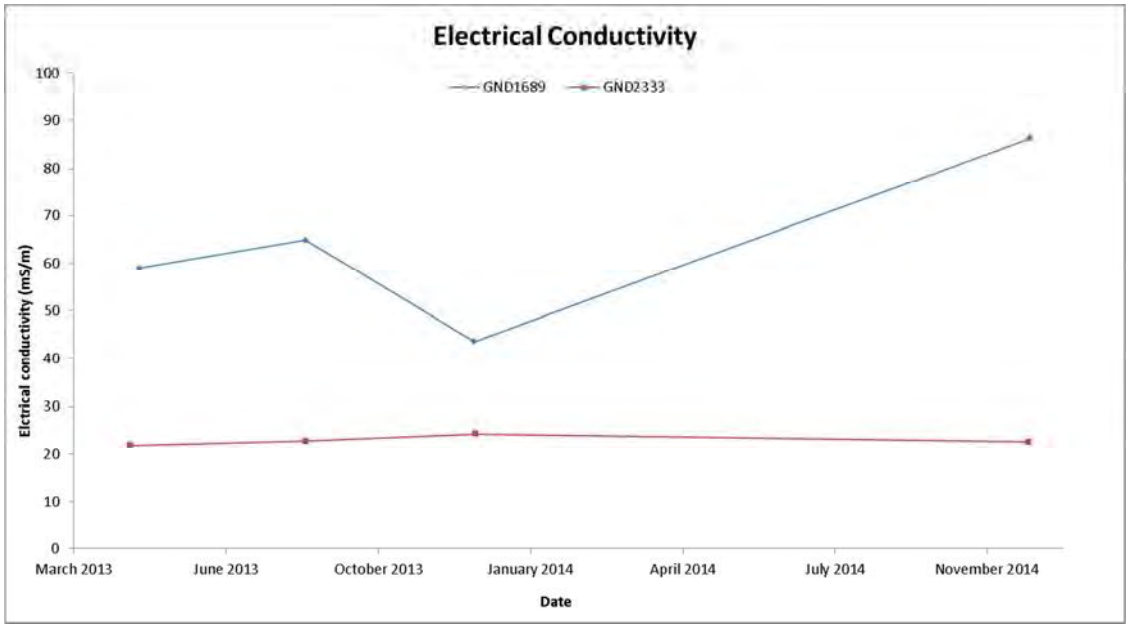

Figure 6 Results of electrical conductivity analysis

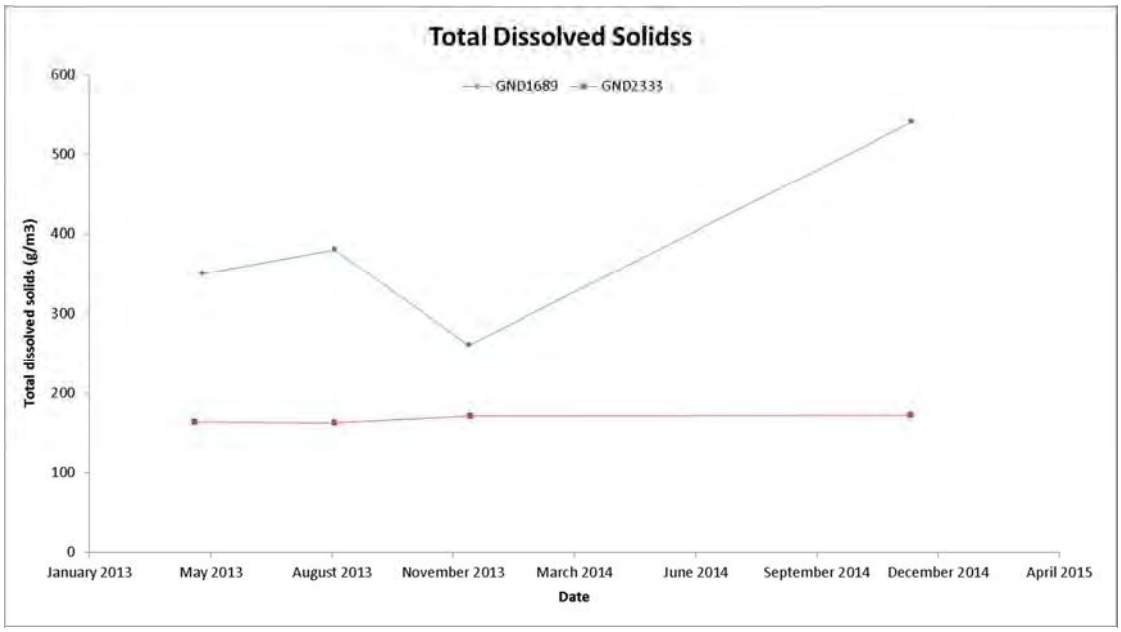

Figure 7 Results of total dissolved solids analysis

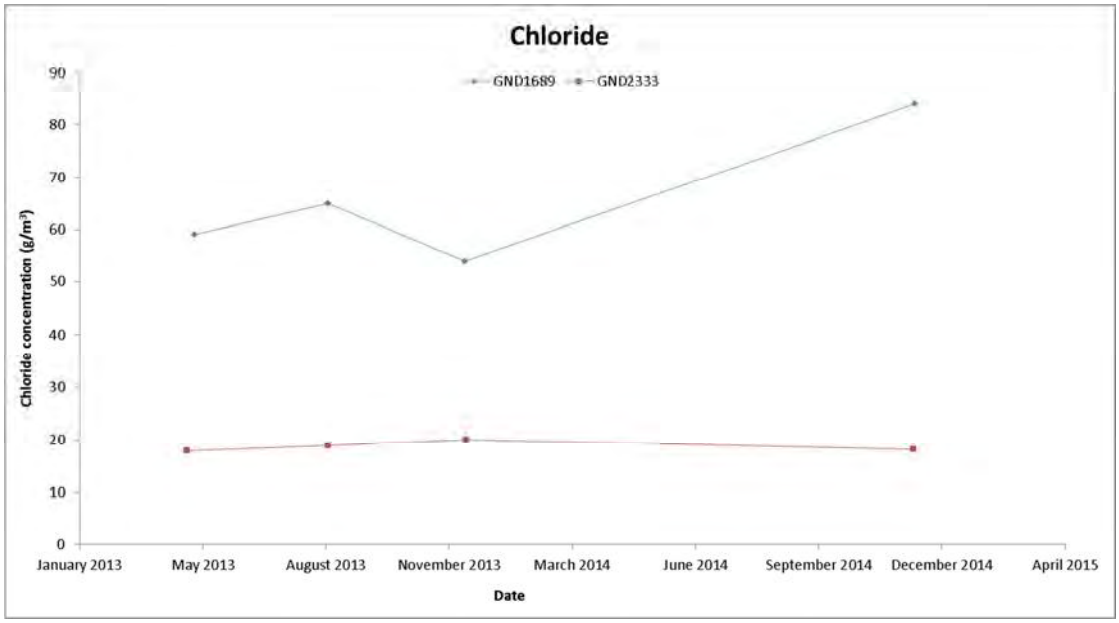

Figure 8 Results of chloride analysis

There were no traces of any substance associated with hydraulic fracturing fluids, or hydrocarbons relating to fracturing activities, in any of the groundwater samples obtained throughout the monitoring period.

Methane was detected in all samples taken from GND1689. The methane/ethane ratios indicate that the gas is biogenic in origin and not derived from deep gas resevoirs. Concentrations were within the expected ranges for shallow groundwater across Taranaki. No methane was detected in samples taken from GND2333.

2.1.2 KA-17 groundwater sampling survey

Analyte concentration in GND2349 and GND2352 remained more stable than at the KA-14 groundwater monitoring sites throughout the monitoring period. Only very minor changes in concentrations were observed, as can be seen in Figures 9 to 12. These changes in concentration are a result of natural variations in water composition and are unrelated to fracturing activities.

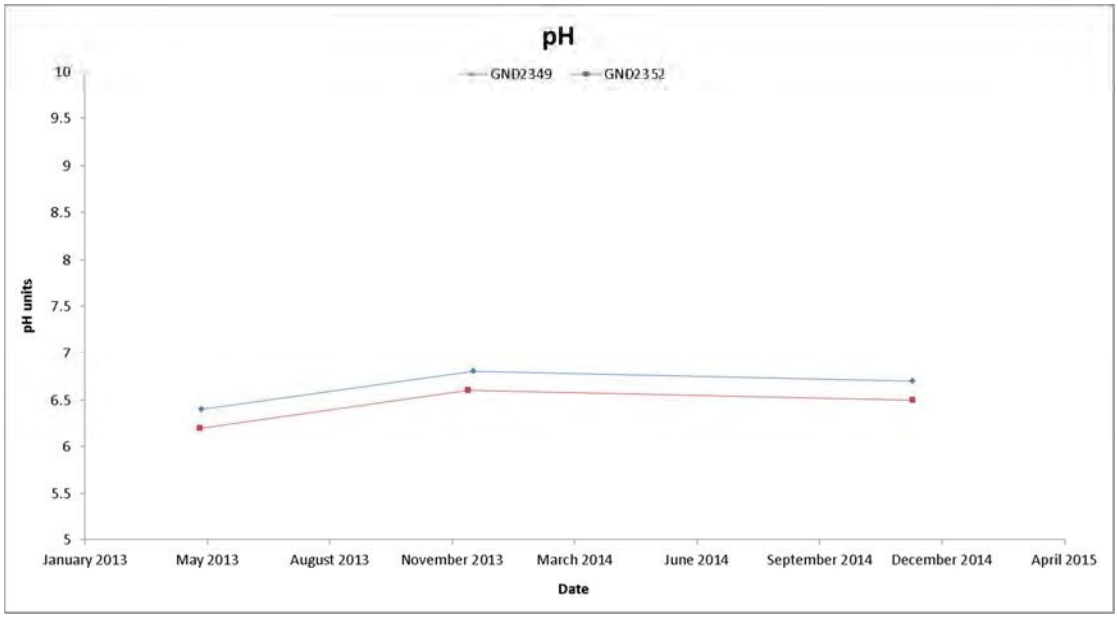

Figure 9 Results of pH analysis

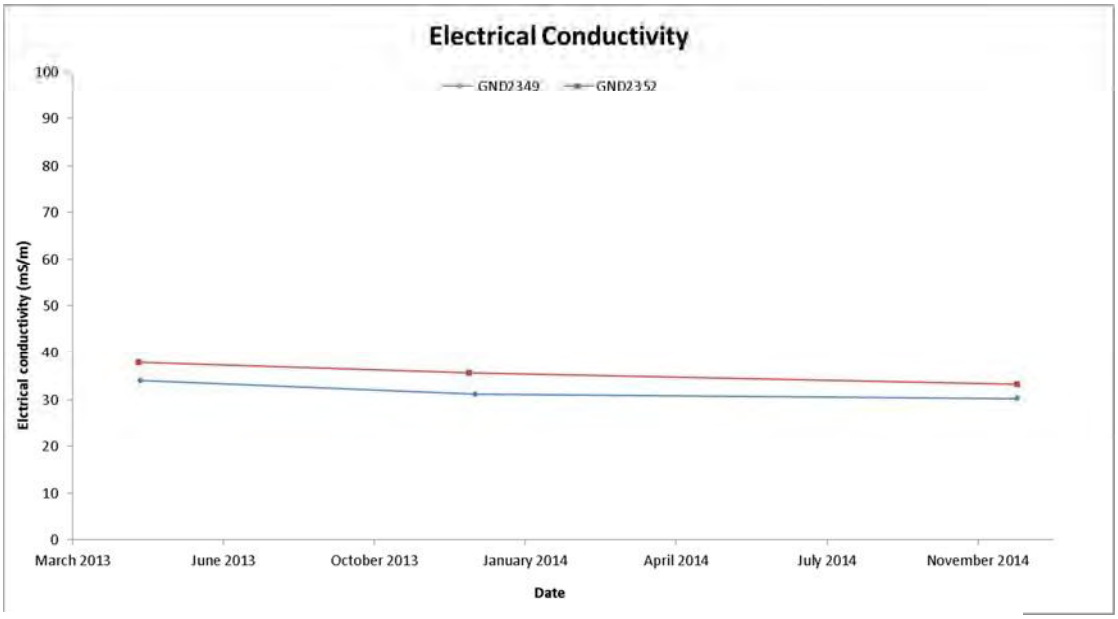

Figure 10 Results of electrical conductivity analysis

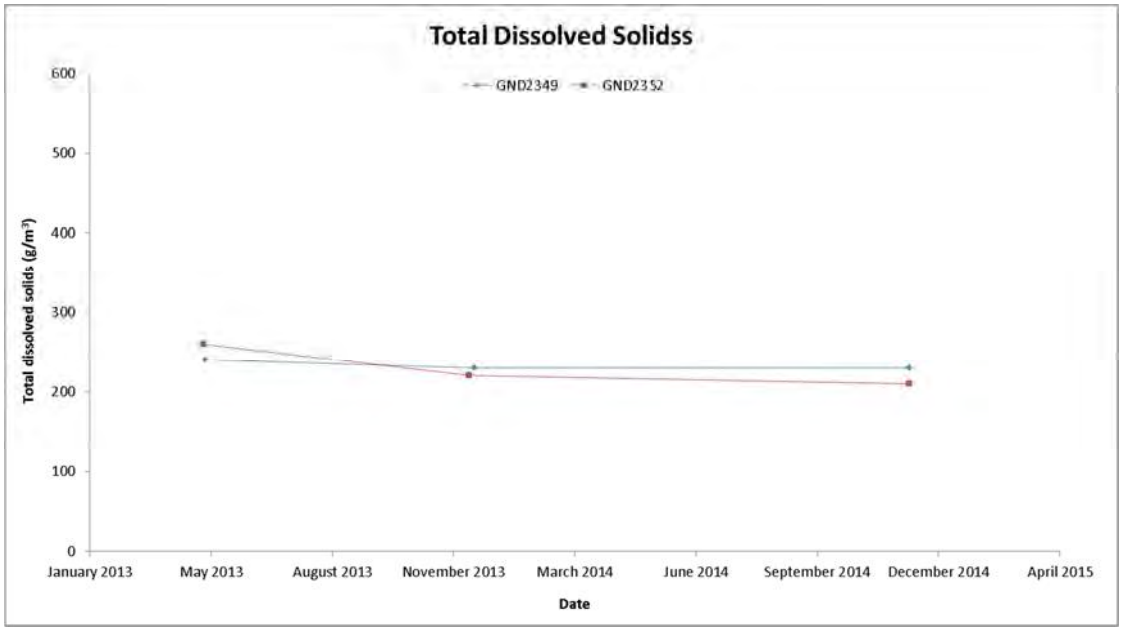

Figure 11 Results of total dissolved solids analysis

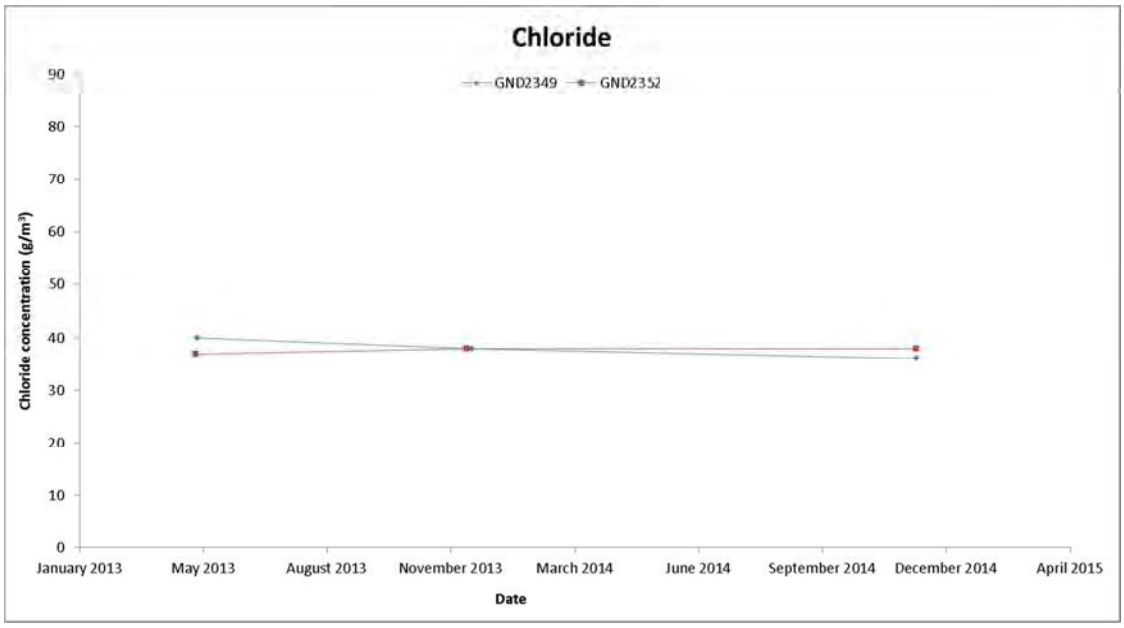

Figure 12 Results of chloride analysis

There were no traces of any substance associated with hydraulic fracturing fluids, or hydrocarbons relating to fracturing activities, in any of the groundwater samples obtained throughout the monitoring period.

Methane was detected in all samples taken from GND2349 and GND2352. The methane/ethane ratios indicate that the gas in GND2349 is biogenic in origin and not derived from deep gas reservoirs. Carbon isotope analysis was not carried out on the samples from GND2352 but concentrations in both wells were within the expected ranges for shallow groundwater across Taranaki.

2.1.3 KA-19 groundwater sampling survey

pH remained consistent throughout the monitoring period in monitoring bores GND2011 and GND2348. Increases in pH were observed in GND0093 and GND2357 between May 2013 and March 2014 before returning to close to pre-fracturing levels in March 2015. Electrical conductivity, total dissolved solids and chloride concentrations remained relatively consistent throughout the monitoring period, with a minor increased observed in GND2357 between March 2014 and March 2015. The changes in concentration are a result of natural variations in water composition and are unrelated to fracturing activities.

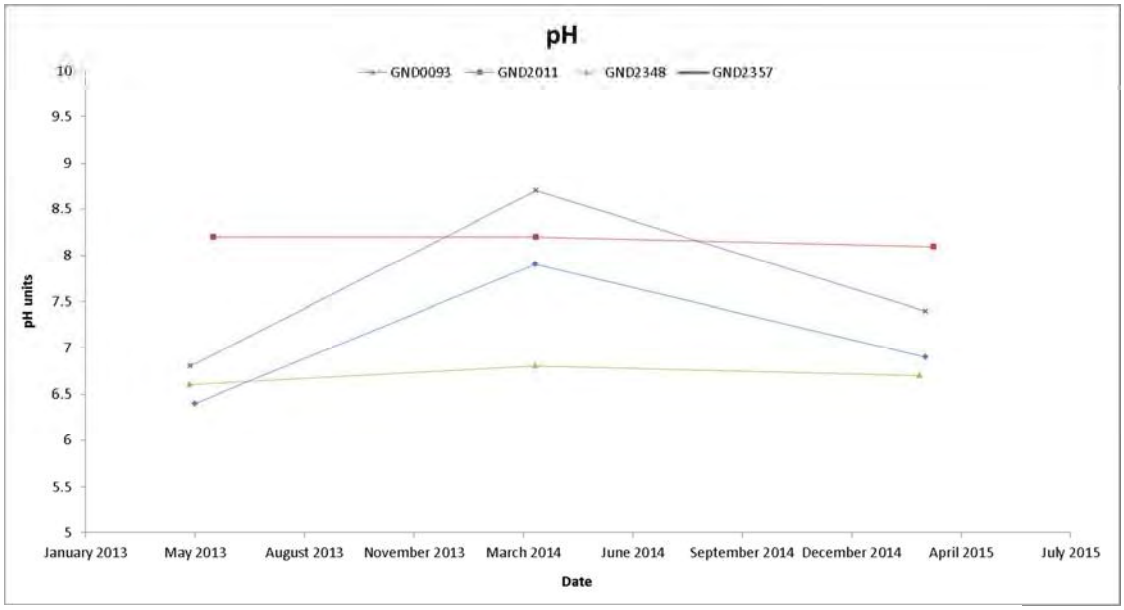

Figure 13 Results of pH analysis

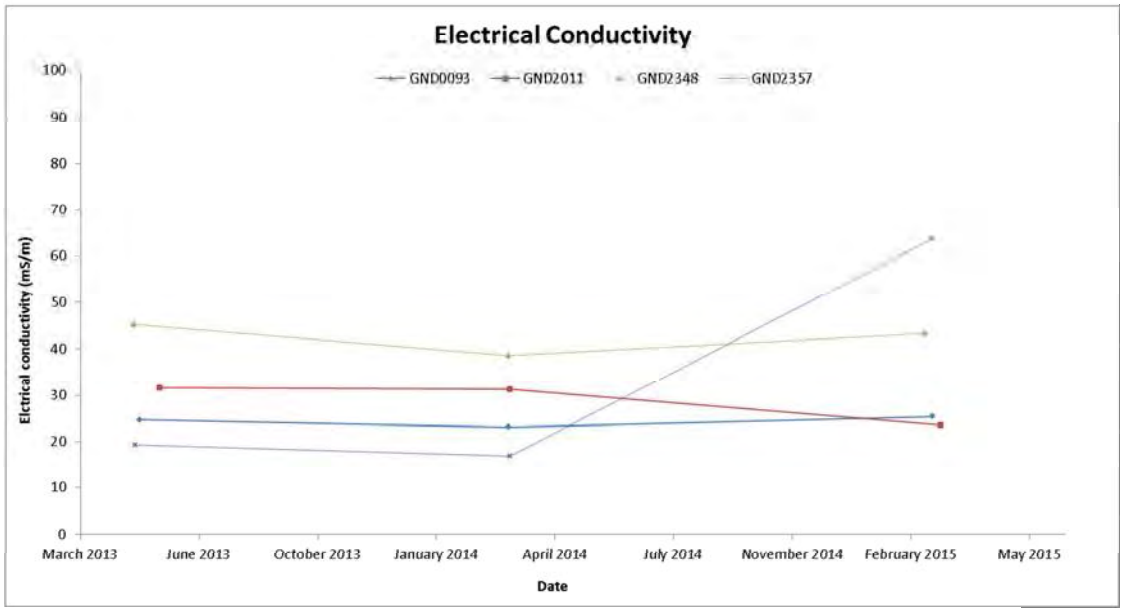

Figure 14 Results of electrical conductivity analysis

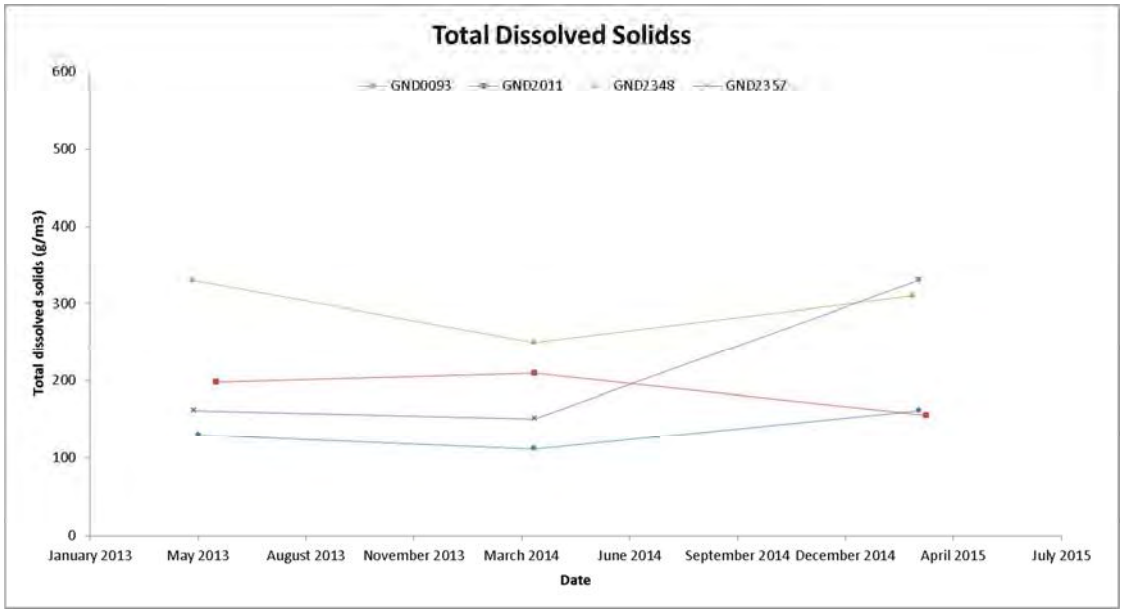

Figure 15 Results of total dissolved solids analysis

There were no traces of any substance associated with hydraulic fracturing fluids, or hydrocarbons relating to fracturing activities, in any of the groundwater samples obtained throughout the monitoring period.

Methane was detected in all samples taken from GND0093, GND2011, GND2348 and GND2357 throughout the monitoring period. Concentrations in these wells were within the expected ranges for shallow groundwater across Taranaki.

The full groundwater chemistry results are shown in Appendix II.

2.2 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 the consent holder. 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 courses of non-compliance or failure to maintain good practices. A pro-active approach that in the first instance avoids issues occurring is favoured.

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

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

In the 2014-2015 period, the Council was not required to undertake significant additional investigations and interventions, or record incidents, in association with STOS's conditions in these resource consents or provisions in Regional Plans.

3. Discussion

3.1 Environmental effects of hydraulic fracturing on useable freshwater

This is a report regarding monitoring for residual environmental effects post hydraulic fracturing that occurred between June and December 2013.

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

The results of post-fracturing groundwater sampling carried out in the vicinity of the KA-14, KA-17 and KA-19 wells showed only very minor variations in water composition in comparison to baseline results. The minor variations in some analytes are a result of natural variations in water composition and unrelated to fracturing activities.

No traces of substances associated with hydraulic fracturing fluids, or hydrocarbons relating to fracturing activities were present in the groundwater during the monitoring period.

Methane was detected in all wells apart from GND2333. Methane/ethane ratios were calculated for GND2352 and GND1689 and indicate the gas is biogenic in origin and not derived from deep gas resevoirs. In all other wells, concentrations were within the expected range for shallow groundwater in Taranaki.

In summary, the monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by STOS prior to the monitoring period being reported, had no subsequential adverse affects on local groundwater resources.

3.2 Evaluation of performance

A tabular summary of STOS's compliance record for the year under review is set out in Tables 3-5.

Table 3 Summary of performance for consent 7995-1

Purpose: *To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3,000 mTVDss beneath the KA1/7/19/20 wellsite*		
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 (groundwater or surface water)	Results of groundwater and surface water 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 the second and subsequent discharges	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 60 days after the hydraulic fracturing programme is completed	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
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. No hydrocarbon based hydraulic fracturing fluid shall be discharged	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 4 Summary of performance for consent 7994-1

Purpose: *To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3000 mTVDss beneath the KA4/14 wellsite*		
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 (groundwater or surface water)	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 the second and subsequent discharges	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 60 days after the hydraulic fracturing programme is completed	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
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. No hydrocarbon based hydraulic fracturing fluid shall be discharged	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

Table 5 Summary of performance for consent 7998-1

Purpose: *To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3000 mTVDss beneath the KA-6/11/17 wellsite*		
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 (groundwater or surface water)	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 the second and subsequent discharges	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 60 days after the hydraulic fracturing programme is completed	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
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

Purpose: *To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3000 mTVDss beneath the KA-6/11/17 wellsite*		
Condition requirement	Means of monitoring during period under review	Compliance achieved?
13. No hydrocarbon based hydraulic fracturing fluid shall be discharged	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 environmental performance and compliance in respect of this consent		High

During the year, STOS demonstrated a high level of environmental and high level of administrative performance with the resource consents as defined in Section 1.1.4.

3.3 Recommendations from the 2012-2014 Biennial Report

In the 2012-2014 Biennial Report, it was recommended:

1. THAT during the 2014-2015 year, a further round of groundwater sampling be carried out across all sites previously surveyed to assess for any delayed effects on local groundwater resources.

   The recommendation was implemented in the 2014-2015 period.

2. THAT following an assessment of the results of the groundwater sampling recommended above, a review be undertaken to determine if any further monitoring is warranted, or whether the programmes can be discontinued, provided no further fracturing occurs at any of the wellsites which were the subject of this programme.

   It was decided that the monitoring programme be discontinued. If any further fracturing occurs at any of the wellsites, a monitoring programme should be reinstated.

3. THAT the option for a review of resource consents in June 2015, as set out in condition 14 of the consents, is not exercised, on the grounds that the current conditions of the consents are adequate to ensure that any significant adverse effects on the environment are avoided.

   There was no review of any DWI consent held by STOS during the 2014-2015 period as it was deemed that the conditions of each consent were adequate to deal with the potential adverse effects of the activity.

3.4 Alterations to monitoring programmes for 2015-2016

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

industrial processes within Taranaki emitting to the atmosphere/discharging to the environment.

It is proposed that for the 2015-2016 year, no further monitoring should be carried out in relation to the fracturing events at the wellsites discussed in this report. Monitoring should recommence, however, if any further fracturing is undertaken at the site.

3.5 Exercise of optional review of consent

Resource consents 7995-1, 7996-1 and 7996-1 provide for an optional review of the consent an annual basis, with the next optional review date being June 2016. Condition 14 of each of the consents allows the Council to review consent conditions to ensure they are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time. The Council can also review the consent in order to further specify the best practicable option and/or to ensure that hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

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

4. Recommendations

1. THAT the monitoring programme be discontinued, providing no further fracturing occurs at any of the wellsites which were the subject of this programme.

2. THAT the option for a review of resource consent(s) in June 2016, as set out in condition 14 of the consents, is not exercised, on the grounds that the current conditions of the consents are adequate to ensure that any significant adverse effects on the environment are avoided.

Glossary of common terms and abbreviations

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

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/m^3	Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.
Incident	An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred.
Intervention	Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.
Investigation	Action taken by Council to establish the circumstances/events surrounding an incident including any allegations of an incident.
Macroinvertebrate	An invertebrate that is large enough to be seen without the use of a microscope.
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.
Median flow	The flow that is exceeded 50% of the time over a given time period.
mS/m	Millisiemens per metre.
m^3	Cubic metre (1,000 litres).
pH	A numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline. The scale is logarithmic i.e. a change of 1 represents a ten-fold change in strength. For example, a pH of 4 is ten times more acidic than a pH of 5.
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.

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

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

Shell Todd Oil Services Ltd (2013) KA-14 Pre-Fracturing Discharge Report

Shell Todd Oil Services Ltd (2013) KA-14 Post-Fracturing Discharge Report

Shell Todd Oil Services Ltd (2013) KA-17 Pre-Fracturing Discharge Report

Shell Todd Oil Services Ltd (2013) KA-17 Post-Fracturing Discharge Report

Shell Todd Oil Services Ltd (2013) KA-19 Pre-Fracturing Discharge Report

Shell Todd Oil Services Ltd (2014) KA-19 Post-Fracturing Discharge Report

Stark JD, (1998) SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. *New Zealand Journal of Marine and Freshwater Research 32(1)*: 55-66.

Taranaki Regional Council (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 consents held by STOS

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:	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-4/14 wellsite at or about (NZTM) 1700895E-5632589N
Expiry Date:	1 June 2017
Review Date(s):	June 2012, June 2013, June 2014, June 2015, June 2016
Site Location:	KA-4/14 wellsite, 598 Palmer Road, Kapuni
Legal Description:	Lot 1 DP 9050 Blk XII XVI Kaupokonui SD (Discharge source & site)
Catchment:	Waiokura

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:	Shell Todd Oil Services Ltd Private Bag 2035 NEW PLYMOUTH 4342
Decision Date:	5 April 2012
Commencement Date:	5 April 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-6/11/17 wellsite at or about (NZTM) 1701956E-5627688N
Expiry Date:	1 June 2017
Review Date(s):	June 2012, June 2013, June 2014, June 2015, June 2016
Site Location:	KA-6/11/17 wellsite, 849 Ahipaipa Road, Kapuni
Legal Description:	Lot 1 DP 10950 Blk XVI Kaupokonui SD (Discharge source & site)
Catchment:	Inaha

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.

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 5 April 2012

For and on behalf of
Taranaki Regional Council

_____

Director-Resource Management

Appendix II

Groundwater chemistry results

Parameter	Unit	GND1689				GND2333			
		Pre HF	Post HF			Pre HF	Post HF		
Sample Date		29/04/2013	16/08/2013	05/12/2013	05/12/2014	23/04/2013	16/08/2013	06/12/2013	04/12/2014
Lab Number		1129270.1	1168498.2	138155	1412327	1127519.3	1168498.1	138154	1412326
Sum of Anions	meq/L	6	6.5	4.1	8.9	2	2.1	2.2	2.1
Sum of Cations	meq/L	7.1	7.8	4.3	10.4	1.98	2.1	2.2	2.2
pH	pH Units	7.3	6.8	9.1	6.9	7	6.5	6.60	6.34
Total Alkalinity	g/m3 as CaCO3	220	230	128	330	47	46	46	49
Bicarbonate	g/m3 at 25°C	270	280	139	400	57	57	56.1	59.8
Total Hardness	g/m3 as CaCO3	42	84	21	91	58	63	63	68
Electrical Conductivity (EC)	mS/m	58.9	64.9	43.4	88.7	21.9	22.8	24.3	22.6
Total Dissolved Solids (TDS)	g/m3	350	380	260	540	164	163	172	173
Dissolved Barium	g/m3	0.091	0.125	0.03	0.22	0.0099	0.0138	-	-
Dissolved Bromine	g/m3	-	0.29	0.27	0.6	-	0.086	0.081	0.085
Dissolved Calcium	g/m3	7.3	14.2	6.8	13.9	13.6	14.2	14.8	15.4
Dissolved Copper	g/m3	<0.0005	< 0.0005	0.0009	<0.0005	0.0017	0.0017	0.0011	0.0005
Dissolved Iron	g/m3	10.7	38	2.7	49	< 0.02	< 0.02	<0.02	<0.02
Dissolved Magnesium	g/m3	5.6	11.7	1.09	13.8	5.9	6.6	6.2	7.2
Dissolved Manganese	g/m3	0.73	2.2	0.124	2.4	0.0012	< 0.0005	0.0015	<0.0005
Dissolved Mercury	g/m3	< 0.00008	< 0.00008	<0.00008	<0.00008	< 0.00008	< 0.00008	<0.00008	<0.00008
Dissolved Nickel	g/m3	0.0006	< 0.0005	0.001	<0.0005	< 0.0005	< 0.0005	<0.0005	<0.0005
Dissolved Potassium	g/m3	22	24	15.2	31	4.4	4.3	6.5	4.1
Dissolved Sodium	g/m3	122	92	78	137	16.1	16.5	16.9	16.8
Dissolved Zinc	g/m3	0.0036	0.068	0.092	0.0051	0.0088	0.0016	0.0172	<0.0010
Bromide	g/m3	0.14	-	-	-	0.09	-	0.081	0.085
Chloride	g/m3	59	65	54	84	17.9	18.9	20	18.1
Nitrite-N	g/m3	< 0.002	< 0.002	<0.002	<0.02	< 0.002	< 0.002	<0.002	<0.002
Nitrate-N	g/m3	0.004	0.006	<0.002	<0.02	3.5	3.4	4.2	4.0
Nitrate-N + Nitrite-N	g/m3	0.005	0.008	<0.002	<0.02	3.5	3.4	4.2	4.0
Sulphate	g/m3	0.6	< 0.5	<0.5	0.6	16.7	18.2	19.0	16.4
Ethylene glycol	g/m3	< 4	< 4	<4	<4	< 4	6	<4	<4
Propylene glycol	g/m3	< 4	< 4	<4	<4	< 4	< 4	<4	<4
Methanol	g/m3	< 2	< 2	<2	<2	< 2	< 2	<2	<2
Benzene	g/m3	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010
Toluene	g/m3	0.0032	0.0019	0.0047	<0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010
Ethylbenzene	g/m3	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010
m&p-Xylene	g/m3	< 0.002	< 0.002	<0.002	<0.002	< 0.002	< 0.002	<0.0010	<0.0010
o-Xylene	g/m3	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	<0.002	<0.002
Formaldehyde	g/m3	< 0.02	< 0.02	<0.02	<0.02	< 0.02	< 0.02	<0.02	<0.02
Ethane	g/m3	< 0.003	< 0.003	0.004	<0.003	< 0.003	< 0.003	<0.003	<0.003
Ethylene	g/m3	< 0.004	< 0.004	<0.003	<0.003	< 0.004	< 0.004	<0.003	<0.003
Methane	g/m3	4.4	1.37	12.6	5.9	< 0.002	< 0.002	<0.002	<0.002
C7 - C9	g/m3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m3	< 0.7	< 0.7	<0.7	<0.7	< 0.7	< 0.7	<0.7	<0.7

Parameter	Unit	GND1689				GND2333			
		Pre HF	Post HF			Pre HF	Post HF		
Sample Date		29/04/2013	16/08/2013	05/12/2013	05/12/2014	23/04/2013	16/08/2013	06/12/2013	04/12/2014
Lab Number		1129270.1	1168498.2	138155	1412327	1127519.3	1168498.1	138154	1412326
Sum of Anions	meq/L	6	6.5	4.1	8.9	2	2.1	2.2	2.1
Sum of Cations	meq/L	7.1	7.8	4.3	10.4	1.98	2.1	2.2	2.2
pH	pH Units	7.3	6.8	9.1	6.9	7	6.5	6.60	6.34
Total Alkalinity	g/m3 as CaCO3	220	230	128	330	47	46	46	49
Bicarbonate	g/m3 at 25°C	270	280	139	400	57	57	56.1	59.8
Total Hardness	g/m3 as CaCO3	42	84	21	91	58	63	63	68
Electrical Conductivity (EC)	mS/m	58.9	64.9	43.4	88.7	21.9	22.8	24.3	22.6
Total Dissolved Solids (TDS)	g/m3	350	380	260	540	164	163	172	173
Dissolved Barium	g/m3	0.091	0.125	0.03	0.22	0.0099	0.0138	-	-
Dissolved Bromine	g/m3	-	0.29	0.27	0.6	-	0.086	0.081	0.085
Dissolved Calcium	g/m3	7.3	14.2	6.8	13.9	13.6	14.2	14.8	15.4
Dissolved Copper	g/m3	<0.0005	< 0.0005	0.0009	<0.0005	0.0017	0.0017	0.0011	0.0005
Dissolved Iron	g/m3	10.7	38	2.7	49	< 0.02	< 0.02	<0.02	<0.02
Dissolved Magnesium	g/m3	5.6	11.7	1.09	13.8	5.9	6.6	6.2	7.2
Dissolved Manganese	g/m3	0.73	2.2	0.124	2.4	0.0012	< 0.0005	0.0015	<0.0005
Dissolved Mercury	g/m3	< 0.00008	< 0.00008	<0.00008	<0.00008	< 0.00008	< 0.00008	<0.00008	<0.00008
Dissolved Nickel	g/m3	0.0006	< 0.0005	0.001	<0.0005	< 0.0005	< 0.0005	<0.0005	<0.0005
Dissolved Potassium	g/m3	22	24	15.2	31	4.4	4.3	6.5	4.1
Dissolved Sodium	g/m3	122	92	78	137	16.1	16.5	16.9	16.8
Dissolved Zinc	g/m3	0.0036	0.068	0.092	0.0051	0.0088	0.0016	0.0172	<0.0010
Bromide	g/m3	0.14	-	-	-	0.09	-	0.081	0.085
Chloride	g/m3	59	65	54	84	17.9	18.9	20	18.1
Nitrite-N	g/m3	< 0.002	< 0.002	<0.002	<0.02	< 0.002	< 0.002	<0.002	<0.002
Nitrate-N	g/m3	0.004	0.006	<0.002	<0.02	3.5	3.4	4.2	4.0
Nitrate-N + Nitrite-N	g/m3	0.005	0.008	<0.002	<0.02	3.5	3.4	4.2	4.0
Sulphate	g/m3	0.6	< 0.5	<0.5	0.6	16.7	18.2	19.0	16.4
Ethylene glycol	g/m3	< 4	< 4	<4	<4	< 4	6	<4	<4
Propylene glycol	g/m3	< 4	< 4	<4	<4	< 4	< 4	<4	<4
Methanol	g/m3	< 2	< 2	<2	<2	< 2	< 2	<2	<2
Benzene	g/m3	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010
Toluene	g/m3	0.0032	0.0019	0.0047	<0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010
Ethylbenzene	g/m3	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010
m&p-Xylene	g/m3	< 0.002	< 0.002	<0.002	<0.002	< 0.002	< 0.002	<0.0010	<0.0010
o-Xylene	g/m3	< 0.0010	< 0.0010	<0.0010	<0.0010	< 0.0010	< 0.0010	<0.002	<0.002
Formaldehyde	g/m3	< 0.02	< 0.02	<0.02	<0.02	< 0.02	< 0.02	<0.02	<0.02
Ethane	g/m3	< 0.003	< 0.003	0.004	<0.003	< 0.003	< 0.003	<0.003	<0.003
Ethylene	g/m3	< 0.004	< 0.004	<0.003	<0.003	< 0.004	< 0.004	<0.003	<0.003
Methane	g/m3	4.4	1.37	12.6	5.9	< 0.002	< 0.002	<0.002	<0.002
C7 - C9	g/m3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m3	< 0.7	< 0.7	<0.7	<0.7	< 0.7	< 0.7	<0.7	<0.7

Parameter	Unit	GND0093			GND2011			GND2348			GND2357		
		Pre HF	Post HF		Pre HF	Post HF		Pre HF	Post HF		Pre HF	Post HF	
Sample Date		06/05/2013	13/03/2014	05/03/2015	23/05/2013	14/03/2014	12/03/2015	01/05/2013	13/03/2014	27/02/2015	02/05/2013	14/03/2014	05/03/2015
Lab Number		1132343.1	1248043.1	151298	1138819.1	1248629.2	151299	1130620.1	1248043.2	151153	1131224.2	1248629.1	151297
Sum of Anions	meq/L	2.3	2.2	2.5	3.4	3.3	2.3	4.3	3.3	3.8	2.5	1.93	6.9
Sum of Cations	meq/L	2.1	2	3.0	3.5	3.2	2.4	4.2	3.9	4.7	1.81	2.3	6.6
pH	pH Units	6.4	7.9	7.00	8.2	8.2	7.75	6.6	6.8	7.02	6.8	8.7	7.53
Total Alkalinity	g/m3 as CaCO3	53	67	79	147	146	97	49	50	53	85	75	310
Bicarbonate	g/m3 at 25°C	65	81	97	176	176	117	60	60	64	104	87	370
Total Hardness	g/m3 as CaCO3	34	39	47	92	87	60	80	76	90	25	25	154
Electrical Conductivity (EC)	mS/m	24.7	23.2	25.4	31.6	31.3	22.4	45.2	38.7	43.3	19.4	17	63.7
Total Dissolved Solids (TDS)	g/m3	130	112	162	198	210	156	330	250	310	162	151	330
Dissolved Barium	g/m3	0.116	0.107	-	0.0036	0.0036	-	0.066	0.056	-	0.0196	0.023	-
Dissolved Bromine	g/m3	-	0.181	0.150	-	-	0.041	-	0.3	0.32	-	0.042	0.134
Dissolved Calcium	g/m3	8.9	9.7	10.6	0.051	0.05	15.0	17.5	16.6	18.8	5.9	5.6	29
Dissolved Copper	g/m3	< 0.0005	< 0.0005	<0.0005	24	22	0.0005	< 0.0005	0.0005	<0.0005	0.0035	0.0149	<0.0010
Dissolved Iron	g/m3	1.34	0.45	12.8	< 0.0005	< 0.0005	0.04	32	27	34	0.89	9.1	11.0
Dissolved Magnesium	g/m3	3	3.6	4.9	0.11	0.06	5.3	8.8	8.4	10.6	2.6	2.7	19.8
Dissolved Manganese	g/m3	0.157	0.146	0.34	8	7.6	0.0125	0.57	0.53	0.63	0.051	0.05	0.27
Dissolved Mercury	g/m3	< 0.00008	< 0.00008	<0.00008	0.026	0.021	<0.00008	< 0.00008	< 0.00008	<0.00008	< 0.00008	< 0.00008	<0.00008
Dissolved Nickel	g/m3	0.0006	< 0.0005	<0.0005	< 0.00008	< 0.00008	<0.0005	0.0009	0.002	0.0007	0.001	0.0014	0.0006
Dissolved Potassium	g/m3	9.5	9	10.0	< 0.0005	< 0.0005	4.1	8.2	8.7	9.6	3.9	5.1	16.1
Dissolved Sodium	g/m3	26	23	28	4.8	4.8	24	28	27	33	23	25	49
Dissolved Zinc	g/m3	0.47	0.042	4.9	34	31	0.0031	0.65	0.47	0.71	5.7	7.4	20
Bromide	g/m3	0.08	-	0.150	0.027	0.0032	0.041	0.3	-	0.32	< 0.05	-	0.134
Chloride	g/m3	34	30	31	15	14.8	11.6	99	83	98	14	13.3	26
Nitrite-N	g/m3	< 0.002	< 0.002	<0.002	< 0.002	< 0.002	<0.002	< 0.02	< 0.02 #1	<0.2	< 0.002	< 0.002	<0.002
Nitrate-N	g/m3	< 0.002	0.007	<0.002	< 0.002	0.01	0.25	< 0.02	< 0.02	<0.2	0.005	< 0.002	<0.002
Nitrate-N + Nitrite-N	g/m3	0.003	0.008	<0.002	< 0.002	0.011	0.25	< 0.02	< 0.02 #1	<0.2	0.007	< 0.002	<0.002
Sulphate	g/m3	14.3	0.5	<0.5	< 0.5	< 0.5	2.3	25	< 0.5	<0.5	18.1	2.8	<0.5
Ethylene glycol	g/m3	< 4	< 4	<4	< 4	< 4	<4	< 4	< 4	<4	< 4	< 4	<4
Propylene glycol	g/m3	< 4	< 4	<4	< 4	< 4	<4	< 4	< 4	<4	< 4	< 4	<4
Methanol	g/m3	< 2	< 2	<2	< 2	< 2	<2	< 2	2	<2	< 2	< 2	<2
Benzene	g/m3	< 0.0010	< 0.0010	<0.0010	< 0.0010	< 0.0010	<0.0010	0.0019	< 0.0010	0.0019	< 0.0010	< 0.0010	<0.0010
Toluene	g/m3	< 0.0010	< 0.0010	<0.0010	< 0.0010	< 0.0010	<0.0010	< 0.0010	< 0.0010	<0.0010	< 0.0010	< 0.0010	0.0018
Ethylbenzene	g/m3	< 0.0010	< 0.0010	<0.0010	< 0.0010	< 0.0010	<0.0010	< 0.0010	< 0.0010	<0.0010	< 0.0010	< 0.0010	<0.0010
m&p-Xylene	g/m3	< 0.002	< 0.002	<0.0010	< 0.002	< 0.002	<0.0010	< 0.002	< 0.002	<0.0010	< 0.002	< 0.002	<0.0010
o-Xylene	g/m3	< 0.0010	< 0.0010	<0.002	< 0.0010	< 0.0010	<0.002	< 0.0010	< 0.0010	<0.002	< 0.0010	< 0.0010	<0.002
Formaldehyde	g/m3	< 0.02	< 0.02	<0.02	< 0.02	< 0.02	<0.02	< 0.02	< 0.02	<0.02	< 0.02	< 0.02	0.02
Ethane	g/m3	< 0.003	< 0.003	<0.003	< 0.003	< 0.003	<0.003	< 0.003	< 0.003	<0.003	< 0.003	< 0.003	<0.003
Ethylene	g/m3	< 0.004	< 0.003	<0.003	< 0.003	< 0.003	<0.003	< 0.004	< 0.003	<0.003	< 0.004	< 0.003	<0.003
Methane	g/m3	3.1	2.1	2.3	1.54	3.6	1.95	0.65	1.02	1.23	3.7	8	16.1
C7 - C9	g/m3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5.2	< 0.2	< 0.2
C15 - C36	g/m3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	6.6	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m3	< 0.7	< 0.7	<0.7	< 0.7	< 0.7	<0.7	< 0.7	< 0.7	<0.7	11.8	< 0.7	<0.7