

Greymouth Petroleum
Acquisitions Company Limited
Deep Well Injection
Monitoring Programme
Biennial Report
2007-2009

Technical Report 2009–93

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Executive summary

This Taranaki Regional Council's Biennial Report for the period July 2007-June 2009 covers the monitoring programme associated with resource consents 4921, 5312, 6659 6728, 7068, 7128 and 7390 held by Greymouth Petroleum Acquisitions Limited [the Company] for their deep well injection and water flooding activities. This is the second monitoring report to be prepared by the Taranaki Regional Council to date on this monitoring programme.

During the period under review 2007-2009, Greymouth Petroleum Limited exercised three resource consents to:

- 1) discharge up to 200 cubic metres/day [5 litres/second] of produced water, well drilling fluids and commercial wastewater from hydrocarbon exploration operations via deepwell injection into the Mount Messenger Formation (4921) and,
- 2) discharge up to 550 cubic metres per day to depths greater than 1000 metres below the ground via injection well for enhanced petroleum recovery purposes at the Kaimiro-O wellsite (5312) and,
- 3) to discharge produced water from hydrocarbon exploration and production operations by deepwell injection at the Turangi-A wellsite (7390) via Turangi-3 well.

This report describes the monitoring programme implemented by the Taranaki Regional Council to assess the Company's environmental performance in relation to the deep well and water flooding activities during 2007-2009 and the results and environmental effects of the Company's activities. In the 2007-2009 monitoring period the Council carried out a total of nine routine inspections of the Company's deep well injection sites. The Company has submitted electronic records and provided information on the consents matter of this report upon request. During this two-year monitoring period the Council collected four samples of injectate. This report contains the results along with the comments associated with the inspections conducted during the period under review.

In the 2007-2009 monitoring period, there were no incidents recorded by the Council that were associated with any of the Company's deep well injection sites.

Records for Kaimiro-11, consent 4921-1, (the first consent referenced above), show that a total of 32,862 m³ of waste was discharged in the two-year period. The average daily volume discharged in this well was 45.5 m³ and the average daily pressure 8.0 bars. Maximum injection pressure recorded at the wellhead was 43 bars. The maximum daily discharge volume of 200 m³ authorised under the consent was complied with at all times, however, the maximum flow-rate consented, 5 litres per second, was exceeded on three occasions.

Records for Kaimiro-17, consent 5312-1, show that a total of 133,042 m³ of water for flooding purposes was discharged in the two-year period. The average daily volume discharged in this well was 182.2 m³ and the average daily pressure 96.3 bars. Maximum injection pressure recorded at the wellhead was 100 bars. The maximum daily discharge volume of 550 m³ authorised under the consent was complied with at all times.

Lastly, records for Turangi-3, consent 7390, show that a total of 14,874 m³ of produced water has been re-injected since the consent was first exercised (27 November 2008); the maximum

pressure registered has been 34 bars (maximum pressure consented is 55 bars) and the maximum volume 112 m³ (maximum volume consented is 300m³).

During 2007-2009, the Company achieved a good standard of environmental performance with respect to consents 5312-1, 4921-1 and 7390-1, and no unauthorised incidents were associated with any of the Company's well injection sites.

This report includes recommendations for the next monitoring period.

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1. Introduction

This Taranaki Regional Council's Biannual Report for the period July 2007-June 2009 covers the monitoring programme associated with resource consents **4921, 5312, 6659, 6728, 7068, 7128** and **7390** held by Greymouth Petroleum Acquisitions Limited [the Company] for their deep well injection and water flooding activities. This is the second monitoring report to be prepared by the Taranaki Regional Council to date on this monitoring programme.

Greymouth's operations base was the former Petroleum Corporation of New Zealand [Petrocorp]. Greymouth Petroleum is a New Zealand company that has been engaged in oil and gas exploration and development in the Taranaki Basin since July 2000 and holds resource consents to discharge produced waters, well drilling fluids, and commercial wastewater via deep well injection and to discharge fresh groundwater at one site for hydrocarbon recovery purposes.

The Company also holds two consents for its operation at the Kaimiro-J site¹: consent **6218-1** relates to the discharge of sand waste- from hydrocarbon production within the Kaimiro Field onto land for storage, which includes the discharge of stormwater from the site onto and into land and into an unnamed tributary of the Mangaoraka Stream in the Waiongana catchment. Consent **4613-2**, allows the discharge of emissions into the air from the flaring of hydrocarbons together with miscellaneous emissions associated with hydrocarbon exploration operations at the Kaimiro-J site; these are reported on separately. In addition to these two consents, the Company also has exercised consent **7390**, which was granted on 10 October 2008; it authorises the discharge of produced water from hydrocarbon exploration and production operations by deepwell injection at the Turangi-A wellsite (via Turangi-3 well).

Greymouth Petroleum Limited has been granted five more consents for deep well injection and is -at the time of the preparation of this report- applying for additional resource consent. Table 1 show the list of consents for deep well injection held by the Company as of February 2010.

1.1 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 and the Council's obligations and general approach to monitoring sites through annual programmes, the resource consents held by Greymouth Petroleum Acquisitions Limited, the nature of the monitoring programme in place for the period under review, and a description of the activities and operations conducted at the Company's deep well injection sites.

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

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

¹ Disposal via injection well GND1377 authorised by Resource Consent 4921 is also located at Kaimiro-J wellsite.

Section 4 presents recommendations to be implemented in the 2009-2011 monitoring year.

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

Table 1 Summary of re-injection consents held by the Company during the period under review

| Consent Number | Description | Location | Expires |
|-------------------|---|--------------------|------------|
| 4921-1 | To discharge up to 200 cubic metres/day [5 litres/second] of produced water, well drilling fluids and commercial wastewater from hydrocarbon exploration operations by deepwell injection into the Matemateaonga Formation at the Kaimiro-J wellsite ² | Upland Road | 01/06/2014 |
| 5312 | To discharge up to 550 cubic metres/day of water to depths greater than 1000 metres below the ground via an injection well for enhanced petroleum recovery purposes at the Kaimiro-O Wellsite | Alfred Road | 01/06/2014 |
| 6659 | To discharge waste drilling fluids and/or produced water from hydrocarbon exploration and production operations by deepwell injection at the Korito wellsite | Kent Road | 01/06/2020 |
| 6728 | To discharge waste drilling fluids and/or produced water from hydrocarbon exploration and production operations by deepwell injection at the Moturoa-5 wellsite | Oceanview Road | 01/06/2020 |
| 7068 | To discharge waste drilling fluids and/or produced water from hydrocarbon exploration and production operations by deepwell injection at the Ngatoro-E wellsite | Upper Dudley Road | 01/06/2021 |
| 7128 | To discharge waste drilling fluids, fracking fluids and/or produced water from hydrocarbon exploration and production operations by deepwell injection at the Omoana-1 wellsite | Mataiwhetu Road | 01/06/2022 |
| 7390 | To discharge produced water from hydrocarbon exploration and production operations by deepwell injection at the Turangi-A wellsite (via Turangi-3 well) | Upper Turangi Road | 01/06/2027 |
| 7493 ³ | <i>To discharge produced water from hydrocarbon exploration and production operations by deepwell injection at the Salisbury wellsite</i> | Johns Road | NA |

1.2 The Resource Management Act (1991) and compliance monitoring reports

The Resource Management Act 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 a discharger, and may include cultural and socio-economic effects;

² Location and depth indicate that the receiving formation is the Mount Messenger.

³ Resource consent application [6261] being processed at the time of writing this report.

- (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 (eg, 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 Taranaki Regional Council is recognising the comprehensive meaning of “effects” inasmuch as is appropriate for each discharge source. Monitoring programmes are not only based on existing permit conditions, but also on the obligations of the Resource Management Act to assess the effects of the exercise of consents.

In accordance with section 35 of the Resource Management Act 1991, the Council undertakes compliance monitoring for consents and rules in regional plans; and maintains an overview of performance of resource users against regional plans and consents.

Compliance monitoring, including impact monitoring, also enables the Council to continuously assess its own performance in resource management as well as that of resource users particularly consent holders. It further enables the Council to continually re-evaluate its approach and that of consent holders to resource management, and, ultimately, through the refinement of methods, to move closer to achieving sustainable development of the region’s resources.

1.2.1 Evaluation of environmental performance

Besides discussing the various details of the performance and extent of compliance during the period under review, this report also assigns an overall rating. The categories used by the Council and their interpretation are as follows:

- a **high** level of environmental performance and compliance indicates that essentially there were no adverse environmental effects to be concerned about, and no, or trivial (such as data supplied after a deadline) non-compliance with conditions.
- a **good** level of environmental performance and compliance indicates that adverse environmental effects of activities during the year were negligible or minor at most, items of concern were resolved positively, co-operatively, and quickly, the Council did not record any verified unauthorised incidents involving significant environmental impacts and was not obliged to issue any abatement notices, there were perhaps some items noted on inspection notices for attention but these items were not urgent nor critical, and follow-up inspections showed they have been dealt with.
- **improvement desirable** indicates that the Council may have been obliged to record a verified unauthorised incident involving significant environmental impacts against the company, and/or abatement notices may have been issued; there were adverse environmental effects arising from activities and intervention by Council staff was required, and there were matters that required urgent intervention, took some time to resolve, or remained unresolved at end of the period under review.

- **poor** performance is used when there were grounds for prosecution or infringement notice

1.3 Process description

Deep well injection is a liquid waste disposal technology. This alternative uses specially designed injection wells to place treated or untreated liquid waste into geologic formations or confined saline aquifers that have no potential to allow migration of contaminants into freshwater aquifers. A typical injection well consists of concentric pipes, which extend several thousand feet down from the surface level into highly saline, permeable injection zones that are confined vertically by impermeable strata.

In Taranaki, contaminants disposed of by deep well injection are limited to produced waters, water-based drilling fluid waste, and contaminated well-site stormwater. The Council has approved on special occasions, the discharge of small volumes of other specified contaminants by deep well injection.

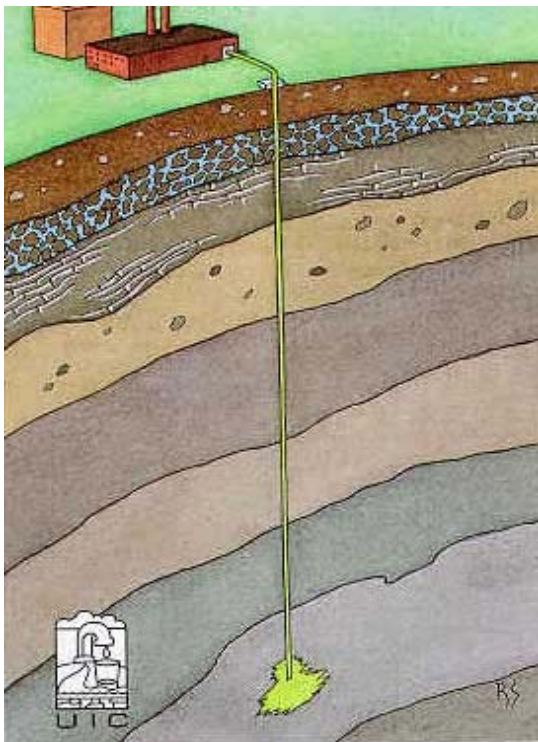


Figure 1 Underground injection control

Injection water for pressurization is a process used to maintain reservoir pressures and to drive hydrocarbon recovery (water-flooding). The water is injected for pressure support of the reservoir (*voidage replacement*) and/or to displace the oil from the reservoir, and push it towards an oil production well. Figure 1 illustrates an underground injection model.

Water-flooding is a secondary recovery process that is implemented when natural reservoir pressures decline, largely due to hydrocarbon extraction. The water injection method used in oil production consists of injecting water back into the reservoir to increase pressure to stimulate production. Technically, either produced waters or fresh water, or a combination of the two, are used for water-flooding.

1.3.1 What Is produced water?

In subsurface formations, naturally occurring rocks are generally permeated with fluids such as water, oil, or gas or some combination of these fluids. It is believed that the rock in most oil-bearing formations was completely saturated with water prior to the invasion and trapping of petroleum (Amyx et al. 1960).

The less dense hydrocarbons migrated to trap locations, displacing some of the water from the formation in becoming hydrocarbon reservoirs. Thus, reservoir rocks normally contain both petroleum hydrocarbons (liquid and gas) and water. Sources

of this water may include flow from above or below the hydrocarbon zone, flow from within the hydrocarbon zone, or flow from injected fluids and additives resulting from production activities. This water is frequently referred to as “formation water” and becomes produced water when the reservoir is produced and these fluids are brought to the surface.

Produced water is any water that is present in a reservoir with the hydrocarbon resource and is produced to the surface with the crude oil or natural gas. When hydrocarbons are produced, they are brought to the surface as a produced fluid mixture. The composition of this produced fluid is dependent on whether crude oil or natural gas is being produced and generally includes a mixture of either liquid or gaseous hydrocarbons, produced water, dissolved or suspended solids, produced solids such as sand or silt, and injected fluids and additives that may have been placed in the formation as a result of exploration and production activities.

Production of coal bed methane (CBM) involves removal of formation water so that the natural gas in the coal seams can migrate to the collection wells. This formation water is also referred to as produced water. It shares some of the same properties as produced water from oil or conventional gas production, but may be quite different in composition.

1.4 Resource consents

Greymouth Petroleum Acquisitions Limited [Greymouth] holds seven resource consents to non-agricultural discharges via deep well injection. Currently, three of them are being exercised.

These seven consents include a combined total of 55 special conditions setting out the requirements that the Company must satisfy. Following is a detailed description of the consents being exercised:

Consent **4921-1** [at Kaimiro-J wellsite] for deep well injection was obtained by Fletcher Challenge Energy Taranaki Limited in January 1996 [**TRK964921**] and later transferred to the Company, on 4 April 2002, and it has been exercised since.

Consent **4921-1** authorises the Company to discharge of up to 200 cubic metres per day [5 litres per second] of produced water, well drilling fluids, and commercial wastewater from hydrocarbon exploration operations by deepwell injection into the Matemateaonga Formation⁴ at GR: P19:092-265. This consent is due to expire on 1 June 2014. The next optional review is provided for in June 2008. The current consent has six special conditions as summarised below:

Special condition 1 prohibits the discharge from endangering or contaminating any freshwater aquifer.

Special conditions 2, 3, and 4 refer to information requirements.

Special condition 5 prohibits the discharge of radioactive waste.

⁴ Receiving formation is reported as being the Mount Messenger in Officer’s Report and by Crown Minerals.

Special condition 6 is a review provision.

Consent **TRK985312** [at Kaimiro-O wellsite] was also originally granted to Petrocorp Exploration Limited, but there are no records that indicate that it was ever exercised under their ownership. On 4 April 2002, the consent was transferred to Greymouth, and it has been exercised since then.

Consent **5312-1**, to discharge up to 550 m³/day of water at a maximum rate of 6.4 l/s to depths of greater than 1000 m for enhanced petroleum recovery purposes at the Kaimiro-O wellsite at or about GR:P19:087-249 via the Kaimiro-17 injection well at the Kaimiro-O wellsite. The consent is also due to expire on 1 June 2014 and has an optional review in June 2008. The current consent has two special conditions as summarised follows:

Special condition 1 prohibits the discharge from endangering or contaminating any freshwater aquifer.

Special condition 2 is a review provision.

Both consents were issued by the Taranaki Regional Council as resource consents under Section 87(e) of the Resource Management Act. Copies of the consent certificates are attached to Appendix I of this report.

Photograph 1 shows Kaimiro-J well-site with the (GND1377) disposal well; Figure 2 shows the locations of the resource consents for deep well injection and water flooding held by Greymouth at 30 June 2007, and Photograph 2 shows an aerial view of the Kaimiro-J site.

1.4.1 General

The Taranaki Basin has been the most explored and commercially successful hydrocarbon province in New Zealand to date. Oil and gas exploration and development has been on-going in the region for 145 years and since the first well in 1865, more than 300 exploration and production wells have been sunk in the basin. A large proportion of these wells have been drilled from onshore sites.

The morphology of the basin is complex, with numerous superimposed sub-basins, depocentres, areas of uplift, and interbedded volcanic structures. This has resulted in a range of exploration opportunities within a multiplicity of plays (Crown Minerals, 2007).

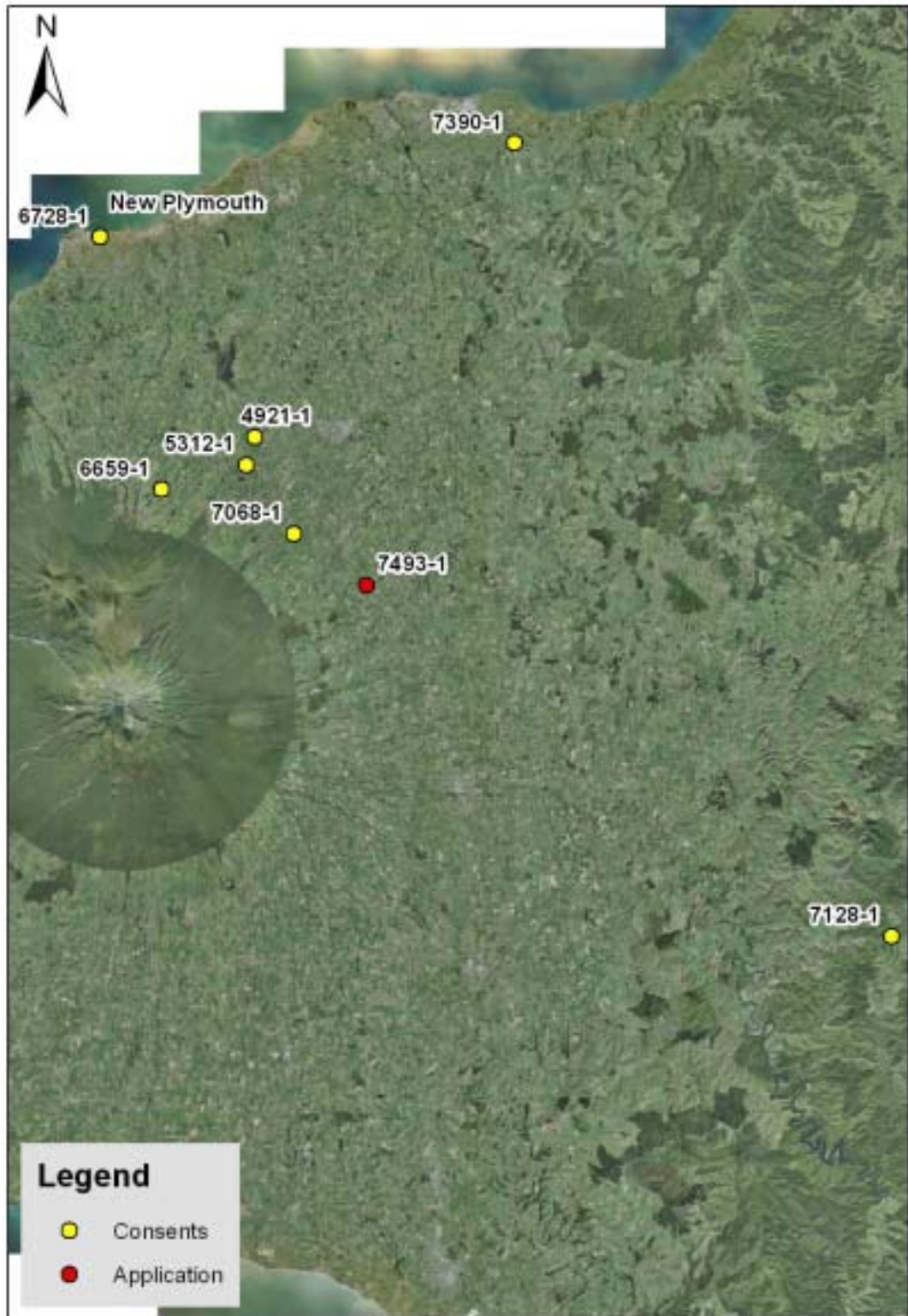


Figure 2 Geographical distribution of consented sites for well-deep injection under Greymouth Petroleum Limited administration

According to Crown Minerals, the Kaimiro Formation comprises a range of lower alluvial plain, delta or coastal plain and marginal marine lithofacies of Early Eocene age. Lithologies are primarily sandstone, mudstone and minor coal. Where thick sections have been penetrated, several depositional cycles are usually evident.

The Kaimiro oil and gas field is a mature onshore producer located 15 kilometres southeast of New Plymouth in the northern part of the Taranaki peninsula. The Kaimiro field is producing from 13 wells on six sites with associated oil and gas production facilities. Production commenced in 1984 and to September 2003, the production had reached 2.7 million barrels oil and 13 billion cubic feet of gas (including Moturoa)⁵.

The disposal of produced waters, waste drilling fluids, and contaminated well-site stormwater by deep well injection has been occurring in Taranaki since the initial development of the Kapuni Field in 1973. The collection, handling, treatment and disposal of produced waters from a producing field are major undertakings and, if done poorly, can have lasting adverse environmental effects. However, under appropriate conditions the disposal of produced waters should have minimal effects.

For the location of deepwell injection wells, local and geological conditions must be thoroughly investigated including such characteristics as structure, stratigraphy, composition and engineering properties of the underlying formations.

Produced waters contain, in addition to salts, hydrocarbon residues and free oil, process additives including anti-scaling agents, anti-corrosion agents, and biocides (until the 1980's, hexavalent and trivalent chromium were contained in anti corrosion agents in some processing systems).

Without treatment to an acceptable standard, the surface disposal of large volumes of produced water, particularly where it can enter surface water, is not an option because of the detrimental biological effects this practice might have, and because surface water resources are heavily relied on by the agricultural industry and the population in general.

Although methods are available to treat produced waters to a suitable standard for surface disposal, such as gas/steam stripping, biological, chemical adsorption and activated carbon, they are generally not practical, or economically viable given the large volumes concerned. The injection of produced waters back into the ground is presently the most cost-effective option for operators to dispose of this type of waste.

A typical injection well has a series of concentric casings which extend from the surface into the disposal interval. The disposal interval is required to be below the freshwater zone and confined vertically by impermeable, laterally persistent, strata. The surface casing should extend below the base of the freshwater zone and be cemented back to the surface. Inside the surface casing is a long string casing that extends down and possibly into the disposal interval. This casing should also be cemented back up the hole to seal off and isolate the disposal interval from the overlying fresh water zone. Waste is injected through the injection tubing inside the string casing, either through perforations in the long string, or out the end of the string casing into the open-hole section below.

⁵ Source: Crown Minerals – The Taranaki Basin producing fields information sheet.

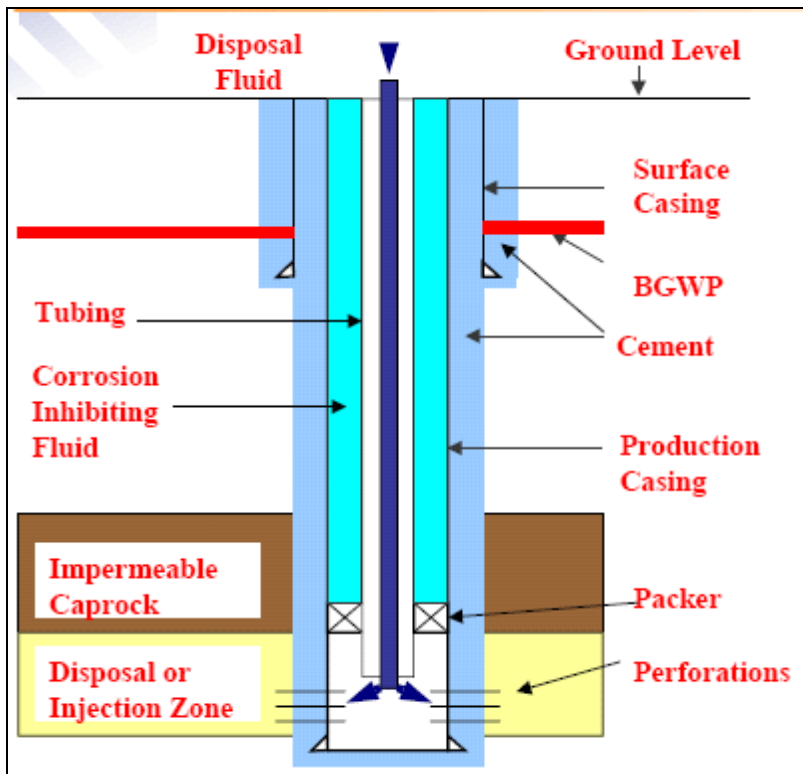


Figure 3 Schematic of well components for deep well injection⁶

The annular space in the string casing is filled with an inert, pressurised, fluid and is sealed at the bottom by a removable packer which prevents injected waste backing up and entering the annulus where it could escape. In other cases, wells are modified to dispose of waste material in a sealed interval of the annulus.

It has been well documented that low pH fluids will degrade some cements with time. The use of non-acid resistant cements in environments containing an aqueous solution of carbon dioxide can slowly dissolve the cement (carbonation). This can result in loss of zonal isolation and the escape of saline fluids beyond the intended zone via the well bore. Cements commonly used in Taranaki wells to isolate zones are Portland based (Class-G or Class-A). These cement types are not resistant to carbonation. While zonal isolation in many existing disposal wells has been achieved with Class-G or Class-A Portland based cement, the Taranaki Regional Council now requires the use of acid resistant cement (i.e. Thermalock, POZMIX, or LATEX 2000) in any new disposal wells.

Injection must be carried out via wells with sound structural integrity. The standard of construction and mechanical integrity of hydrocarbon wells falls under the Crown Minerals Act 1991 (CMA) and is monitored by the Chief Petroleum Inspector. The CMA has no jurisdiction over environmental effects, but does require operators to work within the Resource Management Act. Regional councils are responsible for monitoring environmental effects from hydrocarbon exploration and development

⁶ Source: Byrnes Tom, Resources Applications. Alberta Energy and Utilities Board. Requirements for Produced Water Disposal. July 2004.

activities under the RMA. Sections 15 and 30 of the Resource Management Act 1991 give regional councils responsibility for the discharge of contaminants into the environment. Discharges of contaminants onto or into land that may result in water contamination, may not take place unless expressly allowed by a rule in a regional plan, resource consent, or regulations.

The discharge of contaminants by deep well injection requires resource consent from the Taranaki Regional Council. The activity falls under Rule 51 of the Regional Freshwater Plan for Taranaki and is classified as a discretionary activity that may be non-notified.

At the time of writing this report, there were a total of twenty eight consents for deep well injection in the Province. However, many resource consents have been issued for relatively short-term activities during exploration phase drilling, and some may never be exercised.

Kaimiro-11 well (GND1377) was completed in November 1995 over the Mount Messenger 40" (MM40) sand for fluid disposal. Petrophysics conducted over the formation suggested that there were 14 metres of net sand with a porosity of 24% over a perforated interval of 30 metres. The MM40 unit was defined in the Assessment of Environmental Studies carried out by Petrocorp Exploration as being the first sand encountered stratigraphically below the MM50 bathyal mudstone unit.



Photograph 1 Kaimiro-11 – GND1377

The discharge occurs between 1643 and 1673 metres below ground level into the Mount Messenger Formation. The upper injection zone is confined by a regional extensive seal, the MM40 bathyal mudstone. The Mount Messenger Formation consists of late Miocene turbidites (Browne and Slatt, 2002). Small-scale sedimentary features are abundant throughout the formation. Studies conducted through the use of remote sensing, seismic experiments and well logs, and drill cores, indicate that portions of the Mount Messenger Formation comprise a series of base of slope fan

sandstones and siltstones together with conglomerates deposited in upper bathyal water depths.

1.4.2 Water discharge permits

Section 15(1)(b) of the Resource Management Act stipulates that no person may discharge any contaminant onto or into land in circumstances 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 or a rule in a regional plan, or national regulations.

Groundwater quality is of primary concern to the Regional Council with regard to deep well injection. Proportionally, more water is produced from a hydrocarbon field as more oil or gas is extracted and the productive life of the field diminishes. The issue of produced waters disposal is therefore expected to increase as many producing fields approach the ends of their lives, and as more fields are discovered and developed.

Waste material disposed of by deep well injection is typically highly saline and contains hydrocarbon residues and system additives. Well-site stormwater is generally less contaminated (in terms of salts concentration, hydrocarbon residues, and additives fluids) and there are generally lower volumes to deal with than produced water and drilling fluid waste. Greymouth's consents requirements and conditions were discussed above in Section 1.4.

1.5 Monitoring programme

1.5.1 Introduction

Section 35 of the Resource Management Act sets out an obligation for the Taranaki Regional Council to gather information, monitor, and conduct research on the exercise of resource consents, and the effects arising, within the Taranaki region.

The Taranaki Regional 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. Effective monitoring of deep well injection activities is reliant on the provision of information on a regular basis. This information is received by the Council as part of the Annual Compliance Monitoring Programme, which is implemented for the licensed activity in consultation with the consent holder each year.

An operating injection well should be monitored throughout its working life for any changes in injection conditions that may lead to system failure. An injection well operator has the responsibility of knowing what and where the injected produced water is and for keeping adequate operating records. When an injection well system permanently ceases operating, the well must be properly sealed and a record describing the method and date of sealing should be filed with the Taranaki Regional Council. The monitoring programme for deep well injection requires records to be kept (section 1.5.6). The programmes for 2007 to 2009 for the Company's deep well injection sites consisted of five primary components which are discussed in sections 1.5.2 to 1.5.6.

1.5.2 Programme liaison and management

There is generally a significant investment of time and resources by the Taranaki Regional Council in on going liaison with resource consent holders over consent conditions and their interpretation and application, in discussion over monitoring requirements, preparation for any reviews, renewals, or new consents, advice on the Council's environmental management strategies and the content of regional plans, and consultation on associated matters.

1.5.3 Site inspections

The monitoring programmes required one annual inspection of each active deep well injection site during the monitoring period. The inspections included viewing the injection well monitoring equipment and injection logs, and spot sampling of the injectate.

Periodic inspections of the surface facilities are important to be conducted as the risk of escape of injected fluids through or around the outside of the injection well itself is as important as the risk of leakage through permeable confining beds, fractures or unplugged wells.

1.5.4 Injectate sampling

The monitoring programme included sampling of the discharge (injectate) at active sites for laboratory analysis. Samples were analysed for pH, chlorides, alkalinity, conductivity, suspended solids, and total hydrocarbons.

Monitoring of volumes and chemistry of injected wastewater allow for estimates of the distance travelled and to provide permanent records. Common characteristics that should be monitored continuously are flow, suspended solids, pH, conductivity, temperature, density, dissolved oxygen and chlorine.

1.5.5 Groundwater quality

The monitoring programme included an option to sample up to three groundwater bores in the vicinity of any of the active disposal wells, or to install a bore specifically for this purpose, if warranted. This option would be exercised where, (a) there were grounds to suspect that the structural integrity of a disposal well, or the stratigraphic seals of the disposal interval, has been breached to the extent that contamination of a freshwater aquifer could be occurring as a result, and (b) there were no suitable existing wells to monitor effects. This has not been considered necessary to date.

1.5.6 Information requirements

The monitoring programme sets out the information that is required to be provided by the consent holder each year. An assessment of this information comprised the bulk of the monitoring for the period under review.

Prior to exercising a consent for deep well injection at a particular site, the consent holder is required to provide information on the following: depth of the freshwater-saline water transition at the disposal site; disposal well path and construction details; wellhead equipment and metering facilities; description of waste material; an

assessment of the suitability of disposal zones to accept the waste material; specific well engineering criteria that would trigger concerns about the mechanical integrity of the disposal well and/or disposal interval/s, and a contingency plan to cover such events.

Injection pressure is monitored to provide a record of reservoir performance and as evidence of compliance with regulatory restrictions. Injection pressures are limited to prevent hydraulic fracturing of the injection reservoir and confining beds, or damage to well facilities. Injection pressure should be limited at the wellhead to a value which will not initiate new fractures or propagate existing fractures in the confining zone adjacent to any aquifer that could be used for drinking. Injection pressure as well as flow data should be continuously recorded and made available to the Taranaki Regional Council upon request.

During the monitoring period, the Company discharged waste material via deep well injection through GND1377 [Kaimiro-11 located at Kaimiro-J]. Samples of the injectate to be discharged were taken and analysed; results are discussed in section 2.1.

For each active disposal well the consent holder is required to provide records of the discharge for each monitoring year as follows:

- Well name and location;
- Waste fluid source and type;
- Analytical results from injectate sampling;
- Daily volume injected;
- Daily hours of injection;
- Daily mean injection pressure.

2. Results

2.1 Inspections and results of discharge monitoring

In the 2007-2009 monitoring period the Council carried out a total of nine routine inspections (of which three were combined inspections on GND1377 & GND2106 that are located nearby each other) of the Company's deep well injection sites.

The Company has submitted electronic records and provided information on the consent requirements upon request. During this two-year monitoring period the Council collected four samples of injectate. Below are the results along with the comments associated with the inspections conducted during the period under review:

Consent 4921-1

Kaimiro-11 (GND1377)

Inspection on 2 August 2007

General inspection was carried out to two well sites. Kaimiro-11 [TRC code GND1377]: Site and equipment were found in good order. Injection occurring at time of visit: wellhead pressure 7 to 8 bar, flow analyser reading 80,709 BBLs (barrels = 34.9723 imperial gallons; 158.9873 litres)⁷ total and rate of 8.96 BPD (Barrels per day). Site log viewed at Kaimiro Production Station.

Inspection on 9 April 2009

General inspection was carried out by a Council's Inspector. A sample of produced water was taken during inspection. Sample was registered in the TRC Laboratory as **TRC091216**. No problems or anything of concern was encountered. Table 2 shows the laboratory results obtained.

Inspection on 24 June 2009

General inspection was carried out by a Council's Inspector. All was found in good order at the site. A sample of produced water was collected and taken for analysis to the TRC laboratory with the registration code **TRC091786**. Table 2 displays the laboratory results obtained.

Consent 5312-1

Kaimiro-17 (GND1173)

Inspection on 2 August 2007

Kaimiro-17 [located at Kaimiro-O] – GND1173: Site and equipment were in good order. Ring drains recently cleaned out. Injection not occurring at time of visit, motor idling, wellhead pressure 0 bar.

⁷ B. N. Taylor. "B.8 Factors for Units Listed Alphabetically - Section B". Guide for the Use of SI units. NIST. <http://physics.nist.gov/Pubs/SP811/appenB8.html#B>. Retrieved 28-02-2010.

Table 2 Injectate sampled at Kaimiro-11 on 09 April 2007

| Parameter | Method | Unit | Value |
|---------------------|---------------------|------------------------------------|--------|
| Alkalinity Total | ALKT-1 | g/m ³ CaCO ₃ | 569 |
| Chloride | CL-1 | g/m ³ | 21,600 |
| Conductivity @ 20°C | CONDY-1 | mS/m | 5,040 |
| Bicarbonate | HCO ₃ -1 | g/m ³ HCO ₃ | 694.18 |
| Hydrocarbons | HC-2 | g/m ³ | 670 |
| pH | PH-1 | pH | 7.6 |
| Suspended solids | SS-1 | g/m ³ | 110 |

Table 3 Results for injectate sampled at Kaimiro-11 on 24 June 2009

| Parameter | Method | Unit | Value |
|---------------------|---------------------|------------------------------------|--------|
| Alkalinity Total | ALKT-1 | g/m ³ CaCO ₃ | 585 |
| Chloride | CL-1 | g/m ³ | 22,300 |
| Conductivity @ 20°C | CONDY-1 | mS/m | 5,160 |
| Bicarbonate | HCO ₃ -1 | g/m ³ HCO ₃ | 713.7 |
| Hydrocarbons | HC-2 | g/m ³ | 390 |
| pH | PH-1 | pH | 7.5 |

Results in Tables 2 and 3 are within the range typical for the produced waters disposed of into the Mount Messenger formation in Taranaki.

Abstraction bore pump running, pressure 1.2 bar. Water-flooding log viewed at site and is up-to-date. Injection rate meter not present on piping prior to wellhead. Inspector talked to the officer on duty at Kaimiro Production Station. The meter is being repaired and rates are being calculated from other data until it is reinstalled. The following action was to be taken: Ensure flow meter is reinstalled at Kaimiro-O as soon as possible.

Inspection on 9 April 2009

General inspection was carried out by a Council's Inspector. No problems or matters of concern were found with this injection well.

Inspection on 24 June 2009

A Council's Inspector conducted another general inspection. All was found in good order at this site.

**Consent 7390-1
Turangi-3 (GND2106)**

Inspection on 28 May 2009

Wellsite was inspected by one of the Council's Inspectors, all was found in good order regarding the injection well (GND2106). A produced water sample was taken to the TRC lab for chemical analysis; the sample number assigned was **TRC091540**. The results from this analysis can be seen in Table 4.

Inspection on 24 June 2009

Routine inspection was carried out on this day. Everything was found satisfactory and a sample of produced water was collected for chemical analysis; the sample number assigned was **TRC091788**. The results from this analysis can be seen in Table 5.

Table 4 Results for injectate sampled at GND2106 – Turangi 3 on 28 May 2009

| Parameter | Method | Unit | Value |
|---------------------|---------------------|------------------------------------|--------|
| Alkalinity Total | ALKT-1 | g/m ³ CaCO ₃ | 2,810 |
| Chloride | CL-1 | g/m ³ | 6,820 |
| Conductivity @ 20°C | CONDY-1 | mS/m | 20.5 |
| Bicarbonate | HCO ₃ -1 | g/m ³ HCO ₃ | 3428.2 |
| Hydrocarbons | HC-2 | g/m ³ | 3,500 |
| pH | PH-1 | pH | 7.0 |

Table 5 Results for injectate sampled at GND2106 – Turangi 3 on 24 June 2009

| Parameter | Method | Unit | Value |
|---------------------|---------------------|------------------------------------|-------|
| Alkalinity Total | ALKT-1 | g/m ³ CaCO ₃ | 2,950 |
| Chloride | CL-1 | g/m ³ | 6,800 |
| Conductivity @ 20°C | CONDY-1 | mS/m | 2,000 |
| Bicarbonate | HCO ₃ -1 | g/m ³ HCO ₃ | 3,599 |
| Hydrocarbons | HC-2 | g/m ³ | 5,300 |
| pH | PH-1 | pH | 7.5 |

Values in Tables 4 and 5 are within the typical range for the produced waters disposed of into the Mount Messenger formation in Taranaki and there are not concerns that require attention by either the Council or the consent holder.

**Consent 6728-1
Moturoa-5 well (GND1462)**

Inspection on 06 December 2007

The following was found to be occurring: The site was tidy; neither discharges off site or flaring at present. During this visit it was learnt that produced water had been used to suppress dust. Samples of produced water were taken.

Results from the analyses, showed that levels of chloride were too high for any land application. The following action was to be taken: Cease discharge of produced water to land at site – use reinjection of produced water as per Consent 6728.

2.2 Register of incidents

The Taranaki Regional Council operates and maintains a register of all complaints or reported and discovered excursions from acceptable limits and practices, including non-compliance with consent, which may damage the environment. The register ('unauthorised incident register') includes events where the company concerned has itself notified the Council. The register contains details of any investigation and corrective action taken.

Incidents may be alleged to be associated with a particular site. If there is 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 2007-2009 monitoring period, there were no incidents recorded by the Council that were associated with any of the Company's deep well injection sites.

3. Discussion

3.1 Discussion of plant performance

During the two-year period under review a total of nine compliance monitoring inspections of the Company's active well-injection sites were carried out. No activities resulted in unauthorised incidents being recorded. Only three out of the seven resource consents were exercised during the period under review. Table 6 summarises the status of the activities permitted by the consents held by the Company.

Table 6 Summary of consent status for the period under review 2007-2009

| Consent Number | Status | Comments |
|----------------|----------|---|
| 4921 | Active | Inspected and records received |
| 5312 | Active | Inspected and records received |
| 6659 | Inactive | Not exercised, well was plugged and abandoned |
| 6728 | Inactive | No injection occurred |
| 7068 | Inactive | Not exercised |
| 7128 | Inactive | Not exercised, well was plugged and abandoned |
| 7390 | Active | Inspected and records received |

Kaimiro-11

In terms of the chemical results for the injectate, the levels of contaminants encountered in the samples collected under the period under review were within the ranges typical for the produced waters disposed of via Kaimiro-11. As far as volumes and rates are concerned, no significant changes were detected. Table 7 summarises the daily injected volume and the injection pressure for this well during the monitoring period.

Table 7 Historical daily average volume injected and injection pressure for GND1377 [Kaimiro 11]

| Monitoring year | Daily injected Volume (m ³) | | Injection pressure (bar) | |
|-----------------|---|-----|--------------------------|------|
| | Average | max | Average | Max |
| 2003-2004 | 28.6 | 114 | 5.6 | 43 |
| 2004-2005 | 40.9 | 94 | 12.9 | 43.0 |
| 2005-2006 | 81.2 | 135 | 9.8 | 11.0 |
| 2006-2007 | 50.4 | 108 | 8.6 | 9.0 |
| 2007-2008 | 46.2 | 157 | 7.9 | 8.0 |
| 2008-2009 | 44.8 | 90 | 7.9 | 8.0 |

From the above table, it can be seen that the daily maximum volume discharged during the period under review 2007-2009, was at all times within compliance as the maximum values were never above the consented limit of 200 cubic metres per day. However, on three occasions (01 October 2007, 18 February 2008 and 09 March 2009), the maximum flow-rate consented, 5 litres per second, was exceeded. Compliance in terms of flowrate limits was achieved on all other days (99.5%) while the daily discharge volume complied 100% of the time.

Figure 4 shows a graph for the daily volume injected and pressure of injection from 1 July 2007 to 1 July 2009. Figure 5 show a similar plot for the daily average volume injected and injection rates for 2007-2009 at Kaimiro-17.

There is no reference to maximum injection pressure in consents 4921 or 5312 or in their supporting information; therefore assessment of well performance and effects of injection pressure on the receiving formation is difficult to make.

Maximum injection pressure for injection wells should be less than the measured fracture closure pressure of the injection interval. If the injection interval pressure remains below fracture closure pressure, any existing fractures cannot open, no new fractures can form, and therefore no movement of fluids out of the injection interval can occur.⁸

An additional analysis of the data supplied by the Company suggest that hydro-fracturing (fracing) of the injection zone was not likely to have occurred. In general, hydro-fracing can be inferred from the data where an increase in injection rate and volume coincides with a marked pressure drop. The data does not show such a drop.

⁸ Environmental Protection Agency, USA. Maximum Injection Pressure for Class I wells. Underground Injection Control Section Regional Guidance # 7.

Kaimiro-11 Produced Water Volumes injected for 2007-2009

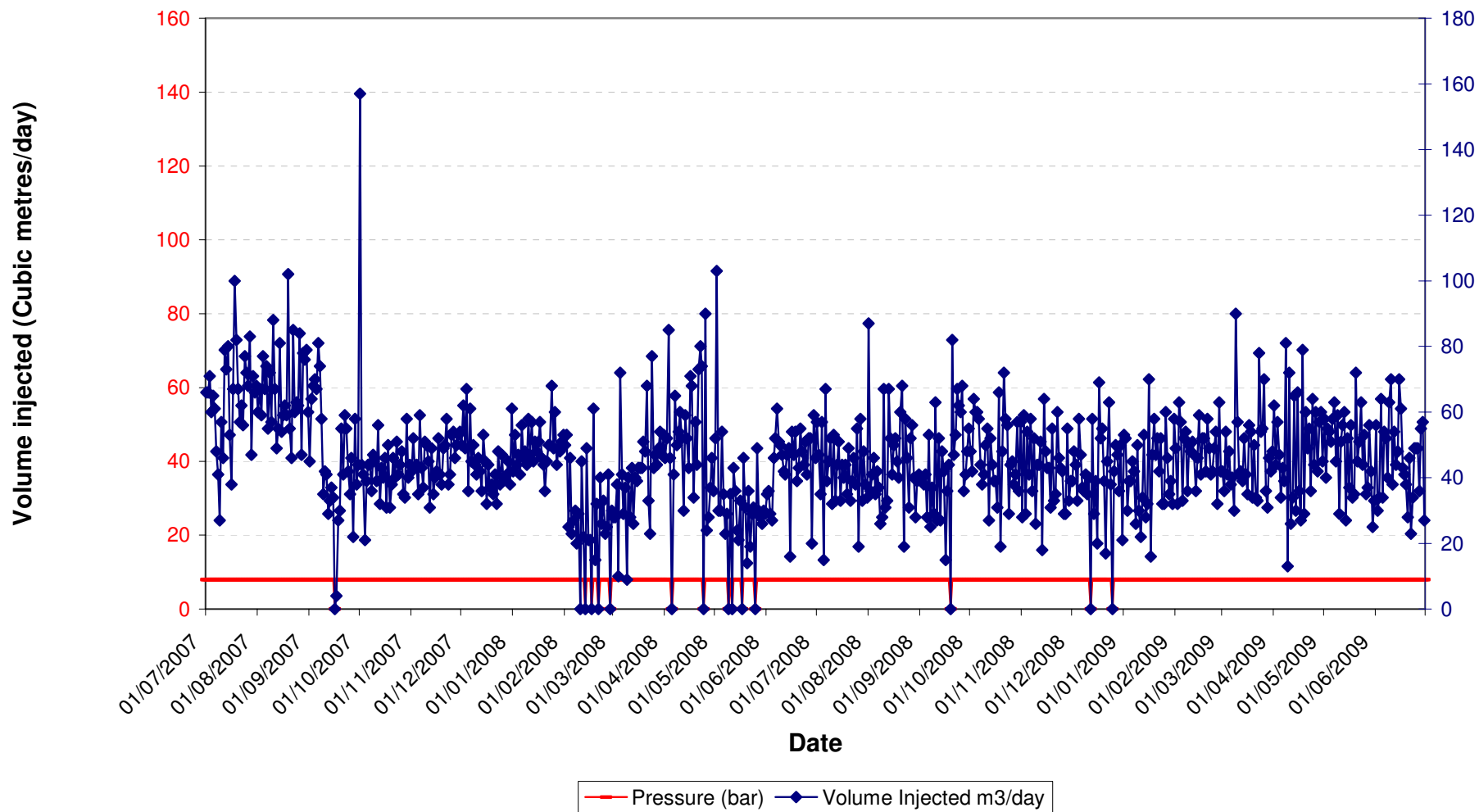


Figure 4 Daily average volume injected and pressure of injection for 2007-2009 at Kaimiro-11

Kaimiro-17 Produced Water Volumes injected for 2007-2009

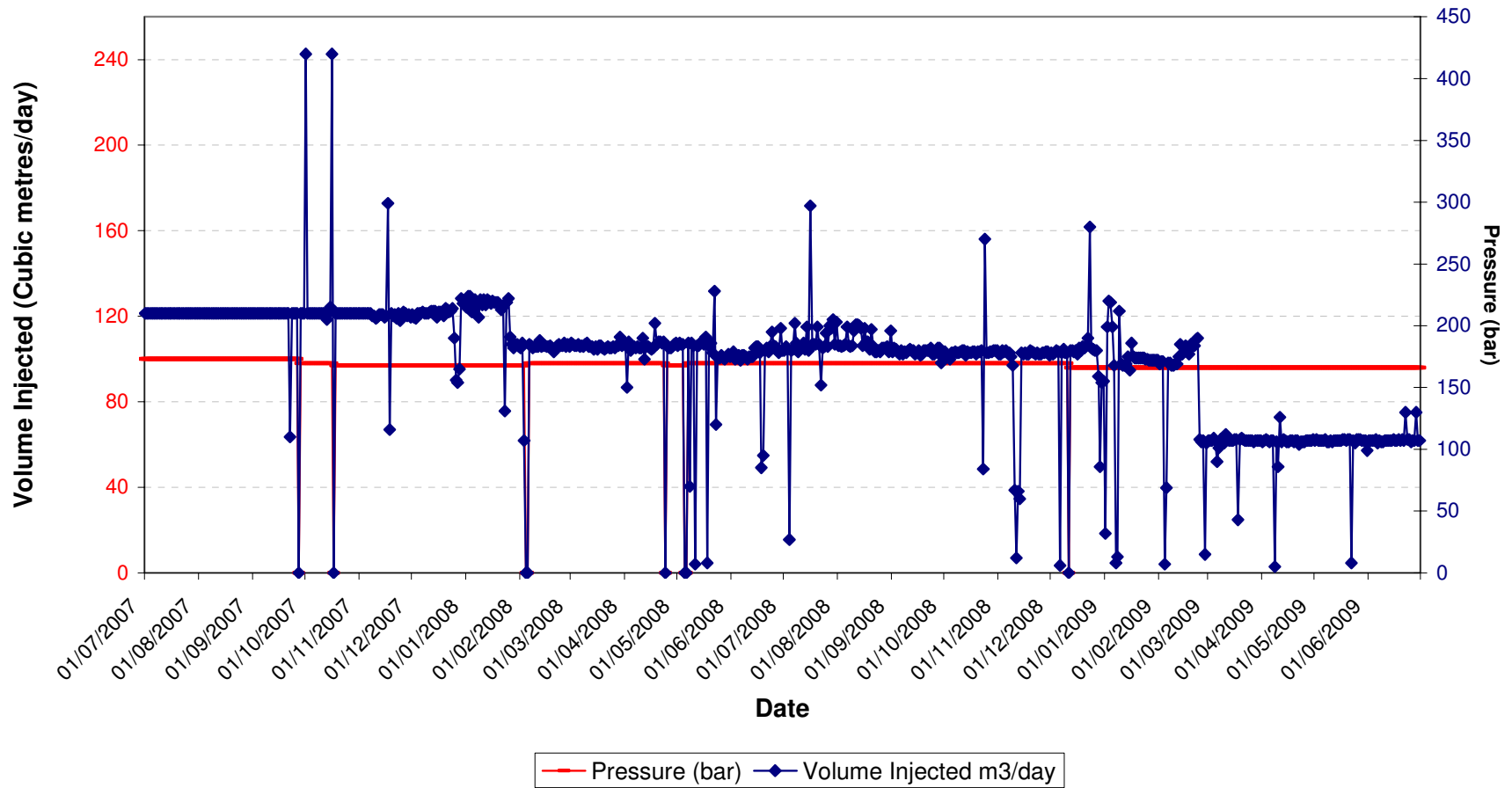


Figure 5 Daily average volume injected and pressure of injection for 2007-2009 at Kaimiro-17

Table 8 shows the totals of volume injected through Kaimiro-11 from 1 July 1 2003 to 30 June 2009.

Table 8 Summary of daily waste disposal for 2003-2007 monitoring period for Kaimiro-11

| Monitoring year | Total Volume Injected (m3) | Difference from Previous year |
|-----------------|----------------------------|-------------------------------|
| 2003-2004 | 10,482 | NA |
| 2004-2005 | 14,916 | +3,605 |
| 2005-2006 | 29,631 | +14,715 |
| 2006-2007 | 18,383 | -11,248 |
| 2007-2008 | 16,870 | -1,513 |
| 2008-2009 | 15,992 | -878 |

Kaimiro-17 (GND1173)

No water quality samples were collected during the monitoring period. In terms of the water quality results, it was shown in the last report that no significant changes had occurred in the water quality of the aquifer since the beginning of the activity. With respect to the volumes injected for water-flooding, Table 9 displays a summary of the daily water injected for water-flooding purposes.

Table 9 Summary of daily waste disposal for 2003-2009 monitoring period for Kaimiro-17

| Monitoring year | Daily injected Volume (m ³) | | Injection pressure (bar) | |
|-----------------|---|------|--------------------------|-----|
| | Average | max | Average | max |
| 2003-2004 | 185.4 | 338 | 22.9 | 24 |
| 2004-2005 | 128.8 | 883* | 77.7 | 100 |
| 2005-2006 | 91.32 | 212 | 73.8 | 90 |
| 2006-2007 | 99.4 | 622* | 50.6 | 92 |
| 2007-2008 | 193.2 | 420 | 96.3 | 100 |
| 2008-2009 | 171.3 | 420 | 96.5 | 98 |

Data provided from Kaimiro-17 shows no breaches of the consent condition for volume injected during the 2007-2009 monitoring period. The average for the injection pressure for the water-flooding operation at Kaimiro-17 for the two years this report covers was 96.4 m³/day.

Consent 7390-1

Turangi-3

Consent 7390 was granted on 10 October 2008; the consent was first exercised on 27 November 2008 and was exercised for 216 days during the period under review. The consent authorises the discharge of produced water from hydrocarbon exploration and production operations by deepwell injection at the Turangi-A wellsite (via

Turangi-3 well). Limits on the injection pressure at the wellhead and on the volumes injected per day are set to 55 bars and 300 m³/day respectively.

The Council requested data for this consent on 09 July 2009 and received it on 11 August 2009. The summary and commentary on the data supplied follows.

Table 10 Daily average volume injected and injection pressure for GND1377 – Turangi-3

| Monitoring year | Daily injected Volume (m ³) | | Injection pressure (bar) | |
|---------------------|---|-----|--------------------------|-----|
| | Average | max | Average | Max |
| Oct 2008- July 2009 | 69 | 112 | 34 | 34 |

Table 11 Summary of daily waste disposal for 2007-2009 monitoring period for Turangi 3

| Monitoring year | Total Volume Injected (m3) | Difference from previous period |
|-----------------|----------------------------|---------------------------------|
| 2008-2009 | 14,874 | NA |

Produced water was sampled from the holding tanks and has been considered representative of the water that is injected down the Turangi-3 well annulus.

The chemical characteristics of the injectate are useful in evaluating the sustainability of a disposal well scheme and can shed light on the potential operational problems related to deep well injection. The Council assesses the quality of the wastes injectate so that the environmental effect can be evaluated.

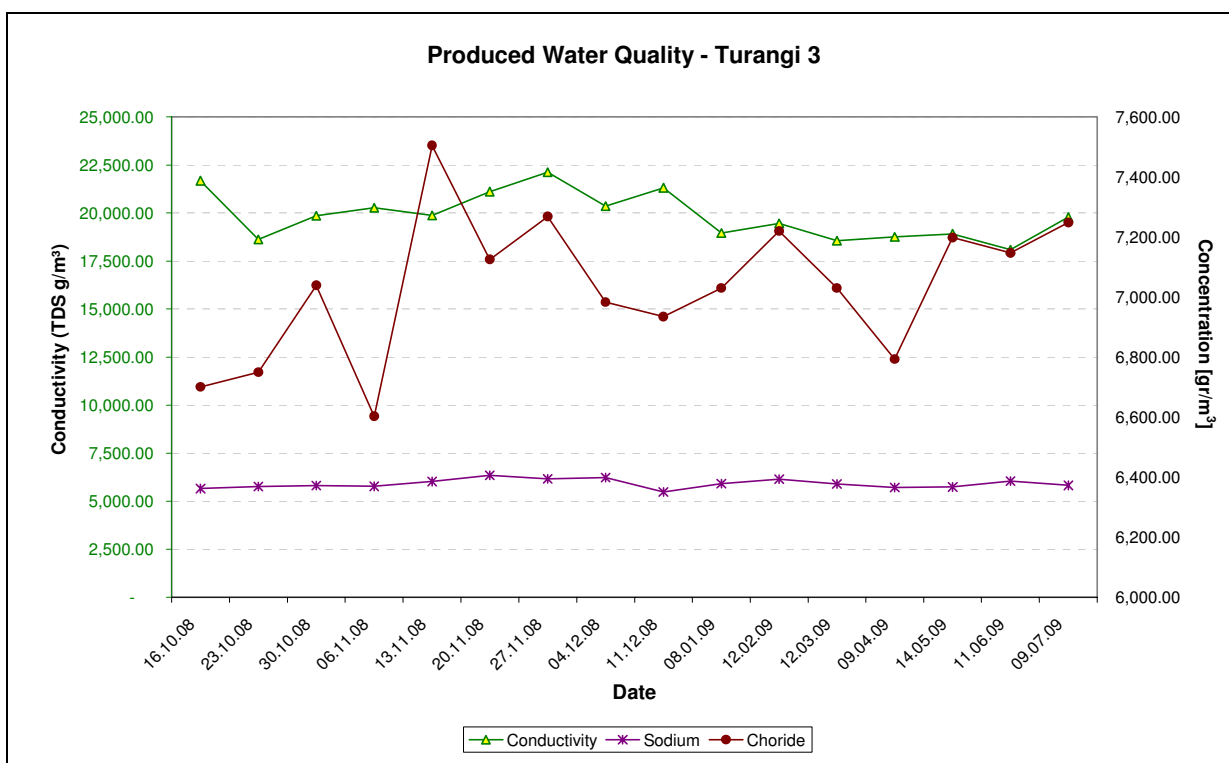


Figure 6 Produced water characteristics of wasted injected via Turangi 3 (1)

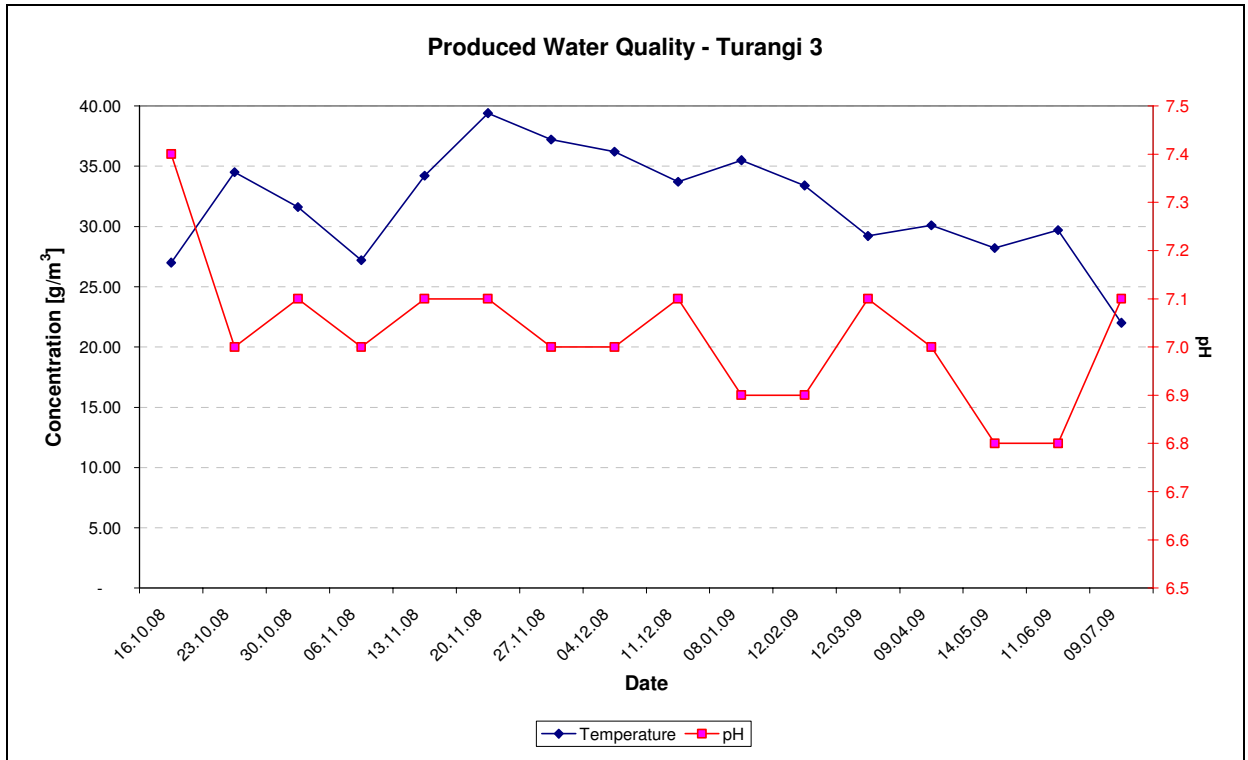


Figure 7 Produced water characteristics of waste injected via Turangi 3 (2)

It is important to monitor the chemical composition of the wastes being disposed of, as they have a marked influence on the corrosivity of the pipes which may trigger more serious problems related with the integrity of the well.

The results provided, do not raise concerns for the compromise of the infrastructure used for carrying out the activity.

3.2 Environmental effects of exercise of discharge permit

Potentially, the main environmental effect of discharging of waste material via deep well injection is the contamination of freshwater aquifers by the discharged material.

Well engineered technology, regional and local geologic characterisation, and site specific mathematical modelling are typically combined at the planning stage of a disposal well to ensure that fluids discharged by deep well injection are contained within the intended disposal interval, and do not migrate into freshwater aquifers.

However, where a hydraulic pathway exists between the injection zone and a freshwater aquifer (e.g. pumpage in an overlying aquifer) waste can migrate from the injection zone into the pumped aquifer.

Potential pathways for contamination of a freshwater aquifer can occur from the rupture of the injection zone stratigraphic seal, or failure of the grout seal in either the disposal well itself or another well that penetrates the disposal interval within the injectate plume. These pathways are most likely in areas of oil and gas exploration because the geological requirements for deep well injection are similar to those for oil and gas exploration, and these activities typically take place in the same areas.

Fluids can potentially be forced upward from the injection zone through transmissive faults or fractures in the confining beds which, like improperly plugged wells, can be pathways for waste migration to freshwater aquifers. Faults or fractures may have formed naturally prior to injection, or may be created by the waste dissolving the rocks of the confining zone. Artificial fractures may also be created by injecting wastewater at excessive pressures.

In some disposal wells, the mechanism of intermittent and continuous waste injection requires hydraulic fracturing (small scale pressure cycling) of the rock in order to accept the waste. In such cases, it should be shown (through simulated fracture growth modelling) that hydro-fracturing will not cause rupturing of stratigraphic seals and allow fractures to propagate upwards into the freshwater zone. The hydraulic fracturing mechanism may affect the quality of potentially usable aquifers through the creation of a hydraulic communication between the aquifer where the produced water is disposed of and an overlying aquifer.

The extent of a fracture is controlled by several factors such as the characteristics of the geologic formation, the presence of natural fractures, the volume of injectate, the type of fracturing fluids used, the pumping pressure, and the depth at which the fracturing is being performed. Deep vertical fractures can propagate vertically to shallower depths and develop a horizontal component.

Produced water is not a single commodity. The physical and chemical properties of produced water vary considerably depending on the geographic location of the field, the geological formation with which the produced water has been in contact for thousands of years, and the type of hydrocarbon product being produced. Produced water properties and volume can even vary throughout the lifetime of a reservoir.

When water-flooding operations are conducted, these properties and volumes may vary even more dramatically as additional water is injected into the formation.

Knowledge of the constituents of specific produced waters is needed for regulatory compliance and for the Company for selecting management and disposal options such as secondary recovery and disposal. Oil and grease are the constituents of produced water that receive the most attention in both onshore and offshore operations, while salt content (expressed as salinity, conductivity, or TDS) is a primary constituent of concern in onshore operations.

In addition to its natural components, produced waters from oil production may also contain groundwater or seawater (generally called "source" water) injected to maintain reservoir pressure, as well as miscellaneous solids and bacteria. Most produced waters are more saline than seawater (Cline 1998). They may also include chemical additives used in drilling and producing operations and in the oil/water separation process.

Produced water from gas production is separated from gas during the production process. In addition to formation water, produced water from gas operations also includes condensed water.

Produced waters from gas production have higher contents of low molecular-weight aromatic hydrocarbons such as benzene, toluene, ethylbenzene, and xylene (BTEX)

than those from oil operations; hence they are relatively more toxic than produced waters from oil production.

Overseas research have shown that the produced waters discharged from gas/condensate platforms are about 10 times more toxic than the produced waters discharged from oil platforms (Jacobs et al. 1992).

The chemicals used for gas processing typically include dehydration chemicals, hydrogen sulfide-removal chemicals, and chemicals to inhibit hydrates. Significant differences between offshore oilfield produced water and offshore gas produced water exist for other parameters as well.

3.2.1 Discussion on recommendations attached to this report

The principal means of surveillance of wastewater injection is the monitoring at the injection well of the volume, flow rate, chemistry, and biology of the injected wastewater and of the injection and annulus pressures combined with periodic inspections of surface and subsurface facilities. The greatest risk of escape of injected fluids is normally through or around the outside of the injection well itself, rather than from leakage through permeable confining beds, fractures or unplugged wells.

Records are to be kept as evidence of compliance with consent conditions as an aid in interpretation of well behavior. Injection pressures are limited to prevent hydraulic fracturing of the injection reservoir and confining beds, or damage to well facilities.

The need for periodically inspecting the surface facilities of injection wells is a precautionary measurement to reduce the occurrence of incidents. In overseas deep-well injection activities, the most frequently reported problem has been the corrosion of tubing and/or casing. Documentation for reported cases have had to do with portions of tubing or casing failing by corrosion and have caused temporary or permanent shut-down of the wells.

3.3 Evaluation of performance

A tabular summary of the Company's compliance record for the two years under review for the three consents exercised is presented in Tables 12 -14 for deep well injection and water-flooding.

Table 12 Summary of consent compliance for 2007-2009 – deep well injection via Kaimiro-11 (consent 4921) Greymouth Petroleum Acquisitions Company Limited

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|---|--|----------------------|
| 1. Injection well log | Receipt of satisfactory information | Yes |
| 2. Consent holder to keep records of amount of wastes injected | Receipt of satisfactory information | Yes |
| 3. Consent holder to keep records of amount of commercial wastes injected | Receipt of satisfactory information | N/A |

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|---|---|----------------------|
| 4. No contamination of any freshwater aquifer | Data assessment. Notification of problems by groundwater user's owners. Discretionary sampling of freshwater aquifers | Yes |
| 5. No reactive fluids are injected | Samples taken in the injectate | Yes |
| 6. Purpose of Consent | To discharge up to 200 cubic metres/day [5 litres/second] of produced water | Yes |
| Overall assessment of consent compliance and environmental performance in respect of this consent | | Good |

Table 13 Summary of consent compliance for 2007-2009 – deep well injection via Turangi-3 disposal well (consent 7390) Greymouth Petroleum Acquisitions Company Limited

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|---|--|----------------------|
| 1. Injection well log | Receipt of satisfactory information | Yes |
| 2. Consent holder to keep records of amount of wastes injected | Receipt of satisfactory information | Yes |
| 3. Consent holder to keep records of amount of commercial wastes injected | Receipt of satisfactory information | N/A |
| 4. No contamination of any freshwater aquifer | Data assessment. Notification of problems by groundwater user's owners. Discretionary sampling of freshwater aquifers. | Yes |
| 5. No reactive fluids are injected | Samples taken in the injectate | Yes |
| 6. Purpose of Consent | To discharge up to 200 cubic metres/day [5 litres/second] of produced water | Yes |
| Overall assessment of consent compliance and environmental performance in respect of this consent | | Good |

Table 14 Summary of Consent compliance for 2007-2009 –water-flooding via Kaimiro-17 (consent 5312-1), Greymouth Petroleum Acquisitions Company

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|---|---|----------------------|
| 1. Injection well log | Receipt of satisfactory information | Yes |
| 2. Consent holder to keep records | Receipt of satisfactory information | Yes |
| 3. No contamination of any freshwater aquifer | Data assessment. Notification of problems by groundwater user's owners. Discretionary sampling of freshwater aquifers | N.A |
| 4. Purpose of Consent | To discharge up to 550 cubic metres/day of produce water | No ⁹ |
| Overall assessment of consent compliance and environmental performance in respect of this consent | | Good |

During 2007-2009 Greymouth Petroleum Acquisitions Company Limited exercised three consents for well injection (Deep well Injection and Water-flooding).

Environmental performance with respect to consents held by the Company for these operations was assessed. During 2007-2009, the Company achieved a good standard of environmental performance with respect to consents 5312-1, 4921-1 and 7390-1.

3.4 Exercise of optional review of consent

Resource consents 5312-1, and 4921-1 provided for an optional review of the consent in June 2008. This condition allowed the Council to review the consents, if there were grounds that conditions in the consents were inadequate to deal with any adverse effects on the environment arising from the exercise of these consents, which were not foreseen at the time the application was considered and which was not appropriate to deal with at that time. The Council opted not to exercise its right to review these two consents as there were no grounds to have another look at the activities as they had been conducted.

3.5 Recommendations from the previous monitoring report

In the previous monitoring report it was recommended:

1. THAT monitoring of discharges by deep well injection and water-flooding in 2007-2008 continue at the same level as for 2003-2007;
2. THAT the consent holder provides an injection well operation management plan that identifies the conditions that would trigger concerns about the integrity of disposal well Kaimiro-11, and the action to be taken by the consent holder when trigger conditions are reached.
3. THAT the consent holder provides an injection well operation management plan that identifies the conditions that would trigger concerns about the integrity of the well used for water-flooding and the action to be taken by the consent holder when trigger conditions are reached.

Recommendations N°2 and N°3 have not been addressed by the consent holder although an Injection Well Operation Management Plan was received for the disposal well at Turangi A wellsite.¹⁰ The same recommendation will be made for the monitoring period 2009-2011.

3.6 Alterations to the monitoring programme for 2009-2011

In designing and implementing the monitoring programmes for water discharges in the region, the Taranaki Regional Council has taken into account the extent of information made available by previous authorities, its relevance under the Resource Management Act, the obligations of the Act in terms of monitoring discharges and effects, and subsequently reporting to the regional community, the scope of assessments required at the time of renewal of permits, and the need to maintain a

¹⁰ In compliance with consent condition # 6 of 7390.

sound understanding of industrial processes within Taranaki discharging to the environment.

In the case of Greymouth Petroleum Acquisitions Company Limited, it is proposed that the monitoring programme for 2009-2011 remain unaltered from that of 2007-2009. A recommendation to this effect is made in section 4 below.

4. Recommendations

1. THAT monitoring of discharges by deep well injection and water-flooding in 2009-2011 continue at the same level as for 2007-2009;
2. THAT the consent holder provides an injection well operation management plan that identifies the conditions that would trigger concerns about the integrity of disposal well Kaimiro-11, and the action to be taken by the consent holder when trigger conditions are reached, by 1 July 2010.
3. THAT the consent holder provides an injection well operation management plan that identifies the conditions that would trigger concerns about the integrity of the Kaimiro-17 well (water-flooding) and the action to be taken by the consent holder when trigger conditions are reached, by 1 July 2010.
4. THAT the Company considers surrendering consents 7128, 6659 as these two wells have been plugged and abandoned.

Glossary of common terms and abbreviations

The following abbreviations and terms are used within this report:

| | |
|----------------------|--|
| Aquifer (freshwater) | a formation, group of formations, or part of a formation that contains sufficient saturated permeable media to yield exploitable quantities of fresh water. |
| Water-flooding | secondary recovery process implemented when natural reservoir pressures decline, largely due to hydrocarbon extraction. |
| bcf | billion cubic feet |
| Conductivity | A measure of the level of dissolved salts in a sample. Usually measured at 20°C and expressed as milli-siemens per metre (mS/m). |
| g/m ³ | Grams per cubic metre. A measure of concentration which is equivalent to milligrams per litre (mg/l), or parts per million (ppm). |
| l/s | litres per second. |
| m ³ | Cubic metre. |
| pH | Numerical system for measuring acidity in solutions, with 7 as neutral. Values lower than 7 are acidic and higher than 7 are 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. |
| Produced water | Water associated with oil and gas reservoirs that is produced along with the oil and gas. Typically highly saline with salt concentrations similar seawater. |
| Fracture gradient | A measure of how the pressure required to fracture rock in the earth's crust changes with depth. It is usually measured in units of "pounds per square inch per foot" (psi/ft) and varies with the type of rock and the strain of the rock. |
| Injectate | Waste material disposed of by deep well injection. |
| 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 subsequent amendments. |
| SS | suspended solids. |
| Temp | Temperature, measured in degrees C. |
| UIR | Unauthorised Incident Register entry- an event recorded by the Council on the basis that it had potential or actual environmental consequences that may represent a breach of a consent or provision in a Regional Plan. |
| Stratigraphic seal | A geological layer or rock unit that is impermeable to fluids. An aquitard, or confining layer. |

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Appendix I

**Resource consents held by
Greymouth Petroleum Acquisition Company Limited**



PRIVATE BAG 713
47 CLOVEN ROAD
STRAEFORD
NEW ZEALAND
PHONE 0-6-765 7127
FAX 0-6-765 5037

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

Name of
Consent Holder: Greymouth Petroleum Acquisitions Company Limited
P O Box 1394
Shortland Street
AUCKLAND

New Address:
PO Box 3394
New Plymouth

Consent Granted
Date: 31 January 1996

Conditions of Consent

Consent Granted: To discharge up to 200 cubic metres/day [5 litres/second] of produced water, well drilling fluids and commercial wastewater from hydrocarbon exploration operations by deepwell injection into the Matemateaonga Formation at or about GR: P19:092-265

Expiry Date: 1 June 2014

Review Date(s): June 2002, June 2008

Site Location: Kaimiro-J Wellsite, Upland Road, Inglewood

Legal Description: Lot 1 DP 14692 & Lot 2 DP 13881 Sec 114 Tarurutangi Blk III Egmont SD

Consent 4921-1

General conditions

- a) That on receipt of a requirement from the Chief Executive, Taranaki Regional Council (hereinafter the Chief Executive), the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.
- b) That unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.
- c) That the consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:
 - (i) the administration, monitoring and supervision of this consent;
 - (ii) charges for the carrying out of the Council's functions under section 35 in relation to this consent; and
 - (iii) charges authorised by regulations.

Special Conditions

- 1) That the consent holder will ensure that injection will not contaminate or endanger any actual or potential usable freshwater aquifer.
- 2) That the consent holder shall keep records of amounts of wastes injected, including injection pressure and rate, and shall make the records available to the Taranaki Regional Council upon request.
- 3) That the consent holder shall keep records of amounts of commercial wastes injected, including the nature and composition, and shall make the records available to the Taranaki Regional Council upon request.
- 4) That the consent holder shall advise the Taranaki Regional Council of the nature of any commercial wastewater prior to disposal, and shall comply with any requirements of the Council regarding treatment or disposal rates of the wastewater.
- 5) That no radioactive fluids are injected.
- 6) That the Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review during June 2002 and/or June 2008, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this consent.

Transferred at Stratford on 10 April 2002

For and on behalf of
Taranaki Regional Council



Chief Executive



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

PRIVATE BAG 713
47 CLOUTEN ROAD
STRATFORD
NEW ZEALAND
PHONE 0-6-765 7127
FAX 0-6-765 5097

Name of Consent Holder: Greymouth Petroleum Acquisitions Company Limited
P O Box 1394
Shortland Street
AUCKLAND
New Address:
PO Box 3394
New Plymouth

Consent Granted Date: 17 April 1998

Conditions of Consent

Consent Granted: To discharge up to 550 cubic metres/day of water to depths greater than 1000 metres below the ground via an injection well for enhanced petroleum recovery purposes at the Kaimiro-O Wellsite at or about GR: P19:087-249

Expiry Date: 1 June 2014

Review Date(s): June 2002, June 2008

Site Location: Kaimiro-O Wellsite, Alfred Road, Egmont Village

Legal Description: Pts 115 & 116 Hua & Waiwhakaiho Hundred Blk III Egmont SD

Consent 5312-1

General conditions


- a) On receipt of a requirement from the Chief Executive, Taranaki Regional Council (hereinafter the Chief Executive), the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.
- b) Unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.
- c) The consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:
 - i) the administration, monitoring and supervision of this consent; and
 - ii) charges authorised by regulations.

Special conditions

1. That the consent holder shall ensure that the discharge will not contaminate, or result in contamination of, any freshwater aquifer.
2. That 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 2002 and/or June 2008, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this consent, which were not foreseen at the time the application was considered and which it was not appropriate to deal with at that time.

Transferred at Stratford on 10 April 2002

For and on behalf of
Taranaki Regional Council



Chief Executive



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

CHIEF EXECUTIVE
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Please quote our file number
on all correspondence

Name of
Consent Holder: Greymouth Petroleum Limited
P O Box 3394
NEW PLYMOUTH

Consent Granted
Date: 9 May 2006

Conditions of Consent

Consent Granted: To discharge waste drilling fluids and/or produced water
from hydrocarbon exploration and production operations by
deepwell injection at the Moturoa-5 wellsite at or about
GR: P19:003-378

Expiry Date: 1 June 2020

Review Date(s): June 2008, June 2014

Site Location: Moturoa-5 wellsite, Oceanview Parade, New Plymouth
[Property owner: Westgate Transport Ltd]

Legal Description: Lot 1 DP 20289 Sec 221 Fitzroy Dist Lot 2 DP 4961 Lot 1
DP 7383 Lot 1 DP 16190 Lot 1 DP 17440 Lot 2 DP 17441
Lot 1 DP 18065 Lot 1 DP 19494 Lot 1 DP 19698 Lot 1 DP
19917 Sec 1 SO 13626

Catchment: Huatoki
Tasman Sea

Tributary: Mangaotuku

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

General conditions

- a) On receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.
- b) Unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.
- c) The consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:
 - i) the administration, monitoring and supervision of this consent; and
 - ii) charges authorised by regulations.

Special conditions

- 1. Prior to the exercise of this consent for each individual well to be used for deepwell injection, the consent holder shall submit, to the written satisfaction of the Chief Executive, Taranaki Regional Council, a log of the injection well, and an injection well operation management plan, to demonstrate that special condition 2 of this consent can be met. The report shall:
 - a) identify the injection zone, including a validated bore log and geophysical log;
 - b) detail the results of fluid sampled from the injection zone, and the proposed wastes to be injected for maximum and mean concentrations for pH, suspended solids, total dissolved solids, salinity, chlorides, and total hydrocarbons;
 - c) demonstrate the integrity of well casing; and
 - d) outline design and operational procedure to isolate the zone.
- 2. The consent holder shall ensure that injection will not contaminate or endanger any actual or potential useable freshwater aquifer.
- 3. The consent holder shall keep daily records of the nature and amounts of all material injected, including injection pressure and rate, and shall make the records available to the Taranaki Regional Council on a 3 monthly basis, and when there has been a significant pressure change event.
- 4. The consent holder shall monitor the injected wastes daily for maximum and mean concentrations for pH, suspended solids, total dissolved solids, salinity, chlorides, and total hydrocarbons and shall make the records available to the Taranaki Regional Council every two months.
- 5. The consent holder shall inject fluids at pressures below the pressure that would be required to fracture the injection formation.

Consent 6728-1

6. The consent holder shall provide to the Taranaki Regional Council during the month of May of each year, for the duration of the consent, a written report on all matters required under special conditions 1, 2, 3, 4 and 5 above.
7. This consent shall lapse on the expiry of five years after the date of commencement of this consent, 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(b) of the Resource Management Act 1991.
8. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent, by giving notice of review during the month following receipt of information required under special condition 6 above, and the month of June 2008 and/or June 2014 required for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource 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.

Signed at Stratford on 9 May 2006

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

CHIEF EXECUTIVE
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Please quote our file number
on all correspondence

Name of
Consent Holder: Greymouth Petroleum Limited
P O Box 3394
NEW PLYMOUTH

Consent Granted
Date: 5 March 2007

Conditions of Consent

Consent Granted: To discharge waste drilling fluids and/or produced water
from hydrocarbon exploration and production operations by
deepwell injection at or about GR: Q19:114-210

Expiry Date: 1 June 2021

Review Date(s): June 2009, June 2015

Site Location: Ngatoro-E wellsite, 561 Upper Dudley Road, Inglewood
[Owners: G & V Robinson]

Legal Description: Pt DP 2282 Sec 11 Pt Sec 17 Pt Sec 3 Blk VII Sec 12
Blk VIII Egmont SD

Catchment: Waitara

Tributary: Manganui
Ngatoro
Ngatoro-iti

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

General conditions

- a) On receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.
- b) Unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.
- c) The consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:
 - i) the administration, monitoring and supervision of this consent; and
 - ii) charges authorised by regulations.

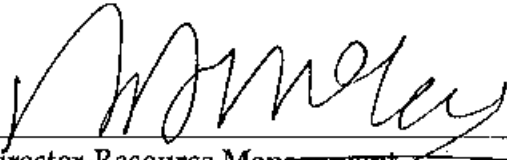
Special conditions

1. Prior to the exercise of this consent for each individual well to be used for deepwell injection, the consent holder shall submit, to the written satisfaction of the Chief Executive, Taranaki Regional Council, a log of the injection well, and an injection well operation management plan, to demonstrate that special condition 2 of this consent can be met. The report shall:
 - a) identify the injection zone, including a validated bore log and geophysical log;
 - b) detail the results of fluid sampled from the injection zone, and the proposed wastes to be injected for maximum and mean concentrations for pH, suspended solids, total dissolved solids, salinity, chlorides, and total hydrocarbons;
 - c) demonstrate the integrity of well casing; and
 - d) outline design and operational procedure to isolate the zone.
2. The consent holder shall ensure that injection will not contaminate or endanger any actual or potential useable freshwater aquifer.
3. The consent holder shall keep daily records of the nature and amounts of all material injected, including injection pressure and rate, and shall make the records available to the Taranaki Regional Council on a 3 monthly basis, and when there has been a significant pressure change event.
4. The consent holder shall monitor the injected wastes daily for maximum and mean concentrations for pH, suspended solids, total dissolved solids, salinity, chlorides, and total hydrocarbons and shall make the records available to the Taranaki Regional Council every two months.
5. The consent holder shall inject fluids at pressures below the pressure that would be required to fracture the injection formation.
6. The consent holder shall provide to the Taranaki Regional Council during the month of May of each year, for the duration of the consent, a written report on all matters required under special conditions 1, 2, 3, 4 and 5 above.

7. This consent shall lapse on the 1 June 2021, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(b) of the Resource Management Act 1991.
8. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent, by giving notice of review during the month following receipt of information required under special condition 6 above, and the month of June 2009 and/or June 2015 required for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource 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.

Signed at Stratford on 5 March 2007

For and on behalf of
Taranaki Regional Council



Director-Resource Management





Discharge Permit
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Name of
Consent Holder: Greymouth Petroleum Limited
P O Box 3394
NEW PLYMOUTH

Consent Granted
Date: 18 July 2007

Conditions of Consent

Consent Granted: To discharge waste drilling fluids, fracking fluids and/or produced water from hydrocarbon exploration and production operations by deepwell injection at the Omoana-1 wellsite at or about 2645309E-6198169N

Expiry Date: 1 June 2022

Review Date(s): June 2010, June 2016

Site Location: Omoana-1 wellsite, Mataiwhetu Road, Omoana, Eltham [BC & JF & S Matthews]

Legal Description: Lot 1 DP 9657 Blk XI Secs 11 & 12 Blk X Secs 4-7 Lots 1 & 2 of Sec 12 Blk Xiomoana SD

Catchment: Whenuakura

General conditions

- a) On receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.
- b) Unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.
- c) The consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:
 - i) the administration, monitoring and supervision of this consent; and
 - ii) charges authorised by regulations.

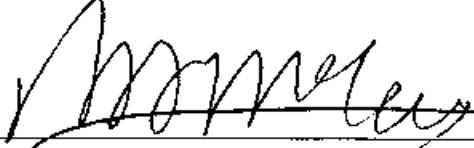
Special conditions

1. Before each well is used for deepwell injection the consent holder shall submit a log of that well and an 'injection operation management plan' for that well. Each management plan shall demonstrate, to the satisfaction of the Chief Executive, Taranaki Regional Council, that special condition 2 of this consent can be met for that well and shall include:
 - a) identify the injection zone, including a validated bore log and geophysical log;
 - b) detail the results of fluid sampled from the injection zone, and the proposed wastes to be injected for maximum and mean concentrations for pH, suspended solids, total dissolved solids, salinity, chlorides, composition of fracturing fluids and total hydrocarbons;
 - c) demonstrate the integrity of well casing; and
 - d) outline design and operational procedure to isolate the zone
 - e) demonstrate that the integrity of the re-injection zone will be maintained
2. The consent holder shall ensure that injection will not contaminate or endanger any actual or potential usable freshwater aquifer.
3. The consent holder shall keep records of injection activities, including injection volumes, pressure and rate, and shall make the records available to the Taranaki Regional Council on a 3 monthly basis, and when there has been a significant pressure change event.
4. The consent holder shall monitor the injected wastes daily for composition of fracturing fluids and for maximum and mean concentrations for pH, suspended solids, total dissolved solids, salinity, chlorides and total hydrocarbons and shall make the records available to the Taranaki Regional Council every two months.
5. The consent holder shall inject fluids at pressures below the pressure that would be required to fracture the injection formation.

6. The consent holder shall provide to the Taranaki Regional Council during the month of May of each year, for the duration of the consent, a written report on all matters required under special conditions 1, 2, 3, 4 and 5 above.
7. This consent shall lapse on the expiry of five years after the date of commencement of this consent, 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(b) of the Resource Management Act 1991.
8. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent, by giving notice of review during the month following receipt of information required under special condition 6 above, and the month of June 2010 and/or June 2016 required for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource 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.

Signed at Stratford on 18 July 2007

For and on behalf of
Taranaki Regional Council



Director-Resource Management



Discharge Permit
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Taranaki Regional Council

CHIEF EXECUTIVE
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Please quote our file number
on all correspondence

Name of
Consent Holder: Greymouth Petroleum Limited
P O Box 3394
NEW PLYMOUTH 4341

Consent Granted
Date: 10 October 2008

Conditions of Consent

Consent Granted: To discharge produced water from hydrocarbon exploration and production operations by deepwell injection at the Turangi-A wellsite (via Turangi-3 well) at or about (NZTM) 1713836E-5681397N

Expiry Date: 1 June 2027

Review Date(s): June 2009, June 2011, June 2015, June 2021 and month following receipt of information required under special condition 6

Site Location: Turangi-A wellsite, Upper Turangi Road, Waitara [Property owner: BA & JM McKenzie]

Legal Description: Sec 21 Blk VI Waitara SD

Catchment: Parahaki

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

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Doc# 520643-v1

Working with people • Caring for our environment

General conditions

- a) On receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.
- b) Unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.
- c) The consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:
 - i) the administration, monitoring and supervision of this consent; and
 - ii) charges authorised by regulations.

Special conditions

- 1. The injection pressure at the wellhead shall not exceed a maximum injection pressure of 55 bars (800 PSI).
- 2. The volume of liquid re-injected shall not exceed 300 cubic metres per day.
- 3. The consent holder shall keep daily records of:
 - a) Maximum and average injection pressure;
 - b) Maximum and average rate of injection; and
 - c) Volume of fluid injected.
- 4. The consent holder shall measure and record the following constituents of the discharge:
 - a) Ph;
 - b) Suspended Solids concentration;
 - c) Temperature;
 - d) Salinity;
 - e) Chloride concentration; and
 - f) Total hydrocarbon concentration.

These constituents shall be measured at time intervals sufficiently frequent to yield data representative of the injected fluid in the opinion of the Chief Executive of the Taranaki Regional Council.

- 5. The Consent holder shall report to the Taranaki Regional Council's Chief Executive, during the month of May of every year, a monthly summary of all records collected in accordance with conditions 3 and 4. The report shall cover details on the major changes in characteristics or sources of injected fluid.

Consent 7390-1

6. Before the well is used for deepwell injection the consent holder shall submit an "Injection Operation Management Plan" which describes the reinjection process and identifies the conditions that would trigger concerns about the integrity of the well, or the injection zone, and the action to be taken by the consent holder if trigger conditions are reached.
7. The consent holder shall ensure that the exercise of this consent not contaminate or put at risk actual or potential usable freshwater aquifer.
8. This consent shall lapse on the expiry of five years after the date of commencement of this consent, 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(b) of the Resource Management Act 1991.
9. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent, by giving notice of review during the month following receipt of information required under special condition 6 above, and the month of June 2009 and/or June 2011 and/or June 2015 and/or June 2021 required for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource 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.

Signed at Stratford on 10 October 2008

For and on behalf of
Taranaki Regional Council


Director-Resource Management

