

NZEC Waihapa Ltd
Deep Well Injection
Monitoring Programme
Annual Report
2013-2014
Technical Report 2014-96

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Executive summary

The following Annual Report by the Taranaki Regional Council (the Council) encompasses the monitoring period 1 July 2013 – 30 June 2014. The report provides details of the deep well injection (DWI) consents held by NZEC Waihapa Ltd (the Company) during the period under review. The report also outlines the Company's DWI activities during this period, discusses the monitoring programme implemented by the Council and its results, and also provides an assessment of Company performance with regard to consent compliance.

During the period under review, the Company held two resource consents for the injection of fluids by DWI, at their Waihapa-F wellsite, Bird Road, Stratford and their Waihapa-D wellsite, Cheal Road, Stratford. Consent 3688-2 permits the discharge of waste drilling fluids, produced water, hydraulic fracturing fluids including return fluids, and stormwater from hydrocarbon exploration and production operations into the Tikorangi Formation. Consent 4094-2 permits the discharge of produced water, contaminated stormwater, water based drilling fluids, and hydraulic fracturing fluids, including return fluids into the Matemateaonga Formation. The consents include a number of special conditions which set out specific requirements with which the Company must comply. Both consents were transferred to the Company consents from Origin Energy Resources New Zealand Limited on 1 November 2013.

During the year under review NZEC Waihapa Ltd demonstrated a high level of environmental performance

The monitoring programme implemented by the Council in respect of the Company's DWI activities included inspections of injection operations, the review and assessment of injection data submitted by the Company, and groundwater monitoring in the vicinity of the Waihapa-F wellsite.

During the period under review, the Council carried out two routine DWI inspection visits. Inspection visits included liaising with on-site staff, identification of the active injection well(s), viewing of the injection well monitoring equipment and injection logs, and the spot sampling of the injectate. In addition to the DWI inspection visits, the Waihapa-F wellsite was visited by Council staff on six separate occasions in the 2013-2014 monitoring period for inspections relating to other consents held by the Company for various activities at the site.

As required by the special conditions of the DWI consents held by the Company, process monitoring data and injection records were supplied to the Council during the 2013-2014 monitoring period. In total 104,967 cubic metres (m³) of fluids were discharged under consent 4094-2. Consent 3688-2 was not exercised during the 2013-2014 monitoring period. An assessment of process data provided by the consent holder and data gathered during Council inspections do not indicate any potential issues with the integrity of the injection well or the injection zone.

Groundwater monitoring carried out by the Council in the vicinity of the Waihapa-F wellsite does not indicate any contamination of shallow aquifers as a result of injection activities, further supporting the conclusion that the injection wells and injection zone remain secure.

The information gathered during inspection visits and the data supplied by the consent holder have been used in compiling this report.

The Council did not receive any complaints or register any unauthorised incidents associated with any of the Company's DWI activities during the 2013-2014 monitoring period.

During the year under review NZEC Waihapa Ltd demonstrated a high level of environmental performance and a high level of administrative performance and compliance with the resource consents.

For reference, in the 2013-2014 year, 60% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of environmental performance and compliance with their consents, while another 29% demonstrated a good level of environmental performance and compliance with their consents.

This report includes recommendations to be implemented during the 2014-2015 monitoring period.

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1. Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

The following Annual Report covers the monitoring period 1 July 2013–30 June 2014. During the period under review, NZEC Waihapa Ltd (the Company) held two resource consents for the disposal of wastes by deep well injection (DWI), at their Waihapa-F wellsite, Bird Road, Stratford and their Waihapa-D wellsite, Cheal Road, Stratford. The resource consents held by the Company permit the discharge of a range of fluids by DWI, including water, drilling mud wastes, waste drill water, produced water and saline groundwater into the Tikorangi and Matemateaonga Formations. The consents include a number of special conditions, setting out specific requirements with which the Company must comply.

The following report provides details of the DWI consents held by the Company during the period under review, and outlines their DWI activities during this period. The report also outlines the compliance monitoring programme implemented by the Taranaki Regional Council (the Council) with regard to these activities, discusses its results, and provides an assessment of the Company's performance with regard to consent compliance. The report concludes with recommendations regarding the future monitoring of the Company's DWI activities.

1.1.2 Structure of this report

The following report comprises five sections as follows:

- Section 1 of this report is a background section. It sets out general information about compliance monitoring under the relevant legislation and the Council's obligations and general approach to monitoring sites through dedicated monitoring programmes. Also covered in this section are the details of the individual resource consents held by the Company, the nature of the monitoring programme in place for the period under review, and a description of the activities and operations conducted on the Company's well sites;
- Section 2 presents the results of monitoring during the period under review, including technical data;
- Section 3 outlines any incidents, interventions and incidents that occurred during period under review;
- Section 4 discusses the results, their interpretation, and their significance for the environment; and
- Section 5 presents recommendations to be implemented in the 2014 – 2015 monitoring period.

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

1.1.3 The Resource Management Act (1991) and monitoring

The *Resource Management Act (1991)* (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 a discharger, and may include cultural and socio-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 (e.g., recreational, cultural, or aesthetic); and
- (e) risks to the neighbourhood or environment.

In drafting and reviewing conditions on discharge permits, and in implementing monitoring programmes, the Council is recognising the comprehensive meaning of 'effects' inasmuch as is appropriate for each discharge source. 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 performance of resource users against regional plans and consents. Compliance monitoring, (covering both activity and impact), also enables the Council to continuously assess its own performance in resource management as well as that of resource users, particularly consent holders. It also enables the Council to continually re-evaluate its approach to resource management, and ultimately, through the refinement of methods, and considered responsible resource utilisation, to move closer to achieving sustainable development of the regions resources.

1.1.4 Evaluation of environmental performance

Besides discussing the various details of the performance and extent of compliance by the consent holder/s during the period under review, this report also assigns a rating as to each 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 (i.e. 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 was 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 2013-2014 year, 60% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of environmental performance and compliance with their consents, while another 29% demonstrated a good level of environmental performance and compliance with their consents.

1.2 Process description

1.2.1 Background

The Taranaki Basin occupies an area of approximately 100,000 square kilometres and is the most explored and commercially successful hydrocarbon producing area in New Zealand. Oil and gas exploration and development has been on-going in the region for nearly 150 years. Since the first well in 1865, over 600 exploration and production wells have been drilled. While the majority of the basin is offshore, the majority of the producing wells are onshore. The geology of the basin is derived from diverse episodes of tectonic activity. The Cretaceous to Quaternary basin fill is up to 9,000 m thick in places.

The modern era of exploration began in New Zealand in 1955 when a Shell-BP-Todd consortium explored a large part of the Taranaki region. The groups first well (Kapuni-1), discovered gas-condensate in Late Eocene Kapuni Group strata, and marked the beginning of New Zealand's natural gas industry. The Kapuni Field commenced commercial production in 1970. The next major discovery was the off-shore Maui field in 1969, which was in full production by 1979. Maui is New Zealand's largest hydrocarbon field to date. Many smaller fields were discovered between 1979 and 1999, including the McKee, Mangahewa, Ngatoro, Kaimiro and Rimu fields. More recent discoveries include the Pohokura gas field in 2001.

Overall, the Taranaki Basin remains relatively under-explored compared to many comparable rift complex basins of its size and potential.

1.2.2 Deep well injection (DWI)

DWI is often utilised as liquid waste disposal technology and provides an alternative to the surface disposal of such material. The DWI process utilises specially designed injection wells to pump liquid waste into deep geological formations, hydrocarbon reservoirs or confined saline aquifers. The receiving formations generally contain water that is too saline to be of any potential use. Impermeable geological seals overlying the injection intervals restrict any potential vertical migration of injected wastes into shallow freshwater aquifers.

A typical injection well consists of concentric casing, cemented into the surrounding rock, which extend into permeable saline formations, at depths far below the base of potentially useable freshwater aquifers. Waste is then injected into the receiving formation by pressure generated by surface pumps. International standards (adopted in the Taranaki Region) for the construction of disposal wells emphasise the importance of surface casing extending to depths below the base of the freshwater zones and that it is cemented back to surface. The standards also highlight the requirement for internal casing strings to be cemented back up the hole to seal off and isolate the disposal interval from the overlying freshwater zones, providing a multi-barrier approach to the protection of freshwater resources. As part of the resource consent application procedure for DWI activities, applicants are required to submit information that details both the design and construction specifications of the injection well(s) and illustrates well integrity and the isolation of the well bore from surrounding formations.

In Taranaki, contaminants disposed of by DWI are generally limited to produced water, saline groundwater, contaminated stormwater, waste drilling fluids, hydraulic fracturing fluids, and production sludges. The Council has approved, on specific occasions, the discharge of small volumes of other specified contaminants by DWI. Any application to discharge waste material not specifically licenced by the relevant resource consent is assessed by the Council on a case by case basis. The Council will assess the composition of the waste for consistency with those specifically approved for disposal. In some cases, a new consent may be required.

Produced water makes up the greatest volume of waste fluids generated by oil and gas exploration and production activities. Produced water is water that is present in a hydrocarbon bearing reservoir, brought to the surface as crude oil or natural gas is extracted from it. 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, formation 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, hydraulic fracturing, and/or production activities. Produced waters may contain, in addition to salts, hydrocarbon residues and free oil, and traces of process additives including anti-scaling agents, anti-corrosion agents and biocides. Proportionally, higher quantities of water are produced from a hydrocarbon field as more oil or gas is extracted and the productive life of the field diminishes. The volume of produced water requiring disposal is therefore expected to increase as many producing fields approach the end of their lives, and as more fields are discovered and developed.

Produced water and drilling fluid wastes are typically highly saline and contain hydrocarbon residues and system additives. Without treatment to an acceptable standard, the surface disposal of large volumes of produced water is not a suitable disposal option, particularly where the discharge can enter surface or groundwater systems. The salts and other contaminants contained within the discharge can adversely affect soil or freshwater biological systems and the quality of water resources used for supply purposes. Although there are methods to treat produced waters to a suitable standard for surface disposal, such as gas/steam stripping, biological and chemical adsorption, and activated carbon, they are generally not practical or economically viable. The injection of produced waters into deep geological formations by DWI is presently the most cost-effective option for the

disposal of this type of waste, and more importantly, is an environmentally sound disposal option.

Produced waters have been disposed of by DWI in Taranaki since the development of the Kapuni Field in 1970. The collection, handling, treatment and disposal of produced water from a producing field are major undertakings and, if not appropriately managed, can have lasting adverse environmental effects. However, under appropriate geological and operational conditions, the disposal of produced waters by DWI should have no more than negligible environmental effects.

The injection of fluids into hydrocarbon bearing reservoirs is also an established oilfield technique for regulating reservoir pressure and/or as a means of enhancing the rate of oil recovery from a reservoir. This process is often referred to as water flooding. Water flooding is a secondary recovery process that is often implemented when natural reservoir pressures decline due to the removal of reservoir fluids during production. The injection of produced fluids back into the reservoir can increase reservoir pressure and stimulate production by driving reserves toward a production well. In certain cases, injected water is heated and injected through a well annulus to reduce oil viscosity, improving oil deliverability through the wellbore. Typically, either produced waters or freshwater, or a combination of the two, are used for water flooding.

Regional councils are responsible for monitoring environmental effects from hydrocarbon exploration and development activities under the RMA. Sections 15 and 30 of the RMA give regional councils the responsibility for regulating the discharge of contaminants into the environment. The discharge 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 other relevant regulations. The control of DWI activities through the resource consenting process and subsequent compliance monitoring is an appropriate regulatory regime. In the Taranaki region, the discharge of contaminants by DWI requires resource consent from the Council. The activity falls under Rule 51 of the Regional Freshwater Plan for Taranaki and is classified as a discretionary activity. The application may be non-notified if no parties are deemed to be adversely affected by the proposed activity.

At the time of writing, there were a total of 19 current resource consents for DWI in Taranaki. However, several resource consents have been issued for relatively short-term activities during exploration phase drilling, and several others have not been, and may never be exercised.

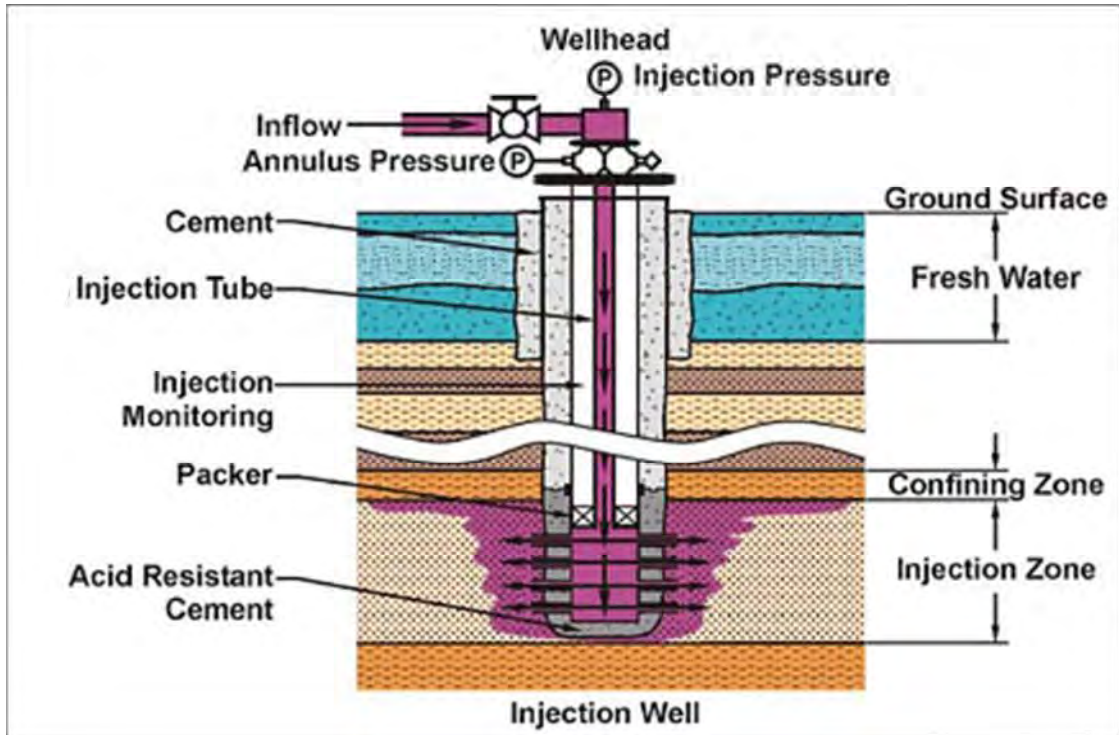


Figure 1 DWI schematic representative of Taranaki sites¹

1.3 Potential environmental effects of exercising a DWI consent

The most significant adverse environmental effect of discharging waste fluids by DWI is the contamination of freshwater aquifers during or following the discharge. Potential pathways for contamination of a freshwater aquifer can be created by the rupture of geological seal confining the injection interval, or failure of the grout seal in either the disposal well or any other well that penetrates the disposal interval. There is also potential for fluids to be forced upward from the injection interval through transmissive faults or fractures in the geological formations overlying the injection interval. 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 or by thermal processes.

There is also the potential for shallow groundwater to be contaminated by surface activities associated with DWI operations, particularly the handling, storage and transport of waste fluids. In all cases, the risk of contamination by spillage or unintended discharge of fluids being managed can be adequately mitigated by ensuring wastes are stored and transported in appropriately constructed and tested storage vessels and pipelines.

In each of the scenarios outlined above, the potential risk can be adequately mitigated by appropriate assessment, design, operation and monitoring of DWI

¹ <https://upstrm.wordpress.com/tag/injection-wells/>

activities. Appropriately engineered technology, regional and local geologic characterisation, and site specific modelling are typically combined at the planning stage of a disposal well to ensure that fluids discharged by DWI will be contained within the intended disposal interval. The assessment of resource consent applications and setting of appropriate conditions address these issues.

1.4 Resource consents

The protection of groundwater quality is of primary concern to the Council when processing resource consent applications for DWI activities. Section 15(1)(b) of the RMA stipulates that no person may discharge any contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant originated 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 national regulations.

Table 1 lists the consents held by the Company during the period under review, the wellsites to which the consents relate and the disposal wells in use at each site. All of the resource consents were issued by the Council under Section 87(e) of the RMA.

Table 1 Summary of DWI consents held by the Company during the 2013-2014 period

Consent number	Wellsite	Injection well(s)	Formation
3688-2	Waihapa-D	Waihapa-5	Tikorangi
4094-2	Waihapa-F	Waihapa-7A	Matemateaonga

A summary of each consent held by the Company for DWI activities during the 2013-2014 monitoring period is included below.

Resource Consent: 3688-2

“To discharge waste drilling fluids, produced water and stormwater from hydrocarbon exploration and production operations by deep well injection at the Waihapa-D wellsite”

Background:

Consent 3688 authorises the discharge of waste fluids by DWI at the Waihapa-D wellsite, Cheal Road, Stratford (Photo 1). The consent was originally granted to Petrocorp Exploration Limited (Petrocorp) on 20 June 1990.

The original consent issued allowed for the discharge of drilling fluids and wastes generated by the drilling site via any well drilled on the named well-site. On 26 May 1992, an application was received to increase the permitted discharge volume to 250 m³/day. The application was subsequently granted on 27 July 1992.

On 27 November 2002, the consent was transferred to Swift Energy New Zealand Limited (Swift). The consent was renewed by Swift on 23 June 2003 and then varied on 2 November 2006. Consent 3688 was transferred to Origin Energy Resources New Zealand (SPV2) Limited on 11 April 2008 and to Origin Energy Resources New Zealand (TAWN) Limited, on 1 December 2008. The consent was transferred to the Company on 1 November 2013.

The consent provides for reviews in June 2016, June 2022 and June 2028 and is due to expire on 1 June 2034. Disposal at the site is via the Waihapa-5 injection well.

The current consent has seven special conditions, as summarised below:

- Special conditions 1, 3 and 4 refer to the Company's process monitoring and data submission requirements;
- Special condition 2 prohibits the discharge from endangering or contaminating any freshwater aquifer;
- Special condition 5 limits injection pressures to those which do not fracture the injection formation;
- Special condition 6 is a lapse clause; and
- Special condition 7 is a consent review provision.



Photo 1 Waihapa-D wellsite and Waihapa-5 disposal wellsite (3688-2)

Resource Consent: 4094-2

“To discharge produced water, contaminated stormwater, water based drilling fluids and hydraulic fracturing fluids, including return fluids by deepwell injection into the Matemateonga formation”



Photo 2 Waihapa-F wellsite and Waihapa-7A disposal well (4094-2)

Background:

Consent 4094 authorises the discharge of waste fluids via the Waihapa-7A well at the Waihapa-F wellsite, Bird Road, Stratford (Photo 2). The consent was originally granted to Petrocorp on 17 June 1992.

On 7 February 2002, the consent was transferred to Swift. On 16 April 2002, an application was received to alter the consent to allow for the discharge of wastes from producing wells other than those at the Waihapa-F wellsite. A revised consent was subsequently granted on 24 April 2002.

Consent 4094 was transferred to Origin Energy Resources New Zealand (SPV2) Limited on 11 April 2008 and to Origin Energy Resources New Zealand (TAWN)

Limited, on 1 December 2008. A consent renewal was applied for in late 2009 and consent 4094-2 was granted on 10 September 2010, permitting the discharge of produced water, contaminated stormwater, and water based drilling fluids by DWI via the Waihapa-7A well. The consent was again varied on 3 September 2013 to include hydraulic fracturing fluids (including return fluids) in the range of fluids approved for discharge via the Waihapa-7A well. The consent was transferred to the Company on 1 November 2013.

The consent provides for reviews in June 2016 and June 2022 and expires on 1 June 2028.

The current consent has six special conditions, as summarised below:

- Special condition 1 states that the well shall operate in accordance with the “Origin Energy Resource NZ Limited – Deep Well Injection Management Plan;”
- Special condition 2 sets a maximum allowable injection pressure of 85 bar (1,232 psi);
- Special condition 3 requires the company adopt the best practicable option as defined in section 2 of the RMA;
- Special conditions 4 and 5 refer to the Company’s process monitoring and data submission requirements; and
- Special condition 6 is a review provision.

1.5 Monitoring programme

1.5.1 Introduction

Section 35 of the RMA sets obligations upon the Council to gather information, monitor, and conduct research on the effects arising from consented activities within the Taranaki region and report upon these.

To perform its statutory obligations, the Council may be required to take 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 by the Council in relation to the Company’s DWI activities consisted of four main components:

- Programme design, liaison and management;
- Site inspections and injectate sampling;
- Assessment of data submitted by the consent holder; and
- Groundwater quality monitoring.

Each component of the monitoring programme is discussed in further detail below.

1.5.2 Programme design, liaison and management

There is generally a significant investment of time and resources by the Council during annual reviews of existing monitoring programmes, and the scoping and design of future monitoring requirements. Significant time is spent managing compliance monitoring programmes throughout the monitoring year, and liaising

with resource consent holders over consent conditions, their interpretation and application. The Council also undertakes discussion during preparation for any consent reviews, renewals, or new consent applications, and provides advice on environmental management strategies, the content of regional plans and various other associated matters.

1.5.3 Site inspections and injectate sampling

The monitoring programme provides for physical inspections to be undertaken at all active DWI sites operated by the Company. The inspections include an examination of the injection wellhead, viewing the monitoring equipment, and the spot sampling of the injectate for laboratory analysis. The sampling of injectate is carried out in order to characterise the general chemical nature of the discharge and also the variation in its chemical composition across the monitoring period. During the period under review samples of the injectate were obtained from storage tanks located at the Waihapa Production Station. The tanks are identified by the Company as tank T-41.

The injectate samples collected were submitted to Council's IANZ accredited laboratory for the following analyses:

- pH;
- Conductivity;
- Alkalinity;
- Chlorides; and
- Total petroleum hydrocarbons.

Table 2 Location of injectate sampling sites

Consent	Wellsite	Injection well	Site code	Sample point
4094-2	Waihapa-F wellsite	Waihapa-7A	GND1634	Tank T-41

1.5.4 Assessment of data submitted by the consent holder

The resource consents held by the Company for DWI include conditions which require the Company to submit injection data and supporting information to the Council within specified timeframes. The injection data submitted by the consent holder forms the basis for assessing consent compliance. The major information requirements are as follows:

1. Information on the disposal well and injection zone

For each well used for DWI, the consent holder was required to provide an "Injection Operation Management Plan." The plans are required to include the operational details of the injection activities and to identify the conditions that would trigger concerns about the integrity of the injection well, the receiving formation or overlying geological seals. The plans are also required to detail the action(s) to be taken by the consent holder if trigger conditions are reached. The Company was also required to submit well construction details, an assessment of the local geological environment, results of well integrity testing and details of the proposed monitoring plan for the injection well. The information requested is required to demonstrate that the exercise

of the consent will not contaminate or endanger any actual or potentially useable freshwater aquifer.

The Council holds a significant volume of information regarding the Company's wells and the underlying geology in the Waihapa area. Data has been gathered where submitted as part of resource consent applications, during specific site investigations, and as part of various compliance monitoring programmes.

2. Discharge records

For each well used for DWI during the period under review, the consent holder was required to provide discharge records. The data required by the conditions of the consents exercised by the Company included the following:

- Injection volumes;
- Injection rate;
- Injection pressures; and
- Results of injectate analysis

The Company provided adequate injection records for the 2013-2014 monitoring year. The data submitted met the requirements stipulated in the DWI consents exercised during this period.

3. Annual reporting

The Company was required to submit annual reports to the Council providing a summary of all injection data gathered over the previous 1 July to 30 June period. The level of detail required in the annual reports varies depending on the conditions of the consents exercised. Additional reporting requirements may also include requirements to provide an assessment of monitoring data and the implications for consent compliance, and/or updated injection modelling reports.

The Company supplied the required annual reports to the Council within the timeframes specified in the relevant consents.

1.5.5 Groundwater quality monitoring

A programme of groundwater monitoring in the vicinity of the Company's active injection site was initiated during the 2012-2013 period when consent 4094-2 was still held by Origin Energy New Zealand (TAWN) Limited, and was continued in the 2013-2014 period, after the consent was transferred to the Company.

In order to select suitable sampling sites for inclusion in the monitoring programme, the Council carried out a survey of groundwater abstractions within 1 kilometre (km) radius of the Company's active injection wellsite. Initially, a desktop review of data held by the Council was conducted, including a search of the Council 'wells' database. The desktop review indicated that the Council held records of a limited number of groundwater abstractions in the areas of investigation.

Following the desktop review, a field survey was undertaken to confirm the location of known abstraction sites, to assess their suitability for sampling, and to identify any additional groundwater abstraction sites that may not have been registered with the Council.

Following the field survey, a private groundwater abstraction site was selected for inclusion in the groundwater monitoring programme. The criteria used in assessing the suitability of each site for inclusion in the programme were the proximity of the sampling site to the Waihapa-F wellsite, the depth to which the bore has been drilled, the construction specifications of the bore, and its susceptibility to contamination by surface runoff.

Details of the groundwater sampling site selected for inclusion in the monitoring programme are listed below in Table 3.

Table 3 Location of groundwater sampling sites

Site code	Type	Distance from injection wellhead (m)	Casing depth (m)	Total depth (m)	High static water level (m)	Aquifer	Comment
GND1031	Bore	748	220	175	26	Matemateaonga	Downgradient of wellsite

2. Results

2.1 Site inspections and injectate sampling

During the period under review, the Council carried out two routine DWI inspections at the Waihapa-F wellsite. In addition, a total of six separate inspections were carried out by Council staff in relation to various activities at the Waihapa-F wellsite during the 2013-2014 monitoring year.

Routine DWI inspections included undertaking a general visual assessment of the operational equipment, storage facilities and associated equipment. No operational issues were identified during the inspections and all equipment appeared in good condition. Company personnel were able to assist by detailing the status of injection equipment, outlining the injection operations being carried out by the Company at that time, and also providing real-time monitoring data on request.

As part of the monitoring programme, spot samples of the injectate were obtained from active injection sites, typically during site inspection visits. The sampling of injectate was carried out on 29 October 2013 and 23 April 2014. The injectate samples were submitted to the Council's IANZ accredited laboratory for physicochemical analysis. The results of the analyses are included below in Table 4. The concentrations of each analyte are within the expected range for produced water samples.

Table 4 Results of injectate sampling undertaken by the Council (2013-2014)

Parameter	Unit	Site GND1634	
		29/10/13	23/04/14
Time	NZST	12:30	14:15
TRC sample number	-	137441	149830
pH	pH Units	6	8
Conductivity @ 20°C	mS/m @ 20°C	3,350	3,900
Alkalinity	g/m ³ CaCO ₃	162	2,980
Chloride	g/m ³	14,300	15,400
Total petroleum hydrocarbons	g/m ³	140	51

2.2 Assessment of data provided by the consent holder

The Company provided full records of injection activities carried out during the 2013-2014 monitoring period, including injection hours, volumes, rate, and pressure data.

Table 5 outlines the Company's injection activities during the period under review. The injection data provided by the Company is summarised in Table 6.

Table 5 Summary of DWI activities during the period under review (2013-2014)

Consent	Wellsite	Injection wells	Total volume discharged (m ³) 01/07/13 – 30/06/14	Discharge period		TRC well ID
				From	To	
4094-2	Waihapa-F wellsite	Waihapa-7A	104,967	04/11/13	30/06/14	GND2328

Table 6 Summary of the Company's 2013-2014 injection data

	4094-2		
	Volume injected (m ³)	Injection pressure (bar)	Injection rate (m ³ /hr)
Total	104,967	-	-
Daily maximum	1632	82	97
Daily average	439	44	50

The injection volume and pressure data provided by the Company for injection carried out under consent 4094-2 is presented graphically in Figures 2 and 3.

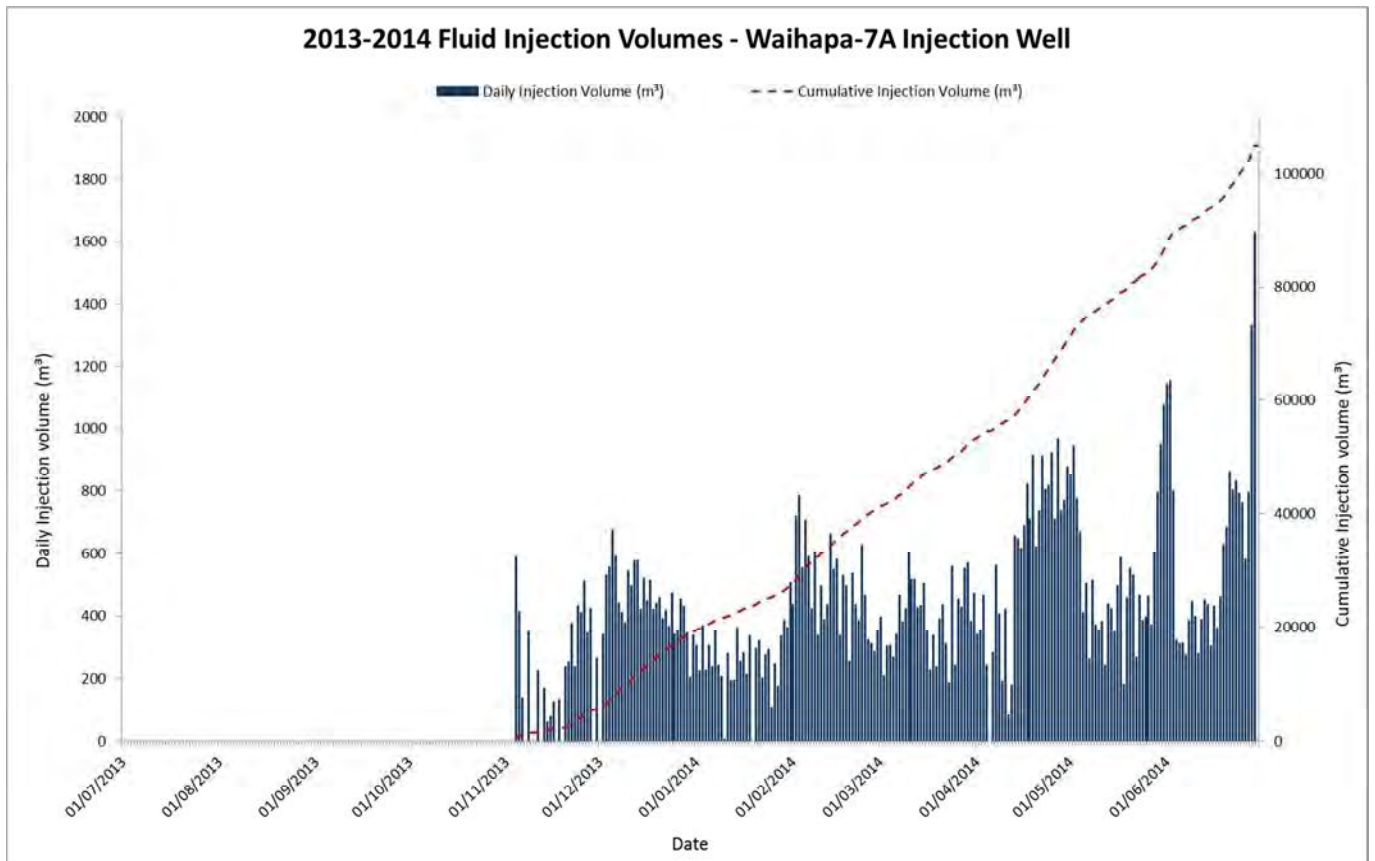


Figure 2 2013-2014 fluid injection volumes – consent 4094-2

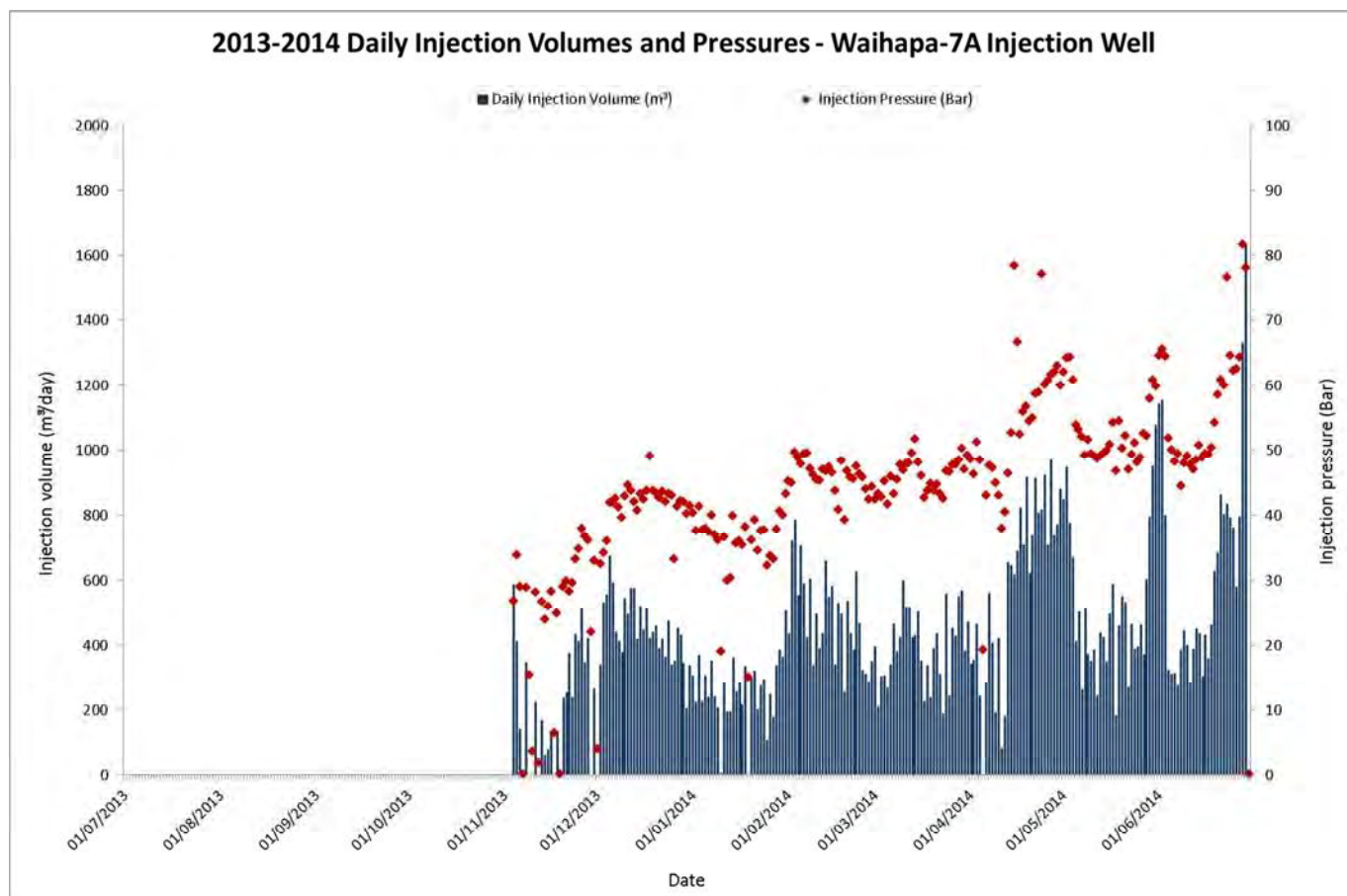


Figure 3 2013-2014 daily injection volumes and pressure – consent 4094-2

In addition to the Council's injectate sampling (Section 2.1), the Company also provided analytical results for samples of produced water injected via the Waihapa-7A injection well. As presented in Table 7, the maximum and mean values associated with the results of these analyses illustrate the variability in the composition of injectate across the monitoring period. The composition of the injectate varies depending on the origin and volume of fluids transferred from each individual waste stream at the time of injection.

Table 7 Range of contaminants in injectate sampled in 2013-2014

Parameter	Unit	Number of samples	Maximum value	Minimum value	Mean value
Temperature	°C	7	23.3	20.0	21.9
pH	pH units	7	7.24	6.27	6.96
Conductivity	mS/cm	7	4,070	2,730	3,369
Salinity	ppt	7	28.5	18.4	22.7
Chloride	mg/l	7	13,721	9,257	10,048
Suspended solids	mg/l	7	225	31	77
Total petroleum hydrocarbons	ppm	6	399	12	189

2.3 Groundwater quality monitoring

As part of the groundwater monitoring programme implemented in the vicinity of the Waihapa-F wellsite, groundwater samples were obtained from GND1031 on 29 October 2013 and 23 April 2014. The samples were collected following standard

groundwater sampling methodologies and generally in accordance with the National Protocol for State of the Environment Groundwater Sampling in New Zealand (2006). The sample collected on 29 October 2013 was analysed in the IANZ accredited Hill Laboratories in Hamilton. The sample collected on 23 April 2014 was analysed in the Council's IANZ accredited laboratory for a basic range of parameters, sufficient to characterise local groundwater quality, and to assess for potential contamination due to injection activities. The results of the analyses performed on the samples collected are outlined in Table 8. The results give no indication of any potential contamination by injected fluids.

Table 8 Results of groundwater sampling undertaken by the Council (2013-2014)

Sample details	Units	GND1031	
TRC sample number	-	TRC137833	TRC149831
Sample date	-	29/10/13	23/04/14
Sample time	NZST	13:00	14:30
Analyte	Units		
Static water level	m	-	-
Temperature	°C	16.0	16.2
pH	pH Units	8.0	8.1
Conductivity (EC)	mS/m@20°C	39	34
Total alkalinity	g/m ³ as CaCO ₃	191	-
Chloride	g/m ³	13.1	11.7
Total hydrocarbons	g/m ³	<0.7	<0.5

3. Investigations, interventions, and incidents

The monitoring programme for the period was based on what was considered to be an appropriate level of monitoring, review of data and liaison with the consent holder. During the monitoring period, matters may arise which require additional activity by the Council e.g. provision of advice and information, investigation of potential or actual causes of non-compliance or failure to maintain best 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 and reported or discovered excursions from acceptable limits and practices, including non-compliance with consents, which may damage the environment. The Incident Register 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).

The Council did not record any incidents associated with any of the Company's DWI activities during the 2013-2014 monitoring period.

4. Discussion

During the period under review, the Company exercised one DWI consent at its Waihapa-F wellsite; 4094-2. This consent authorises discharge of various forms of fluid into the Matemateaonga Formation via the Waihapa-7A injection well. During the period under review, produced water, emanating from hydrocarbon producing wells operated by the Company, was the main source of fluid for injection.

Consent 4094-2 was exercised by the Company between 29 October 2013 and 30 June 2014. During this period, 104,967 m³ of fluid was injected, at an average rate of 50 m³/hour. The average injection pressure was 44 bar.

The special conditions of Consent 4094-2 specify a maximum authorised injection pressure of 85 bar. A review of the injection data provided by the Company indicates the maximum injection pressure reached during the period under review was 82 bar, which occurred on 28 June 2014. The maximum injection pressure was within the limit specified in the consent.

For the well used for DWI during the monitoring period, the consent holder has provided sufficient information regarding well construction and the injection interval to satisfy the relevant consent conditions and monitoring programme information requirements. However, if deemed necessary, the Council may request further information from the consent holder that illustrates that the injection wells and the receiving formation remain secure.

During the 2013-2014 monitoring period, consent holder performance was assessed on compliance with consent conditions. There is a particular emphasis on record keeping requirements, data provision, and the analysis data provided. Compliance with the conditions of consent 4094-2 during the 2013-2014 monitoring period is summarised below in Section 4.1.

The consent holder is required to ensure that the discharge does not result in any contamination of any actual or potentially useable freshwater aquifer. Compliance with this condition is based on the assessment of consent holder submitted data and the sampling and analysis of local groundwater abstractions.

During the period under review, groundwater sampling sites in the vicinity of the Waihapa-F wellsite were sampled. The results of the analyses carried out do not indicate any form of contamination of local groundwater as a result of the Company's injection activities.

No complaints were received from the public with regard to any of the Company's DWI activities during the period under review, and no incidents were recorded by the Council.

4.1 Discussion of site performance

During the period under review, the Company exercised DWI consent 4094-2. A summary of the Company's level of compliance with the special conditions attached to consent 4094-2 is provided in Table 9.

Table 9 Summary of Company performance with regard to consent 4094-2

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Consent holder must operate in accordance in Injection Operation Management Plan.	Receipt of satisfactory information	Yes
2. Injection pressure must not exceed 85 Bar (1232 PSI)	Assessment of consent holder records	Yes
3. Consent holder shall at all times adopt best practicable option (BPO to prevent and/or minimise environmental impact)	Assessment of consent holder records and site inspection results	Yes
4. Provision of records for discharge volumes, rates, and pressures	Receipt of well discharge data	Yes
5. Chemical analysis of discharge and submission to the Council	Receipt of discharge analysis results	Yes
6. Review provision	N/A	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		High
Overall assessment of consent compliance and administrative performance in respect of this consent		High

Overall, in 2013-2014, the Company achieved a '**High**' standard of environmental performance and a '**High**' level of administrative performance with respect to DWI consent 4094-2. The criteria associated with a 'high' level of environmental performance and a 'high' level of administrative performance are outlined in Section 1.1.4 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."

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."

4.2 Environmental effects of exercise of consents

The most significant potential adverse environmental effect arising as a result of fluid injection is the contamination of freshwater aquifers. The protection of groundwater is fundamental to the protection of surface water and consequently, groundwater

should be protected to the greatest extent practicable from serious or irreversible damage arising from human activity.

Well engineering technology, regional and local geologic characterisation, and site specific modelling are typically combined at the planning stage of an injection well to ensure that injected fluids are contained within the intended disposal interval. This information is typically supplied to the Council when an application for consent to discharge fluids by DWI is lodged, and used to assess the potential for adverse environmental effects resulting from the proposed activity.

The DWI consents exercised during the period under review permit the injection of waste fluids into the Matemateaonga Formation. Discharges to the Matemateaonga Formation via the Waihapa-7A well occur at depths of approximately 1,190 m TVD (below ground level). The injection interval is overlain by thick layers of impermeable siltstones and mudstones, confining the injected waste material within the intended zone.

The results of the sampling and analysis of groundwater in the vicinity of the wellsite location indicates that injection operations have not resulted in the migration of contaminants to shallow aquifers utilised for water supply in the area surrounding the site.

The natural geological characteristics of the strata overlying the injection intervals, the engineering of the injection wells, the monitoring of injection activities and their regulation all contribute to minimise the potential for any adverse environmental effect resulting from DWI activities.

4.3 Alterations to monitoring programme for 2014-2015

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, the obligations of the RMA in terms of monitoring emissions/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 sound understanding of industrial processes within Taranaki emitting to the atmosphere/discharging to the environment.

It is proposed that the range of monitoring carried out during the 2013-2014 period in relation to the Company's DWI activities be continued during the 2014-2015 monitoring period.

Recommendations to this effect are included in Section 5 of this report.

4.4 Exercise of optional review of consents

The next optional review dates for consents 3688-2, and 4094-2 are provided for in June 2016.

The Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent. A review may be 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.

Based on the results of monitoring carried out in the period under review, and in previous years as set out in earlier annual compliance monitoring reports, it is considered that there are no grounds to require a consent review to be pursued or grounds to exercise the review options. A recommendation to this effect is presented in Section 5 of this report.

5. Recommendations

1. THAT the range of monitoring carried out during the 2013-2014 period in relation to the Company's DWI activities be continued during the 2014-2015 monitoring period.
2. THAT the Council notes there is no requirement at this time for a consent review to be pursued or grounds to exercise the review options.

Glossary of common terms and abbreviations

The following abbreviations and terms are used within this report:

Aquifer (freshwater)	A formation, or group or part of a formation that contains sufficient saturated permeable media to yield exploitable quantities of fresh water.
Conductivity	A measure of the level of dissolved salts in a sample. Usually measured at 20°C and expressed as millisiemens per metre (mS/m) or as Total Dissolved Solids (g/m ³).
Confining layer	A geological layer or rock unit that is impermeable to fluids.
Deep well injection (DWI)	Injection of fluids at depth for disposal or enhanced recovery.
Freshwater/saline water water interface	The depth in a well at which fresh water becomes saline. The interface may be a gradational or sharp transition, depending on geology. The FW-SW transition is demonstrated by down-hole geophysical logging.
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).
Hydraulic fracturing (HF)	The process of increasing reservoir permeability by injecting fluids at pressures sufficient to fracture rock within the reservoir (“fracking”).
Injectate	Fluid disposed of by deep well injection.
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 what were the circumstances/events surrounding an incident including any allegations of an incident.
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 to seawater and containing low levels of hydrocarbons.
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.
TRC	Taranaki Regional Council (the Council).
TVD	True vertical depth.

Water flooding

A method of thermal recovery in which hot water is injected into a reservoir through specially distributed injection wells. Hot water flooding reduces the viscosity of the crude oil, allowing it to move more easily toward production wells.

Bibliography and references

Ministry for the Environment (2006). A National Protocol for State of the Environment Groundwater Sampling in New Zealand. Ref. ME781.

Stevens G. 2001. Taranaki : *In: Groundwaters of New Zealand*, M.R, Rosen and P.A. White (*eds*). New Zealand Hydrological Society Inc., Wellington. P381-386.

Taranaki Regional Council (2012). Origin Energy Resources New Zealand Limited Deep Well Injection Monitoring Programme Triennial Report (2009-2012). Technical report 2011-85. Document number 1114242.

Appendix I

DWI consent exercised in 2013-2014 period

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

Name of
Consent Holder: NZEC Waihapa Limited
P O Box 8440
NEW PLYMOUTH 4342

Decision Date
(Change): 3 September 2013

Commencement Date
(Change): 3 September 2013 (Granted: 10 September 2010)

Conditions of Consent

Consent Granted: To discharge produced water, contaminated stormwater, water based drilling fluids and hydraulic fracturing fluids, including return fluids, by deepwell injection into the Matemateaonga Formation

Expiry Date: 1 June 2028

Review Date(s): June 2016, June 2022

Site Location: Waihapa-F wellsite, 7 Bird Road, Stratford

Legal Description: Sec 10 Blk III Ngaere SD (Discharge source & site)

Grid Reference (NZTM) 1717193E-5642014N

Catchment: Patea

Tributary: Ngaere

*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 consent holder shall operate the well in accordance with the "Origin Energy Resources NZ Limited - Deep Well Injection Management Plan" dated June 2010. In particular, Section 7 of the plan (page 11) which 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.
2. The injection pressure at the wellhead shall not exceed a maximum injection pressure of 85 bars (1,232 PSI).
3. 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 minimise any actual or likely adverse effect on the environment; in particular, ensuring that the injection material is contained within the injection zone.
4. The consent holder shall keep daily records of:
 - a) maximum injection pressure;
 - b) maximum and average rate of injection; and
 - c) volume of fluid injected;

during operation of the well. These records shall be provided to the Taranaki Regional Council at the end of each month.

5. The consent holder shall measure and record the following constituents of the discharge at the end of each month:
 - a) pH;
 - b) suspended solids concentration;
 - c) temperature;
 - d) salinity;
 - e) chloride concentration; and
 - f) total hydrocarbon concentration.

The consent holder shall provide to Taranaki Regional Council, during the month of May of every year, a summary of all records collected in accordance with this condition. The consent holder must also provide any details on the major changes in characteristics or sources of injected fluid.

Consent 4094-2

6. 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 of June 2016 and/or June 2022, 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 1 November 2013

For and on behalf of
Taranaki Regional Council



Director-Resource Management