Shell Todd Oil Services Limited
Deep Well Injection
Monitoring Programme
Annual Report
2012-2013

Technical Report 2013-66

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Executive summary

The following Annual Report by the Taranaki Regional Council (the Council) outlines Shell Todd Oil Services Limited's (the Company) deep well injection (DWI) activities during the monitoring period 1 July 2012 – 30 June 2013. The report provides details of the DWI consent held by the Company during the period under review, and the compliance monitoring programme implemented by the Council with regard to this consent. The report also discusses the results of the monitoring carried out, and provides an assessment of Company performance with regard to consent compliance.

During the period under review, the Company held resource consent 1336-3, authorising the injection of produced water, and other approved contaminates by DWI, at the KA-1/7 wellsite, Palmer Road, Kapuni, and the KA-09 wellsite, Lower Duthie Road, Kapuni. Injection at the KA-1/7 wellsite is authorised via the KA-01 and KA-07 wells, and via the KW-2 well at the KA-09 wellsite. The consent includes a number of special conditions, setting out specific requirements with which the Company must comply.

During the period under review, injection was carried out exclusively via the KW-2 well, with the KA-01 and KA-07 wells providing contingency disposal options. The monitoring of the Company's DWI activities by the Council included undertaking inspections of injection operations, the review and assessment of injection data submitted by the Company, and groundwater monitoring in the vicinity of the active injection site.

The Council carried out two inspections of the Company's active DWI sites during the period under review. Inspection visits comprised liaison with on-site staff, identification of the active injection well, viewing the injection well monitoring equipment and injection logs, and spot sampling of the injectate.

As required by the special conditions of consent 1336-3, the Company supplied the Council with process monitoring data and injection records, at the required intervals. Data supplied by the Company was reviewed by the Council on submission. In total, the Company discharged 62,228 cubic metres (m^3) of fluids by DWI during the 2012-2013 monitoring period. The volumes of fluid discharged, and the pressure at which it was injected into the receiving formations, were within the limits specified in the respective resource consents.

The information gathered during inspection visits and the data supplied by the consent holder for Council audit 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 2012-2013 monitoring period. The Company has demonstrated a **high** level of environmental performance and compliance with the resource consent exercised during this period.

For reference, in the 2012-2013 year, 35% 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 59% demonstrated a good level of environmental performance and compliance with their consents.

This report includes recommendations to be implemented during the 2013–2014 monitoring period.

Table of contents

List of tables

List of Figures

1. Introduction

1.1 Compliance monitoring programme reports and the Resource Manage Act 1991

1.1.1 Introduction

The following Annual Report covers the monitoring period 1 July 2012–30 June 2013. During the period under review, Shell Todd Oil Services Limited (the Company) held resource consent 1336-3. The consent authorises the injection of produced water, and other approved contaminates via injection wells at their KA-1/7 wellsite, Palmer Road, Kapuni, and the KA-09 wellsite, Lower Duthie Road, Kapuni. The consent includes a number of special conditions, setting out specific requirements with which the Company must comply.

The following report provides details of the DWI consent held by the Company during the period under review and outlines the Company's DWI activities during this period. The report also outlines the monitoring programme implemented by the Taranaki Regional Council (the Council) with regard to these activities, discusses its results, and provides an assessment of Company 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 consent 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 2013-2014 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 (the 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;
(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 Act to assess the effects of the exercise of consents. In accordance with section 35 of the Act, 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

In addition to discussing the various details of the performance and extent of compliance by the Company during the period under review, this report also assigns an overall compliance 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 inconsequential (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 monitoring period were negligible or minor at most, or, 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, or, 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, and any inconsequential non compliances with conditions were resolved positively, co-operatively, and quickly.

- **improvement desirable (environmental)** or **improvement desirable (compliance)** (as appropriate) indicates that the Council may have been obliged to record a verified unauthorised incident involving measurable environmental impacts, and/or, there were measurable 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, and/or, there were on-going issues around meeting resource consent conditions even in the absence of environmental effects. Abatement notices may have been issued.

- **poor performance (environmental)** or **poor performance (compliance)** indicates generally that the Council was obliged to record a verified unauthorised incident involving significant environmental impacts, or there were material failings to comply with resource consent conditions that required significant intervention by the Council even in the absence of environmental effects. Typically there were grounds for either a prosecution or an infringement notice.

For reference, in the 2012-2013 year, 35% 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 59% 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 pipes, 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 being 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, HF 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 abstracted from it. When hydrocarbons are abstracted from a reservoir, 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, 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 abstracted, and the productive life of the field diminishes. The issue of produced water 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 Act. Sections 15 and 30 of the Act 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 18 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.

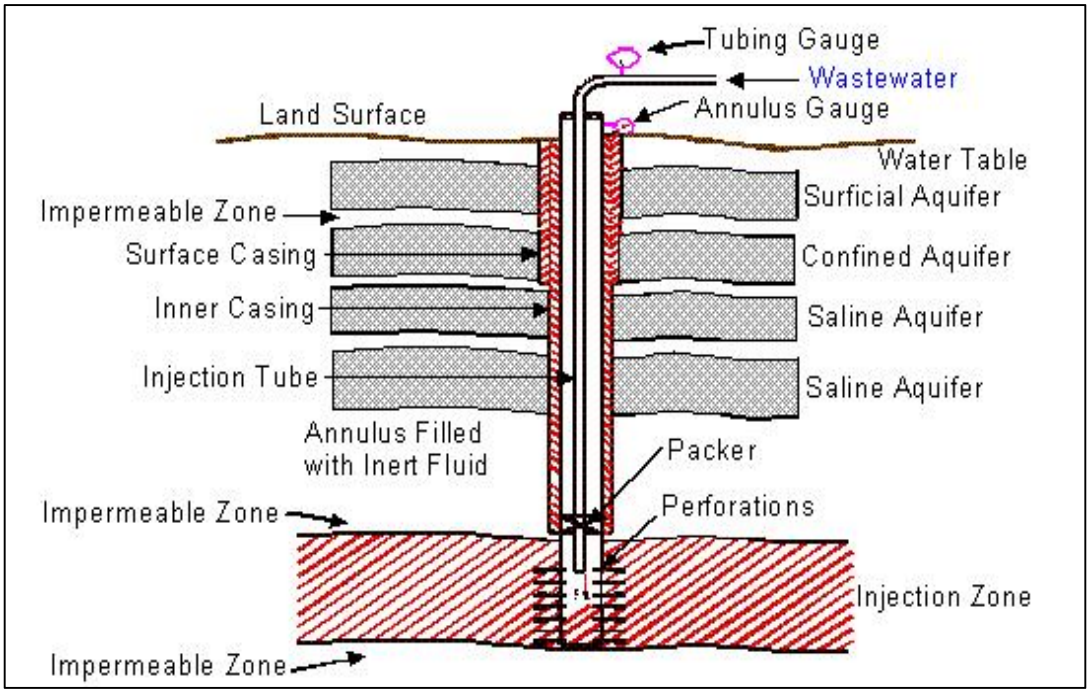

Figure 1 DWI schematic representative of Taranaki sites[1]

1.3 Potential environmental effects of exercising a DWI consent

The main potential environment 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 formations. 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 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] http://web.deu.edu.tr/atiksu/ana58/deepwell.html

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 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 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 details the consent held by the Company for DWI during the period under review, the wellsites to which the consent relates and the injection wells in use at each site. All resource consents are issued by the Council under Section 87(e) of the Act.

Table 1 Summary of DWI consents held by the Company during the 2012-2013 period

Consent	Wellsite	Injection Well(s)	Formation
1336-3	KA-09	KW-2	Matemateaonga
	KA-1/7	KA-01	Mangahewa
	KA-1/7	KA-07	Mangahewa

A summary of the resource consent held by the Company for DWI activities during the 2012-2013 monitoring period is included below.

Resource Consent: 1336-3

"To discharge up to 2,000 cubic metres/day of produced water and approved contaminants by deepwell injection into the Matemateaonga Formation via well KW-2or into the Mangahewa Formation via contingency back-up wells KA-01 and KA-07."

Background:
The first recorded discharges by DWI in the Kapuni field were carried out under water right 130. Records kept at the Council indicate that from 1973 to 1984, a total of 900,000 cubic metres (m^3) of produced water was discharged at the Kapuni production station, via well KW-1. The discharge was into a freshwater aquifer in the Matemateaonga Formation at a depth of 502 to 538 m true vertical depth (TVD) below ground level. In 1981, when water right 130 was renewed, the Council required the consent holder to nominate a new injection well, and that discharges via the KW-1 well cease. KW-1 was retained for emergency disposal purposes, and periodic discharges of produced water occurred via the well until 1990. Water right 130 expired on 1 June 1991. No adverse environmental effects were reported, and KW-1 was plugged and abandoned in December 2000.

On 10 October 1984, consent TRK931336 was granted to Shell BP & Todd Oil Services Limited, covering DWI activities within the Kapuni field. The consent was subsequently transferred to Shell Todd Oil Services limited (STOS) on 24 January 1991. Consent TRK931336 permitted the discharge of up to 800 m^3/day of produced water into the Matemateaonga Formation, via the KW-2 well, a non-producing gas well. On 26 September 1990, an application was received from the Company, seeking to increase the authorised discharge volume from 800 m^3/day to 1,200 m^3/day.

This application was granted on 17 April 1991. On 7 August 1991, special dispensation was approved for a one-off disposal of up to 132 m^3 of neutralised acids via KW-2.

A consent renewal application was received from the consent holder on 19 November 1992. The application also sought an increase in the authorised discharge volume to 2,000 m^3/day. A revised consent (1336-2) was granted on 10 February 1993. On 19 December 2003, the consent conditions were varied to allow for discharge by DWI via two contingency wells, KA-01 and KA-07, at the KA-1/7 wellsite.

Consent 1336-3 commenced on 21 April 2005. The consent authorises the discharge of up to 2,000 m^3/day of produced water into the Matemateaonga Formation via the KW-2 well, or into the Mangahewa Formation, via contingency wells KA-01 and KA-07.

On 31 July 2009, the Company applied for a further variation to consent 1336-3. Due to continual changes in additive technology, and the evolving requirements of a mature field such as Kapuni, there are changes in the nature of additives that may enter the produced water system, and subsequently require disposal by DWI. Rather than requiring the Company to apply for a variation of consent with every change made to the range of additives being used, it was considered preferable that the Company sought prior approval from the Council for any changes to the additives being used on a case-by-case basis. This variation to the consent was approved on 5 October 2009.

The Council waived its option to review consent 1336-3 in June 2011, as it was deemed that the consent conditions were adequate to deal with the potential adverse effects of the activity. The next optional review is provided for in June 2017.

Consent 1336-3 is due to expire on 1 June 2023.

The current consent has 11 special conditions, as summarised below:

- Special condition 1 requires the best practicable option to be adopted for the discharge;
- Special conditions 2, 3, 5, 6 and 8 refer to information and data submission requirements;
- Special condition 4 prohibits the discharge from endangering or contaminating any freshwater aquifer;
- Special condition 7 limits injection pressures to those which do not fracture the stratigraphic seals of the injection zone;
- Special condition 9 details the consent lapse and expiry dates;
- Special condition 10 contains review provisions; and
- Special condition 11 allows for the introduction of new chemicals to the produced water system, provided they can reasonably be expected to be used in petrochemical well maintenance and development, and they will not have environmental effects that are more adverse than current chemicals in use.

Figure 2 shows the location of the DWI consent held by the Company during the period under review. A copy of the consent certificate is attached in Appendix I of this report.

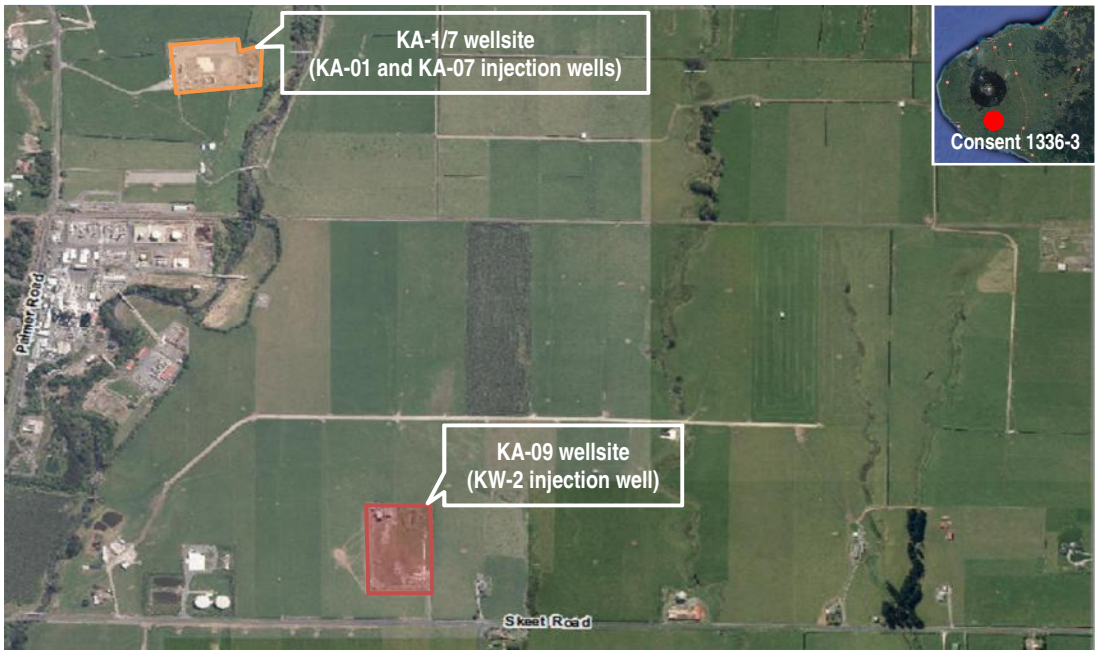

Figure 2 Location of consent 1336-3 and associated injection wells

1.5 Monitoring programme

1.5.1 Introduction

Section 35 of the Act 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 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. Samples of injectate were obtained from a holding tank located at the Kapuni Production Station, which stores waste fluid prior to injection. The tank is identified by the Company as tank T604.

Table 2 Location of sample points for active DWI sites

Consent	Wellsite	Injection well(s)	Site code	Sample point
1336-3	KA-09	KW-2	GND1412	Tank T604
	KA-1/7	KA-01	GND1683	N/A - contingency well
	KA-1/7	KA-07	GND1684	N/A - contingency well

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

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

1.5.4 Consent holder data submission requirements

The resource consent held by the Company for DWI includes 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 interval

The conditions of consent 1336 required the Company to submit a management plan for the operation of their injection wells. The plan was required to include details of the injection wells and their operation. The information requested is required to demonstrate that the exercise of the consent will not contaminate or endanger any actual or potentially useable freshwater aquifers.

The Council holds a significant volume of information regarding the Company's injection wells and the underlying geology in the Kapuni field. Data has been gathered

during the resource consenting process, 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. Specific data requirements included the following:

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

The Company provided adequate injection records for the 2012-2013 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 an annual report to the Council providing a summary of all injection data gathered over the previous 1 July to 30 June period. The annual report was also required to detail how compliance has been achieved with the special conditions of consent exercised during the monitoring period. The Company provided an annual written report which met the requirements of the consent condition. The report however, which should have been submitted in May 2013, was not received until August 2013. The Company indicated at an early stage that they could not meet the required timeline for submission due to the volume of compliance reports required for submission in the May to July period. After further consultation with the Company, they have indicated they will be lodging an application to vary the reporting condition attached to the consent to extend the report submission date until August of each year. As the Company indicated at an early stage that they were not going to be able to submit the annual report prepared within the required timeframe, and kept the Council informed of during the process of compiling the report, it was deemed that no follow up action was required.

1.5.5 Groundwater quality monitoring

A programme of groundwater monitoring in the vicinity of the Company's active injection sites was initiated during the 2012-2013 period. The programme provides for the biannual sampling of groundwater from selected groundwater abstraction sites.

In order to select suitable sampling sites for inclusion in the monitoring programme, the Council carried out a survey groundwater abstractions within a 1 kilometre (km) radius of the KA-09 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 number of groundwater abstractions in the area of investigation.

Following the desktop review, a field survey was undertaken to confirm the location of known abstraction sites and to assess their suitability for sampling.

The field survey was also used as an opportunity to identify any additional groundwater abstraction sites that are not currently registered with the Council.

Following the field survey, two private groundwater abstraction sites located in the vicinity of the KA-09 wellsite were selected for inclusion in the monitoring programme. The criteria used in assessing the suitability of a site for inclusion in the programme was the proximity of the site to the active injection well, the depth to which the bore or well has been drilled or excavated, the construction of the bore or well, and its susceptibility to contamination by surface run-off.

Details of the sites selected for inclusion in the monitoring programme are listed below in Table 3.

Table 3 Location of groundwater sampling sites (2012-2013)

Site code	Type	Distance from wellsite (m)	Casing depth (m)	Total depth (m)	High static water level (m)	Aquifer
GND2341	Well	436	N/A	8.74	4.65	Volcanics
GND2345	Bore	870	NR*	64.0	NR**	Volcanics

* Not Recorded: Bore log not available
** Not Recorded: Design of the bore prevents static water level from being measured from the ground surface

In addition to the ground water sampling carried out by the Council during the period under review, the Company contracted URS New Zealand Limited (URS) to carry out groundwater monitoring in the vicinity of the KA-09 wellsite. URS obtained samples of groundwater from four existing groundwater abstractions on two separate occasions. Details of the sites sampled by URS are included in Table 4.

It has been agreed that the Company will continue to carry out its own groundwater monitoring in the vicinity of any active injection wells during the forthcoming 2013-2014 monitoring period.

Table 4 Location of groundwater abstraction sampled by the Company (2012-2013)

URS reference	Site code	Type	Distance from wellsite (m)	Casing depth (m)	Total depth (m)	High static water level (m)	Aquifer
Site 1	GND1143	Bore	948	40	65	18	Volcanics
Site 2	GND1701	Bore	2971	92	337	NR*	Matemateaonga
Site 3	GND2369	Bore	4643	280	448	NR*	Matemateaonga
Site 4	GND1659	Bore	4020	123	432	6	Matemateaonga

* Not Recorded: Design of the bore prevents static water level from being measured from the ground surface

2. Results

2.1 Site inspections and injectate sampling

During the period under review, the Council carried out two routine inspections in relation to the Company's DWI activities. Inspections were undertaken at the Kapuni Production Station on 11 September 2012 and 16 April 2013. The Kapuni Production Station serves as a central fluid collection and storage facility for waste fluids generated within the Kapuni field. All fluid injection is also controlled and monitored from the production station.

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 provide real-time monitoring data on request.

As part of the monitoring programme, spot samples of the injectate were obtained during the inspection visits. The injectate samples were submitted to the Council's IANZ accredited laboratory for physicochemical analysis. The results of the analysis are included below in Table 5. The concentrations of each analyte are within the expected range for injectate samples comprised predominantly of produced water.

Table 5 Results of injectate sampling undertaken by the Council (2012-2013)

Parameter	Unit	Site GND1412	
		11/09/12	16/04/13
Time	NZST	14:20	09:25
TRC sample number	-	TRC122838	TRC135571
pH	pH units	8	7.1
Conductivity @ 20°C	mS/m @ 20^0C	3,200	3,300
Alkalinity	g/m^3 $CaCO_3$	6,630	6,620
Chloride	g/m^3	9,840	10,600
Total petroleum hydrocarbons	g/m^3	79	230

2.2 Assessment of data provided by the consent holder

The Company provided a record of injection data for the 2012-2013 monitoring period, including injection volume, rate and pressure data. The injection data provided by the Company is summarised in Tables 6 and 7. The data provided by the Company is also presented graphically in Figures 3 and 4.

Table 6 Summary of DWI activities during the period under review (2012-2013)

Consent	Wellsite	Injection wells	Total volume discharged (m^3) 01/07/12 – 30/06/13	Discharge period		TRC well ID
				From	To	
1336-3	KA-09	KW-2	62,228	01/07/12	30/06/13	GND1412
	KA-1/7	KA-01	-	-	-	GND1683
	KA-1/7	KA-07	-	-	-	GND1684
		Total	62,228	01/07/12	30/06/13	-

Table 7 Summary of the Company's 2012-2013 injection data

	1336-3 – KW-2 injection well		
	Volume injected (m^3)	Injection pressure (bar)	Injection Rate (m^3/hr)
Total	62,228	N/A	N/A
Daily Maximum	790	65*	147
Daily Average	171	47	20

*Several pressure readings in excess of 200 bar were recorded during the monitoring period. These readings were explained as transmitter errors, as no pumping was occurring at the time. The inaccurate pressure readings were removed from the dataset to enable the calculation of maximum and mean pressures.

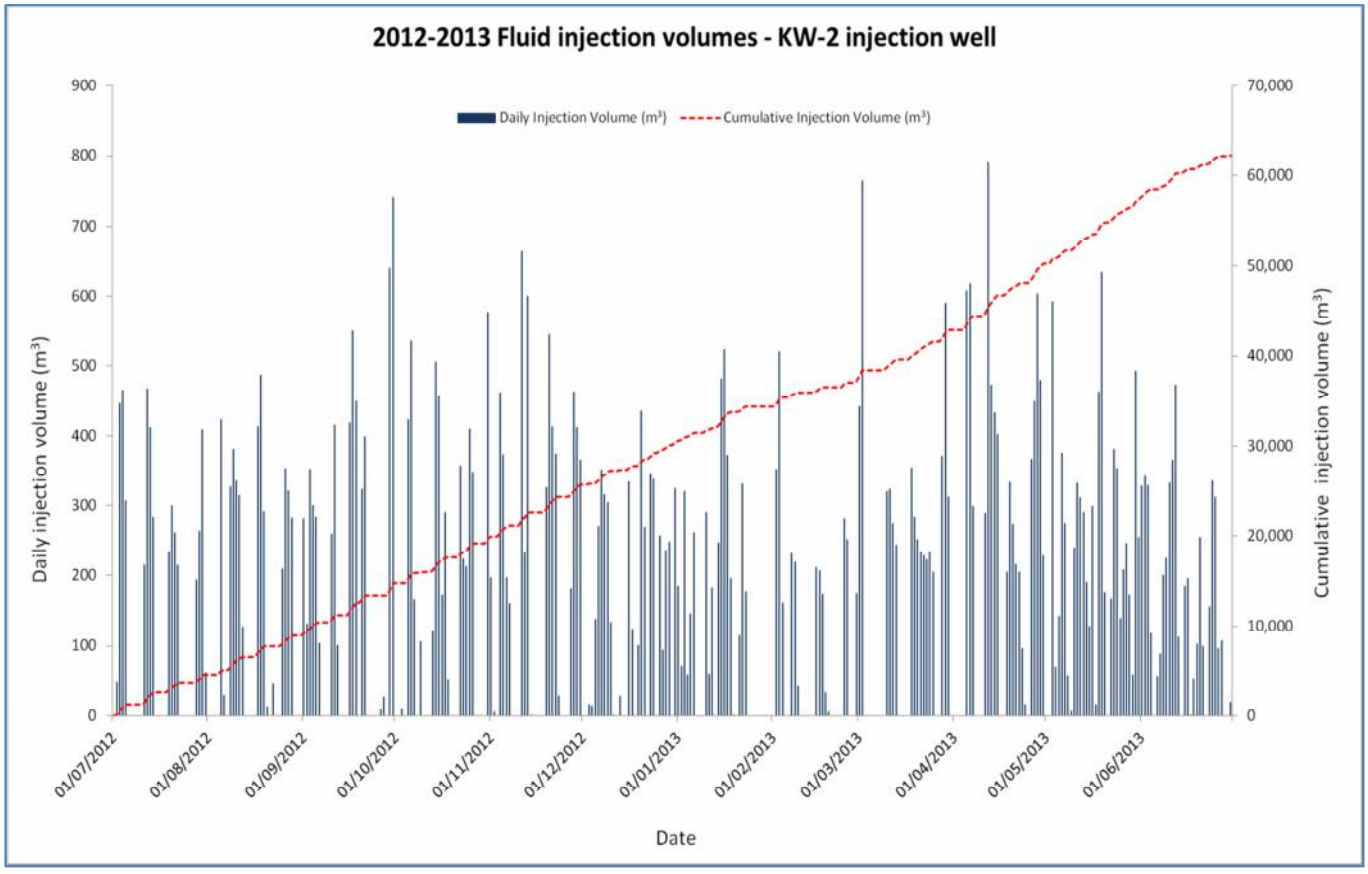

Figure 3 2012-2013 fluid injection volumes – KW-2 injection well (1336-3)

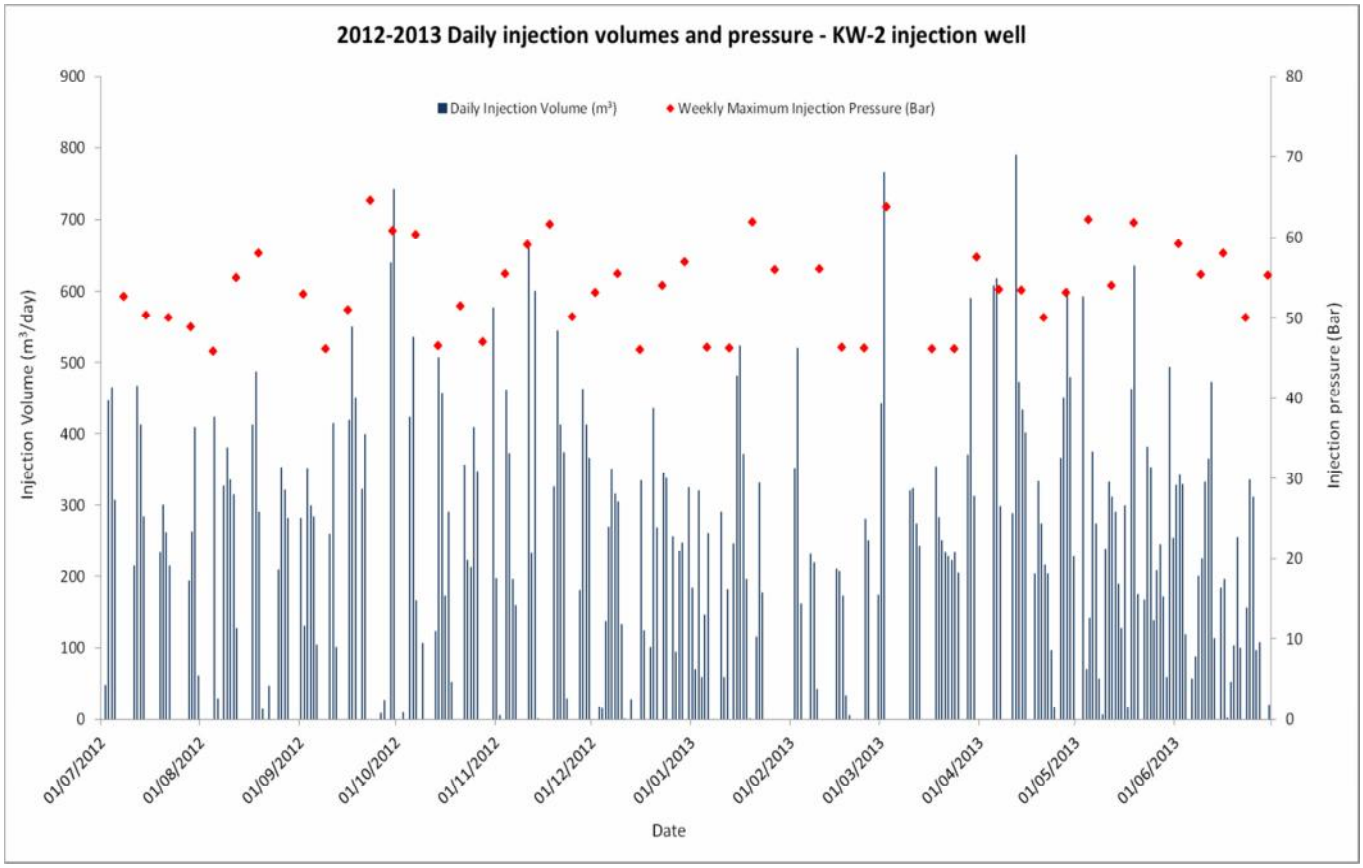

Figure 4 2012-2013 injection volumes and pressure – KW-2 injection well (1336-3)

In addition to the injectate sampling carried out by the Council (Section 2.1), the Company also provided results of their own analysis of KW-2 injectate samples. The results of the analyses are presented below in Table 8.

Table 8 Range of contaminants in KW-2 injectate samples (2012-2013)

Parameter	Unit	Number of samples	Maximum value	Minimum value	Mean value
pH	pH units	36	7.5	6.7	7.0
Salinity	g/m³	36	25,800	9,100	19,806
Chloride	ppm	36	11,125	5,652	9,711
Total suspended solids	g/m³	36	67	24	43
Total dissolved solids	g/m³	34	33,560	23,857	25,774
Total petroleum hydrocarbons	ppm	36	317	26	107

The maximum and mean values associated with the results of the analyses carried out 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 source at the time of sampling.

2.3 Groundwater quality monitoring

Groundwater samples were obtained by the Council from selected sampling locations in the vicinity of the KA-09 wellsite during May 2013. 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 samples were 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 carried out are outlined in Table 9.

The results give no indication of any potential contamination of shallow groundwater as a result of fluid injection via the KW-2 well.

Table 9 Results of groundwater sampling undertaken by the Council (2012-2013)

Sample details	**Units**	**GND2341**	**GND2345**
TRC sample number	-	TRC135572	TRC135573
Sample date	-	23/05/2013	13/05/2013
Sample time	NZST	13:55	12:42
Analyte	**Units**		
Static water level	m	4.65	NR*
Temperature	ºC	12.6	11.6
pH	pH units	6.6	6.8
Conductivity	mS/m@20ºC	28.5	29.3
Alkalinity	g/m^3 as $CaCO_3$	76	116
Chloride	g/m^3	36.3	33.7
Total hydrocarbons	g/m^3	<0.5	<0.5

* Not Recorded: Unable to gain direct access to bore on day of sampling.

During the period under review, the Company also conducted groundwater sampling at four sites in the vicinity of the KA-09 wellsite. Sampling was conducted on 19 December 2012 and 2 May 2013. The samples were collected by URS following standard groundwater sampling methodologies. The samples were submitted to Hill Laboratories Limited for analysis. The results of the analyses are included in Appendix II.

The results give no indication of any potential contamination of shallow groundwater as a result of fluid injection via the KW-2 well.

The results of the analysis of groundwater samples for dissolved gases indicate the presence of methane gas within local groundwater. Dissolved methane gas is commonly found in groundwater across the Taranaki region, including in areas where no hydrocarbon exploration or production has occurred. The concentrations of dissolved methane gas are within the typical range for Taranaki groundwater.

As part of their assessment of dissolved gas concentrations, URS submitted samples of groundwater from each sampling site to GNS Science (GNS) for carbon isotope analysis. The analysis of carbon isotopes is used to determine the isotopic signature of methane gas, which can be used as an indicator of its origin. Shallow methane gas, derived from the breakdown of organic material close to the surface (e.g. swamps), is termed biogenic. Alternatively, thermogenic methane is normally produced in deeper formations.

Compositionally, shallow biogenic gas is easily recognisable from thermogenic gas, as the former is nearly 100% methane, while thermogenic methane usually occurs in the company of the related gases, ethane, propane, butane and pentane, derived from thermal decomposition (King, 2012). They can also be discriminated on the basis of their common stable (non-radioactive) carbon isotopes, ^{12}Carbon (^{12}C has 6 neutrons) and ^{13}Carbon (^{13}C has 7 neutrons). Biogenic methane contains more ^{12}Carbon while thermogenic methane contains more of the ^{13}C carbon isotope. By analysing the relative concentration of ^{13}C carbon isotope (δ^{13}C), it can be determined whether the methane present is biogenic or thermogenic in origin. Generally, a δ^{13}C value that exceeds -50‰ indicates biogenic methane, and a δ^{13}C value less than-50‰ indicates thermogenic methane. The higher or lower the δ^{13}C values, the stronger the isotopic signature. A δ^{13}C value in the vicinity of -50‰ can indicate a mixture of both biogenic and thermogenic methane.

In areas where the injection of fluids under pressure is occurring, i.e. within the vicinity of DWI or hydraulic fracturing sites, the presence of thermogenic methane may indicate the fracturing of the stratigraphic seals overlying the injection interval, or the presence of a conduit between the injection interval and the overlying freshwater aquifers.

The results of the δ^{13}C analysis carried out by the GNS are outlined below in Table 10. The results indicate that in all samples, the methane gas present is biogenic in origin and is likely to be present as a result of the biological breakdown of organic matter in shallow subsurface and not related to the Company's injection activities, nor to natural gas seeps.

The concentration of dissolved methane at each monitoring site did increase during the course of the monitoring period and this trend will be monitored during the forthcoming 2013-2014 period.

Table 10 Results of GNS δ^{13}C analysis (2012-2013)

URS reference	Sample date	δ^{13}C composition (‰)	Gas origin
Site 1	2 May 2013	-64	Biogenic
Site 2	2 May 2013	-64	Biogenic
Site 3	2 May 2013	-64	Biogenic
Site 4	2 May 2013	-64	Biogenic

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 Unauthorised Incident Register (UIR) 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 consents during the 2012-2013 monitoring period.

4. Discussion

During the period under review, the Company exercised consent 1336-3 for the injection of fluids by DWI. The consent authorises the injection of produced water, and other approved contaminates, into the Mateamateaonga Formation via the KW-2 well, or into the Mangahewa Formation via contingency back-up wells KA-01 and KA-07.

During the period under review, the only well utilised for the injection of waste fluids was the KW-2 well, located at the Company's KA-09 wellsite. During this period, a total of 62,228 m^3 of fluid was injected, at an average of 171 m^3/day. The average injection pressure was 47 bar, with a maximum pressure of 65 bar.

Consent 1336-3 specifies a maximum daily injection volume of 2,000 m^3. A review of the injection data provided by the Company indicates the daily maximum volume injected was 790 m^3, on 23 May 2013. The maximum daily injection volume is well below the maximum daily volume authorised by the consent.

Consent 1336-3 does not stipulate a maximum injection pressure, but requires fluids to be injected at pressures below that which would cause fracturing of the stratigraphic seals confining the injection interval. The maximum injection pressure reached during the period under review was 65 bar, which occurred on 20 May and 21 May 2013. There is no evidence to suggest that the injection of fluids by DWI has resulted in any fracturing of the stratigraphic seals that confine the injection interval.

The consent holder has provided sufficient information for the KW-2 well 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 wells being used for the injection and the receiving formation remain secure.

During the 2012-2013 period, consent holder performance was assessed on compliance with consent conditions, with a particular emphasis on record keeping requirements and information provision, and the analysis of the information and data provided. Compliance with the conditions of the DWI consent exercised during the 2012-2013 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 actual or potential 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, two groundwater sampling sites were identified in the vicinity of the KA-09 wellsite, and sampled by the Council. Groundwater monitoring sites were also identified and sampled by URS on behalf of the Company. The results of the analyses carried out on all samples collected do not indicate any form of contamination as a result of fluid injection via the KW-2 well.

The results of the analyses carried out do indicate the presence of dissolved methane gas within local groundwater. Further analysis of the isotopic signature of the gas indicates that it is biogenic in origin.

Biogenic methane is commonly found in groundwater across the Taranaki region, including areas where no hydrocarbon exploration or production has occurred. The gas is present due to the biological breakdown of organic material within shallow subsurface formations. The concentrations of dissolved methane gas are within the typical range for Taranaki groundwater.

It is noted that the concentration of dissolved methane at each monitoring site increased during the period under review. This trend will be monitored during the forthcoming 2013-2014 period.

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 1336-3. A summary of the Company's level of compliance with the special conditions attached to consent 1336-3 is provided in Table 11.

Table 11 Summary of Company performance with regard to consent 1336-3 (2012-2013)

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Adopt best practice operations for DWI	Assessment of consent holder records and environmental performance	Yes
2. Exercise consent in accordance with consent application	Assessment of consent holder records	Yes
3. Provision of well and injection zone information	Receipt of satisfactory information	Yes
4. No contamination of freshwater aquifers	Assessment of consent holder records	Yes
5. Provision of records for discharge volumes, rates, and pressures	Receipt of well discharge data	Yes
6. Provision of records of chemical analysis of discharge	Receipt of discharge analytical results	Yes
7. No fracturing of stratigraphic seals of injection formation	Assessment of consent holder records	Yes*
8. Provision of annual report on deep well injection activities	Receipt of annual report from consent holder	Yes**
9. Lapse clause	Receive notice of exercise of consent	Yes
10. Consent review clause	N/A	N/A
11. Only approved chemicals to be discharged by DWI	Discharge of approved chemicals only	Yes
Overall assessment of consent compliance and environmental performance in respect of this consent		**High**

* No evidence to suggest any contamination of freshwater aquifers has occurred in the period under review

** Report submitted late

Overall, in 2012-2013, the Company achieved a '**high**' standard of environmental performance with respect to consent 1336-3. The criteria associated with a 'high' level of environmental performance are outlined in Section 1.1.4 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 inconsequential (such as data supplied after a deadline) non-compliance with conditions."

4.2 Environmental effects of exercise of discharge permit

The most significant potential adverse environment effect arising as a result of fluid injection is the contamination of freshwater aquifers. The protection of groundwater is also 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 mathematical modelling are typically combined at the planning stage of a 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 consent exercised by the Company during the period under review authorises the discharge of waste fluids into the Matemateaonga Formation, via the KW-2 well, or into the Mangahewa Formation via contingency back-up wells KA-07 and KA-09. All discharges during the 2012-2013 monitoring period were via the KW-2 well, located at the KA-09 wellsite.

The KW-2 well is perforated near the base of Matemateaonga Formation, between 1,245 – 1,288 m TVD below ground level. The injection interval is referred to as the MAT-60 unit, and is comprised of sequences of clayey sandstone and siltstones. Electric log data from KA-04 and KA-07 wells indicate that the thickness of MAT-60 ranges between 130 - 157 m. The MAT-60 interval is targeted for injection due to the predominance of permeable sandstone facies. It is expected that the fluids injected via the KW-2 well follow the dip of the MAT-60 unit in a south-westerly direction.

A number of faults are present in the Matemateaonga Formation, running in a north-east to south-west direction. Fault seal analysis has indicated that faults in the vicinity of the KW-2 well are unlikely to provide a potential conduit between the injection interval and potable shallow aquifers. As such, it is concluded that the injection interval is vertically separated from the deepest water abstraction point in the area (438 m TVD below ground level, 1.9 km south-west of KW-2) by multiple layers of relatively low permeability and continuous stratigraphic seals, within a formation thickness in excess of 500 m.

Figure 5 provides a schematic representation of the relative positions of KW-2, the deepest groundwater abstraction well in the local area, and the major geological layers as interpreted from well logs.

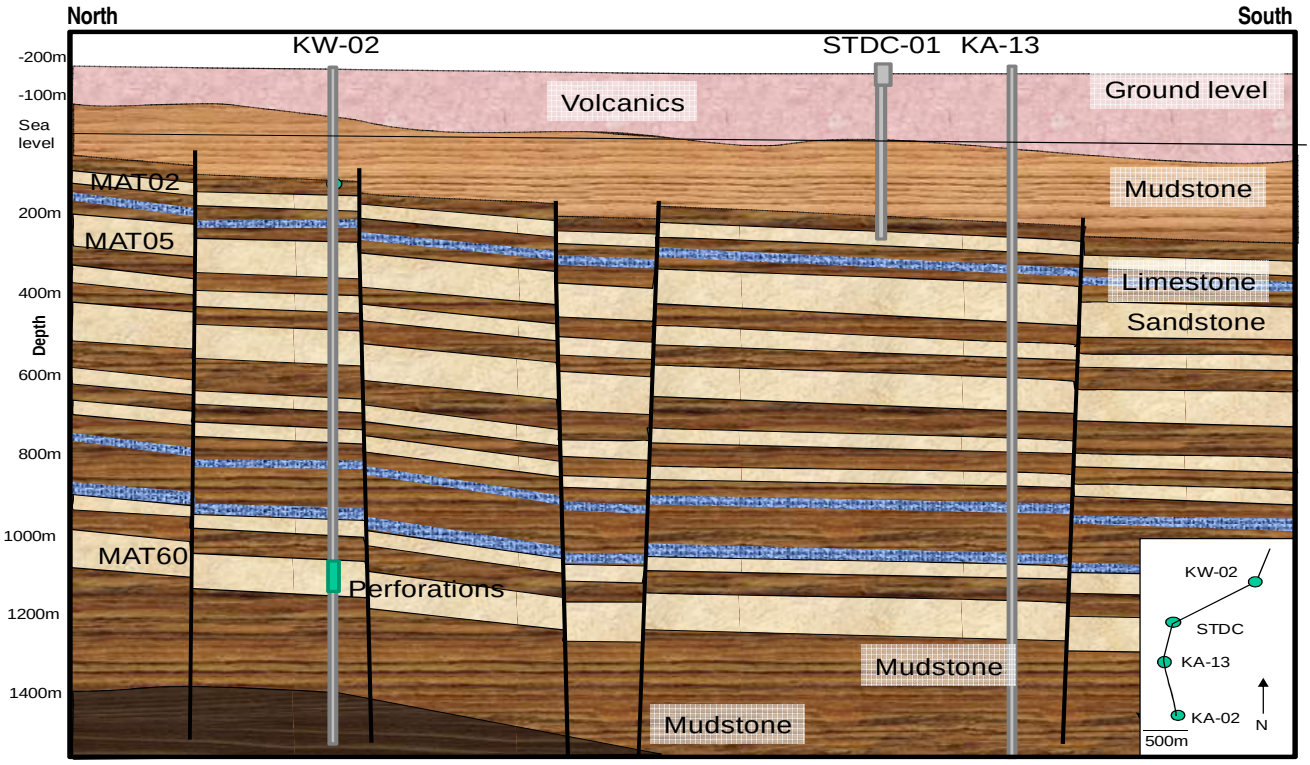

Figure 5 Schematic section through Kapuni wells (location of faults is indicative only)

Well integrity is critical in ensuring that the injection of waste fluids by DWI does not result in the release of contaminants outside of the intended injection interval. The Company carries out regular routine monitoring of well integrity by running time-lapse temperature surveys in the KW-2 well. Any loss of integrity and loss of contaminants outside the injection interval is indicated by spikes of increased temperature (in the shallow section of the well which is cooler than injected water) or reduced temperature (in the deeper part of the well). Injected water typically has a temperature of 16 ^{0}C, whilst the undisturbed formation fluid temperature at 1,200 m TVD below ground level is approximately 26 ^{0}C.

An increase in annulus pressure could also indicate a loss of integrity, and potential leakage outside of the well casing. The Company monitors annular pressure daily during injection. The assessment of the pressure data by the Company and the Council does not indicate any significant increases in well annular pressure, supporting the conclusion that the injection well remains secure.

During the period under review, temperature and pressure surveys were carried out in the KW-2 well in November 2012 and May 2013. The results of these surveys, and continuous annular pressure monitoring data, confirm the integrity of the well tubing and casing.

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

There is no evidence to suggest that the injection of fluids by DWI at any of the Company's active injection sites has resulted in the vertical migration of contaminants outside of the intended injection interval.

4.3 Recommendations from the previous monitoring report

In the 2009-2012 Triennial Report, it was recommended:

1. THAT all monitoring of the Company's DWI activities carried out during the 2009-2012 period be continued during the 2012-2013 monitoring period.

   The recommendation was implemented in the 2012-2013 period.

2. THAT biannual sampling of shallow groundwater in the vicinity of active injection wells be included in the monitoring programme for the forthcoming period.

   The implementation of this recommendation commenced in the 2012-2013 period. Monitoring sites in the vicinity of the KA-09 wellsite were selected to monitor any effects of injection under consent 1336-3 on local groundwater. The Company will continue to implement the groundwater monitoring requirements for the forthcoming monitoring period.

3. THAT the Company maintain full weekly records of all injection data, as required by the relevant resource consents, including nature of material injected, injection volumes, pressures and rates. The consent holder should ensure that these records are submitted at the time intervals specified by the conditions of exercised consents.

   The recommendation was implemented in the 2012-2013 period.

4. THAT the Company provides the Council, in May of each year, an annual written DWI report detailing all activities authorised by the consents held by the company for these activities. The report should include the results of any well integrity or formation analyses carried out, and an assessment of the injection data submitted.

   The Company provided an annual written report which met the requirements of the consent condition. However, the report, which should have been submitted in May, was not received until August 2013. The Company indicated that they could not meet the required timeline for submission due to the volume of compliance reports required for submission in the May to July period. After consultation with the consent holder, they have indicated they will be lodging an application to vary the reporting condition attached to the consent to extend the report submission date back until August of each year.

5. 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.

   There was no review of any DWI consent held by the Company during the 2012-2013 period.

4.4 Alterations to the monitoring programme for 2013-2014

In designing and implementing the monitoring programmes for air/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 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 in the 2012-2013 period be continued in the 2013-2014 period. It has been agreed however that the Company will use their consultant (URS) to carry out the groundwater monitoring component of the programme in the forthcoming monitoring period. Groundwater samples will be obtained on a biannual basis from the groundwater monitoring sites utilised during the 2012-2013 period.

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

4.5 Exercise of optional review of consent

An optional review of consent 1336-3 is next provided for in June 2017, prior to consent expiry on 1 June 2023.

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 included in Section 5 of this report.

5. Recommendations

1. THAT the range of monitoring carried out during the 2012-2013 period in relation to the Company's DWI activities be continued during the 2013-2014 monitoring period.

2. THAT the Company maintain full daily records of all injection data required by the relevant resource consent, including the nature of material injected, injection volumes, pressures and rates.

3. THAT, during the 2013-2014 monitoring period, the Company carries out sampling of shallow groundwater on a biannual basis, at the same sites sampled during 2012-2013 monitoring period. Groundwater samples should also be analysed for the same range of parameters as those samples taken during the 2012-2013 baseline sampling round.

4. THAT, if the Company feels they cannot meet the annual reporting timeframes currently attached to consent 1336-3, a revised submission date should be discussed and agreed with the Council, and a consent variation application lodged.

5. 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 freshwater.
Bcf	Billion cubic feet.
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.
Fracture gradient	A measure of how the pressure required to fracture rock in the earths 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.
Freshwater-saline-water interface	The depth in a well at which freshwater 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 ("fraccing").
Injectate	Fluid disposed of by deep well injection.
L/s	Litres per second.
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.
mbgl	Metres below ground level.
m^3	Cubic metre.
Packer	A down hole device used to isolate the annulus from the production conduit, enabling controlled production, injection or treatment.
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.
Power fluid	Pressurized fluids used to transmit and control energy into oil/gas wells. Cheal power fluid is a heated combination of fresh and produced water.
ppt	Parts per thousand.
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).
The Act	Resource Management Act 1991 and subsequent amendments.
TRC	Taranaki Regional Council (the Council).
TVDSS	True vertical depth sub sea. Given as metres below sea level.
UI	Unauthorised Incident.
UIR	Unauthorised Incident Register – contains a list of events recorded by the Council on the basis that they may have the potential or actual environmental consequences that may represent a breach of a consent or provision in a Regional Plan.
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

Environmental Protection Agency, United States. An introduction to the technology of subsurface wastewater injection. Environmental Protection Technology Series (EPA-600/2-77-240)

King, G.E. 2012: Hydraulic Fracturing 101: What every representative, environmentalist, regulator, reporter, investor, university researcher, neighbour and engineer should know about estimating frac risk and improving frac performance in unconventional gas and oil wells. Society Petroleum Engineers International paper (SPE 152596) to SPE Hydraulic Fracturing Technology Conference held in The Woodlands, Texas, USA, 6-8 February 2012.

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

Shell Todd Oil Services Limited. Report to the Taranaki Regional Council on Produced water re-injection at KW-2 August 2013. Document 1250596.

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. Disposal of contaminants by deep well injection; A guide to applicants seeking resource consent to discharge contaminants by deep well injection in Taranaki. Unpublished memorandum September 2005; 12pp. Document number 100856.

Taranaki Regional Council (2012). Shell Todd Oil Services Limited Deep Well Injection Monitoring Programme Triennial Report 2009-2012. Technical Report 2012-66. Document number 1170675.

Appendix I

DWI consent exercised in 2012-2013 period

Consent 1336-3

TARANAKI REGIONAL COUNCIL
CHIEF EXECUTIVE
PRIVATE BAG 713
47 CLOTEN ROAD
STRATFORD
NEW ZEALAND
PHONE: 06-765 7127
FAX: 06-765 5097
www.trc.govt.nz

Please quote our file number on all correspondence

Discharge Permit

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

Name of Consent Holder:	Shell Todd Oil Services Limited Private Bag 2035 NEW PLYMOUTH 4342
Change To Conditions Date:	5 October 2009 [Granted: 21 April 2005]

Conditions of Consent

Consent Granted:	To discharge up to 2,000 cubic metres/day of produced water and approved contaminants by deepwell injection into the Matemateaonga Formation via well KW-2 at or about (NZTM) 1702850E-5629709N or into the Mangahewa Formation via contingency back-up wells KA-01 and KA-07 at or about (NZTM) 1701107E-5630144N and 1701159E-5630128N
Expiry Date:	1 June 2023
Review Date(s):	June 2011, June 2017
Site Location:	KW-2 wellsite, Lower Duthie Road, Kapuni KA-01 & KA-07 wellsites, Palmer Road, Kapuni
Legal Description:	Lot 1 DP 11291 Pt Sec 14 Blk XVI Kaupokonui SD [KW-2]; Lots 1 & 2 DP 11138 Blk XVI Kaupokonui SD [KA-01, KA-07]
Catchment:	Inaha Kapuni

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

Conditions 1 to 10 [unchanged]

1. The consent holder shall 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 effects on the environment from the exercise of this consent.

2. The exercise of this consent shall be carried out in general accordance with the information submitted in support of application 3817. In the case of any contradiction between the documentation submitted in support of application 3817 and the conditions of this consent, the conditions of this consent shall prevail.

3. 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, 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.

4. The resource consent holder shall ensure that injection will not contaminate or endanger any actual or potential useable freshwater aquifer.

5. The consent holder shall keep weekly 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 an annual basis, and when there has been a significant pressure change event.

6. The consent holder shall monitor the injected wastes weekly 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 on an annual basis.

7. The consent holder shall inject fluids at pressures below the pressure that would be required to fracture the stratigraphic seals of the injection formation.

8. 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 3, 4, 5, 6 and 7 above.

9. 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.

10. 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 2011 and/or June 2017, 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.

Condition 11 – new

11. The chemicals introduced to the produced water system and subsequently discharged by deepwell injection under this consent shall only be those listed in the product table on page 1 of the information submitted in support of application 6314, and other chemicals that:

    a) can reasonably be expected to be used in petrochemical well maintenance and development in accordance with industry best practice;
    b) have environmental effects that are no more adverse than those listed in the product table on page 1 of the information submitted in support of application 6314;
    c) have been certified by the Chief Executive, Taranaki Regional Council as complying with a) and b) above; and
    d) have been the subject of a specific request for certification in accordance with c) above that includes details of the concentration of the contaminant and an assessment of the effects of using the chemical in the manner proposed.

Signed at Stratford on 5 October 2009

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Appendix II

Results of URS groundwater sampling

Analyte	Units	Site 1		Site 2		Site 3		Site 4	
		(19/12/2012)	(02/05/2013)	(19/12/2012)	(02/05/2013)	(19/12/2012)	(02/05/2013)	(19/12/2012)	(02/05/2013)
Sum of Anions	meq/L	3.0	3.2	3.7	3.7	3.5	3.4	4.1	4.1
Sum of Cations	meq/L	2.8	3.0	3.6	3.5	3.2	3.3	3.8	4.2
pH	pH Units	7.0	6.8	8.4	8.4	8.8	8.9	8.1	8.1
Total Alkalinity	g/m^3 as $CaCO_3$	105	113	169	166	158	154	188	185
Total Hardness	g/m^3 as $CaCO_3$	55	61	52	51	13.3	13.4	101	113
Conductivity (EC)	mS/m	31.9	32.3	33.8	33.3	31.8	31.4	37.3	36.6
Total disolved solids (TDS)	g/m^3	210	220	200	210	199	198	220	230
Dissolved Barium	g/m^3	0.026	0.03	0.00199	0.0021	0.00108	0.0011	0.006	0.007
Dissolved Calcium	g/m^3	14.4	15.0	13.8	13.1	3.8	4.0	24.0	27.0
Dissolved Copper	g/m^3	0.0007	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Dissolved Iron	g/m^3	1.43	1.89	0.05	0.06	<0.02	0.07	0.17	0.20
Dissolved Magnesium	g/m^3	4.8	5.6	4.2	4.4	0.9	0.87	9.6	11.3
Dissolved Manganese	g/m^3	0.52	0.61	0.015	0.0129	0.0066	0.0073	0.03	0.03
Dissolved Mercury	g/m^3	<0.00008	<0.00008	<0.00008	<0.00008	<0.00008	<0.00008	<0.00008	<0.00008
Dissolved Nickel	g/m^3	0.0086	0.0165	0.0024	0.0008	<0.0005	<0.0005	<0.0005	<0.0005
Dissolved Potassium	g/m^3	11.5	12.1	1.41	1.43	1	0.85	3	3.3
Dissolved Sodium	g/m^3	31	31	58	56	67	70	39	42
Dissolved Zinc	g/m^3	0.31	0.49	0.0053	0.0012	<0.0010	0.0029	0.0068	0.0022
Bromide	g/m^3	0.15	0.14	0.06	0.07	0.07	0.07	0.07	0.07
Chloride	g/m^3	34	35	11.4	12.0	11.6	12.3	12.0	12.9
Nitrite-N	g/m^3	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nitrate-N	g/m^3	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002
Nitrate-N + Nitrite-N	g/m^3	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002
Sulphate	g/m^3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylene glycol	g/m^3	<4	<4	<4	<4	<4	<4	<4	<4
Propylene glycol	g/m^3	<4	<4	<4	<4	<4	<4	<4	<4
Methanol	g/m^3	<2	<2	<2	<2	<2	<2	<2	<2
Benzene	g/m^3	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Toluene	g/m^3	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Ethylbenzene	g/m^3	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
m&p-Xylene	g/m^3	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
o-Xylene	g/m^3	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Formaldehyde	g/m^3	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
C7 - C9	g/m^3	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
C10 - C14	g/m^3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
C15 - C36	g/m^3	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Total hydrocarbons (C7 - C36)	g/m^3	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Ethane	g/m^3	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Ethylene	g/m^3	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Methane	g/m^3	0.64	4.4	2.3	5.4	1.94	4.9	2.8	6.4