TAG Oil (NZ) Limited
Cheal-E Wellsite
Monitoring Programme Report
2013-2014

Technical Report 2014–51

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Executive summary

TAG Oil (NZ) Limited established a hydrocarbon exploration site located on Sole Road, in the Patea catchment. The site is called Cheal-E wellsite. This report covers the period from July 2013 to August 2014. During this period, the Cheal-E wellsite was established with five wells drilled and tested. Three of the five wells are now in production.

During the monitoring period, TAG Oil demonstrated a high level of environmental performance at the Cheal-E wellsite.

This report for TAG Oil (NZ) Limited describes the monitoring programme implemented by the Taranaki Regional Council (the Council) to assess TAG Oil (NZ) Limited's environmental performance in relation to drilling operations at the Cheal-E wellsite during the period under review, and the results and environmental effects of TAG Oil (NZ) Limited's activities.

TAG Oil (NZ) Limited holds five resource consents for the activities at the Cheal-E wellsite, which include a total of 63 consent conditions setting out the requirements that TAG Oil (NZ) Limited must satisfy. TAG Oil (NZ) Limited holds consent 9550-1 to discharge treated stormwater, treated surplus drilling water and treated produced water from hydrocarbon exploration and production operations onto land and into an unnamed tributary of the Ngaere Stream; consent 9551-1 to take groundwater; consent 9552-1 to discharge stormwater and sediment, deriving from soil disturbance undertaken for the purpose of constructing the wellsite; consent 9548-1 to discharge contaminants to air from hydrocarbon exploration; and consent 9549-1 to discharge emissions to air associated with hydrocarbon producing wells at the Cheal-E wellsite.

The Council's monitoring programme for the period under review included 20 inspections of the site and surrounding environment, at approximately fortnightly intervals. Fifteen stormwater samples and eight surface water samples were obtained for analysis. Analysis showed that all of the samples obtained were compliant. Biomonitoring surveys were conducted prior to the commencement of drilling activities, and following the completion of drilling activities at the Cheal-E wellsite. These surveys concluded that drilling activities at the Cheal-E wellsite did not cause any impacts on the macroinvertebrate communities in an unnamed tributary of the Ngaere Stream, as there was no change detected between the pre-drilling and post-drilling biomonitoring surveys performed.

TAG Oil (NZ) Limited notified the Council of its intention to combust gas intermittently on 5 October 2013, 25 October 2013 and 29 November 2013. Following these dates, gas combustion occurred intermittently over the course of a few days in conjunction with well testing. No offensive or objectionable odours, smoke or dust associated with activities at the wellsite were observed.

Drilling fluids and cuttings were disposed of at a consented off site facility.

The site was generally neat, tidy, and well maintained and site staff were cooperative with requests made by officers of the Council, with any required works completed to a satisfactory standard.

During the monitoring period, TAG Oil (NZ) Limited demonstrated a high level of environmental and performance and administrative compliance with the resource consents.

This report includes recommendations for future drilling operations at this site.

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1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

This report outlines the compliance monitoring programme implemented by the Taranaki Regional Council (the Council) in respect of the consents held by TAG Oil (NZ) Limited that relate to exploration activities at Cheal-E wellsite. This report covers the results and findings of the monitoring programme from July 2013 to August 2014. During this period, Cheal-E wellsite, located off Sole Road in the Stratford District, was established with five wells (E1, E2, E3, E4 and E5) which were drilled and tested. Three of the five wells are now in production.

One of the intents of the *Resource Management Act 1991* (RMA) is that environmental management should be integrated across all media, so that a consent holder's use of water, air, and land should be considered from a single comprehensive environmental perspective. Accordingly, the Council generally implements integrated environmental monitoring programmes and reports the results of the programmes jointly. This report discusses the environmental effects of TAG Oil (NZ) Limited's use of water, land, and air.

1.1.2 Structure of this report

Section 1 of this report is a background section. It sets out general information about compliance monitoring under the RMA and the Council's obligations and general approach to monitoring sites through annual programmes, the resource consent held by TAG Oil (NZ) Limited in the Patea catchment, the nature of the monitoring programme in place for the period under review, and a description of the activities and operations conducted at the Cheal-E wellsite during exploration activities.

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

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

Section 4 presents recommendations to be implemented during future drilling operations.

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

1.1.3 The Resource Management Act (1991) and monitoring

The *Resource Management Act 1991* (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 (eg, recreational, cultural, or aesthetic);
(e) risks to the neighbourhood or environment.

In drafting and reviewing conditions on discharge permits, and in implementing monitoring programmes, the Council is recognising the comprehensive meaning of 'effects' in as much 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, including impact monitoring, also enables the Council to continuously assess its own performance in resource management as well as that of resource users particularly consent holders. It further enables the Council to continually re-evaluate its approach and that of consent holders to resource management, and, ultimately, through the refinement of methods, to move closer to achieving sustainable development of the region's resources.

1.1.4 Evaluation of environmental and consent performance

Besides discussing the various details of the performance and extent of compliance by the consent holder during the period under review, this report also assigns an overall rating. The categories used by the Council, 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 compliance

- **High** The administrative requirements of the resource consents were met, or any failure to do this had trivial consequences and were addressed promptly and co-operatively.

- **Good** Perhaps some administrative requirements of the resource consents were not met at a particular time, however this was addressed without repeated interventions from the Council staff. Alternatively adequate reason was provided for matters such as the no or late provision of information, interpretation of 'best practical option' for avoiding potential effects, etc.

- **Improvement required** Repeated interventions to meet the administrative requirements of the resource consents were made by Council staff. These matters took some time to resolve, or remained unresolved at the end of the period under review. The Council may have issued an abatement notice to attain compliance.

- **Poor** Material failings to meet the administrative requirements of the resource consents. Significant intervention by the Council was required. Typically there were grounds for an infringement notice.

For reference, in the 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

Site description

TAG Oil (NZ) Limited holds a ten year Petroleum Mining Permit No. 38156 to prospect, explore, and mine for condensate, gas, LPG, oil and petroleum within an area of 30.3 km^2. The Cheal-E wellsite is one of many sites within this area that have been established in order to explore, evaluate and produce hydrocarbons.

The Cheal-E wellsite is located approximately 2.6 km along Sole Road, approximately 2.6 km from Ngaere. The approximate regional location is shown in Figure 1. The Cheal-E wellsite was established in 2013 and involved the removal of topsoil to create a firm level foundation on which to erect a drilling rig and house associated equipment. Site establishment also involved the installation of:

- Wastewater control, treatment and disposal facilities;
- A system to collect and control stormwater and contaminants;
- A gas combustion system; and
- Other on-site facilities such as accommodation, parking and storage.

The nearest residence is approximately 730 m away from the wellsite. Bunding, earthworks and good site location helped minimise any potential effects on the neighbours.

Figure 1 Aerial view displaying the locality of the Cheal-E wellsite, with approximate regional location (inset)

Well development

The process of drilling a well can take a few weeks to several months, depending on the depth of the well, the geology of the area, and whether the well is vertical or horizontal.

Drilling fluids, more commonly known as 'drilling muds', are required in the drilling process for a number of reasons, including:

- As a safety measure to ensure that any pressurized liquids encountered in the rock formation are contained;
- To transport drill cuttings to the surface;
- To cool and lubricate the drilling bit;
- To provide information to the drillers about what is happening down hole and the actual geology being drilled; and
- To maintain well pressure and lubricate the borehole wall to control cave-ins and wash-outs.

The well is drilled progressively using different sized drill bits. The width of the well is widest at the surface as smaller drill bits are used as the well gets deeper. Once each section of the well is drilled, a steel casing is installed. Cement is then pumped down the well to fill the annulus (the space between the steel casing and the surrounding country rock). This process is repeated until the target depth is reached, with each section of steel casing interlocked with the next.

Production tubing is then fitted within the steel casing to the target depth. A packer is fitted between the production tubing and casing to stop oil/gas/produced water from entering the annulus. The packer is pressure tested to ensure it is sealed.

The construction aspects that are most important for a leak-free well include the correct composition and quality of the cement used, the installation method, and the setting time. The aim is to ensure that the cement binds tightly to the steel casing and the rock, and leaves no cavities through which liquids and gases could travel.

Once the well is sealed and tested the casing is perforated at the target depth, allowing fluids and gas to flow freely between the formation and the well.

Management of stormwater, wastewater and solid drilling waste

The Cheal-E wellsite is located approximately 60 m to the west of the nearest waterbody which is an unnamed tributary of the Patea catchment.

Management systems were put in place to avoid any adverse effects on the surrounding environment from exploration and production activities on the wellsite. There are several sources of potential contamination from water and solid waste material which require appropriate management. These include:

- Stormwater from 'clean' areas of the site [for example parking areas] which run off during rainfall. There is potential that this runoff will pick up small amounts of hydrocarbons and silt due to the nature of the activities on-site;

- Stormwater which collects in the area surrounding the drilling platform and ancillary drilling equipment. This stormwater has a higher likelihood of contact with potential contaminants, particularly drilling mud;
- Produced water which flows from the producing formation and is separated from the gas and water phase at the surface; and
- Drill cuttings, mud and residual fluid which are separated from the liquid waste generated during drilling.

An important requirement of the site establishment is to ensure that the site is contoured so that all stormwater and any runoff from 'clean' areas of the site flow into perimeter drains. The drains direct stormwater into a skimmer pit system on-site consisting of two settling ponds. Any hydrocarbons present in the stormwater float to the surface and can be removed. The ponds also provide an opportunity for suspended sediment to settle. Treated stormwater is then discharged from the wellsite onto and into land, and subsequently into an unnamed tributary in the Patea catchment.

Drilling mud and cuttings brought to the surface during drilling operations are separated out using a shale shaker. The drilling mud and some of the water is then reused for the drilling process. Cuttings were collected in bins located at the base of the shaker and disposed of offsite at a consented facility.

Flaring from exploration activities

It is possible that flaring may occur during the following activities:

- Well testing and clean-up;
- Production testing;
- Emergencies; and
- Maintenance and enhancement activities [well workovers].

1.3 Resource consents

1.3.1 Background

TAG Oil (NZ) Limited holds five resource consents related to exploration activities at the Cheal-E wellsite site, as follows:

- Discharge Permit 9550-1; granted 6 May 2013;
- Water Permit 9551-1; granted 6 May 2013;
- Discharge Permit 9552-1; granted 16 April 2013;
- Discharge Permit 9548-1;granted 1 November 2013 and
- Discharge Permit 9549-1; granted 1 November 2013.

Each of the consent applications were processed on a non-notified basis as TAG Oil (NZ) Limited obtained the landowner approvals as an affected party, and the Council were satisfied that the environmental effects of the activity would be minor. The consents are discussed in further detail below.

Copies of the consents can be found within Appendix 1 of this report.

1.3.2 Water discharge permit (treated stormwater and treated produced water)

Section 15(1)(a) of the RMA stipulates that no person may discharge any contaminant into water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or by national regulations.

The Council determined that the application to discharge treated stormwater, treated produced water and surplus drill water fell within Rule 44 of the Regional Fresh Water Plan for Taranaki (RFWP), which provides for a discharge as a discretionary activity.

The discharge of stormwater may result in contaminants (for example sediment, oil) entering surface water. These contaminants have the potential to smother or detrimentally affect in-stream flora and fauna. On-site management of stormwater, as discussed in section 1.2 above, is necessary to avoid/remedy any adverse effects on water quality.

TAG Oil (NZ) Limited holds water discharge permit **9550-1** to discharge treated stormwater, and treated produced water from hydrocarbon exploration and production operations at the Cheal-E wellsite, onto land and into an unnamed tributary of the Ngaere Stream.

This permit was issued by the Council on 6 May 2013 under Section 87(e) of the RMA. It is due to expire on 1 June 2028.

Consent conditions were imposed on TAG Oil (NZ) Limited to ensure that adverse effects were avoided in the first instance. A summary of conditions can be viewed in Table 3, Section 3.3.

1.3.3 Water abstraction permit (groundwater)

Section 14 of the RMA stipulates that no person may take, use, dam or divert any water, unless the activity is expressly allowed for by resource consent or a rule in a regional plan, or it falls within some particular categories set out in Section 14.

The Council determined that the application to take groundwater fell within Rule 49 of the RFWP as the rate and daily volume of the groundwater abstraction might exceed that of the permitted activity (Rule 48). Rule 49 provides for groundwater abstraction as a controlled activity, subject to two conditions:

- *The abstraction shall cause not more than a 10% lowering of static water-level by interference with any adjacent bore;*
- *The abstraction shall not cause the intrusion of saltwater into any fresh water aquifer.*

Any produced water will be from reserves far below that which is used for domestic or farm purposes. Shallow groundwater (which does not have any saltwater content) was protected by casing within the bore hole. Given these factors, the abstraction would not cause the above effects.

In granting the consent it was considered that the taking of groundwater was unlikely to have any adverse effect on the environment.

The Council was satisfied that the proposed activity would meet all the standards for a controlled activity. It was therefore obliged to grant the consent but imposed conditions in respect of those matters over which it reserved control. Those matters over which the Council reserved its control were:

- Volume and rate of abstraction;
- Daily timing of abstraction;
- Effects on adjacent bores, the aquifer, river levels, wetlands and sea water intrusion;
- Fitting of equipment to regulate flows and to monitor water volumes, levels, flows and pressures;
- Payment of administrative charges;
- Monitoring and report requirements;
- Duration of consent; and
- Review of the conditions of consent and the timing and purpose of the review.

TAG Oil (NZ) Limited holds water permit 9551-1 to take groundwater as 'produced water', during hydrocarbon exploration and production activities at the Cheal-E wellsite.

This permit was issued by the Council on 6 May 2013 under Section 87(d) of the RMA. It is due to expire on 1 June 2028.

Consent conditions were imposed on TAG Oil (NZ) Limited to ensure that adverse effects were avoided in the first instance. A summary of conditions can be viewed within Table 4, Section 3.3.

1.3.4 Water discharge permit (stormwater and sediment – earthworks)

Section 15(1)(a) of the RMA stipulates that no person may discharge any contaminant into water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or by national regulations.

Council considered that the application fell under Rule 27 of the RFWP as a controlled activity (which may be non-notified without written approval), subject to one standard condition to be met:

- *A site erosion and sediment control management plan shall be submitted to the Taranaki Regional Council.*

TAG Oil (NZ) Limited supplied a site erosion and sediment control management plan in support of the application.

The Council was satisfied that the activity would meet all the standards for a controlled activity. It was therefore obliged to grant the consent but imposed conditions in respect of those matters over which it reserved control. Those matters over which the Council reserved its control were:

- Approval of a site erosion and sediment control management plan and the matters contained therein;

- Setting of conditions relating to adverse effects on water quality and the values of the waterbody;
- Timing of works;
- Any measures necessary to reinstate the land following the completion of the activity;
- Monitoring and information requirements;
- Duration of consent;
- Review of conditions of consent and the timing and purpose of the review; and
- Payment of administrative charges and financial contributions.

TAG Oil (NZ) Limited holds water discharge permit 9552-1 to discharge stormwater and sediment, deriving from soil disturbance undertaken for the purpose of constructing the Cheal-E wellsite, onto land and into an unnamed tributary of the Ngaere Stream.

This permit was issued by the Council on 16 April 2013 under Section 87(e) of the RMA. It is due to expire on 1 June 2018.

Consent conditions were imposed on TAG Oil (NZ) Limited to ensure that adverse effects are avoided in the first instance. A summary of conditions can be viewed in Table 5, Section 3.3.

1.3.5 Air discharge permit (exploration activities)

Section 15(1)(c) of the RMA stipulates that no person may discharge any contaminant from any industrial or trade premises into air, unless the activity is expressly allowed for by a resource consent , a rule in a regional plan, or by national regulations.

The Council determined that the application to discharge emissions to air associated with the exploration activities at the Cheal-E wellsite fell within Rule 9 of the Regional Air Quality Plan (RAQP).

The standard conditions associated with Rule 9 are as follows:

- *Flare or incinerator point is at least 300 metres from any dwelling house;*
- *The discharge to air from the flare must not last longer than 15 days cumulatively, including of testing, clean-up, and completion stages of well development or work-over, per zone to be appraised; and*
- *No material to be flared or incinerated, other than those derived from or entrained in the well steam.*

Provided that the activities were conducted in accordance with the applications and in compliance with the recommended special conditions, no significant effects were anticipated.

TAG Oil (NZ) Limited holds air discharge permit 9548-1 to discharge contaminants to air from hydrocarbon exploration at the Cheal-E wellsite, including combustion involving flaring or incineration of petroleum recovered from natural deposits, in association with well development or redevelopment and testing or enhancement of well production flows.

This permit was issued by the Council on 1 November 2013 under Section 87(e) of the RMA. It is due to expire on 1 June 2018.

Consent conditions were imposed on TAG Oil (NZ) Limited to ensure that adverse effects are avoided in the first instance. A summary of conditions can be viewed in Table 6, Section 3.3.

1.3.6 Air discharge permit (production activities)

Section 15(1)(c) of the RMA stipulates that no person may discharge any contaminant from any industrial or trade premises into air, unless the activity is expressly allowed for by a resource consent , a rule in a regional plan, or by national regulations.

The Council determined that the application to discharge emissions to air associated with the production activities at the Cheal-E wellsite fell within Rule 11 of the RAQP.

The standard condition of Rule 11 states that the:

- *Flare or incinerator point is a distance equal to or greater than 300 metres from any dwelling house.*

TAG Oil (NZ) Limited holds air discharge permit **9549-1** to discharge emissions to air associated with hydrocarbon producing wells at the Cheal-E wellsite.

This permit was issued by the Council on 1 November 2013 under Section 87(e) of the RMA. It is due to expire 1 June 2028.

Consent conditions were imposed on TAG Oil (NZ) Limited to ensure that adverse effects are avoided in the first instance. A summary of conditions can be viewed in Table 7, Section 3.3.

1.4 Monitoring programme

1.4.1 Introduction

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

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

The monitoring programme for exploration wellsites consist of seven primary components. They are:

- Programme liaison and management;
- Site inspections;
- Chemical sampling;
- Solid waste monitoring;
- Air quality monitoring;

- Discharges to land (hydraulic fracturing and deep well injection); and
- Biomonitoring surveys.

The monitoring programme for the Cheal-E wellsite focused primarily on programme liaison and management, site inspections, physicochemical sampling, biomonitoring surveys and discharges to land. However, all seven components are discussed below.

1.4.2 Programme liaison and management

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

1.4.3 Site inspections

Inspection and examination of wellsites is a fundamental and effective means of monitoring and are undertaken to ensure that good environmental practices are adhered to and resource consent special conditions complied with.

The inspections are based on internationally recognised and endorsed wellsite monitoring best-practice checklists developed by the Alberta Energy Resources Conservation Board and the USEPA, adapted for local application.

The inspections also provide an opportunity for monitoring officers to liaise with staff about on-site operations, monitoring and supervision; discuss matters of concern; and resolve any issues in a quick and informal manner.

Inspections pay special attention to the ring drains, mud sumps, treatment by skimmer pits and the final discharge point from the skimmer pit on to land and then to any potential receiving waters.

During each inspection the following are checked:

- Weather;
- Flow rate of surface waters in the general vicinity;
- Flow rate of water take;
- Whether pumping of water was occurring;
- General tidiness of site;
- Site layout;
- Ring drains;
- Hazardous substance bunds;
- Treatment by skimmer pits/sedimentation pits;
- Drilling mud;
- Drill cuttings;
- Mud pit capacity and quantity contained in pit;
- Sewage treatment and disposal;
- Cementing waste disposal;

- Surface works;
- Gas combustion systems, whether flaring was in progress, and if there was a likelihood of flaring, whether the Council had been advised;
- Discharges;
- Surface waters in the vicinity for effects on colour and clarity, aquatic life and odour;
- Site records;
- General observations; and
- Odour (a marker for any hydrocarbon and hazardous chemical contamination).

1.4.4 Chemical sampling

The Council may undertake sampling of discharges from site and from sites upstream and downstream of the discharge point to ensure that resource consent special conditions are complied with and to determine whether site activities were causing any adverse effects within the receiving environment.

1.4.5 Solid wastes

The Council monitors any disposal of drill cuttings on-site via mix-bury cover to ensure compliance with resource consent conditions and to determine whether site activities were causing any adverse effects within the receiving environment.

In recent times consent holders have opted to remove drilling waste from the site by contractor and dispose of it at licensed disposal areas (land farming), which are monitored separately.

1.4.6 Air quality monitoring

Air quality monitoring is carried out in association with the well testing and clean-up phase, where flaring can occur.

During site inspections, assessments are made by Council Inspecting Officers to ensure that operators undertake all practicable steps to mitigate any effects from flaring gas.

Inspecting Officers check that that plant equipment is working effectively, that there is the provision of liquid and solid separation, and that on-site staff have regard to wind direction and speed at the time of flaring.

It is also a requirement that the Council and immediate land owners are notified prior to any gas being flared when practicable. This requirement was checked to ensure compliance with consent conditions and to determine whether site activities were causing any adverse effects within the receiving environment.

1.4.7 Discharges to land (hydraulic fracturing)

If hydraulic fracturing activities are undertaken at site, sampling and analysis of the return flow of hydraulic fracturing fluids and nearby bores are carried out. These inspections of the site, surrounding land and water are carried out to ensure that no observable effects have occurred as a result of the discharge to land. Pre and post

hydraulic fracturing reports are submitted by the consent holder detailing among other things, the effectiveness of the mitigation measures put in place to protect the environment.

1.4.8 Biomonitoring surveys

Biomonitoring surveys in any nearby streams may be carried out pre and post occupation of the wellsite to assess whether the activities carried out on-site, and associated discharges have had any effect on ecosystems.

2. Results

2.1 Water

2.1.1 Inspections

The Cheal-E wellsite, adjacent land and streams were inspected 20 times during this monitoring period. Below is a copy of the comments that were noted on the day of each inspection.

2 July 2013
Site inspection occurred during the second day of earthworks in relation to the initial development of the site. The first culvert was being placed in the stream at time of inspection. The access track and pad were under development. Earth bunds were being developed about the perimeter of the site to ensure all stormwater was directed through a sediment pond. Construction of the sediment pond was underway. Discussions were held with on-site staff in relation to sediment controls. It appeared that they had good knowledge of the requirements. A 1600 mm diameter culvert had replaced the consented 1500 mm diameter culvert as discussed on-site. The culvert had been laid to consent conditions, with the backfill and rock rip rap to be completed. Council officers requested a second silt control measure (hay bales) to be placed downstream.

19 July 2013
Earthworks were continuing on-site with the culverts and access track in place. Silt and sediment controls along the access track were in place and sufficient to address any silt and sediment runoff from the access track. Rock rip-rap had been placed about the culverts. No areas were identified on the access track that required further attention. Site staff were advised to continue to monitor the silt controls particularly during periods of wet weather and to address any areas of concern. The pad was under construction with gravel placed on approximately one third of the pad. Ring drains and / or bunding were in place around the excavation area. This either directed stormwater to the settling pond on-site, or retained the stormwater on-site allowing it to soak into the ground rather than running off-site to surface water. The settling pond was working well and had not yet discharged overland. Silt fencing between the earth bund and the stream was in place and working well. The site appeared to be well managed with on-site staff aware of their obligations regarding silt and sediment control.

6 August 2013
Earth works were nearing completion at the site. All silt and sediment controls remained in place and appeared to be working well. Hydro-seeding had been applied to establish vegetation on ring drain banks, with further seeding to be carried out in coming weeks. Skimmer pits were aligned and were functioning as designed. The well site was near complete with two conductors installed, and three further conductors were yet to be installed. It was anticipated that the Nova-1 drilling rig was to be set up on-site within the coming week.

22 August 2013
Site works were nearing completion. All ring-drains were in place and directing all site stormwater through the skimmer pit treatment system prior to discharge. The discharge comprised a short distance of overland flow before potentially entering a

small tributary flowing to a culvert under the access track. Skimmer pits were lined with a shut off valve in place on the discharge pipe. On-site personnel were spoken to and asked to ensure that the ring drains had a gradient to allow all discharge to flow towards the skimmer pits without ponding in the ring drains themselves. Skimmer pits were discharging at the time of inspection. A sample was obtained of the discharge. Samples of the receiving waters upstream and downstream of the discharge point were also obtained. Drilling had begun on-site and the top hole of the first well was being cased at the time of inspection. The site appeared to be clean and tidy at the time of the inspection. Silt controls on the access track and below the earth bunding of the site (between the site and the stream) remained in place. Site staff were advised to continue to ensure that the silt and sediment controls remained in place until the site and surrounding area had stabilised.

2 September 2013
Site inspection found that site was in a good clean and tidy order. Drilling of the first well had reached TVD and was expected to be completed in the coming week. Well logging was taking place on-site. The chemical store area had been bunded and lined, hence containing any spills within the bunded area allowing for quick clean up and preventing any spills penetrating into shallow groundwater. The ring drains and skimmer pits appeared to be in a good working order with no ponding within the ring drain system. Further hydro-seeding had taken place about the site to assist in stabilisation of earth. Skimmer pits were full but not discharging at the time of the inspection. A sample was taken from the skimmer pits to ensure that the discharge would comply with consent conditions should a discharge occur.

23 September 2013
Works to the ring drain were to be undertaken within the immediate future to ensure that site water in the ring drains were directed to the skimmer pits, as the ring drain closest to the stream had some ponding issues. Discussions were held with on-site staff regarding the works. Skimmer pits were discharging at time of inspection, a sample was obtained of the discharge. Samples of the receiving waters upstream and downstream of the discharge point were also obtained.

4 October 2013
All surface water was directed to the skimmer pits via the ring-drain system. A very small discharge from the second skimmer pit outflow was occurring; however this could not be sampled. The skimmer pits appeared to be very clean. A sample was obtained from the skimmer pits to ensure that the discharge would comply with consent conditions. Ring drain works had not yet been carried out. The site was dry with only a very small amount of water running in the drains which appeared to be flowing towards the skimmer pits.

11 October 2013
Installation of production facilities was continuing. The site was tidy with a small cement spill from Halliburton equipment that was to be cleaned up. The chemical area was bunded and well maintained. The ring drain works were yet to be completed along the perimeter, near the security hut. A small discharge was occurring from the skimmer pits, but was insufficient to be sampled and was not found to be entering the nearby waterbody. A sample was obtained from the skimmer pits to ensure that the discharge would comply with consent conditions.

18 October 2013
The installation of production facilities was continuing. The chemical store area was bunded and lined. A small discharge was occurring from the skimmer pits, but did not appear to be entering the nearby waterbody. A sample was obtained from the skimmer pits to ensure that any discharge would comply with consent conditions.

23 October 2013
The installation of production facilities was continuing. The chemical store area was bunded and lined. Discussions were held with on-site staff regarding the perimeter drain works, which were to be carried out when heavy equipment was removed (in approximately two weeks' time). Skimmer pits were discharging at the time of inspection; a sample was obtained of the discharge. Samples of the receiving waters upstream and downstream of the discharge point were also obtained.

1 November 2013
The installation of production facilities was continuing. The site was very active with heavy equipment, but appeared to be in a clean and tidy state. Skimmer pits were full and were discharging at time of inspection. A sample was obtained of the discharge. Samples of the receiving waters upstream and downstream of the discharge point were also obtained. The ring drain remediation plan had been lodged with the Council and was due to be completed within 7-10 days.

8 November 2013
The drilling of well E4 had commenced at the time of inspection. The site appeared clean and tidy. Discussions were held with on-site staff regarding two holes in the pad which required filling. Contractors on-site and were to fill holes and commence the ring drain works, weather permitting. Skimmer pits appeared full but were not discharging; the valve was to be kept closed until sample results were returned. A sample was obtained from the second skimmer pit. Silt controls surrounding the culvert where the skimmer discharge entered the surface water needed to be reinstated.

15 November 2013
Flaring was occurring on-site at the time of inspection. The flare was producing a very small amount of visible exhaust. Well E1 was producing. The ring drain works had been completed on the left hand side of the pad. The wellsite appeared to be in a clean and tidy condition. The skimmer pit outlet valve was closed at the time of inspection; a sample was obtained from the second skimmer pit in any case. The activities at the site were compliant with consent conditions at the time of inspection.

2 December 2013
The drilling of well E5 had commenced, with wire-lining contractors present on-site. The site appeared clean and tidy with the chemical store area correctly bunded and covered. Skimmer pits were not discharging at time of inspection; however a sample was obtained from the second skimmer pit. The activities at the site were compliant with consent conditions at the time of inspection.

16 January 2014
Flaring was occurring on-site at the time of inspection. As a result grey smoke was being produced, yet was dispersing quickly. Contractors were on-site applying paint to a large tank, the area had been contained with mesh cloth to minimise any

potential spray drift. The bunded area around the condensate tank was clean and tidy. This bunded area was also being used to store chemicals. The first skimmer pit had most of the water removed as the pad had been rolled using the skimmer pit water in the compaction as new metal was applied. Skimmer pits were not discharging at time of inspection; however a sample was obtained from the second skimmer pit.

18 February 2014

A workover rig was on-site completing well E5. The site was clean and tidy with no apparent signs of spills. A second condensate tank had been installed within the bunded area, as had an over head control arm for tanker loading. A larger thermal oxidiser had been deployed and was in use burning hydrocarbons at the time of inspection. Skimmer pits were not discharging at time of inspection; however a sample was obtained from the second skimmer pit. Consents were compliant at time of inspection.

8 May 2014

Contractors were on-site at the time of inspection loading out. Additional contractors were on-site carrying out a wax cut on one of the wells. The site appeared clean and tidy with no apparent signs of any spills. The larger thermal oxidiser was in use during inspection and there was no visible discharge. The skimmer pits were at a level where a discharge could occur; however the shut off valve was closed until in-house sampling results were available. A sample was obtained from the second skimmer pit.

2 July 2014

Inspection was conducted following a heavy rainfall event. The skimmer pits appeared clear of visual contaminants. The ring drains and bunds also appeared clear. Some combustion had been undertaken via the thermal oxidisers and no offensive smoke or odours were detected in conjunction with this.

17 July 2014

Inspection found that production was continuing on site. The site was found to be in a general clean and tidy order. Two IBC's on-site were used to store oily waste prior to appropriate disposal off-site. Both IBC's had a reasonable amount of oil spilt on the tops. This could track over the surface during wet weather. It was advised to site staff that it would be beneficial to store these IBC's either over a solid bund or relocate the IBC’s within the bund in which the crude oil tanks were contained. Two thermal oxidisers were in operation on site. No light and/or smoke was observed being emitted from either oxidiser, with the only visible sign of combustion being a heat shimmer. Skimmer pits were not discharging at the time of the inspection. Samples were taken from the second skimmer pit to ensure compliance with resource consent conditions should a discharge occur. It was observed that the water level in the second skimmer pit was lower than that of the first, and lower than the discharge point. The lining had come away from the walls in the second pit. This potentially indicated that water had collected behind the liner and that there was a hole in the liner. Site staff were advised to inspect and ensure that the integrity of the liner had not been compromised.

12 August 2014
TAG Oil (NZ) Limited notified the Council that repairs had been made to tears found in the skimmer pit linings, however leakage was still suspected. The pits had been pumped out previously and now ground water intrusion was forcing the liners to lift. Ground water below the liners was to be pumped back into the skimmer pits to force the liners to settle. On going monitoring of the pit levels would be carried out. If this was unsuccessful, TAG Oil (NZ) Limited would consult with the Council on how to address this. TAG Oil (NZ) Limited advised that upgrading the skimmer pit liners was also being explored as a long term solution. Contractors were on-site to carry out the pump work.

2.1.2 Results of discharge monitoring

During the period under review a total of 15 stormwater samples were obtained. Stormwater was observed discharging from the wellsite skimmer pits on four occasions. Four samples were obtained in conjunction with this. The remaining 11 stormwater samples were obtained from the second skimmer pit to ensure compliance with consent conditions in anticipation of potential discharges.

Analysis of the samples obtained showed that all of the samples were compliant or would have been compliant with resource consent conditions should a discharge have occurred. Results are detailed in Table 1 and sampling locations can be seen in Figure 2.

Table 1 Results of stormwater samples obtained from the Cheal-E wellsite during the monitoring period

Date	Chloride *g/m³*	Hydrocarbons *g/m³*	pH *pH*	Suspended Solids *g/m³*	Sampling location
22 Aug 2013	10.9	<0.5	6.9	11	Discharge
02 Sep 2013	8.0	<0.5	6.9	3	Second skimmer pit
23 Sep 2013	15.4	<0.5	6.9	9	Discharge
04 Oct 2013	16.2	<0.5	6.9	3	Second skimmer pit
11 Oct 2013	21.2	<0.5	7.2	3	Second skimmer pit
18 Oct 2013	21.8	<0.5	7.2	6	Second skimmer pit
23 Oct 2013	17.7	<0.5	7.3	3	Discharge
01 Nov 2013	17.5	<0.5	6.8	30	Discharge
08 Nov 2013	19.9	<0.5	7	7	Second skimmer pit
15 Nov 2013	20.8	<0.5	7.0	2	Second skimmer pit
02 Dec 2013	39.4	<0.5	7.0	2	Second skimmer pit
16 Jan 2014	37.8	<0.5	7.0	2	Second skimmer pit
18 Feb 2014	43.0	0.7	7.1	2	Second skimmer pit
08 May 2014	27.7	<0.5	7.2	<2	Second skimmer pit
17 Jul 2014	7.9	<0.5	7.0	4	Second skimmer pit

All sewage was directed for treatment through a septic tank system and removed by contractor to a licensed disposal facility.

2.1.3 Results of receiving environment monitoring

During the period under review, eight stream samples were obtained in conjunction with the stormwater discharges, on 22 August 2014, 23 September 2013, 23 October 2013 and 1 November 2013, from an unnamed tributary of the Ngaere Stream to ensure that stormwater discharges were not having an adverse effect on the receiving stream environment. Of the stream samples obtained, no exceedences were recorded in relation to consent 6403-1. Negligible effects were noted in the stream. Results are detailed in Table 2 and sampling locations can be seen in Figure 2.

Table 2 Results of surface water samples obtained from an unnamed tributary of the Ngaere Stream during the monitoring period under review

Date	Chloride *g/m³*	Hydrocarbons *g/m³*	pH *pH*	Suspended Solids *g/m³*	Sampling location
23 Aug 2013	10.9	<0.5	6.3	4	Upstream of discharge
	16.9	<0.5	6.8	6	Downstream of discharge
23 Sep 2013	18.0	<0.5	6.0	<2	Upstream of discharge
	17.5	<0.5	6.0	<2	Downstream of discharge
23 Oct 2013	16.0	<0.5	6.7	6	Upstream of discharge
	15.7	<0.5	6.7	5	Downstream of discharge
01 Nov 2013	15.0	0.9	6.4	4	Upstream of discharge
	16.9	<0.5	5.9	13	Downstream of discharge

Figure 2 Stormwater and surface water sampling locations at the Cheal-E wellsite

The receiving surface water body was inspected regularly in conjunction with site inspections. No effects were observed and the stream appeared clear with no visual change in colour or clarity. In addition, no odour, oil, grease films, scum, foam or

suspended solids were observed in the stream as a result of activities at the Cheal-E wellsite during the monitoring period.

2.2 Air

2.2.1 Inspections

Air quality monitoring inspections were carried out in conjunction with general compliance monitoring inspections. See Section 2.1.1 for comments concerning site inspections.

2.2.2 Results of discharge monitoring

TAG Oil (NZ) Limited notified the Council of its intention to combust gas at the Cheal-E wellsite on 5 October 2013, 25 October 2013 and 29 November 2013. Following these dates, gas combustion occurred intermittently over the course of a few days in conjunction with well testing. During this time a thermal oxidisers were largely employed for the combustion of gas and to maintain a pilot flare for emergency gas combustion / depressurisation.

During routine inspections, no offensive or objectionable odours, smoke or dust associated with activities at the Cheal-E wellsite were observed. From observations during site inspections, including the inspection of the flare log maintained by TAG Oil (NZ) Limited, it appeared that special conditions relating to the control of emissions to air from the combustion of hydrocarbons were complied with.

2.2.3 Results of receiving environment monitoring

No chemical monitoring of air quality was undertaken during the testing phase of the Cheal-E wellsite as gas combustion activities were minimal and the controls implemented by TAG Oil (NZ) Limited did not give rise to any concerns with regard to air quality.

2.2.4 Other ambient monitoring

No other ambient air sampling was undertaken, as the controls implemented by TAG Oil (NZ) Limited did not give rise to any concerns with regard to air quality.

2.3 Land

2.3.1 Inspections

Land monitoring inspections were carried out in conjunction with general compliance monitoring inspections. See Section 2.1.1 for comments concerning site inspections.

2.3.2 Results of discharge and receiving environment monitoring

TAG Oil (NZ) Limited notified the Council of its intention to commence construction of the Cheal-E wellsite on 27 June 2013. Controls implemented during the earthworks phase of the construction of the Cheal-E wellsite did not give rise to any concerns. For the most part, silt and sediment retention methods proved successful and no significant adverse effects were observed as a result of this. From observations during site inspections, it appeared that special conditions relating to the control of discharges originating from soil disturbance for the purposes of constructing the wellsite were complied with.

2.3.3 Land status

The wellsite was constructed on relatively flat rural dairy farming area. Relatively minor earthworks were required to construct the site. The land had not been reinstated at the time of the last inspection as the site was still in use.

2.4 Biomonitoring surveys

Biomonitoring surveys were performed prior to the commencement of drilling activities on 27 June 2013, and following the completion of drilling activities on 25 August 2014, at the Cheal-E wellsite. These surveys indicate whether or not consented discharges into and near the unnamed tributary of the Ngaere Stream have had a detrimental effect upon the macroinvertebrate communities of this stream.

Both the pre and post drilling biomonitoring surveys were undertaken at three established sites; 45 m upstream of the farm boundary fence (site 1), immediately downstream of farm boundary fence (site 2) and 70 m downstream of boundary (site 3), as seen in Figure 3.

The Council's 'vegetation sweep' sampling technique was used at the three sites to collect streambed macroinvertebrates from the unnamed tributary of the Mangawharawhara Stream. This has provided baseline data for any future assessment of consented discharge effects from the Cheal-E wellsite on the macroinvertebrate communities of this stream. Samples were processed to provide number of taxa (richness), MCI, and $SQMCI_S$ scores for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects of organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The $SQMCI_S$ takes into account taxa abundances as well as sensitivity to pollution. It may indicate subtle changes in communities, and therefore be the more relevant index if non-organic impacts are occurring. Significant differences in either the MCI or the $SQMCI_S$ between sites may indicate the degree of adverse effects (if any) of the discharge being monitored.

Summaries of each biomonitoring survey are as follows. A complete copy of the biomonitoring surveys can be found within Appendix II of this report.

Figure 3 Biomonitoring site in an unnamed tributary of the Ngaere Stream in relation to the Cheal-E wellsite

27 June 2013

This June 2013 survey of three sites, upstream and downstream of the intended skimmer pit discharge point, was undertaken prior to drilling at the Cheal-E wellsite and site construction. Taxa richnesses were moderate and within a narrow range for all sites and the macroinvertebrate communities of the stream contained similar proportions of 'tolerant' and 'moderately sensitive' taxa but no 'highly sensitive' taxa. A total of 26 taxa was found through the reach of the stream surveyed, with 10 of these taxa (38.5%) found at all three sites and 7 taxa (27%) found at any two of these sites. Characteristic taxa were relatively similar between sites with three 'tolerant' taxa and one 'moderately sensitive' taxa abundant at all three sites.

There were no significant differences in MCI scores between sites, a reflection of the similarities in habitat at each site. These MCI scores indicated that the stream communities were of poor 'health' (TRC, 2013) but similar to the biological health recorded at 'control' sites in similar streams at a comparative altitude elsewhere in the region. A significant change in $SQMCI_S$ score was recorded between site 2 and site 3, which can be attributed to a change in sampling technique used at each site.

25 August 2014

The August 2014 survey of three sites, upstream and downstream of the intended skimmer pit discharge point, was undertaken following drilling at the Cheal-E wellsite and site construction. Taxa richnesses were moderate at site 2 and 3, but moderately low at site 1. The macroinvertebrate communities of the stream contained similar proportions of 'tolerant' and 'moderately sensitive' taxa but no 'highly sensitive' taxa. A total of 23 taxa was found through the reach of the stream surveyed, with 10 of these taxa (43%) found at all three sites and four taxa (17%) found at any two of these sites. Characteristic taxa were relatively similar between sites with one 'tolerant' taxon and one 'moderately sensitive' taxon abundant at all three sites.

A comparison of the pre-drill and post-drill survey results show a significant (Stark, 1998) increase in MCI score at site 2 (by 11 units) and a significant increase in $SQMCI_S$ score at site 3. There was also a significant increase in $SQMCI_S$ score between site 1 and site 2 in the current survey. Variations in MCI and $SQMCI_S$ score and taxa richness between sites and surveys is considered to be due to habitat variability rather than a change in water quality, although sampling technique will also have had an influence.

The MCI scores recorded in this survey indicated that the stream communities were of fair 'health' (TRC, 2013), but slightly better than the biological health recorded at 'control' sites in similar streams at a comparative altitude elsewhere in the region. There was no indication from the results of the two surveys that the discharge from the Cheal-E wellsite has impacted on the biological communities of the unnamed tributary of the Ngaere Stream.

2.5 Contingency plan

TAG Oil (NZ) Limited has provided a general contingency plan, as required by Condition 4 of resource consent 9550-1 with site specific maps. The contingency plan has been reviewed and approved by officers of the Council.

2.6 Investigations, interventions and incidents

The Council operates and maintains a register of all complaints or reported and discovered excursions from acceptable limits and practices, including non-compliance with consents, which may damage the environment. The 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.

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

In the monitoring period under review, the Council was not required to undertake significant additional investigations and interventions, or record incidents, in association with TAG Oil (NZ) Limited's conditions in resource consents or provisions in Regional Plans.

Any minor actual or potential non-compliance with consent conditions were addressed during site inspections. TAG Oil (NZ) Limited staff would quickly take steps to ensure that requests made by Council Inspecting Officers were adhered to.

3. Discussion

3.1 Discussion of consent exercise

All five resource consents relating to the Cheal-E wellsite, consents 9550-1 (to discharge treated stormwater, surplus drilling water and produced water onto land and into and unnamed tributary of the Ngaere Stream), 9551-1 (to take groundwater as 'produced water'), 9552-2 (to discharge treated stormwater and sediment, deriving from soil disturbance undertaken for the purpose of constructing the Cheal-E wellsite), 9548-1 (to discharge contaminants to air from hydrocarbon exploration), and 9549-1 (to discharge emissions to air associated with hydrocarbon producing wells) were exercised and actively monitored.

Monitoring has shown that the management on site ensured that no significant adverse effects to the environment occurred during the monitoring period.

3.2 Environmental effects of exercise of consents

Stormwater

The discharge of stormwater from earthworks has the potential for sediment and other contaminants to enter surface water where it may detrimentally affect in-stream flora and fauna. To mitigate these effects, TAG Oil (NZ) Limited established perimeter drains during the construction of the wellsite, and care was taken to ensure runoff from disturbed areas was directed into the drains or directed through adequate silt control structures.

Once the wells were constructed, attention was given to controlling stormwater that ran off the wellsite and the associated plant and equipment.

Adverse effects on surface water quality can occur if contaminated water escapes through the stormwater system. Interceptor pits are designed to trap sediment and hydrocarbons through gravity separation. Any water that is unsuitable for release via the interceptor pits was directed to the drilling sumps, or removed for off-site disposal.

TAG Oil (NZ) Limited also undertook the following mitigation measures in order to minimize off-site adverse effects:

- All stormwater was directed via perimeter drains to the skimmer pits for treatment prior to discharge;
- Additional bunding was constructed around the bulk fuel tank, chemical storage area, and other areas where runoff from areas containing contaminants could occur;
- Regular inspections of the interceptor pits occurred; and
- Maintenance and repairs were carried out if required.

Interceptor pits do not discharge directly to surface water, instead they discharge onto and into land where the discharge usually soaks into the soil before reaching any surface water. Evidence of a leak within a skimmer pit during the period under review led to an investigation and remedial interventions by the Company.

However, if high rainfall had resulted in the discharge reaching the surface water, significant dilution would have occurred.

There are numerous on-site procedures included in drilling and health and safety documentation that are aimed at preventing spills on-site, and further procedures that address clean-up to remedy a spill situation before adverse environmental effects have the opportunity to occur (for example bunding of chemicals and bulk fuel).

Groundwater

Small amounts of groundwater may have been encountered as produced water during operations at the wellsite. It was anticipated that the abstraction of groundwater would not impact on any groundwater resource and that the groundwater would not be affected as it would be protected by the well casing.

Flaring

The environmental effects from flaring have been evaluated in monitoring reports prepared by the Council in relation to the flaring emissions from specific wells in the region.

The Council has previously undertaken field studies at two wells (one gas, and the other producing oil and heavier condensates); together with dispersion modelling at a third site[1]. More recently two studies have focused on field investigations and modelling of emissions from flares involving fracturing fluids.[2]

In brief, the previous studies found that measurements of carbon monoxide, carbon dioxide, and methane concentrations to be safe at all points downwind, including within 50 m of the flare pit. Measurements of suspended particulate matter found concentrations typical of background levels, and measurements of PM_{10} found compliance with national standards even in close proximity to the flare. Beyond 120 m from the flare pit, concentrations of polyaromatic hydrocarbons (PAH) approached background levels, as did levels of dioxins beyond 250 m from the flare.

In summary, the studies established that under combustion conditions of high volume flaring of gases with some light entrained liquids etc., atmospheric concentrations of all contaminants had reduced by a distance of 250 m downwind to become essentially typical of or less than elsewhere in the Taranaki environment (e.g. urban areas). These levels are well below any concentrations at which there is any basis for concern over potential health effects.

The measures to be undertaken by TAG Oil (NZ) Limited to avoid or mitigate actual or potential adverse environmental impacts on air quality included:

- The use of a test separator to separate solids and fluids from the gas during all well clean-ups, and workover activities where necessary, thus reducing

[1] Taranaki Regional Council, *Fletcher Challenge Energy Taranaki Ltd, Mangahewa 2 Gas Well Air Quality Monitoring Programme Report 1997 – 98*, August 1998.
[2]Taranaki Regional Council: *Atmospheric Dispersion Modelling of Discharges to Air from the Flaring of Fracturing Fluid*, Backshall, March 2013; and *Investigation of air quality arising from flaring of fracturing fluids -emissions and ambient air quality, Technical Report 2012– 03,* Taranaki Regional Council May 2012.

emissions to air. In particular, this would reduce the potential for heavy smoke incidents associated with elevated PAH and dioxin emissions;

- Use of a thermal oxidizer instead of open flare;
- Records of combustion events are kept by TAG Oil (NZ) Limited and provided to the Council;
- Every endeavor was made by TAG Oil (NZ) Limited to minimise the total volume of gas flared while ensuring that adequate flow and pressure data was gathered to inform their investment decision; and
- Every endeavor was made by TAG Oil (NZ) Limited to minimise smoke emissions from the thermal oxidizer.

Odour and dust

Suppression of dust with water was to be implemented if it was apparent that dust may adversely affect off-site parties. Odour may stem from the product, flare/thermal oxidizer, or some of the chemicals used on-site. Care was taken to minimise the potential for odour emissions (for example by keeping containers sealed, and ensuring the flare burnt cleanly).

Hazardous substances

The use and storage of hazardous substances on-site has the potential to contaminate surface water and soils in the event of a spill. In the unlikely event of a serious spill or fire, the inappropriate storage of flammable materials could result in air, soil and water contamination.

TAG Oil (NZ) Limited was required to implement the following mitigation measures:

- All potentially hazardous material were used and stored in accordance with the relevant Hazardous Substances and New Organisms regulations;
- All areas containing hazardous chemicals were bunded;
- Sufficient separation of chemicals from the flare pit were maintained for safety reasons;
- In the unlikely event of a spill escaping from bunded areas, the site perimeter drain and interceptor pit system was implemented to provide secondary containment on-site; and
- A spill contingency plan was prepared that sets out emergency response procedures to be followed in the event of a spill.

Summary

There were no significant adverse environmental effects observed to water, land or air as a result of the wellsite activities during the monitoring period.

3.3 Evaluation of performance

A tabular summary of TAG Oil (NZ) Limited's compliance record for the period under review is set out in Tables 3 to 7.

Table 3 Summary of performance for consent 9550-1 to discharge treated stormwater, treated surplus drilling water and treated produced water from hydrocarbon exploration and production operations at the Cheal-E wellsite, onto land and into an unnamed tributary of the Ngaere Stream

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Consent holder to adopt best practicable option at all times	Inspection of site, procedures & processes	Yes
2. Maximum stormwater catchment area shall be no more than 2 Ha	Plans, procedures and processes	Yes
3. Five days written notice provided to the Council prior to site works and drilling	Notification received	Yes
4. Council to approve prepared contingency plan in relation to the wellsite prior to exercise of consent	Contingency plan approved	Yes
5. The stormwater system shall be designed, managed and maintained in accordance with information submitted	Comparative inspections in accordance with information submitted	Yes
6. All discharges from the site shall flow to a perimeter drain and skimmer pit	Inspection	Yes
7. Skimmer pits shall have a combined capacity of no less than 330 m^3 and retain hydrocarbons	Inspection and physicochemical sampling	Yes
8. All stormwater pits shall be lined with impervious material	Inspection	Yes
9. Perimeter drains and skimmer pits to be installed prior to the commencement of works at the site	Inspection	Yes
10. Constituents in discharges shall meet the following standards: a) pH 6.0 – 9.0 b) Suspended solids <100 g/m^3 c) Hydrocarbon <15 g/m^3 d) Chloride 50 g/m^3	Physicochemical sampling	Yes
11. Following a mixing zone of 20 m , discharges shall not give rise to an increase in temperature of more than 2°C	Physicochemical sampling	Yes
12. Following the mixing zone, the discharge shall not give rise to adverse effects in the receiving waters	Inspection	Yes

13. The Council shall be advised in writing 48 hrs prior to reinstatement of the site	Notification	N/A
14. Consent shall lapse if not implemented	Exercise of consent confirmed by inspection	N/A
15. Notice of Council to review consent	No provision for review during period	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		High
Overall assessment of administrative performance in respect of this consent		High

Table 4 Summary of performance for consent 9551-1 to take groundwater as 'produced water', during hydrocarbon exploration and production activities at the Cheal-E wellsite

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. The abstraction must not cause more than a 10% lowering of static water level by interference with any adjacent bore	No complaints received	N/A
2. The abstraction does not cause the intrusion of salt water into any freshwater aquifer	No complaints received	N/A
3. A well log to 1,000 m must be submitted to the Council	Well log to 1,000 m submitted	Yes
4. Consent shall lapse if not implemented by date specified	Consent exercised	N/A
5. Notice of Council to review consent	Notice of intention not served	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		High
Overall assessment of administrative performance in respect of this consent		High

Table 5 Summary of performance for consent 9552-1 to discharge stormwater and sediment, deriving from soil disturbance undertaken for the purpose of constructing the Cheal-E wellsite, onto land and into an unnamed tributary of the Ngaere Stream

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. The discharge of stormwater from land shall not exceed more than 2.65 ha	Inspections and plans	Yes
2. Consent holder to adopt best practicable option at all times	Inspections, procedures and processes	Yes
3. Seven days written notice prior to site earthworks commencing	Notification received	Yes
4. All run off from any exposed soil shall pass through settlement ponds or sediment traps or other sediment control measure of equal standard	Inspections	Yes

5. Condition 4 shall cease to apply, and sediment control measures removed when the area is stabilised	Inspections	Yes
6. All earth worked areas shall be stabilised as soon as practicable	Inspection	Yes
Overall assessment of consent compliance and environmental performance in respect of this consent		High
Overall assessment of administrative performance in respect of this consent		High

Table 6 Summary of performance for consent 9548-1 to discharge contaminants to air from hydrocarbon exploration at the Cheal-E wellsite, including combustion involving flaring or incineration of petroleum recovered from natural deposits, in association with well development or redevelopment and testing or enhancement of well production flows

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Definitions	-	N/A
2. Incineration shall only occur in a device with a minimum chimney height as directed by the Regional Air Quality Plan	Inspection	Yes
3. Flaring shall only occur over a contained area consisting of impermeable material	Inspection	Yes
4. Flaring and incineration shall only occur within 20 metres of the location NZTM 1714326E – 5639641N	Inspection	Yes
5. Consent shall not be exercised for more than an accumulated duration of 15 days per zone for up to 12 wells	Inspection of records	Yes
6. Council must be notified 24hrs prior to initial flaring of each zone	Notification received	Yes
7. Occupants of dwellings within 300 m of the wellsite shall be provided with notification at least 24 hrs prior to flaring, when practicable	Notification	Yes
8. No material to be flared or incinerated, other than those derived from or entrained in the well stream	Inspection of thermal oxidisers	Yes
9. All gas flared must first be treated by effective liquid and solid separation and recovery	Inspection of thermal oxidisers	Yes
10. If effective separation could not be achieved, the consent holder shall reinstate effective separation as soon as possible; if separation could not be achieved within 3 hours, combustion must cease	Inspection of thermal oxidisers and Company records	Yes
11. If effective liquid and solid separation could not achieved, the consent holder shall provide to the Council a report	Inspection of thermal oxidisers and Company records	N/A

Condition requirement	Means of monitoring during period under review	Compliance achieved?
12. Best practicable option to be adopted	Inspections, procedures and processes	Yes
13. No offensive or objectionable odour or smoke at or beyond the boundary	Inspection	Yes
14. Control of carbon monoxide, nitrogen dioxide, sulphur dioxide and fine particles	Inspection of Company records	Yes
15. Control of other emissions	Inspection of Company records	Yes
16. Analysis of typical gas and condensate stream from field to be made available to the Council	Available upon request	N/A
17. All permanent tanks used as hydrocarbon storage vessels fitted with vapour recovery systems	Inspection	Yes
18. Consent holder shall make available to the Council a flaring log detailing all flaring events including time, duration, zone, volumes flared and smoke events	Inspection of Company records	Yes
19. Consent shall lapse if not implemented	Consent exercised	N/A
20. Notice of Council to review consent	No provision for review during period	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		High
Overall assessment of administrative performance in respect of this consent		High

Table 7 Summary of performance for consent 9549-1 to discharge emissions to air associated with hydrocarbon producing wells at the Cheal-E wellsite

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Definitions	-	N/A
2. Incineration shall only occur in a device with a minimum chimney height as directed by the Regional Air Quality Plan	Inspection	Yes
3. Flaring shall only occur over a contained area consisting of impermeable material	Inspection	Yes
4. Flaring and incineration shall only occur within 20 metres of the location NZTM 1714326E – 5639641N	Inspection	Yes
5. Council must be notified 24hrs prior to continuous flaring or incineration expected to occur for more than five minutes	Notification received	Yes
6. Occupants of dwellings within 200 m of the wellsite shall be provided with notification at least 24 hrs prior to flaring, when practicable	Notification	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
7. No material to be flared or incinerated, other than those derived from or entrained in the well stream	Inspection	Yes
8. All gas flared must first be treated by effective liquid and solid separation and recovery	Inspection	Yes
9. Best practicable option to be adopted	Inspections, procedures and processes	Yes
10. No offensive or objectionable odour or smoke at or beyond the boundary	Inspection	Yes
11. All permanent tanks used as hydrocarbon storage vessels fitted with vapour recovery systems	Inspection	Yes
12. Control of carbon monoxide, nitrogen dioxide, sulphur dioxide and fine particles	Inspection of Company records	Yes
13. Control of other emissions	Inspection of Company records	Yes
14. Analysis of typical gas and condensate stream from field to be made available to the Council	Available upon request	Yes
15. Consent holder shall make available to the Council a flaring log detailing all flaring events including time, duration, zone, volumes flared and smoke events	Inspection of Company records	Yes
16. Consent shall lapse if not implemented	Consent exercised	N/A
17. Notice of Council to review consent	No provision for review during period	N/A
18. No material to be flared or incinerated, other than those derived from or entrained in the well stream	Inspection of flare pit	Yes
Overall assessment of consent compliance and environmental performance in respect of this consent		High
Overall assessment of administrative performance in respect of this consent		High

During the monitoring period, TAG Oil (NZ) Limited demonstrated a high level of environmental performance and administrative compliance with the resource consents. The site was generally neat, tidy, and well maintained.

3.4 Exercise of optional review of consents

Each resource consent includes a condition which allows the Council to review the consent, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of the resource consent, which were not foreseen at the time the application was considered or which it was not appropriate to deal with at the time. The next provisions for review are in 2016.

Based on the results of monitoring during the period under review, it is considered that there are no grounds that require a review to be pursued. A recommendation to this effect is presented in section 4.

3.5 Alterations to monitoring programmes

In designing and implementing the monitoring programmes for air and water discharges and water abstractions at wellsites in the region, the Council takes into account the extent of information made available by previous and other authorities, its relevance under the Act, the obligations of the Act in terms of monitoring emissions/discharges and effects, and of 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 wellsite processes within Taranaki.

The Council has routinely monitored wellsite activities for more than 20 years in the region. This work has included in the order of hundreds of water samples and biomonitoring surveys in the vicinity of wellsites, and has demonstrated robustly that a monitoring regime based on frequent and comprehensive inspections is rigorous and thorough, in terms of identifying any adverse effects from wellsite and associated activities. Furthermore, with regard to hydraulic fracturing activities, baseline groundwater monitoring samples have demonstrated that hydraulic fracturing discharges have not given rise to any significant adverse effects on groundwater aquifers within the region. However, the Council had for a time not routinely required the imposition of additional targeted physicochemical and biological monitoring unless a site-specific precautionary approach indicated this would be warranted for certainty and clarity around site effects.

In addition, the Council has also noted a desire by some community areas or individuals for a heightened level of information feedback and certainty around the results and outcomes of monitoring at wellsites. The Council has therefore moved to extend the previous regime, to make the sampling and extensive analysis of groundwater and surface waters in the general vicinity of a wellsite where hydraulic fracturing occurs, and biomonitoring of surface water ecosystems, an integral part of the basic monitoring programme for such activities.

Therefore, it is proposed that for any further work at the Cheal-E wellsite, the new standard programme will continue to be repeated, notwithstanding the lack of any effects or concerns previously found. A recommendation to this effect is attached to this report.

4. Recommendations

1. THAT this report be forwarded to the Company, and to any interested parties upon request;

2. THAT the monitoring of future consented activities at Cheal-E wellsite continue to include biomonitoring surveys;

3. THAT the monitoring of future consented activities include sampling and extensive analysis of both groundwater and surface waters in the general vicinity of the wellsite if hydraulic fracturing is to commence at the Cheal-E wellsite;

4. THAT, subject to the findings of monitoring of any further activities at the Cheal-E wellsite consents 9550-1, 9551-1, 9548-1 and 9549-1 shall not be reviewed in 2016.

Glossary of common terms and abbreviations

The following abbreviations and terms may have been used within this report:

Al*	Aluminium.
As*	Arsenic.
Biomonitoring	Assessing the health of the environment using aquatic organisms.
BOD	Biochemical oxygen demand. A measure of the presence of degradable organic matter, taking into account the biological conversion of ammonia to nitrate.
BODF	Biochemical oxygen demand of a filtered sample.
Bund	A wall around a tank to contain its contents in the case of a leak.
CBOD	Carbonaceous biochemical oxygen demand. A measure of the presence of degradable organic matter, excluding the biological conversion of ammonia to nitrate .
cfu	Colony forming units. A measure of the concentration of bacteria usually expressed as per 100 millilitre sample.
COD	Chemical oxygen demand. A measure of the oxygen required to oxidise all matter in a sample by chemical reaction.
Condy	Conductivity, an indication of the level of dissolved salts in a sample, usually measured at 20°C and expressed in mS/m.
Cu*	Copper.
DO	Dissolved oxygen.
DRP	Dissolved reactive phosphorus.
E.coli	Escherichia coli, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
Ent	Enterococci, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre of sample.
F	Fluoride.
FC	Faecal coliforms, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
Fresh	Elevated flow in a stream, such as after heavy rainfall.
g/m^3	Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.
Incident	An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred.
Intervention	Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.
Investigation	Action taken by Council to establish what were the circumstances/events surrounding an incident including any allegations of an incident.

l/s	Litres per second.
MCI	Macroinvertebrate community index; a numerical indication of the state of biological life in a stream that takes into account the sensitivity of the taxa present to organic pollution in stony habitats.
mS/m	Millisiemens per metre.
Mixing zone	The zone below a discharge point where the discharge is not fully mixed with the receiving environment. For a stream, conventionally taken as a length equivalent to 7 times the width of the stream at the discharge point.
NH_4	Ammonium, normally expressed in terms of the mass of nitrogen (N).
NH_3	Unionised ammonia, normally expressed in terms of the mass of nitrogen (N).
NO_3	Nitrate, normally expressed in terms of the mass of nitrogen (N).
NTU	Nephelometric Turbidity Unit, a measure of the turbidity of water.
O&G	Oil and grease, defined as anything that will dissolve into a particular organic solvent (e.g. hexane). May include both animal material (fats) and mineral matter (hydrocarbons).
Pb*	Lead.
pH	A numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline. The scale is logarithmic i.e. a change of 1 represents a ten-fold change in strength. For example, a pH of 4 is ten times more acidic than a pH of 5.
Physicochemical	Measurement of both physical properties(e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment.
PM_{10}	Relatively fine airborne particles (less than 10 micrometre diameter).
Resource consent	Refer Section 87 of the RMA. Resource consent include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15).
RMA	Resource Management Act 1991 and subsequent amendments.
SS	Suspended solids.
Temp	Temperature, measured in °C (degrees Celsius).
Turb	Turbidity, expressed in NTU.
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.
Zn*	Zinc.

*an abbreviation for a metal or other analyte may be followed by the letters 'As', to denote the amount of metal recoverable in acidic conditions. This is taken as indicating the total amount of metal that might be solubilised under extreme environmental conditions. The abbreviation may alternatively be followed by the letter 'D', denoting the amount of the metal present in dissolved form rather than in particulate or solid form.

For further information on analytical methods, contact the Council's laboratory.

Appendix I

Resource consents

Discharge Permit

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

Name of Consent Holder:	Cheal Petroleum Limited P O Box 402 NEW PLYMOUTH 4340
Decision Date:	16 April 2013
Commencement Date:	16 April 2013

Conditions of Consent

Consent Granted:	To discharge stormwater and sediment, deriving from soil disturbance undertaken for the purpose of constructing the Cheal-E wellsite, onto land and into an unnamed tributary of the Ngaere Stream
Expiry Date:	1 June 2018
Site Location:	Cheal-E wellsite, Sole Road, Stratford (Property owner: J O'Neill)
Legal Description:	Sec 31 Blk VI Ngaere SD (Discharge source & site)
Grid Reference (NZTM)	1714467E-5639749N
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. This consent authorises the discharge of stormwater from no more than 2.65 ha of land where earthworks is being undertaken for the purpose of establishing the Cheal-E wellsite.

2. 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 associated with the discharge of contaminants from the site.

3. At least 7 working days before the commencement of earthworks for the purpose of wellsite construction and establishment, the consent holder shall notify the Taranaki Regional Council of the proposed start date for the earthworks. Notification shall include the consent number and a brief description of the activity consented and shall be emailed to worknotification@trc.govt.nz.

4. All run off from any area of exposed soil shall pass through settlement ponds or sediment traps with a minimum total capacity of:

   a) 100 cubic metres for every hectare of exposed soil between 1 November to 30 April; and

   b) 200 cubic metres for every hectare of exposed soil between 1 May to 31 October;

   unless other sediment control measures that achieve an equivalent standard are agreed to by the Chief Executive of the Taranaki Regional Council.

5. The sediment control measures necessary to comply with condition 4 above shall be constructed before soil is exposed for the construction of the wellsite and shall remain in place, in respect of any particular area, until that area is stabilised.

   Note: For the purpose of conditions 5 and 6, "stabilised" in relation to any site or area means inherently resistant to erosion or rendered resistant, such as by using rock or by the application of basecourse, colluvium, grassing, mulch, or another method to the reasonable satisfaction of the Chief Executive, Taranaki Regional Council and as specified in the Taranaki Regional Council's Guidelines for Earthworks in the Taranaki Region, 2006. Where seeding or grassing is used on a surface that is not otherwise resistant to erosion, the surface is considered stabilised once, on reasonable visual inspection by an officer of the Taranaki Regional Council, an 80% vegetative cover has been established.

6. All earthworked areas shall be stabilised vegetatively or otherwise as soon as is practicable and no longer than 6 months after the completion of soil disturbance activities.

Signed at Stratford on 16 April 2013

For and on behalf of
Taranaki Regional Council

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Chief Executive

Discharge Permit

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

Name of Consent Holder:	Cheal Petroleum Limited P O Box 402 NEW PLYMOUTH 4340
Decision Date:	6 May 2013
Commencement Date:	6 May 2013

Conditions of Consent

Consent Granted:	To discharge treated stormwater, treated surplus drilling water and treated produced water from hydrocarbon exploration and production operations at the Cheal-E wellsite, onto land and into an unnamed tributary of the Ngaere Stream
Expiry Date:	1 June 2028
Review Date(s):	June 2016, June 2022
Site Location:	Cheal-E wellsite, Sole Road, Stratford (Property owner: J O'Neill)
Legal Description:	Sec 31 Blk VI Ngaere SD (Discharge source & site)
Grid Reference (NZTM)	1714467E-5639749N
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 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 associated with the discharge of contaminants from the site.

2. Stormwater discharged shall be collected from a catchment area of no more than 2 Ha.

3. At least 5 working days prior, the consent holder shall advise the Chief Executive, Taranaki Regional Council of the date of each of the following events:

   a) commencement of any site works (site works includes the introduction of a drilling rig, drilling equipment or any other associated equipment or facilities to the site for any purpose other than for the construction of the site);
   b) commencement of any well drilling operation; and
   c) recommencement of any site works or drilling operations following a period of inactivity exceeding 30 days.

   If any of these events is rescheduled or delayed, the consent holder shall immediately provide further notice advising of the new date.

   Any advice given in accordance with this condition shall include the consent number and the wellsite name and be emailed to worknotification@trc.govt.nz.

4. The consent holder shall maintain a contingency plan that, to the satisfaction of the Chief Executive, Taranaki Regional Council, details measures and procedures to be undertaken to prevent spillage or accidental discharge of contaminants not authorised by this consent and measures to avoid, remedy or mitigate the environmental effects of such a spillage or discharge. The contingency plan shall be provided to the Council prior to discharging from the site.

5. Subject to other conditions of this consent the design, management and maintenance of the stormwater system shall be undertaken in accordance with the information submitted in support of the consent application 7413, in particular drawing number 12531-02.

6. All discharges from the site, including from any containment pit or hydrocarbon combustion facility (e.g. flare pit, thermal oxidiser), shall flow to a perimeter drain and skimmer pit. Perimeter drains shall be designed, including by having a positive grade and low permeability, to ensure that runoff flows directly to a skimmer pit without ponding.

7. Skimmer pits shall have a combined capacity of no less than 330 m^3, and be designed to retain any hydrocarbons that enter them.

8. All skimmer pits and any other stormwater retention areas shall be lined with an impervious material to prevent seepage through the bed and sidewalls, and all skimmer pits shall have a valve that can be shut off to prevent any discharge from the site.

9. Perimeter drains and skimmer pits necessary to comply with the conditions of this consent shall be installed before any site works commences. Site works includes the introduction of a drilling rig, drilling equipment or any other associated equipment or facilities to the site for any purpose other than for the construction of the site.

10. Constituents in the discharge shall meet the standards shown in the following table.

Constituent	Standard
pH	Within the range 6.0 to 9.0
suspended solids	Concentration not greater than 100 gm^{-3}
total recoverable hydrocarbons	Concentration not greater than 15 gm^{-3} [as determined by infrared spectroscopic technique]
chloride	Concentration not greater than 50 gm^{-3}

11. After allowing for a mixing zone of 20 metres, the discharge shall not give rise to an increase in the temperature of the receiving waters of more than 2 degrees Celsius.

12. After allowing for a mixing zone of 20 metres, the discharge shall not give rise to any of the following effects in the receiving water:

    a) the production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials;
    b) any conspicuous change in the colour or visual clarity;
    c) any emission of objectionable odour;
    d) the rendering of fresh water unsuitable for consumption by farm animals;
    e) any significant adverse effects on aquatic life.

13. The consent holder shall advise the Chief Executive, Taranaki Regional Council, in writing at least 48 hours prior to the reinstatement of the site and the reinstatement shall be carried out so as to minimise adverse effects on stormwater quality. Notification shall include the consent number and a brief description of the activity consented and be emailed to worknotification@trc.govt.nz.

14. This consent shall lapse on 30 June 2018, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

15. 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 6 May 2013

For and on behalf of
Taranaki Regional Council

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Director-Resource Management

Water Permit

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

Name of Consent Holder:	Cheal Petroleum Limited P O Box 402 NEW PLYMOUTH 4340
Decision Date:	6 May 2013
Commencement Date:	6 May 2013

Conditions of Consent

Consent Granted:	To take groundwater as 'produced water', during hydrocarbon exploration and production activities at the Cheal-E wellsite
Expiry Date:	1 June 2028
Review Date(s):	June 2016, June 2022
Site Location:	Cheal-E wellsite, Sole Road, Stratford (Property owner: J O'Neill)
Legal Description:	Sec 31 Blk VI Ngaere SD (Site of take)
Grid Reference (NZTM)	1714385E-5639682N
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 ensure the abstraction does not cause more than a 10% lowering of static water-level by interference with any adjacent bore.

2. The consent holder shall ensure the abstraction does not cause the intrusion of salt water into any freshwater aquifer.

3. The consent holder shall submit a summary well log to a depth of 1000 metres within three months of completion of drilling. The report shall:

   (a) include confirmation of the datum from which measurements are referenced;
   (b) provide a log to show the true vertical depth to all geological formation tops intersected within the freshwater zone;
   (c) identify the true vertical depth to, and thickness of, any freshwater aquifers intersected by the well;
   (d) identify the true vertical depth to the freshwater- saline water interface in the well.

4. This consent shall lapse on 30 June 2018, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

5. 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 6 May 2013

For and on behalf of
Taranaki Regional Council

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Director-Resource Management

Discharge Permit

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

Name of Consent Holder:	Cheal Petroleum Limited P O Box 402 NEW PLYMOUTH 4340
Decision Date (Change):	1 November 2013
Commencement Date (Change):	1 November 2013 (Granted: 13 May 2013)

Conditions of Consent

Consent Granted:	To discharge contaminants to air from hydrocarbon exploration at the Cheal-E wellsite, including combustion involving flaring or incineration of petroleum recovered from natural deposits, in association with well development or redevelopment and testing or enhancement of well production flows
Expiry Date:	1 June 2028
Review Date(s):	June 2016, June 2022 and as per special condition 20
Site Location:	Cheal-E wellsite, Sole Road, Stratford (Property owner: J O'Neill)
Legal Description:	Sec 31 Blk VI Ngaere SD (Discharge source & site)
Grid Reference (NZTM)	1714326E-5639641N

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. For the purposes of this consent:

   (a) 'flaring' means the uncontrolled or partially controlled open air burning of hydrocarbons derived from or entrained in the well stream. 'Flare', as a verb, has the corresponding meaning and, as noun, means the flame produced by flaring.

   (b) 'incineration' means the controlled, enclosed burning of formation hydrocarbons within a device designed for the purpose. 'Incinerate' has the corresponding meaning.

   (c) 'Combustion' means burning generally and includes both flaring and incineration as well as other burning such as fuel in machinery.

2. Incineration shall only occur in a device with a minimum chimney height determined by the method detailed in Appendix VIII of the *Regional Air Quality Plan for Taranaki.*

3. Flaring shall only occur over a pit, or similar containment area, consisting of impermeable material that prevents any liquid from leaking through its base or sidewalls and discharging to land.

4. Flaring and incineration shall only occur within 20 metres of the location defined by NZTM 1714326E-5639641N.

5. Discharges to air from flaring or incineration shall not last longer than 15 days, cumulatively, inclusive of testing, clean-up, and completion stages of well development or work-over, per zone to be appraised to a maximum of four zones per well, for up to 12 wells.

6. The consent holder shall notify the Chief Executive, Taranaki Regional Council, at least 24 hours before the flaring or incineration from each zone commences. Notification shall include the consent number and a brief description of the activity consented and be emailed to worknotification@trc.govt.nz.

7. At least 24 hours before any flaring or incineration, other than in emergencies, the consent holder shall provide notification to the occupants of all dwellings within 300 metres of the wellsite and all landowners within 200 metres, of the commencement of flaring or incineration. The consent holder shall include in the notification a 24-hour contact telephone number for a representative of the consent holder, and shall keep and make available to the Chief Executive, Taranaki Regional Council, a record of all queries and complaints received in respect of any combustion activity.

8. No material shall be flared or incinerated, other than those derived from or entrained in the well stream.

9. To the greatest extent possible, all gas that is flared or incinerated must first be treated by effective liquid and solid separation and recovery.

10. Only gaseous hydrocarbons originating from the well stream shall be flared or incinerated, except that if, for reasons beyond the control of the consent holder, effective separation can not be achieved and combustion of liquid hydrocarbon is unavoidable, the consent holder shall reinstate effective separation as soon as possible and if separation can not be achieved within 3 hours combustion must cease.

11. If liquid hydrocarbon is combusted in accordance with the exception provided for in condition 10 the consent holder shall prepare a report that details:

    (a) the reasons that separation could not be achieved;

    (b) the date and time that separation was lost and reinstated;

    (c) what was done to attempt to reinstate separation and, if it the attempt was unsuccessful the reasons why.

    The report shall be provided to the Chief Executive, Taranaki Regional Council within 5 working days from the date of combustion of liquid hydrocarbon.

12. 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 potential effect on the environment arising from any emission to air, including, but not limited to having regard to the prevailing and predicted wind speed and direction at the time of initiation, and throughout, any episode of combustion so as to minimise offsite effects (other than for the maintenance of a pilot flame).

13. The discharge shall not cause any objectionable or offensive odour or any objectionable or offensive smoke at or beyond the boundary of the property where the wellsite is located.

14. The consent holder shall control all emissions of carbon monoxide, nitrogen dioxide, fine particles (PM_{10}) and sulphur dioxide to the atmosphere from the site, in order that the maximum ground level concentration of any of these contaminants arising from the exercise of this consent measured under ambient conditions does not exceed the relevant ambient air quality standard as set out in the Resource Management (National Environmental Standards for Air Quality Regulations, 2004) at or beyond the boundary of the property on which the wellsite is located.

15. The consent holder shall control all emissions of contaminants to the atmosphere from the site, other than those expressly provided for under special condition 14, in order that they do not individually or in combination with other contaminants cause a hazardous, noxious, dangerous, offensive or objectionable effect at a distance greater than 100 metres from the emission source.

16. The consent holder shall make available to the Chief Executive, Taranaki Regional Council, upon request, an analysis of a typical gas and condensate stream from the field, covering sulphur compound content and the content of carbon compounds of structure C_6 or higher number of compounds.

17. All permanent tanks used as hydrocarbon storage vessels, shall be fitted with vapour recovery systems.

18. The consent holder shall record and make available to the Chief Executive, Taranaki Regional Council, a 'combustion log' that includes:

    (a) the date, time and duration of all flaring or incineration episodes;

    (b) the zone from which flaring or incineration occurred;

    (c) the volume of substances flared or incinerated;

    (d) whether there was smoke at any time during the combustion episode and if there was, the time, duration and cause of each 'smoke event'.

19. This consent shall lapse on 30 June 2018, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

20. 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:

    (a) during the month of June 2016 and/or June 2022; and/or
    (b) within 1 month of receiving a report provided in accordance with condition 11;

    for any of the following purposes:

    (i) dealing with any significant adverse effect on the environment arising from the exercise of the consent which was not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
    (ii) requiring the consent holder to adopt specific practices in order to achieve the best practicable option to remove or reduce any adverse effect on the environment caused by the discharge; and/or
    (iii) to alter, add or delete limits on mass discharge quantities or ambient concentrations of any contaminant; and/or
    (iv) reducing emissions or environmental effects that may arise from any loss of separation.

Signed at Stratford on 1 November 2013

For and on behalf of
Taranaki Regional Council

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Director-Resource Management

Discharge Permit

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

Name of Consent Holder:	Cheal Petroleum Limited P O Box 402 NEW PLYMOUTH 4340
Decision Date (Change):	1 November 2013
Commencement Date (Change):	1 November 2013 (Granted: 13 May 2013)

Conditions of Consent

Consent Granted:	To discharge emissions to air associated with hydrocarbon producing wells at the Cheal-E wellsite
Expiry Date:	1 June 2028
Review Date(s):	June 2016, June 2022
Site Location:	Cheal-E wellsite, Sole Road, Stratford (Property owner: J O'Neill)
Legal Description:	Sec 31 Blk VI Ngaere SD (Discharge source & site)
Grid Reference (NZTM)	1714326E-5639641N

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. For the purposes of this consent:

   (a) 'flaring' means the uncontrolled or partially controlled open air burning of hydrocarbons derived from or entrained in the well stream. 'Flare', as a verb, has the corresponding meaning and, as noun, means the flame produced by flaring.

   (b) 'incineration' means the controlled, enclosed burning of formation hydrocarbons within a device designed for the purpose. 'Incinerate' has the corresponding meaning.

   (c) 'Combustion' means burning generally and includes both flaring and incineration as well as other burning such as fuel in machinery.

2. Incineration shall only occur in a device with a minimum chimney height determined by the method detailed in Appendix VIII of the *Regional Air Quality Plan for Taranaki*.

3. Flaring shall only occur over a pit, or similar containment area, lined with impermeable material that prevents any liquid from leaking through its base or sidewalls and discharging to land.

4. Flaring and incineration shall only occur within 20 metres of the location defined by NZTM 1714326E-5639641N.

5. Other than in emergencies, the consent holder shall notify the Chief Executive, Taranaki Regional Council, whenever the continuous flaring or incineration of hydrocarbons (other than purge gas) is expected to occur for more than five minutes in duration. Notification shall be no less than 24 hours before the flaring or incineration commences. Notification shall include the consent number and be emailed to worknotification@trc.govt.nz.

6. At least 24 hours before any flaring or incineration, other than in emergencies, the consent holder shall provide notification to the occupants of all dwellings within 300 metres of the wellsite and all landowners within 200 metres, of the commencement of flaring or incineration. The consent holder shall include in the notification a 24-hour contact telephone number for a representative of the consent holder, and shall keep and make available to the Chief Executive, Taranaki Regional Council, a record of all queries and complaints received in respect of any combustion activity.

7. No material shall be flared or incinerated, other than those derived from or entrained in the well stream.

8. To the greatest extent possible, all gas that is flared or incinerated must first be treated by effective liquid and solid separation and recovery.

9. 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 potential effect on the environment arising from any emission to air, including, but not limited to having regard to the prevailing and predicted wind speed and direction at the time of initiation, and throughout, any episode of combustion so as to minimise offsite effects (other than for the maintenance of a pilot flame).

10. The discharge shall not cause any objectionable or offensive odour or any objectionable or offensive smoke at or beyond the boundary of the property where the wellsite is located.

11. All permanent tanks used as hydrocarbon storage vessels, shall be fitted with vapour recovery systems.

12. The consent holder shall control all emissions of carbon monoxide, nitrogen dioxide, fine particles (PM_{10}) and sulphur dioxide to the atmosphere from the site, in order that the maximum ground level concentration of any of these contaminants arising from the exercise of this consent measured under ambient conditions does not exceed the relevant ambient air quality standard as set out in the Resource Management (National Environmental Standards for Air Quality Regulations, 2004) at or beyond the boundary of the property on which the wellsite is located.

13. The consent holder shall control all emissions of contaminants to the atmosphere from the site, other than those expressly provided for under special condition 12, in order that they do not individually or in combination with other contaminants cause a hazardous, noxious, dangerous, offensive or objectionable effect at a distance greater than 100 metres from the emission source.

14. The consent holder shall make available to the Chief Executive, Taranaki Regional Council, upon request, an analysis of a typical gas and condensate stream from the field, covering sulphur compound content and the content of carbon compounds of structure C6 or higher number of compounds.

15. The consent holder shall record and make available to the Chief Executive, Taranaki Regional Council, a 'combustion log' that includes:

    (a) the date, time and duration of all flaring or incineration episodes;

    (b) the zone from which flaring or incineration occurred;

    (c) the volume of substances flared or incinerated;

    (d) whether there was smoke at any time during the combustion episode and if there was, the time, duration and cause of each 'smoke event'.

16. This consent shall lapse on 30 June 2018, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

17. 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 any of the following purposes:

    (a) dealing with any significant adverse effect on the environment arising from the exercise of the consent which was not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or

    (b) requiring the consent holder to adopt specific practices in order to achieve the best practicable option to remove or reduce any adverse effect on the environment caused by the discharge; and/or

    (c) to alter, add or delete limits on mass discharge quantities or discharge or ambient concentrations of any contaminant.

Signed at Stratford on 1 November 2013

For and on behalf of
Taranaki Regional Council

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Director-Resource Management

Appendix II

Biomonitoring surveys

To Job Manager; Callum MacKenzie
From Freshwater Biologist; Brooke Thomas
Report No BT009
Document 1290581
Date 07 January 2014

Biomonitoring of the unnamed tributary of the Ngaere Stream prior to drilling by TAG Oil (NZ) Ltd at the Cheal-E wellsite, June 2013

Introduction

This biological survey was performed prior to drilling of the Cheal-E well, to provide baseline data on the macroinvertebrate community of the unnamed tributary of the Ngaere Stream. A second survey will be performed following drilling of the well, to determine whether or not treated stormwater and discharges of uncontaminated site water and production water onto land and into the unnamed tributary of the Ngaere stream have had a detrimental effect upon macroinvertebrate communities of this stream.

Methods

Cheal-E wellsite stormwater and site production water is to be discharged from a skimmer pit on to land and into the unnamed tributary of the Ngaere Stream (Figure 1). This survey was undertaken on 27 June 2013 at three newly established sites; 45 m upstream of the farm boundary fence (site 1), immediately downstream of farm boundary fence (site 2) and just downstream of a lone tree, 70m downstream of boundary (site 3).

Two different sampling techniques were used to collect streambed macroinvertebrates in the unnamed tributary of the Ngaere Stream, downstream of the stormwater discharges from the Cheal-E well site. The Council's standard 'vegetation sweep' technique was used at sites 1 and 2 and a combination of the 'kick-sampling' and 'vegetation sweep' sampling techniques was used at site 3 (Table 1, Figure 1). The 'kick-sampling' and 'vegetation sweep' techniques are very similar to Protocol C1 (hard-bottomed, semi-quantitative) and C2 (soft-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Table 1: Biomonitoring sites and sampling methods used in the unnamed tributary of the Ngaere Stream related to the Cheal-E wellsite.

Site no.	Site code	Grid reference (NZTM)	Location	Sampling method	Altitude (m asl)
1	NGR000280	1714464E-5639753N	45m u/s of farm boundary fence	Vegetation sweep	220
2	NGR000281	1714472E-5639710N	Immediately downstream of farm boundary fence	Vegetation sweep	220
3	NGR000283	1714501E-5639656N	Just downstream of lone tree, 70m d/s of boundary	Kick-sweep	220

Figure 1 Biomonitoring sites in the Ngaere Stream in relation to the Cheal-E wellsite.

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology which uses Protocol P1 of NZMWG protocols of sampling macroinvertebrates in wadeable streams (Stark et al, 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= estimated 20-99 individuals;
VA (very abundant)	= estimated 100-499 individuals;
XA (extremely abundant)	= estimated 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience.

By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

Results and discussion

At the time of this late morning survey stream temperatures were 12.1°C (site 1 and site 2), and 12.0 °C (site 3). A moderate flow of clear, uncoloured water was noted at all three sites. Substrate at site 1 and site 2 comprised predominantly sand and silt with a small amount of fine gravel, whereas site 3 only comprised sand and silt.

No periphyton growth was noted at any of the sites. Macrophytes were recorded on both the stream bed and at the edges of the bank at all three sites. It was noted that macrophytes at site 3 had been sprayed and appeared dead. No shading was recorded at any of the three sites.

Macroinvertebrate communities

Table 2 summarises the results of this macroinvertebrate survey performed prior to drilling of the Cheal-E wellsite. Comparative data for sites in similar streams are presented in Table 3.The macroinvertebrate fauna recorded by the current survey are presented in Table 4.

Table 2: Number of taxa, MCI and $SQMCI_S$ in the Ngaere Stream prior to drilling of Cheal-E wellsite.

Site No.	No taxa	MCI value	$SQMCI_S$ value
1	17	74	3.2
2	19	75	3.9
3	17	76	2.7

Table 3: Range and median number of taxa, MCI values and $SQMCI_S$ scores for control sites at altitudes between 200 and 249 m asl ((TRC, 1999 (updated 2013)).

	No. of taxa	MCI value	$SQMCI_S$ value
No. Samples	169	169	90
Range	5-33	52-108	1.5-6.3
Median	18	79	4.0

Table 4: Macroinvertebrate fauna of the Ngaere Stream in relation to the Cheal-E pre-drill survey sampled 27 June 2013.

Taxa List	Site Number	MCI score	1	2	3
	Site Code		NGR000280	NGR000281	NGR000283
	Sample Number		FWB13228	FWB13229	FWB13230
ANNELIDA (WORMS)	Oligochaeta	1	VA	A	VA
	Lumbricidae	5	-	R	R
MOLLUSCA	*Potamopyrgus*	4	A	XA	VA
	Sphaeriidae	3	-	-	R
CRUSTACEA	Copepoda	5	-	-	R
	Ostracoda	1	C	A	A
	Paracalliope	5	VA	VA	A
	Paraleptamphopidae	5	R	-	R
	Talitridae	5	R	-	R
EPHEMEROPTERA (MAYFLIES)	*Zephlebia group*	7	C	R	-
COLEOPTERA (BEETLES)	Hydrophilidae	5	-	R	-
TRICHOPTERA (CADDISFLIES)	*Polyplectropus*	6	A	A	R
	Psilochorema	6	R	R	R
	Oxyethira	2	R	R	-
	Triplectides	5	R	-	-
DIPTERA (TRUE FLIES)	*Paralimnophila*	6	-	R	-
	Chironomus	1	A	R	C
	Corynoneura	3	-	-	R
	Orthocladiinae	2	R	R	-
	Polypedilum	3	R	C	C
	Paradixa	4	R	C	R
	Empididae	3	R	R	-
	Ephydridae	4	-	R	-
	Sciomyzidae	3	-	R	-
	Austrosimulium	3	VA	VA	A
ACARINA (MITES)	Acarina	5	-	-	R
		No of taxa	17	19	17
		MCI	74	75	76
		SQMCIs	3.2	3.9	2.7
		EPT (taxa)	4	3	2
		%EPT (taxa)	24	16	12

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

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

Site 1- 45m upstream of farm boundary fence

A moderate community richness of seventeen taxa was found at site 1 (Table 2 and Table 4), one taxa less than the median richness found at similar sites elsewhere in the region (Table 3). The macroinvertebrate community comprised of a significant proportion of 'tolerant' taxa (59%), which was reflected in the MCI score of 74 units. This MCI score was slightly lower than the median MCI score for 'control' sites in similar streams at comparative altitudes (Table 3).

The community at this site was characterised by four 'tolerant' taxa (very abundant oligochaete worms and sandfly larvae (*Austrosimulium*), abundant snail (*Potamopyrgus*) and

chironomid midge larvae)); and two 'moderately sensitive' taxa (very abundant amphipod (*Paracalliope*) and abundant caddisfly (*Polyplectropus*)).

The numerical dominance of tolerant taxa resulted in a $SQMCI_S$ score of 3.2 units, which was 0.8 unit fewer than the median score for 'control' sites in similar streams at this altitude (Table 3).

Site 2- Immediately downstream of farm boundary fence

A moderate community richness of nineteen taxa was found at site 2 (Table 2 and Table 4), two taxa more than found at site 1, and one taxa more than the median richness found at similar sites (Table 3). The macroinvertebrate community comprised a significant proportion of 'tolerant' taxa (63%), which was reflected in the MCI score of 75 units, and was an insignificant 1 unit higher than recorded at the upstream 'control' site. This MCI score was an insignificant 4 units fewer than the median MCI score for 'control' sites in similar streams at comparative altitudes (Stark, 1998) (Table 3).

This community was characterised by four 'tolerant' taxa (extremely abundant snail (*Potamopyrgus*), sandfly larvae (*Austrosimulium*), oligochaete worms and seed shrimp (Ostracoda)); and two 'moderately sensitive' taxa (amphipod (*Paracalliope*) and caddisfly (*Polyplectropus*)).

The numerical dominance of tolerant taxa resulted in a $SQMCI_S$ score of 3.9 units, which was 0.1 unit fewer than the median score for 'control' sites in similar streams at this altitude (Table 3) and 0.7 unit higher than the upstream control site.

Site 3- 70 metres downstream of boundary fence

A moderate community richness of seventeen taxa was found at site 3 (Table 2 and Table 4), the same result as the upstream control site, and one less than the median richness found at similar sites elsewhere in the region (Table 3). In comparison to the two upstream sites, the macroinvertebrate community comprised of a lesser proportion of 'tolerant' taxa (53%), which was reflected in the MCI score of 76 units; an insignificant 2 units higher than site 1, 1 unit higher than site 2 and 3 units less than the median MCI score for 'control' sites in similar streams at comparative altitudes (Stark, 1998) (Table 3).

This community was characterised by four 'tolerant' taxa (oligochaete worms, seed shrimp (ostracoda), snail (*Potamopyrgus*) and sandfly larvae (*Austrosimulium*)); and one 'moderately sensitive' taxa (amphipod (*Paracalliope*)).

A numerical dominance of tolerant taxa resulted in the $SQMCI_S$ score of 2.7 units which was significantly lower (by 1.3 units), than the median score for 'control' sites in similar streams at this altitude elsewhere the region (Stark, 1998) (Table 3), and significantly lower (by 1.2 units) than what was recorded at site 2. However this was not significantly different to what was recorded at the upstream control site. The significant change in $SQMCI_S$ score between site 2 and site 3 can most likely be attributed to the difference in sampling methods used and also to a change in habitat between the two sites; with live macrophytes recorded at site 2 and only dead macrophytes recorded at site 3.

Summary and Conclusions

The Councils 'vegetation sweep' and a combination of 'vegetation sweep' and 'kick-sampling' techniques were used at three sites to collect streambed macroinvertebrates from the Ngaere Stream. This has provided baseline data for any future assessment of skimmer pit discharge effects from the Cheal-E wellsite on the macroinvertebrate communities of this stream. Samples were processed to provide number of taxa (richness), MCI, and $SQMCI_S$ scores for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects of organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The $SQMCI_S$ takes into account taxa abundances as well as sensitivity to pollution. It may indicate subtle changes in communities, and therefore be the more relevant index if non-organic impacts are occurring. Significant differences in either the MCI or the $SQMCI_S$ between sites may indicate the degree of adverse effects (if any) of the discharge being monitored.

This June 2013 survey of three sites, upstream and downstream of the intended skimmer pit discharge point, was undertaken prior to drilling at the Cheal-E wellsite and site construction. Taxa richnesses were moderate and within a narrow range for all sites and the macroinvertebrate communities of the stream contained similar proportions of 'tolerant' and 'moderately sensitive' taxa but no 'highly sensitive' taxa. A total of 26 taxa was found through the reach of the stream surveyed, with 10 of these taxa (38.5%) found at all three sites and 7 taxa (27%) found at any two of these sites. Characteristic taxa were relatively similar between sites with three 'tolerant' taxa and one 'moderately sensitive' abundant at all three sites.

There were no significant differences in MCI scores between sites, a reflection of the similarities in habitat at each site. These MCI scores indicated that the stream communities were of poor 'health' (TRC, 2013) but similar to the biological health recorded at 'control' sites in similar streams at a comparative altitude elsewhere in the region. A significant change in $SQMCI_S$ score was recorded between site 2 and site3, which can be attributed to a change in sampling technique used at each site.

A further survey will be conducted following the completion of all drilling and well-testing activities at the Cheal-E wellsite, to determine whether any discharges to land, and into the unnamed tributary of the Ngaere Stream, have had effects on the macroinvertebrate communities of this stream.

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To Job Manager; Callum MacKenzie
From Freshwater Biologist; Brooke Thomas
Report No BT036
Document 1421688
Date October 2014

Biomonitoring of the unnamed tributary of the Ngaere Stream following drilling by TAG Oil (NZ) Ltd at the Cheal-E wellsite, August 2014

Introduction

This biological survey was performed following drilling of the Cheal-E well to determine whether or not treated stormwater and uncontaminated site and production water discharges from the drilling site onto land, and into the Ngaere Stream had any effects upon the communities of the stream. A survey was also conducted prior to drilling to provide baseline data on the macroinvertebrate community of the stream (Thomas, 2014).

Methods

Cheal-E wellsite stormwater and site production water was discharged from a skimmer pit on to land and into the unnamed tributary of the Ngaere Stream (Figure 1). This survey was undertaken on 25 August 2014 at three newly established sites; 45 m upstream of the farm boundary fence (site 1), immediately downstream of farm boundary fence (site 2) and just downstream of a lone tree, 70m downstream of boundary (site 3).

Two different sampling techniques were used to collect streambed macroinvertebrates in the unnamed tributary of the Ngaere Stream, downstream of the stormwater discharges from the Cheal-E well site. The Council's standard 'vegetation sweep' technique was used at sites 2 and 3 and a combination of the 'kick-sampling' and 'vegetation sweep' sampling techniques was used at site 1 (Table 1, Figure 1). The 'kick-sampling' and 'vegetation sweep' techniques are very similar to Protocol C1 (hard-bottomed, semi-quantitative) and C2 (soft-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Table 1: Biomonitoring sites and sampling methods used in the unnamed tributary of the Ngaere Stream related to the Cheal-E wellsite.

Site no.	Site code	Grid reference (NZTM)	Location	Sampling method	Altitude (m asl)
1	NGR000280	1714464E-5639753N	45m u/s of farm boundary fence	Kick-sweep	220
2	NGR000281	1714472E-5639710N	Immediately downstream of farm boundary fence	Vegetation sweep	220
3	NGR000283	1714501E-5639656N	Just downstream of lone tree, 70m d/s of boundary	Vegetation sweep	220

Figure 1 Biomonitoring sites in the Ngaere Stream in relation to the Cheal-E wellsite.

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology which uses Protocol P1 of NZMWG protocols of sampling macroinvertebrates in wadeable streams (Stark et al, 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= estimated 20-99 individuals;
VA (very abundant)	= estimated 100-499 individuals;
XA (extremely abundant)	= estimated 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience.

By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

Results and discussion

At the time of this late morning survey the stream temperature was 11.0°C at all threes sites and an uncoloured, clear, moderate and slow flow was recorded. The substrate at site 2 and site 3 comprised predominantly of silt, with sand, fine gravel and coarse gravel. Some cobbles were also noted at site 2. The substrate at site 1 comprised predominantly of sand and fine and coarse gravels with smaller portions of silt and cobbles. No periphyton growth was noted at any of the sites. Macrophytes were recorded growing on both the stream bed and at the edges of the stream bank at sites 2 and 3, whilst at site 1 they were only recorded growing at the edges of the stream. Site 2 and site 3 were completely unshaded whereas site 1 was partially shaded.

Macroinvertebrate communities

Table 2 summarises the results of the current macroinvertebrate survey performed following drilling of the Cheal E well, along with results from the pre-drill survey. Comparative data for sites in similar streams are presented in Table 3.The macroinvertebrate fauna recorded by the current survey are presented in Table 4.

Table 2: Number of taxa, MCI and $SQMCI_s$ in the Ngaere Stream prior to drilling of Cheal-E wellsite.

Site No.	Site Code	No of taxa		MCI value		$SQMCI_s$ value	
		Pre-drill (Jun 13')	Post-drill (Aug 14')	Pre-drill (Jun 13')	Post-drill (Aug 14')	Pre-drill (Jun 13')	Post-drill (Aug 14')
1	NGR000280	17	11	74	82	3.2	3.2
2	NGR000281	19	18	75	86	3.9	4.3
3	NGR000238	17	18	76	84	2.7	4.0

Table 3: Range and median number of taxa, MCI values and $SQMCI_s$ scores for control sites at altitudes between 200 and 249 m asl ((TRC, 1999 (updated 2013)).

	No. of taxa	MCI value	$SQMCI_s$ value
No. Samples	169	169	90
Range	5-33	52-108	1.5-6.3
Median	18	79	4.0

Table 4: Macroinvertebrate fauna of the Ngaere Stream in relation to the Cheal-E post-drill survey sampled 25 August 2014.

Taxa List	Site Number	MCI score	Site 1	Site 2	Site 3
	Site Code		NGR000280	NGR000281	NGR000283
	Sample Number		FWB14227	FWB14228	FWB14229
ANNELIDA (WORMS)	Oligochaeta	1	A	VA	VA
	Lumbricidae	5	-	-	R
MOLLUSCA	*Potamopyrgus*	4	R	VA	XA
	Sphaeriidae	3	-	-	R
CRUSTACEA	Ostracoda	1	R	A	A
	Paracalliope	5	A	XA	VA
	Paraleptamphopidae	5	-	-	C
EPHEMEROPTERA (MAYFLIES)	*Austroclima*	7	C	R	A
	Zephlebia group	7	C	A	VA
ODONATA (DRAGONFLIES)	*Xanthocnemis*	4	-	R	-
COLEOPTERA (BEETLES)	Hydrophilidae	5	-	R	-
TRICHOPTERA (CADDISFLIES)	*Polyplectropus*	6	R	A	C
	Oeconesidae	5	-	R	R
DIPTERA (TRUE FLIES)	*Paralimnophila*	6	R	R	R
	Orthocladiinae	2	C	R	C
	Polypedilum	3	-	C	R
	Tanypodinae	5	-	R	R
	Dolichopodidae	3	R	-	-
	Paradixa	4	-	C	-
	Empididae	3	-	-	R
	Ephydridae	4	-	R	-
	Austrosimulium	3	VA	C	VA
ACARINA (MITES)	Acarina	5	-	C	C
		No of taxa	11	18	18
		MCI	82	86	84
		SQMCIs	3.3	4.3	4.0
		EPT (taxa)	3	4	4
		%EPT (taxa)	27	22	22
'Tolerant' taxa	'Moderately sensitive' taxa	'Highly sensitive' taxa			

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

Site 1- 45m upstream of farm boundary fence

A moderately low community richness of 11 taxa was found at site 1 (Table 2 and Table 4), six taxa less than what was recorded in the pre-drill survey and seven taxa less than the median richness found at similar sites elsewhere in the region (Table 3). The macroinvertebrate community continued to contain a significant proportion of 'tolerant' taxa (55%), which was reflected in the MCI score of 82 units. This represented a slight increase from the pre-drill survey (by 8 MCI units) and was slightly higher than the median MCI score for 'control' sites in similar streams at comparative altitudes (Table 3).

The community at this site was characterised by two 'tolerant' taxa (oligochaete worms and very abundant sandfly larvae (*Austrosimulium*)); and one 'moderately sensitive' taxon (amphipod (*Paracalliope*)).

The numerical dominance of 'tolerant' taxa resulted in the $SQMCI_S$ score of 3.3 units, which was slightly higher (by 0.1 unit) than what was recorded in the pre-drill survey and 0.7 unit fewer than the median score for 'control' sites in similar streams at this altitude (Table 3).

Site 2- Immediately downstream of farm boundary fence

A moderate community richness of 18 taxa was found at site 2 (Table 2 and Table 4), seven taxa more than found at site 1, one taxon less than what was recorded in the pre-drill survey and the same number of taxa as the median richness found at similar sites (Table 3). The macroinvertebrate community comprised equal proportions of 'tolerant' and 'sensitive' taxa which was reflected in the MCI score of 86 units; 11 units higher that what was recorded in the pre-drill survey, and an insignificant (Stark, 1998) 4 units higher than at the upstream 'control' site. This MCI score was an insignificant 7 units higher than the median MCI score for 'control' sites in similar streams at comparative altitudes (Stark, 1998) (Table 3).

This community was characterised by three 'tolerant' taxa (snail (*Potamopyrgus*), oligochaete worms and seed shrimp (Ostracoda)); and three 'moderately sensitive' taxa (extremely abundant amphipod (*Paracalliope*), mayfly (*Zephlebia* group) and caddisfly (*Polyplectropus*)).

The numerical dominance by 'sensitive' taxa resulted in a $SQMCI_S$ score of 4.3 units, which was slightly higher (by 0.4 unit) than what was recorded in the pre-drill survey, and higher (by 0.3 unit) than the median score for 'control' sites in similar streams at this altitude (Table 3) and 0.7 unit higher than the upstream control site. There was a significant (Stark, 1998) increase in $SQMCI_S$ score (by 1 unit) between site 1 and site 2 in the current survey. This can be attributed to an increased abundance of sensitive taxa, particularly to the increase of the 'sensitive' amphipod (*Paracalliope*). This and the six other significant differences in individual taxa abundances between these adjacent sites were probably related to subtle variations in habitat between sites 1 and 2 and the variation in sampling technique used to collect each sample.

Site 3- 70 metres downstream of boundary fence

A moderate community richness of 18 taxa was found at site 3 (Table 2 and Table 4), one taxon less than that recorded in the pre-drill survey, the same as that recorded at site 2 and the same result as the median richness found at similar sites elsewhere in the region (Table 3). In comparison to the two upstream sites (and similarly to the pre-drill survey), the macroinvertebrate community comprised of a lesser proportion of 'tolerant' taxa (44%), which was reflected in the MCI score of 84 units; an insignificant 2 units higher than site 1, 2 units lower than site 2 and 5 units more than the median MCI score for 'control' sites in similar streams at comparative altitudes (Stark, 1998) (Table 3).

This community was characterised by four 'tolerant' taxa (oligochaete worms, seed shrimp (Ostracoda), snail (*Potamopyrgus*) and sandfly larvae (*Austrosimulium*)); and three 'moderately sensitive' taxa (amphipod (*Paracalliope*) and mayflies (*Austroclima* and *Zephlebia* group)).

A numerical dominance by mainly 'tolerant' taxa resulted in the $SQMCI_S$ score of 4.0 units, which was significantly (Stark, 1998) higher than that recorded in the pre-drill survey (by 1.3 units), slightly lower than the upstream control site (by 0.7 unit) and slightly lower (by 0.3 unit) than that recorded at site 2. This score was the same as the median score for 'control' sites in similar streams at this altitude elsewhere the region (Table 3). The significant change in $SQMCI_S$ score between the pre-drill and post-drill surveys can be attributed mainly to the macrophyte coverage available at the time of the survey. Only dead macrophytes were noted

in the pre-drill surveys, whereas macrophytes were recorded as widespread, growing at the edges and on the bed of the stream in the current survey.

Summary and Conclusions

The Councils 'vegetation sweep' and a combination of the 'vegetation sweep' and 'kick-sampling' techniques were used at three sites to collect streambed macroinvertebrates from the Ngaere Stream. This has provided data to compare with baseline data for the assessment of skimmer pit discharge effects from the Cheal-E wellsite on the macroinvertebrate communities of this stream. Samples were processed to provide number of taxa (richness), MCI, and $SQMCI_S$ scores for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects of organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The $SQMCI_S$ takes into account taxa abundances as well as sensitivity to pollution. It may indicate subtle changes in communities, and therefore be the more relevant index if non-organic impacts are occurring. Significant differences in either the MCI or the $SQMCI_S$ between sites may indicate the degree of adverse effects (if any) of the discharge being monitored.

This August 2014 survey of three sites, upstream and downstream of the intended skimmer pit discharge point, was undertaken following drilling at the Cheal-E wellsite and site construction. Taxa richnesses were moderate at site 2 and 3, but moderately low at site 1. The macroinvertebrate communities of the stream contained similar proportions of 'tolerant' and 'moderately sensitive' taxa but no 'highly sensitive' taxa. A total of 23 taxa was found through the reach of the stream surveyed, with 10 of these taxa (43%) found at all three sites and four taxa (17%) found at any two of these sites. Characteristic taxa were relatively similar between sites with one 'tolerant' taxon and one 'moderately sensitive' taxon abundant at all three sites.

A comparison of the pre-drill and post-drill survey results show a significant (Stark, 1998) increase in MCI score at site 2 (by 11 units) and a significant increase in $SQMCI_S$ score at site 3. There was also a significant increase in $SQMCI_S$ score between site 1 and site 2 in the current survey. Variations in MCI and $SQMCI_S$ score and taxa richness between sites and surveys is considered to be due to habitat variability rather than a change in water quality, although sampling technique will also have had an influence.

The MCI scores recorded in this survey indicated that the stream communities were of fair 'health' (TRC, 2013), but slightly better than the biological health recorded at 'control' sites in similar streams at a comparative altitude elsewhere in the region. There was no indication from the results of the two surveys that the discharge from the Cheal-E wellsite has impacted on the biological communities of the unnamed tributary of the Ngaere Stream.

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