Todd Energy Limited
Mangahewa-E Wellsite
Monitoring Programme Report
2013-2015

Technical Report 2015–54

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Executive summary

Todd Energy Limited established a wellsite located on Tikorangi Rd East, within the New Plymouth district, in the Waiau catchment. The site is called Mangahewa-E wellsite. This report for the period May 2013 to June 2015 describes the monitoring programme implemented by the Taranaki Regional Council (the Council). The report assesses the Company's environmental performance in relation to drilling operations at the Mangahewa-E wellsite during the period under review, and the results and environmental effects of Todd Energy Limited's activities. During this period, a wellsite was established with 4 wells drilled (Mangahewa-17, Mangahewa-18, Mangahewa-19, and Mangahewa-20), tested and hydraulically fractured.

Todd Energy Limited holds six resource consents for the activities at the Mangahewa-E wellsite, which include a total of 73 consent conditions setting out the requirements that the Company must satisfy. The Company holds consent 9456-1 to take groundwater; consent 9454-1 to discharge emissions to air from hydrocarbon exploration; consent 9455-1 to discharge emissions to air associated with production activities; consent 9452-1 to discharge stormwater and sediment, deriving from soil disturbance from earthworks during construction onto land; consent 9453-1 to discharge treated stormwater and treated produced water from hydrocarbon exploration and production activities on and into land where it may enter an unnamed tributary of the Waiau Stream; and consent 9457-1 to discharge contaminants associated with hydraulic fracturing activities into land.

During the monitoring period, Todd Energy Limited demonstrated an overall improvement required level of environmental performance.

The Council's monitoring programme for the period under review included 32 inspections of the site and surrounding environment, at approximately fortnightly intervals. 20 stormwater samples and 3 surface water samples were obtained for analysis. Furthermore, biomonitoring surveys were performed prior to the commencement of drilling and following their completion at the Mangahewa-E wellsite.

Todd Energy Limited notified the Council of its intention to combust gas intermittently on 19 November 2014 and 13 January 2015. Following these dates, gas combustion occurred intermittently over the course of a few days in conjunction with well testing. One complaint was received in relation to black smoke emissions arising from flaring activities, and an infringement notice was issued following investigation. No offensive or objectionable odours or dust associated with activities at the wellsite were observed. The drilling fluids and cuttings were disposed of at a consented off site facility.

The site was generally neat and tidy, although ongoing maintenance was required regarding the stormwater collection and treatment system, as silt and sediment build up was at times excessive. This subsequently resulted in a high suspended solid level on two occasions. No adverse environmental effects were noted on either occasion. Site staff were cooperative with requests made by officers of the Council, with any required works completed to a satisfactory standard.

During the year, the Company demonstrated a good level of administrative performance with the resource consents. An improvement in the Company's environmental performance is desirable.

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

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1. Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

This report is for the period May 2013 to June 2015 by the Taranaki Regional Council (the Council) on the monitoring programme associated with resource consents held by Todd Energy Limited (the Company). During this period, a wellsite was established with 4 wells drilled (Mangahewa-17, Mangahewa-18, Mangahewa-19, and Mangahewa-20), tested and hydraulically fractured.

This report covers the results and findings of the monitoring programme implemented by the Council in respect of the consents held by the Company that relate to exploration activities at Mangahewa-E wellsite located along Tikorangi Road East in the New Plymouth district.

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

1.1.4 Evaluation of environmental and administrative performance

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

Environmental performance is concerned with actual or likely effects on the receiving environment from the activities during the monitoring year.

Administrative performance is concerned with the Company's approach to demonstrating consent compliance in site operations and management including the timely provision of information to Council (such as contingency plans and water take data) in accordance with consent conditions.

Events that were beyond the control of the consent holder and unforeseeable (i.e. a defence under the provisions of the *RMA* can be established) may be excluded with regard to the performance rating applied. For example loss of data due to a flood destroying deployed field equipment.

The categories used by the Council for this monitoring period, and their interpretation, are as follows:

Environmental Performance

- **High:** No or inconsequential (short-term duration, less than minor in severity) breaches of consent or regional plan parameters resulting from the activity; no adverse effects of significance noted or likely in the receiving environment .The Council did not record any verified unauthorised incidents involving significant

environmental impacts and was not obliged to issue any abatement notices or infringement notices in relation to such impacts.

- **Good:** Likely or actual adverse effects of activities on the receiving environment were negligible or minor at most. There were some such issues noted during monitoring, from self reports, or in response to unauthorised incident reports, but these items were not critical, and follow-up inspections showed they have been dealt with. These minor issues were resolved positively, co-operatively, and quickly. The Council was not obliged to issue any abatement notices or infringement notices in relation to the minor non-compliant effects; however abatement notices may have been issued to mitigate an identified potential for an environmental effect to occur.

  For example:

  - High suspended solid values recorded in discharge samples, however the discharge was to land or to receiving waters that were in high flow at the time;
  - Strong odour beyond boundary but no residential properties or other recipient nearby.

- **Improvement required:** Likely or actual adverse effects of activities on the receiving environment were more than minor, but not substantial. There were some issues noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent minor non-compliant activity could elevate a minor issue to this level. Abatement notices and infringement notices may have been issued in respect of effects.

- **Poor:** Likely or actual adverse effects of activities on the receiving environment were significant. There were some items noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent moderate non-compliant activity could elevate an 'improvement required' issue to this level. Typically there were grounds for either a prosecution or an infringement notice in respect of effects.

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

1.2 Process description

Site description

Todd Energy Limited holds an 18 year Petroleum Mining Permit No. 38150 to prospect, explore, and mine for condensate, gas, LPG, oil and petroleum within an area of 44.36 km^2. The Mangahewa-E wellsite is one of many sites within this area that have been established in order to explore, evaluate and produce hydrocarbons.

The Mangahewa-E wellsite is located approximately 3.76 km along Tikorangi Road East, approximately 3.41 km from Tikorangi, as per Figure 1. The Mangahewa-E wellsite was established in 2013 and involved the removal of topsoil to create a firm and 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 450 m away from the wellsite. Bunding, earthworks and good site location helped minimise any potential for off site effects for the neighbours.

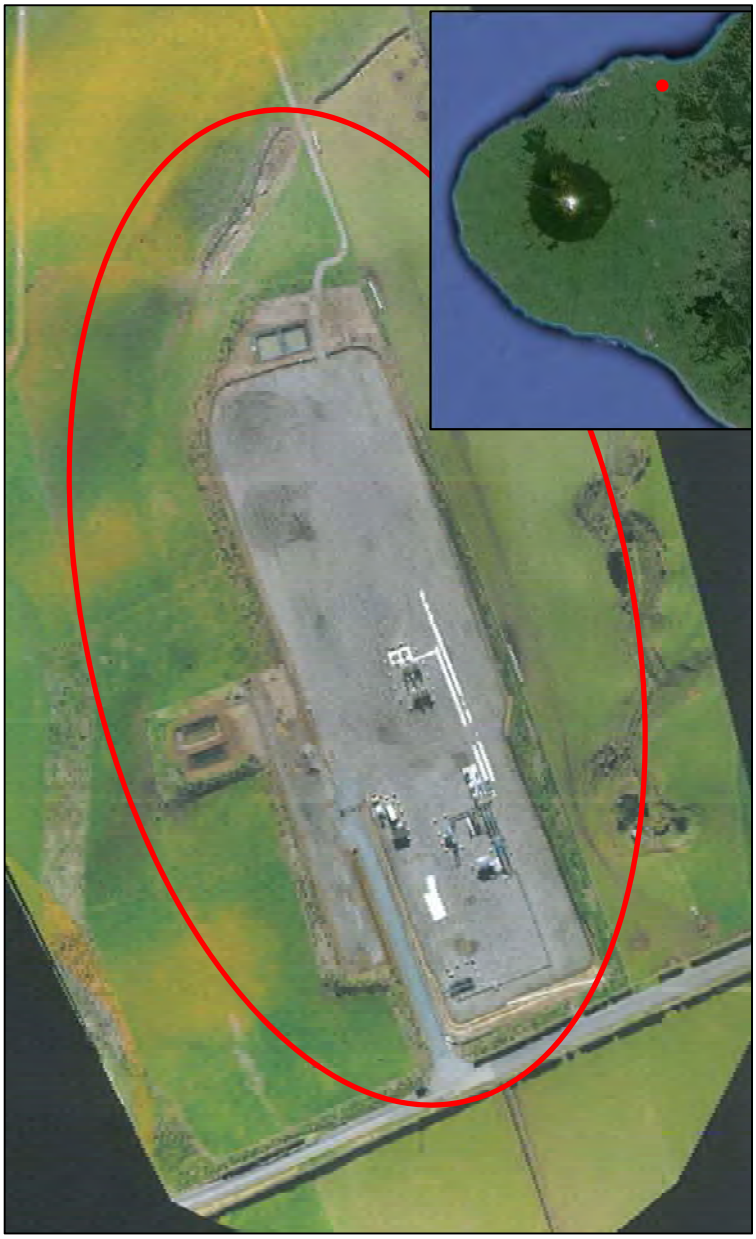

Figure 1 Aerial view depicting the locality of the Mangahewa-E wellsite, with approximate regional location (insert).

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 pressurised 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 the 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 Mangahewa-E wellsite is located approximately 110 m to the west of the nearest waterbody which is an unnamed tributary of the Waiau Stream.

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 (e.g. 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 consequently into an unnamed tributary of the Waiau Stream.

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.

Hydraulic fracturing

In late 2012 the Parliamentary Commissioner for the Environment released an interim report on hydraulic fracturing within New Zealand. The purpose of this report is firstly to assess the environmental risks with hydraulic fracturing, and secondly to assess whether the policies, laws, regulations and institutions in New Zealand are adequate for managing these risks. The following discussion has been based upon this report.

The first known hydraulic fracturing operation was in 1989 at Petrocorp's Kaimiro-2 gas well in Taranaki. Since then, almost all of the hydraulic fracturing that has taken place in New Zealand has been done within the Taranaki region.

By the early 2000's New Zealand started exploring options for more unconventional ways of getting access to natural gas, and especially oil. These are considered to be more expensive than conventional drilling, but as the price of oil has risen and new technologies have been developed, these unconventional methods are growing.

The most common unconventional source of oil and gas in the Taranaki region has been extracting natural gas and oil from 'tight sands'. The boundary between tight sands and conventional reservoirs is ill-defined and generally based on whether the reservoir will have an economic production flow without hydraulic fracturing.

The process of hydraulic fracturing involves using a fracturing fluid, which is primarily water (typically made up of around 95-97% treated water). This fluid also contains various chemicals, including the three main components, which are:

- An inert proppant which keeps the induced fracture open when pumping is stopped, such as medium grained sand, or small ceramic pellets;
- A gelling substance to carry the proppant into the cracks; and
- A de-gelling substance to thin the gel to allow the fracturing fluid to return to the surface while leaving the proppant in the fractures.

The chemicals associated with the fracturing fluid are trucked to the site, stored in concentrated form, and mixed immediately before the hydraulic fracturing commences.

After the casing is perforated at the desired depth, the fracturing fluid is injected under high pressure into the well and is forced through the small holes into the rocks, creating cracks. This high downhole pressure is maintained for a brief period of time (approximately 1 hour) in order to exceed the fracture strength of the reservoir rock and cause artificial fractures.

Once a fracture has been initiated, the fracturing fluid and proppant are carried into the fracture. The placement of proppant in the fractures is assisted by the use of cross-linked gels. These are solutions, which are liquid at the surface but, when mixed, form long-chain polymer bonds and thus become gels that transport the proppant into the formation.

Once in the formation these gels 'break' back with time and temperature to a liquid state and are flowed back to surface as back flow without disturbing the proppant wedge, trapped in the hydraulic fracture. With continued flow, formation hydrocarbon fluids should be drawn into the fracture, through the perforations into the wellbore and to the surface.

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 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.

Todd Energy Limited holds water permit **9456-1** to take groundwater as 'produced water' during hydrocarbon exploration and production activities. This permit was issued by the Council on 1 February 2013 under Section 87(d) of the RMA. It is due to expire on 1 June 2027.

Condition 1 requires that the abstraction shall not cause more than 10% lowering of static water level by interference with any adjacent bore.

Condition 2 requires that the abstraction shall not cause saltwater intrusion into any fresh water aquifer.

Condition 3 requires the submission of a summary well log to the depth of 1000 m including a geological log; depth to, and thickness of, any freshwater aquifers; and the TVD to the freshwater-saline water interface.

Conditions 4 and 5 provided for review of the consent.

1.3.2 Water discharge permit (treated stormwater)

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 Company holds water discharge permit **9453-1** to discharge treated stormwater and produced water from hydrocarbon exploration and production operations at the Mangahewa-E wellsite onto land and into an unnamed tributary of the Waiau Stream. This permit was issued by the Council on 19 June 2014 under Section 87(e) of the RMA. It is due to expire on 1 June 2027.

Condition 1 requires the consent holder to adopt the best practicable option to prevent or minimise adverse effects of the discharge on the environment.
Condition 2 imposes a limit on the stormwater catchment size.

Condition 3 requires the consent holder to notify of commencement of any site works or drilling operations.

Condition 4 requires site specific details relating to contingency planning for the site.

Condition 5 requires the design, management and maintenance of the stormwater system to be undertaken in accordance with information submitted in the application.

Conditions 6, 7 and 8 detail requirements for the capture, storage, and application of the discharge; and the design and construction of skimmer pits, drains and other retention areas.

Conditions 9 to 12 impose limits on contaminants in the discharge, and stipulate effects the discharge shall not give rise to in the receiving waters.

Condition 13 requires the consent holder to advise the Council of reinstatement of the site.

Conditions 14 and 15 provide for review of the consent.

1.3.3 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.

Todd Energy Limited holds water discharge permit **9452-1** to discharge stormwater and sediment from earthworks during construction of the Mangahewa-E wellsite onto and into land and into an unnamed tributary of the Waiau Stream. This permit was issued by the Council on 21 December 2012 under Section 87(e) of the RMA. It is due to expire on 1 June 2017.

Condition 1 authorises the discharge of stormwater associated with earthworks undertaken to establish the Mangahewa wellsite as shown on submitted documents.

Condition 2 requires the consent holder to adopt the best practicable option at all times to prevent or minimize adverse effects of the discharge on the environment.

Condition 3 requires 7 days written notice to the Council prior to the commencement of earthworks.

Condition 4 requires all run off to pass through a skimmer pit system.

Condition 5 allows for obligations laid out in Condition 4 to cease only when the area is stabilised.

Condition 6 requires stabilisation of vegetation as soon as practicable and no longer than 6 months after earthworks are completed.

1.3.4 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 Company holds air discharge permit **9454-1** to discharge emissions to air from flaring during hydrocarbon exploration associated with well development or redevelopment and testing or enhancement of well production flows at the Mangahewa-E wellsite. This permit was issued by the Council on 31 January 2013 under Section 87(e) of the RMA. It is due to expire on 1 June 2027.

Condition 1 limits the duration of flaring during well testing.

Condition 2 specifies the requirements for the flare pit.

Conditions 3 and 4 specify the requirements for notification prior to flaring.

Conditions 5 to 8 specify the types of substances which may be flared to gases from the well stream, and the processes for undertaking flaring.

Condition 9 requires the consent holder to adopt the best practicable option.

Conditions 10 to 12 stipulate limits on contaminants and effects from flaring, and any other emissions from the wellsite.

Condition 13 requires the consent holder to provide an analysis of gas and condensate to the Council on request.

Condition 14 specifies the requirements for hydrocarbon storage.

Condition 15 requires the consent holder to provide a flaring log to the Council.

Conditions 16 and 17 provide for review of the consent.

1.3.5 Land discharge permit (hydraulic fracturing)

Sections 15(1)(b) and (d) of the RMA stipulate that no person may discharge any contaminant onto land if it may then enter water, or from any industrial or trade premises onto land under any circumstances, unless the activity is expressly allowed for by a resource consent , a rule in a regional plan, or by national regulations.

The Company holds discharge permit **9457-1** to contaminants associated with hydraulic fracturing activities into land at depths greater than 3,200 mTVDss beneath Mangahewa-E wellsite. This permit was issued by the Council on 26 February 2013 under Section 87(e) of the RMA. It is due to expire on 1 June 2020.

Conditions 1, to 4 impose limits on the discharge process and contamination of freshwaters.

Conditions 5 to 8 specify the requirements for the sampling and monitoring programmes, and cover bore suitability and water sampling protocols and analysis.

Conditions 9 to 12 specify the requirements for recording and reporting, including pre- and post-fracturing discharge reports, as well as notification of discharge.

Condition 13 requires the consent holder to provide access allowing the sampling of hydraulic fracture fluids and return fluids.

Condition 14 requires the consent holder to adopt the best practicable option to prevent or minimise adverse effects.

Condition 15 stipulates that the fracture fluid shall be no less than 95% water and proppant by volume.

Condition 16 allows for review of the consent.

1.4 Monitoring programme

1.4.1 Introduction

Section 35 of the *Resource Management Act 1991* (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 well sites consists of seven primary components. They are:

- Programme liaison and management;
- Site inspections;
- Chemical sampling;
- Solid wastes monitoring;
- Air quality monitoring;
- Discharges to land (hydraulic fracturing); and
- Biomonitoring surveys.

The monitoring programme for the Mangahewa-E wellsite focused primarily on programme liaison and management, site inspections, chemical sampling, discharges

to land and biomonitoring surveys. 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;
- new consents;
- advice on the Council's environmental management strategies and content of regional plans and;
- consultation on associated matters.

1.4.3 Site inspections

The Mangahewa-E wellsite was visited 32 times during the monitoring period. With regard to consents for the abstraction of or discharge to water, the main points of interest were plant processes with potential or actual discharges to receiving watercourses, including contaminated stormwater and process wastewaters. Air inspections focused on plant processes with associated actual and potential emission sources and characteristics, including potential odour, dust, noxious or offensive emissions. Sources of data being collected by the consent holder were identified and accessed, so that performance in respect of operation, internal monitoring, and supervision could be reviewed by the Council. The neighbourhood was surveyed for environmental effects.

1.4.4 Chemical sampling

The Council undertook sampling of both the discharge from the site and the water quality upstream and downstream of the discharge point and mixing zone. Stormwater was collected and treated onsite using a ring drain and skimmer pit system which then flowed into a wetland for further treatment. Samples analysing suspended solid content were collected at the end of the wetland in order to maximise the benefits of this system. All other analyses were performed on samples collected from the skimmer pit discharge.

The Mangahewa-E skimmer pit discharge and wetland discharge were sampled on two occasions, and the sample analysed for hydrocarbons, pH and chloride (skimmer pits) and suspended solids (wetland). When the stormwater system was not discharging, samples were obtained from the storage skimmer pits and analysed for the same parameters. The unnamed tributary of the Waiau Stream was sampled on two occasions, and the sample analysed for hydrocarbons, conductivity, suspended solids, pH and chloride.

1.4.5 Solid wastes

The consent holder 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.

Assessments are made by Council Inspecting Officers during site inspections to ensure that operators undertake all practicable steps to mitigate any effects from flaring gas. Inspecting Officers check that the 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 also 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)

Sampling and analysis of the hydraulic fracturing, return flow fluids and nearby bores were carried out during the period under review. In addition, inspections of the site and surrounding land and water were carried out to ensure that no observable effects had occurred as a result of the discharge to land. Pre and post hydraulic fracturing reports were submitted by the consent holder detailing among other things, the effectiveness of the mitigation measures put in place to protect the environment.

The results and performance of the hydraulic fracturing programme and all related activities are assessed in a separate hydraulic fracturing report by the TRC.

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 Mangahewa-E wellsite, adjacent land and streams were inspected 32 times during this monitoring period. Below is a copy of the comments that were noted on the day of each inspection.

21 May 2013
An inspection was carried out while a large amount of archaeological excavations were taking place on site. All soil removed during these excavations was piled on site with the lower portion ringed off by silt cloth and fencing to prevent the movement of large amounts of earth during periods of wet weather. The site was clean and tidy, with appropriate sediment control measures in place in relation to the size of the operation.

19 September 2013
Earthworks were continuing on-site. The topsoil stripping had been completed, exposing large amounts of earth. Nova-flow drainage pipe had been laid in the drain and small stream area, and earthfill was being placed above the now subsurface drainage. Silt controls were in place, with a small drain running along the north eastern boundary to a silt retention pond that was surrounded by silt cloth fencing and hay bales in place at the discharge point. The majority of the site drains to a single location at the base of the buried drain. The discharge rate was swift, and further silt fencing at the discharge location was recommended to assist in slowing the rate of discharge and prevent scouring of the drain just prior to the culvert.

The Company was advised to ensure that all runoff passed through the silt retention structures, and that the wellsite excavation and development process adhered to consent conditions.

25 September 2013
A site inspection found that excavation work was continuing on-site with large volumes of soil being moved in order to establish a level pad area. The excess soil was being used to fill a small gully adjacent to the site. The piping of the drain at the base of the gully appeared to be working well with the discharge that was coming from the end of the subsurface drainage meeting consent criteria.

Due to the natural contour of the site, all stormwater was directed to the base of the gully on the western boundary of the site. The silt and sediment retention devices in place consisted of a settling pond, hay bale and silt fencing. At the time of the inspection, the discharge from the sediment pond was clean and clear, however due to the swift flow from the settling pond into the receiving drain the silt fencing and hay bale within the drain were not working to their optimum. It was recommended that silt fencing or hay bales should be placed along the base gully at the head of the settling pond. This allowed for treatment of the surface water prior to entry into the settling pond and therefore would allow the settling pond to work more efficiently in providing final treatment to the discharge. The discharge point from the settling pond was narrow, which in turn created a swiftly-flowing discharge. The Company was advised to consider widening the discharge across the width of the pond so that the discharge was shallow and spread over a greater distance (i.e. creating a swale). This

would slow the speed of the discharge and also assist in decanting only the surface water off the top of the pond for discharge. On-going maintenance was required to ensure that the discharge was of a good quality.

8 October 2013
Earthworks were continuing on site with the final level nearly established. Silt controls were inspected and it was noted that the controls in place were improved from the previous inspection.

The settling pond captured all site water prior to discharge. Discharge of water from the settling pond was via two silt fences, then into a final smaller silt pond prior to final discharge into the receiving waters. The discharge from the settling pond was at a slower rate than the previous inspection and this had assisted in ensuring no sediment was being picked up from the base of the drain as it left the settling pond. The receiving waters were inspected and were running clean and clear. The Company was advised to ensure that the bund at the far end of the side, opposite the road frontage, was maintained so that all water was directed for treatment prior to discharge.

21 October 2013
A site inspection found that earthworks were continuing on site. Both the settling pond and silt cloth were inspected and were in a good working order. Discharge into the receiving waters was clean and clear with no negative impacts on the receiving waters observed at the time of inspection. The inspection was completed following a recent period of heavy rain and although silt was observed travelling towards the low point on site it appeared that the measures in place were adequate to treat the stormwater from the site.

Staff onsite were spoken to and advised that should the sediment pond begin to fill with sediment during the earthworks operation, it would be necessary to have it cleaned out to maintain the pond volume. The site appeared to be well-managed at the time of the inspection.

25 November 2013
A site meeting with Tony Alcock (BTW) and Owen Burgess (Burgess and Crowley) took place regarding the plans for construction of a wetland to receive and treat both skimmer pit discharge and stormwater from the earth-worked areas about the site.

An inspection found that silt and sediment controls were in place and appeared to be working well. The silt and sediment controls were to be changed in the coming days due to contouring of the area where the current controls were located. Further controls were to be established downstream, including construction of a wetland to capture and treat stormwater prior to final discharge into the receiving waters.

A final level for the site had been obtained, and metal was being imported and placed onto the drill pad area. Contouring of the surrounding areas was nearing completion and was scheduled to be grassed as soon as was practicable. Dust issues on site were being managed with a water truck. Silt and sediment controls appeared to be well managed at the time of inspection.

10 December 2013
A site inspection found that earthwork activities were continuing onsite associated with the establishment of the site. The drill pad was close to being contoured at its final level. The small gully adjacent to the site had been filled in and topsoil was being spread over the upper portion of the gully. The Company was advised to consider grassing this portion of the construction area upon completion in an effort to stabilise it as soon as practicable.

Recent heavy rain had resulted in erosion at various locations about the site. The silt and sediment treatment processes on the site appeared to have worked well, however they were now full of solids and required maintenance prior to the next period of wet weather. Staff were also advised to ensure that the base of the silt fencing was buried 200mm below ground. Some sediment was visible in the stream below the culvert and settling ponds. Placing further treatment (i.e: a small silt pond) in that portion of the stream was recommended to rectify this. At the time of inspection the stream was flowing clean and clear.

29 January 2014
Site earthworks were in the completion stages, with the skimmer and flare pits yet to be established – discharge from the site was still being managed through the settling ponds used for earthworks control. Schramm and Honnor were onsite, drilling the second of four conductors. The wetland area, built to filter the skimmer pit discharges, was reaching the final stages of contouring. A scruffy dome had been installed at the end of the wetland (where the headwaters of the filled-in gully) had been piped to. A culvert leading from the scruffy dome connected the treated skimmer pit discharge to a constructed drain. Staff were advised to be aware of dust generated from heavy machinery entering and exiting site.

6 March 2014
A site inspection was carried out after the completion of a large majority of the earthworks at the site. The skimmer pits had been dug and were planned to be lined in the next few days. The flare pits were currently under construction. Work was continuing on site installing conductors and pipe work for the pending drilling operation. Some of the exposed soil outside the boundary of the site had been seeded, however the weather at the time was unfavourable to germinating grass.

Scruffy domes were in place at low points to the west of the site. The domes were sitting proud above the ground surface to allow some silt and sediment to be retained prior to stormwater discharging into the top of the domes. All collected stormwater was discharged into a low lying area which will later be planted out to form the treatment wetland. This area was also intended to capture any skimmer pit discharge water. A scruffy dome at the low point in the northern end of the pending wetland had been installed and was again sitting approximately half a meter above the ground surface. This allowed it to act as a decanter for the treated stormwater passing over it for final discharge from the site.

In general the site appeared to be very well managed and controlled. Tony Alcock (BTW) was spoken to on site and he was able to easily explain all the processes underway on site at the time. He was very informative and appeared to have a competent understanding of what was required both from a practical and legislative (i.e. Resource Consent compliance) aspect.

25 March 2014
A site inspection found that the earthworks stage of site development was nearing completion. Four drill conductors intended for the initial drilling campaign had been installed on site. Ring drains were in place so all stormwater collected on the pad area was now directed to a skimmer pit treatment system. The skimmer pit was lined and had a shut-off valve in place. Boots to secure and seal the lining about the discharge pipes were to be installed that day or the next. The flare pits had been contoured on-site and the lining of those was anticipated to occur in the following week. Much of the exposed soil about the perimeter of the site had been seeded and the grass was beginning to grow, which would greatly increase stabilisation of the exposed areas. Further seeding and re-seeding was also planned for the following weeks.

Silt and sediment controls for the site consisted of raised scruffy domes at low points of the exposed soils. These acted as decanters in skimming the surface water off any stormwater that collected within these areas. Final treatment consisted of a reasonable-sized settling pond area with a raised scruffy dome at the end of the elongated pond, which again acted as a decanter to skim the surface stormwater for discharge following treatment in the settling pond.

15 April 2014
The site was occupied with rigging up of the drilling platform at the time of inspection and works were being carried out to complete the two flare pits. The skimmer pits were close to discharging and appeared to be high in suspended solids; samples were retrieved from the second skimmer pit near the outflow point. The shut-off valve was inspected and found to be in the open position. A visual inspection of downstream surface water showed no visual impacts from site discharges. Appropriate sediment controls were in place around the earthworks, minimising sediment mobilisation to surface water. The onsite chemical area was covered; however it was recommended that the bunding should be looked at to ensure spills were excluded from the stormwater system.

2 May 2014
A site inspection found that the drilling of wells Mangahewa 17, 18, 19 & 20 was continuing, with the top holes of wells 17 and 18 completed. The wells were being drilled in a batch drilling process meaning all wells were being drilled simultaneously. At the time of inspection water-based drilling muds were being used for the completion of the top hole drilling operation. All non hazardous chemicals were being stored on site in an appropriate manner. Drill cuttings were being sent to Remediation New Zealand for appropriate disposal. The flare pit was under construction on site with a flare box being utilized on site by the drilling rig.

The ring drains were inspected and were well-defined and contoured towards the skimmer pits. The skimmer pits were inspected and were working as designed. There was no discharge from the skimmer pits at the time of inspection. A visual inspection of the pits found that they were rather turbid as a result of suspended solids being entrained within the stormwater system. Some sediment retention devices (silt cloth) had been placed within the ring drains about the outlet to the skimmer pits. Further devices were planned to be installed within the drains later that day. Hydro-seeding about the ring drains had also been undertaken in an effort to stabilize the soil and prevent sediment mobilization. Silt fences had been installed about the scruffy domes in the earthworked gully beside the site. The majority of this area had been seeded

however it was recommended that silt and sediment controls remain in place and be actively managed until this area was stabilized.

An inspection of the settling pond at the downstream extent of the well site and associated earthworked areas was also inspected. This pond had been fenced to prevent stock from entering the water body. The settling pond was receiving discharge from the skimmer pits and off-site earthworked areas. Fine sediment had settled onto the base of the settling pond with water within the pond being clean and clear. Discharge into the receiving environment would be via an overflow into the top of a raised scruffy dome at the bottom end of the pond. Although not discharging at the time of the inspection, the settling pond was working effectively in treating the stormwater discharge from the site and associated areas.

22 May 2014

The drilling campaign was continuing on-site, and work was being carried out in the production area of the pad. The site was clean and tidy; all chemicals were correctly bunded and stored so as to avoid exposure. Sediment still appeared to be an issue on site, and the skimmer pits were very grey and cloudy. Some silt controls were in place in the ring drain.

The shut-off valve was in the open position, however the skimmer pit levels were such that no discharge was occurring. Samples were retrieved from second skimmer pit. A visual inspection of the receiving waters showed no impacts from discharges. Photos and GPS points were taken to assist with a consent variation currently being undertaken by the Council.

4 June 2014

A site inspection found that the drilling campaign was ongoing, with the Mangahewa 20 intermediate section near completion. The drill rig was scheduled to move to Mangahewa 19 to complete intermediate section following this. Perimeter and bund planting was beginning to establish. The pad area was clean and tidy; site chemicals were stored in steel bunded containers or under cover and protected from the elements. The skimmer pits were at the level of the discharge pipe, however they were not discharging at the time of inspection, and the shut-off valve was in the open position. Samples were retrieved from the skimmer pit near outflow point. A section of silt fence at the stormwater entry point into the skimmer pits was required to be filled in to prevent stormwater flowing underneath the fence. A Council officer spoke with the rig manager about this, and this resulted in work being undertaken immediately.

27 June 2014

The site had received large amounts of rain in the previous 24 hrs. The drilling was continuing with the completion of the intermediate section of Mangahewa 17; the rig was scheduled to move to Mangahewa 18 to start the intermediate and lower sections respectively. The northern ring drain was full to the point of almost breaching, as a result of silt controls at the point where stormwater entered the skimmer pits. A decision was made to remove the silt fence and allow the stormwater to flow unhindered to the skimmers, thereby avoiding untreated surface water breaching the system and escaping the site. Silt was still an issue for the site, and samples were retrieved from the skimmer pits which were discharging at the time of inspection.

It was recommended that additional silt control measures be investigated to ensure discharging stormwater was compliant with consent conditions.

4 July 2014
A meeting took place onsite with BTW to discuss sediment controls and issues regarding the site. Present were Adam Du Fall and Jared Glasgow (TRC) and Nik Pyselmann (BTW).

Numerous hay bales had been placed in the perimeter drain in a bid to reduce suspended solids from entering the skimmer pit system. Alternatives to the hay bales included coconut matting and sand bagging to create miniature settling ponds; adding additional height to the wetland scruffy dome to increase retention time; and investigating options to reduce sediment entering the discharge from the two scruffy domes further up the catchment. Hydroseeding all exposed soil areas to reduce sediment mobilisation was also another option.

Casing of the intermediate section of the last well was going on at the site, and drilling was planned to start on the bottom section upon completion. The skimmers were not discharging during the inspection, so samples were retrieved near the outfall of the pits.

10 July 2014
Works were continuing in the production area of the site. The site was clean and tidy with all chemicals stored in bunded steel containers and no evidence of recent spills. The skimmer pits were cloudy but not discharging to wetland, and the wetland was not discharging either. A visual inspection of the downstream receiving environment showed no more than minor effects.

Samples were retrieved from the skimmer pit near the outfall.

18 July 2014
Drilling was continuing on the bottom hole of Mangahewa-18, with approximately 140 m until target depth was reached. Coconut matting, hay bales and sandbags had been strategically placed in sections of the ring drain in a bid to reduce sediment mobilisation. The section where the ring drain entered the skimmer pits had been very well constructed. Scruffy domes in the upstream catchment had been given the same improvements. The site was clean and tidy with chemicals stored in bunded steel containers or under cover, and no signs of a recent spill. The skimmer pits were not discharging during inspection, and samples were retrieved from the second skimmer pit.

25 July 2014
Schlumberger were onsite logging Mangahewa-18. Some vegetation had begun to establish in paddocks adjacent to the wellsite, and these areas had been fenced to exclude stock from grazing. Vegetation was yet to take hold on the soil bund surrounding the flare pit. The wetland was dry during the inspection, and the coconut matting installed in the perimeter drain appeared to be catching some sediment, however the skimmer pits were still cloudy.

The skimmer pits were not discharging during inspection, and samples were retrieved near the outfall from the pits.

8 August 2014
A meeting with BTW took place onsite to address the installed silt controls and assess whether further controls were required to ensure consent compliance.

Drilling was continuing on site, Mangahewa-18 had been completed, and the rig was now engaged in completing the bottom hole section of Mangahewa-17.
Silt control improvements in the eastern perimeter drain appeared to be working well, however the skimmer pits were still very milky in appearance. The skimmer pits were discharging to the wetland however the wetland itself was not discharging. The scruffy dome in the wetland had been raised 300 mm to allow for increased retention time; and three holes which had previously held brackets securing the scruffy dome to the concrete cellar were allowing surface water to discharge from the wetland well below the level of the scruffy dome.

The areas around the scruffy domes in the upper catchment had collected vast amounts of sediment and needed to be monitored to ensure this sediment was not tracking through silt cloth and into the discharge. Rilling in the pasture surrounding these domes was still apparent. Samples were retrieved from the skimmer pits to assess sediment concentrations coming from the site.

The Company was advised that the large area of ponding adjacent to the proposed clip tank area would need to be addressed when the base course for the clip tank was brought to site.

Pastoral land surrounding the upper catchment scruffy domes required monitoring to ensure that the silt controls in place were still effective – these would need to be altered where necessary. Exposed soil adjacent to the permits hut needed to be stabilised as soon as possible, and the silt trap monitored to ensure silt was not escaping around the silt cloth.

21 August 2014
A site inspection found that drilling of the bottom holes for wells Mangahewa-17, 18, 19 & 20 was continuing. Logging was occurring at the time of inspection with cementing planned for the coming days. The site was found to be clean and tidy. All non-hazardous chemicals were either stored within internal bunded containers on site or covered out of the weather.

Sediment controls consisting of sandbags, hay bales and coconut matting were in place about the ring drains. These measures appeared to be working well. The skimmer pits appeared to be slightly turbid and were not discharging at the time of the inspection. Samples were taken from the second skimmer pit to ensure compliance with consent conditions should a discharge occur.

Hydro-seeding had taken place about the flare pits and also on the exposed bank along the northern boundary to the drill pad.

Grass was beginning to take on the previously exposed soil where the gully was piped and filled. The settling pond appeared to be working well and a lot of sediment was retained within the pond. The pond only had minimal water at the bottom end and hence it was not considered appropriate to sample.

No issues were identified at the time of inspection, however staff were advised to ensure that stock continued to be kept off the fill area and any areas where grass had not taken and was due to be re-grassed as weather conditions improved.

4 September 2014

The bottom hole section in Mangahewa-19 was being completed at the time of inspection.

Areas of the western ring drain had been hydroseeded, as had the flare pit bund. The clip tank had been erected and was being filled via permitted water take from the Waiau Stream. The skimmer pits were not discharging during the inspection, and the wetland was also dry. Samples were retrieved from the second skimmer pit near the outfall.

Cattle were observed in the paddock where the lower scruffy dome was located adjacent to the wetland; soil stabilisation via vegetation had not been met and further disturbance had been caused. The mid scruffy dome was no longer elevated above the surrounding environment, and the surrounding silt fence required maintenance as a pathway allowing sediment to enter the waterway was present in the southern corner. The upper scruffy dome was no longer elevated above the surrounding environment, and the cellar had sediment present up to the discharge level. The silt fencing appeared robust, and severe rilling was present in the pasture at the base of the flare bund leading to the scruffy dome.

10 September 2014

A meeting took place onsite with Geoff Bourke from Todd and landowner Kevin Sarten to discuss options concerning the pasture adjacent to the wellsite.
Kevin was to till in additional grass seed in the two paddocks adjacent to the western boundary of the wellsite. The seed was to be laid across the gradient to avoid surface water rilling the seed channels. The lower three scruffy domes were to be raised 300 mm to ensure they were proud of the surrounding pasture; and the current silt controls were to remain in place until the grass seed had taken and stabilisation had been achieved. Gravel deposits within the wellsite and located next to the perimeter drain would benefit from bunding, i.e. using a bio-sock, to reduce sediment entering the skimmer pit system. This also had potential to be utilised around stockpiled soil and gravel next to the flare pit. Grass seeding was planned to be carried out following forecasted heavy rain that week.

9 October 2014

Well Mangahewa-20 had reached total depth, and the drill rig was currently pulling out of hole. Logging was scheduled to begin once this had been completed. A bio sock had been placed around some of the gravel piles, and this could also be implemented around the gravel pile situated next to the clip tank on the western perimeter drain boundary. The flare pit vegetation was well established; and grass seeding (as discussed with Kevin and Geoff) had taken place 10 days prior to site inspection and was starting to sprout. The scruffy domes had also been lifted in the areas discussed. Burgess Crowley Civil Ltd. staff were onsite completing works to the scruffy dome areas, including spreading mulch to dissipate rain energy. The holes in the wetland riser had been filled in, the wetland was not discharging and the receiving environment looked good with established vegetation growth. The skimmer pits were very grey in appearance, with a very small discharge that was too small to sample. A

sample was instead retrieved from the skimmer pit near the outflow. The onsite clip tank was near capacity – a permitted water take was being exercised during the inspection. Onsite chemical storage was in bunded steel containers or under cover (for dry material).

30 October 2014

The site was engaged in the deconstruction of the Big Ben rig, McLeod cranes were onsite carrying out the heavy lift operations. Ponding areas on the pad were to be graded after the rig left site. Stormwater was present in the ring drains and upon entering the skimmer system it was still vey cloudy and silt laden. Rilling of the perimeter drain wall had caused a blockage, stopping the majority of the stormwater flowing to the skimmer system. Site staff were informed and were attending to the sediment as soon as possible. Vegetation was well established in the adjacent pasture, with only the very low lying areas where topsoil has deposited left to vegetate.
The wetland was discharging during the inspection, and samples were retrieved and photos taken. The receiving environment had evidence of fine silt deposits from recent discharges.

14 November 2014

Site staff were engaged in a meeting at the Tikorangi hall, and very few people were on site. A Vause coil tubing unit was on site. A second clip tank had been erected and was at capacity.

A section of the eastern perimeter drain had been piped to accommodate the newly constructed and concrete-bunded produced water and condensate tanks area; surface water in this location was still being directed to the perimeter drain. The skimmer pit system was not discharging during inspection, and as the wetland was nearly dry, samples were retrieved from the second skimmer pit near the outfall. Satisfactory stabilisation of the disturbed area adjacent to the wellsite had been achieved, with at least 80% vegetation established at the time of inspection.

19 November 2014

A site inspection was carried out in conjunction with the first hydraulic fracture of Well 17. Diagnostic fracture injection testing (DFIT) had been carried out, however the main fracture was unable to be completed and was likely to be postponed. The site was clean and tidy with chemicals stored in steel bunded containers and no visible signs of recent spills. The skimmer pits were not discharging during the inspection, and no samples were taken as M.Harob was onsite with a vacuum truck to suck out the skimmer pit contents (to remove sediment that had settled out). M.Harob was also going to address an area of the perimeter drain where rainfall had caused scouring of the pad and the deposited material had caused a partial blockage to the drain.

28 November 2014

In inspection was carried out while coil tubing was being prepared in anticipation of hydraulic fracturing in the deepest zone of Well 19. Wells 20 and 17 had been completed, however it looked likely that the contingency zones in 20 would also be carried out. The site was clean and tidy with chemicals stored on bunded trays or in bunded steel containers.

The first skimmer pit had had approximately two thirds pumped out and the contents had been run through two silt traps by way of concave hay bale arrangements. This

system appeared to have worked well, with the majority of sediment retained in the first trap. From the silt traps, the skimmer contents then flowed across vegetated pasture before entering the wetland. This system was to continue until both skimmers were drained, on the condition that the pump rate was controlled such that the silt traps were not overwhelmed; no scouring of the down gradient pasture occurred; landowner approval had been sought and granted; pumping would cease should any hydrocarbon sheen become present in the skimmer pit being pumped; and that treatment of discharged stormwater prior to entry to surface water was through the wetland.

An indicative sample was retrieved from the second skimmer pit. Sediment present in the perimeter drain adjacent to the clip tank was still required to be removed to ensure stormwater was directed to the skimmer system.

2 December 2014

A site inspection was carried out in anticipation of the next hydraulic fracture campaign. At the time, the site was engaged in testing Well 17, and flaring was occurring at time of inspection. A grey translucent discharge was being generated; however this was dissipating within 30 - 40 m and no effects were observed offsite. The Company was looking at applying water to the flare to increase combustion efficiency.

A vacuum truck was onsite and a pump had been set up in the skimmer pit system to continue the draining of pits. Once the water level was sufficiently low the sides were to be water-blasted and sediment removed. No samples were retrieved during the inspection as the skimmer pit levels were well below the discharge level.

7 January 2015

An inspection was carried out to ensure consent compliance post- hydraulic fracturing. The site was currently engaged in demobilising half of the well-testing equipment prior to sending it to the Mangahewa-C site. Wells 17 and 18 had been tied into production, while 19 and 20 were shut in pending some coil work. The flare pit was undergoing works to ensure a more complete combustion. Wells 19 and 20 were not being brought on line until those works had been completed.

The contents of the skimmer pits were very clear, and algae rafts were beginning to form. The skimmer pits were not discharging to the wetland at the time of inspection, so samples were retrieved from near the outflow point. The onsite clip tank contents were to be released to the perimeter drain and through the skimmer pit and wetland system. It was strongly recommended that the discharge was controlled to avoid scouring of the perimeter drain.

15 January 2015

Testing equipment had been brought back to site from Mangahewa-C and well testing was ongoing. The flare pit had been dug out and the rocks have been removed. Approximately one third of the rocks had been left in the flare pit and water added. Another burner tip had been added to increase the total to two, and works had been carried out as it was believed that the rocks were choking the flare and causing incomplete combustion.

The skimmer pits were not discharging during the inspection, so samples were retrieved from near the skimmer pit outfall.

26 January 2015

An inspection was undertaken while on-going well testing was taking place on site. The site was dry and in a tidy order. Ring drains were in place and vegetation had established within the drains which would help to filter the stormwater. The skimmer pits were inspected and were not discharging. A sample was taken from the skimmer pits to ensure compliance with resource consent conditions should a discharge occur. The flare pit was not operating at the time of inspection.

2.1.2 Results of discharge monitoring

During the period under review a total of 20 stormwater samples were obtained. Stormwater was observed discharging from the wellsite skimmer pits on two occasions, and four samples (two at the skimmer pits and two at the wetland) were obtained in conjunction with this. The remaining 16 stormwater samples were obtained from the second skimmer pit to ensure compliance with certain consent conditions in anticipation of potential discharges.

Results are detailed in Table 1 and sampling locations can be seen in Figure 2.

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

Date	Chloride *g/m3*	Hydrocarbons *g/m3*	pH *pH*	Suspended Solids *g/m3*	Sampling location
15 Apr 2014	2.7	<0.5	6.9	200	Second skimmer pit
22 May 2014	10.3	<0.5	6.8	90	Second skimmer pit
04 Jun 2014	17.3	<0.5	7.5	160	Second skimmer pit
27 Jun 2014	10.2	<0.5	6.6	190	Skimmer pit discharge + wetland discharge
04 Jul 2014	14.1	<0.5	7.0	84	Second skimmer pit
10 Jul 2014	16.9	<0.5	7.2	46	Second skimmer pit
18 Jul 2014	14.9	<0.5	6.6	63	Second skimmer pit
25 Jul 2014	15.2	<0.5	6.8	30	Second skimmer pit
08 Aug 2014	12	<0.5	7.1	90	Second skimmer pit
21 Aug 2014	11.4	<0.5	7.5	49	Second skimmer pit
04 Sep 2014	10.7	<0.5	7.4	24	Second skimmer pit
09 Oct 2014	14.3	<0.5	6.8	41	Second skimmer pit
30 Oct 2014	8.7	<0.5	-	360	Skimmer pit discharge
30 Oct 2014	17.2	-	6.8	120	Wetland discharge
14 Nov 2014	11.8	<0.5	8.0	43	Second skimmer pit
28 Nov 2014	12.6	<0.5	8.3	61	Second skimmer pit
07 Jan 2015	51	<0.5	8.8	5	Second skimmer pit
15 Jan 2015	53.7	<0.5	8.3	5	Second skimmer pit
26 Jan 2015	55.6	<0.5	8.4	4	Second skimmer pit

Samples obtained on 30 Oct 2014 returned elevated levels of suspended solids in the wetland discharge. Although this value exceeded the limit as specified by condition 9 of consent 9453-1, no actual non-compliances occurred as this is still within the limits of uncertainty for this analysis method.

The discharge sample obtained on 27 June 2014 returned an elevated level of suspended solids (190 g/m^3) in the wetland discharge, which contravened Section 15(1) (b) of the Resource Management Act and special condition 9 of resource consent 9453-1. This high count was most likely attributed to sediment entering the wetland from adjacent pasture in the upper catchment which had been contoured during the wellsite construction phase and was yet to be stabilised vegetatively. In addition, no adverse effects were noted in the nearby stream. Following discussions and significant sediment control upgrades at the site, no further action was taken.

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, three samples were obtained in conjunction with the stormwater discharges on 27 June 2014 and 30 October 2014 from an unnamed tributary of the Waiau Stream to ensure that stormwater discharges were not having an adverse effect on the receiving stream environment. Of the stream samples obtained, one exceedance on 27 June 2014 was recorded in relation to consent 9453-1. Results are detailed in Table 2 and sampling locations can be seen in Figure 2.

Table 2 Samples obtained from an unnamed tributary of the Waiau Stream during the monitoring period under review

Date	Chloride ***g/m3***	Conductivity ***mS/m@20C***	Hydrocarbons ***g/m3***	pH ***pH***	Suspended Solids ***g/m3***	Sampling location
27 Jun 2014	-	-	-	-	-	Upstream
	10.7	7.0	<0.5	6.3	180	Downstream
30 Oct 2014	21.2	11.8	<0.5	7.0	2	Upstream
	17	10	<0.5	6.2	27	Downstream

Figure 2 Stormwater and surface water sampling locations at the Mangahewa-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 Mangahewa-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

Todd Energy Limited notified the Council of its intention to combust gas at the Mangahewa-E wellsite on 19 November 2014 and 13 January 2015. Following these dates, gas combustion occurred intermittently over the course of a few days in conjunction with well testing. During this time a flare pit was largely employed for the combustion of gas, to maintain a pilot flare and for emergency gas combustion / depressurisation.

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

2.2.3 Results of receiving environment monitoring

No chemical monitoring of air quality was undertaken during the testing phase of the Mangahewa-E wellsite as gas combustion activities were minimal.

2.2.4 Other ambient monitoring

No other ambient air sampling was undertaken, as the controls implemented by Todd Energy Limited did not give rise to any concerns with regard to air quality.

2.3 Land

2.3.1 Land status

The well site was constructed on a flat rural dairy farming area. Relatively extensive earthworks were required to construct the site. The land had not been reinstated at the time of the last inspection (26 January 2015) as the site was still in use.

2.4 Biomonitoring surveys

Biomonitoring surveys were performed prior to the commencement of drilling activities on 16 May 2014, and following the completion of drilling and hydraulic fracturing activities on 12 November 2014 and 13 January 2015 respectively, at the Mangahewa-E wellsite. The purpose of the surveys was to determine whether or not consented discharges of treated stormwater, treated produced water and surplus drilling water from hydrocarbon exploration and production activities on and into land where it may enter an unnamed tributary of the Waiau Stream have had a detrimental effect upon the macroinvertebrate communities of this stream.

The biomonitoring surveys were undertaken at three established sites; a control site 10 m upstream of the tributary confluence (site 1), a primary impacted site 15 m upstream of the tributary confluence and 40 m downstream of the wetland treatment system (site 2) and a secondary impacted site 15 m downstream of the tributary confluence (site 3), as seen in Figure 3.

Figure 3 Biomonitoring sites in the two unnamed tributaries of the Waiau Stream in relation to the Mangahewa-E wellsite.

The Councils' '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 Mangahewa-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. A summary of the biomonitoring surveys are as follows. A complete copy of the biomonitoring surveys can be found within Appendix II of this report.

The May 2014 pre-drill survey, the November 2014 post-drill survey and the January 2015 post-frac survey of three sites, upstream and downstream of the skimmer pit discharge point to land near an unnamed tributary of the Waiau stream was conducted

as a result of drilling and fracking at the Mangahewa-E wellsite. Taxa richness were similar among sites but varied between sampling occasions with a pattern of moderately low, moderate and low taxa richness observed indicating non wellsite related changes (e.g. water levels, temperature etc) except for the site 2 post-drill survey which had a moderately low taxa richness instead of the moderate taxa richness observed in sites 1 and 3. The taxa present at site 2 during the post-drill are characteristic of slow to very slow flowing streams that are organically rich but this does not explain the low taxa richness. Site 2 is situated on in a tributary of a different character to the tributary where sites 1 and 3 were located, which may have been a factor in the lower taxa richness observed. If site 2 was affected by a wellsite discharge then lower taxa richness would also be expected at site 3 which was not found.

In general taxa richness, MCI and $SQMCI_S$ values were reasonably congruent which indicated that the two unnamed tributaries were of 'poor' health and that there were significant differences in taxa richnesses and $SQMCI_S$ values between surveys which were attributable to factors such as reduction in flows and loss of macrophytes and not wellsite discharges to nearby land. Sites 1 and 3 were also more similar in community composition to each other probably because they were in the same tributary as opposed to site 2 which was in a different unnamed tributary.

2.5 Contingency plan

Todd Energy Limited have provided a general contingency plan, as required by Condition 4 of resource consent 9453-1 with site specific maps which cover all onshore sites that they operate. 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).

During the period under review, there were issues regarding the amount of suspended sediment in the treated stormwater discharge, and a black smoke event observed by the inspecting officers; one infringement notice was issued to Todd Energy Limited in relation to these non-compliances.

Issues with the performance of the silt and sediment controls in place at the site were raised during 15 of the 32 inspections conducted by TRC officers. These related to the type and efficiency of silt retention structures in place, the volume of sediment in the retention ponds, the timing of stabilisation of earthworked areas, and the need for ongoing management and maintenance of the stormwater treatment system.

An inspecting officer visited the site on 27 June 2014 following a heavy rainfall event, and stormwater discharge samples were retrieved. Analysis of the sample results found that the stormwater sample taken from the scruffy dome at the northern end of the wetland had a suspended solids level of 190 g/m^3. A downstream surface water sample taken beyond the 25 m mixing zone found a suspended solids level of 180 g/m^3. This contravened Section 15(1)(b) of the RMA and special condition 9 of resource consent 9453-1. Following discussions, it was established that this was likely the result of ineffective soil stabilisation following earthworks in the adjacent pasture of the upper catchment. Taking this into consideration, and in light of subsequent significant sediment control upgrades, no further enforcement action was taken.

On 29 December 2014, notification was received concerning black smoke at the Mangahewa-E site. Investigation found that the relatively short duration 'black smoke' event was the consequence of following an incorrect procedure - reducing the separator pressure rather than increasing it, allowing more liquids to 'carry over' into the flare pit. The ignition of the liquid had caused the black smoke which contravened Section 15(1)(b) of the RMA and special conditions 6 and 7 of resource consent 9454-1. It was deemed that the reduction of separator pressure causing the carry over of liquids to the flare pit, resulting in discharges of black smoke, was not beyond the consent holder's control, and was not unavoidable. Infringement notice EAC-20709 was issued to Todd Energy Limited.

Figure 4 Black smoke event at Mangahewa-E wellsite, 29 December 2014.

Any minor actual or potential non-compliance with consent conditions were addressed during site inspections. Todd Energy Limited staff would quickly take steps to ensure that requests made by Council Inspecting Officers were adhered to without delay.

3. Discussion

3.1 Discussion of consent exercise

Of the 6 resource consents relating to the Mangahewa-E wellsite, consents 9456-1(to take groundwater, as 'produced water', during hydrocarbon exploration), 9454-1 (to discharge emissions to air from hydrocarbon exploration), 9455-1 (to discharge emissions to air associated with production activities), 9452-1 (to discharge stormwater and sediment, deriving from soil disturbance from earthworks during construction onto land), 9453-1 (to discharge treated stormwater, treated produced water and surplus drilling water from hydrocarbon exploration and production activities on and into land where it may enter an unnamed tributary of the Waiau Stream), and 9457-1 (to discharge contaminants associated with hydraulic fracturing activities into land), were exercised and actively monitored.

Drilling waste including drilling muds, cuttings and other wastes were transported off site to a consented facility.

It is considered that all remaining resource consent conditions were complied with during the monitoring period, including the provision of various pieces of information (contingency plan, notifications etc.).

Monitoring has shown that the management on-site ensured that no 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, Todd Energy 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.

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.

Todd Energy Limited also undertook the following mitigation measures in order to minimise 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. 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 (e.g. 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, from contamination by drilling or fracturing activities.

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.

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[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.**

The measures to be undertaken by Todd Energy 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 emissions to air. In particular, this would reduce the potential for heavy smoke incidents associated with elevated PAH and dioxin emissions;
- Records of flaring events are kept by Todd Energy Limited and provided to the Council;
- Every endeavor was made by Todd Energy 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 Todd Energy Limited to minimise smoke emissions from the flare.

Odour and dust

Suppression of dust with water was to be implemented if it was apparent that dust may be travelling in such a direction to adversely affect off site parties. Odour may stem from the product, flare, or some of the chemicals used on site. Care was taken to minimize the potential for odour emissions (e.g. 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 storage of flammable materials could have resulted in air, soil and water contamination.

Todd Energy 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.

Hydraulic fracturing

The process of hydraulic fracturing results in some chemicals (e.g. clay stabilisers) being absorbed into the rock, where some may be residually trapped near the fracture face. The chemicals used in the fracturing process are classified as hazardous substances. However, these additives used in the process make up less than 5% of the total volume of fluid, the remaining being water and proppant. In a concentrated form some of the chemicals used in the fluid are toxic, but prior to the activity they are

highly diluted as part of the process. The majority of the fluid returns to the surface for controlled disposal at a consented facility.

Hence, there is a discharge of contaminants (energy, chemicals, water and inert sand/ small ceramic pellets) to land at considerable depth that has minor and temporary changes to the physical and chemical condition of the land (reservoir) in a way that does not affect other foreseeable users of the land and water resources.

The interval fractured is generally over 3 km below the surface. It is isolated by a considerable thickness of impermeable rock. The reservoir sands are known to contain hydrocarbons at pressures that exceed hydrostatic pressure, proving that the cap rock is relatively impermeable to the flow of water and hydrocarbons over very long time scales and high pressures.

The potential for the hydraulic fracturing activities to trigger seismic activity, particularly if located near faults within the formation has also been raised as a concern by some individuals. However, hydraulic fracturing is designed to create certain fractures in the rock and on a geological scale these are insignificant. The fissures created by the fracturing discharge are generally less than 400 m long, several mm wide and roughly 20 m thick into reservoir rock. These are very small features on a geological scale, and are not envisaged to create any increased risk of significant seismic activity.

The risk of the reservoir being fractured with a failure of the geological seal causing fracture fluids to migrate upwards and contaminate groundwater resources is considered extremely low. This is a result of numerous geological seals acting as natural barriers that stop any fracture fluids migrating upward.

Concern has also been raised that shallow groundwater may become contaminated from chemicals used in the hydraulic fracturing process. It is alleged that fluids may return to the surface via poorly sealed well casing or via cracks created through the fracturing process, rendering groundwater unsafe for human consumption. These hydrogeological risks of hydraulic fracturing affecting potable groundwater arise from two potential sources. The integrity of the well being used for the hydraulic fracturing, including the well casing and cement programme; and the geologic integrity of the reservoir seal and seals above this.

As a result of fracture design and modelling, coupled with extensive monitoring, the potential for groundwater to be impacted by hydraulic fracturing of a properly constructed well is extremely low and highly unlikely.

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 Todd Energy Limited's compliance record for the period under review is set out in Tables 3 to 7.

Table 3 Summary of performance for consent 9456-1 to take groundwater as 'produced water'

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	Complaints and sampling	Yes
2. The abstraction does not cause the intrusion of salt water into any freshwater aquifer	Water sampling adjacent bores pre/post drilling	Yes
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	Notification received and confirmed by inspection	N/A
5. Notice of Council to review consent	Notice of intention not served	N/A
Overall assessment of environmental performance and compliance in respect of this consent		High
Overall assessment of administrative performance in respect of this consent		High

Table 4 Summary of performance for consent 9454-1 to discharge emissions to air from exploration activities

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Consent shall not be exercised for more than an accumulated duration of 15 days per zone	Inspection of records	Yes
2. Location of flare shall be NZTM: 1714093E – 5678329N	Inspection	Yes
3. Council must be notified 24hrs prior to initial flaring of each zone	Notification received	Yes
4. Consent holder to notify all landowners 24 hrs prior to flaring	Notification and complaints	Yes
5. Only material from the well stream to be flared	Inspection	Yes
6. All gas flared must first be treated by effective liquid and solid separation and recovery	Inspection of flare pit and flare tank	No – one incidence of black smoke due to following incorrect procedure
7. Only substances originating from the well stream shall be combusted	Inspection of flare pit and flare tank	No – one incidence of black smoke due to following incorrect procedure

Condition requirement	Means of monitoring during period under review	Compliance achieved?
8. If liquid hydrocarbon is combusted, consent holder to provide detailed report within 5 working days	Receipt of report	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. Control of carbon monoxide, nitrogen dioxide, sulphur dioxide and fine particles	Inspection of Company records	Yes
12. Control of other emissions	Inspection of Company records	Yes
13. Analysis of typical gas and condensate stream from field to be made available to the Council	Available upon request	N/A
14. All permanent tanks used as hydrocarbon storage vessels fitted with vapour recovery systems	Inspection	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	Notice of intention not served	N/A
Overall assessment of environmental performance and compliance in respect of this consent Overall assessment of administrative performance in respect of this consent		Improvement required High

Table 5 Summary of performance for consent 9455-1 to discharge emissions to air from production activities

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Council must be notified 24 hrs prior to flaring when practicable	Notification	Yes
2. Landowners must be notified 24 hrs prior to flaring	Notification	Yes
3. Location of flare shall be NZTM: 1714093E – 5678329N	Inspection	Yes
4. All gas flared must first be treated by effective liquid and solid separation and recovery	Inspection of flare pit and flare tank	Yes

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

Table 6 Summary of performance for consent 9452-1 to discharge stormwater and sediment from earthworks

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Consent authorises earthworks for the purpose of establishing the Mangahewa-E wellsite	Inspection	Yes
2. Consent holder to adopt best practicable option at all times	Visually inspecting site, procedures & processes	Yes
3. 7 days written notice prior to site earthworks commencing	Notification received	Yes
4. All run off from exposed areas to pass through skimmer pits	Inspection	Yes
5. The obligation in condition 4 shall cease only when the area is stabilized	Inspection	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
6. All earthworked areas shall be stabilised as soon as practicable	Inspection	Yes
Overall assessment of environmental performance and compliance in respect of this consent		High
Overall assessment of administrative performance in respect of this consent		High

Table 7 Summary of performance for consent 9453-1 to discharge treated stormwater and produced water into an unnamed tributary of the Waiau Stream

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Consent holder to adopt best practicable option at all times	Visually inspecting site, procedures & processes	Yes
2. Maximum stormwater catchment area shall be no more than 30,000 m^2	Plans, procedures and processes	Yes
3. 5 days written notice provided to the Council prior to site works and drilling	Notification received	Yes
4. Consent holder to maintain 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	No – continued issues with silt and sediment controls at site.
6. All discharges from the site shall flow to a perimeter drain and skimmer pit	Inspection	No – continued issues with silt and sediment controls at site.
7. All skimmer pits and retention areas to be lined with impervious material	Inspection	Yes
8. Skimmer pits shall have a combined capacity of no less than 200 m^3 and retain hydrocarbons	Inspection and physicochemical sampling	Yes
9. 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
10. The pH may exceed 9.0 if the result of photosynthetic activity within the skimmer pits, but shall not increase pH of the receiving waters by more than 0.5 pH units.	Inspection and physicochemical sampling	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
11. Following a mixing zone of 25 m , discharges shall not give rise to: a) An increase in temperature of more than 2°C b) Biochemical oxygen demand of more than 2.00 gm^{-3} c) Chloride concentration of more than 50 gm^{-3}	Physicochemical sampling	Yes
12. Following the mixing zone, the discharge shall not give rise to adverse effects in/on 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	Notice of intention not served	N/A
Overall assessment of environmental performance and compliance in respect of this consent Overall assessment of administrative performance in respect of this consent		Improvement required High

During the monitoring period, Todd Energy Limited demonstrated an improvement required level of environmental performance and compliance with the resource consents. The cumulative adverse effects of the persistent minor issues with silt and sediment controls at the site have contributed to this rating, along with the unauthorised black smoke event that was the result of following an incorrect procedure. The incidents that occurred in respect of resource consents 9453-1 and 9454-1 have been discussed in Section 2.6.

During the monitoring period, Todd Energy Limited demonstrated a high level of administrative performance, as shown by the timely and satisfactory manner with which they provided required information and responded to requests from Council officers.

3.4 Exercise of optional review of consents

Resource consents 9453-1, 9454-1, 9455-1, and 9456-1 include 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 provision for review for these consents was in June 2015.

Based on the results of monitoring during the period under review, it was considered that there were no grounds that required a review to be pursued for any of these consents in 2015, and there will also be no grounds for review for the next date, June 2021. 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 Mangahewa-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 Mangahewa-E wellsite continues to include the sampling and extensive analysis of both groundwater and surface waters in the general vicinity of a wellsite where hydraulic fracturing occurs;

3. THAT the monitoring of future consented activities at Mangahewa-E wellsite continues to include biomonitoring surveys;

4. THAT, subject to the findings of monitoring of any further activities at the Mangahewa-E wellsite consents 9453-1, 9454-1, 9455-1, 9456-1, and 9457-1 shall not be reviewed in 2021.

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

Water Permit

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

Name of Consent Holder:	Todd Energy Limited P O Box 802 NEW PLYMOUTH 4340
Decision Date:	1 February 2013
Commencement Date:	1 February 2013

Conditions of Consent

Consent Granted:	To take groundwater as 'produced water', during hydrocarbon exploration and production activities at the Mangahewa-E wellsite at or about (NZTM) 1714172E-5678428N
Expiry Date:	1 June 2027
Review Date(s):	June 2015, June 2021
Site Location:	Mangahewa-E wellsite, Tikorangi Road East, Waitara (Property owner: K & L Sarten)
Legal Description:	Lot 3 DP 18870 (Site of take)
Catchment:	Waiau

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 31 March 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 2015 and/or June 2021, 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 15 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:	Todd Energy Limited PO Box 802 New Plymouth 4340	
Decision Date (Change):	18 August 2015	
Commencement Date (Change):	18 August 2015	(Granted Date: 1 February 2013)

Conditions of Consent

Consent Granted:	To discharge treated stormwater and produced water from hydrocarbon exploration and production operations at the Mangahewa-E wellsite, onto land and into an unnamed tributary of the Waiau Stream
Expiry Date:	1 June 2027
Review Date(s):	June 2021
Site Location:	Mangahewa-E wellsite, Tikorangi Road East, Waitara (Property owner: KA & LE Sarten)
Legal Description:	Lot 3 DP 18870 (Discharge source & site)
Grid Reference (NZTM)	1714122E–5678529N (Skimmer pit discharge) 1714138E–5678618N (Wetland discharge)
Catchment:	Waiau

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 30,000 m^2.

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, and
   b) commencement of any well drilling operation.

   If either 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 a brief description of the activity consented 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 Taranaki Regional Council prior to discharging from the site.

5. Subject the 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 7632 in particular Drawing No 12119-01, Rev 2.

6. All runoff from the site, including any discharged from the flare pit, shall flow to a perimeter drain and/or skimmer pit. Perimeter drains shall be designed, including by having a positive grade and low permeability, to ensure that runoff flows directly to the skimmer pit without ponding.

7. All skimmer pits and any other stormwater retention areas shall be lined with an impervious material to prevent seepage through the bed and sidewalls.

8. Skimmer pits shall have a combined capacity of no less than 200 m^3 and be designed to retain any hydrocarbons that enter them.

9. Constituents in the discharge shall meet the standards shown at the locations described in the following table.

Constituent	Standard	Discharge Location
pH	Within the range 6.0 to 9.0	Shut-off valve cellar adjacent to skimmer pits (1714122E-5678529N)
Chloride	Concentration not greater than 230 gm^{-3}	
total recoverable hydrocarbons	Concentration not greater than 15 gm^{-3} (as determined by infrared spectroscopic technique)	
suspended solids	Concentration not greater than 100 gm^{-3}	Scruffy dome at the northern end of the wetland (1714138E-5678618N)

10. The pH may exceed 9.0 if the exceedance is a result photosynthetic activity within the skimmer pits, but in any case the discharge shall not result in the pH of the receiving water increasing by more than 0.5 pH units after allowing for a mixing zone of 25 metres.

11. After allowing for a mixing zone of 25 metres, the discharge shall not cause any of the following effects in the receiving:

    a) an increase in the temperature of more than 2 degrees Celsius;

    b) the filtered carbonaceous biochemical oxygen demand to exceed 2 gm^{-3}; or

    c) the chloride concentration to exceed 50 gm^{-3}.

12. After allowing for a mixing zone of 25 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 31 March 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 2015 and/or June 2021, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Signed at Stratford on 18 August 2015

For and on behalf of
Taranaki Regional Council

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A D McLay
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:	Todd Energy Limited P O Box 802 NEW PLYMOUTH 4340
Decision Date:	21 December 2012
Commencement Date:	21 December 2012

Conditions of Consent

Consent Granted:	To discharge stormwater and sediment, deriving from soil disturbance undertaken for the purpose of constructing the Mangahewa-E wellsite, onto land where it may enter an unnamed tributary of the Waiaua stream at or about (NZTM) 1714165E-5678459N
Expiry Date:	1 June 2017
Site Location:	Mangahewa-E wellsite, Tikorangi Road East, Waitara (Property owner: K & L Sarten)
Legal Description:	Lot 3 DP 18870 (Discharge source and site)
Catchment:	Waiaua

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 earthworks undertaken for the purpose of establishing the Mangahewa wellsite as shown on Drawing No 12119-01 provided with the application.

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 skimmer pits 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 obligation described in condition 4 above shall cease to apply, and accordingly the erosion and sediment control measures may be removed, in respect of any particular area, only when the 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.

   Note: For the purposes of this condition "stabilised" has the same definition as that set out in condition 5.

Signed at Stratford on 15 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:	Todd Energy Limited P O Box 802 NEW PLYMOUTH 4340
Decision Date:	31 January 2013
Commencement Date:	31 January 2013

Conditions of Consent

Consent Granted:	To discharge contaminants to air from hydrocarbon exploration at the Mangahewa-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 at or about (NZTM) 1714093E-5678329N
Expiry Date:	1 June 2027
Review Date(s):	June 2015, June 2021 and as per special condition 17
Site Location:	Mangahewa-E wellsite, Tikorangi Road East, Waitara (Property owner: K & L Sarten)
Legal Description:	Lot 3 DP 18870 (Discharge source and site)

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. Flaring shall not occur on more than 15 days, cumulatively, per zone for each well (with a maximum of 6 zones per well), for up to 8 wells.

2. Flaring shall only occur in a flare pit that is located at NZTM 1714093E-5678329N and lined with impermeable material that prevents any liquid from leaking through its base or sidewalls.

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

4. At least 24 hours before any flaring, other than in emergencies, the consent holder shall provide notification to the occupants of all dwellings and all landowners within 1000 metres, of the commencement of flaring. 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 flaring activity.

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

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

7. Only gaseous hydrocarbons originating from the well stream shall be combusted, 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.

8. If liquid hydrocarbon is combusted in accordance with the exception provided for in condition 7 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.

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 from the flare, 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 flaring so as to minimise offsite effects (other than for the maintenance of a pilot flare flame).

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

11. The consent holder shall control all emissions of carbon monoxide, nitrogen dioxide, fine particles (PM10) 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.

12. The consent holder shall control all emissions to the atmosphere from the site of contaminants other than those expressly provided for under special condition 11, 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 flare pit.

13. 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.

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

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

    (a) the date, time and duration of all flaring episodes;
    (b) the zone from which flaring occurred;
    (c) the volume of substances flared;
    (d) whether there was smoke at any time during the flaring episode and if there was, the time, duration and cause of each 'smoke event'.

16. This consent shall lapse on 31 March 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:

    (a) during the month of June 2015 and/or June 2021; and/or
    (b) within 1 month of receiving a report provided in accordance with special condition 8;

    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;
    (iv) reducing emissions or environmental effects that may arise from any loss of separation.

Signed at Stratford on 15 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:	Todd Energy Limited P O Box 802 NEW PLYMOUTH 4340
Decision Date:	26 February 2013
Commencement Date:	26 February 2013

Conditions of Consent

Consent Granted:	To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3200 mTVDss beneath the Mangahewa-E wellsite
Expiry Date:	1 June 2020
Review Date(s):	June annually
Site Location:	Mangahewa-E wellsite, Tikorangi Road East, Waitara (Property owner: K & L Sarten)
Legal Description:	Lot 3 DP 18870 [Discharge source and site]
Grid Reference (NZTM)	1714172E-5678428N
Catchment:	Waiau

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 to section 36 of the Resource Management Act.

Special conditions

1. The discharge point shall be deeper than 3200 mTVDss.

   Note: mTVDss = metres true vertical depth subsea, i.e. the true vertical depth in metres below mean sea level.

2. There shall be no discharge of hydraulic fracturing fluids into the reservoir after 1 June 2015.

3. The consent holder shall ensure that the exercise of this consent does not result in contaminants reaching any useable fresh water (groundwater or surface water). Useable fresh groundwater is defined as any groundwater having a Total Dissolved Solids concentration of less than 1000 mg/l.

4. The consent holder shall undertake a programme of sampling and testing that monitors the effects of the exercise of this consent on fresh water resources to assess compliance with condition 3 (the 'Monitoring Programme'). The Monitoring Programme shall be certified by the Chief Executive, Taranaki Regional Council ('the Chief Executive'), before this consent is exercised, and shall include:

   (a) the location of the discharge point(s);
   (b) the location of sampling sites; and
   (c) sampling frequency with reference to a hydraulic fracturing programme.

5. The Monitoring Programme shall include sampling of groundwater from a bore installed in accordance with NZS 4411:2001. The bore shall be of a depth, location and design determined after consultation with the Chief Executive, Taranaki Regional Council.

6. All water samples taken for monitoring purposes shall be taken in accordance with recognised field procedures and analysed for:

   (a) pH;
   (b) conductivity;
   (c) total dissolved solids;
   (d) major ions (Ca, Mg, K, Na, total alkalinity, bromide, chloride, nitrate-nitrogen, and sulphate);
   (e) trace metals (barium, copper, iron, manganese, nickel, and zinc);
   (f) total petroleum hydrocarbons;
   (g) formaldehyde;
   (h) dissolved methane and ethane gas;
   (i) methanol;
   (j) glycols;

(k) benzene, toluene, ethylbenzene, and xylenes (BTEX); and
(l) carbon-13 composition of any dissolved methane gas discovered (^{13}C-CH_4).

Note: The samples required, under conditions 4 and 6 could be taken and analysed by the Council or other contracted party on behalf of the consent holder.

7. All sampling and analysis shall be undertaken in accordance with a *Sampling and Analysis Plan*, which shall be submitted to the Chief Executive for review and certification before the first sampling is undertaken. This plan shall specify the use of standard protocols recognised to constitute good professional practice including quality control and assurance. An International Accreditation New Zealand (IANZ) accredited laboratory shall be used for all sample analysis. Results shall be provided to the Chief Executive within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 3.

Note: The Sampling and Analysis Plan may be combined with the Monitoring Programme required by condition 4.

8. The consent holder shall undertake well and equipment pressure testing prior to any hydraulic fracture programme on a given well to ensure any discharge will not affect the integrity of the well and hydraulic fracturing equipment.

9. Any hydraulic fracture discharge shall only occur after the consent holder has provided a comprehensive 'Pre-fracturing discharge report' to the Chief Executive. The report shall be provided at least 14 days before the discharge is proposed to commence and shall detail the hydraulic fracturing programme proposed, including as a minimum:

(a) the specific well in which each discharge is to occur, the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment), and the duration of the hydraulic fracturing programme;
(b) the number of discharges proposed and the geographical position (i.e. depth and lateral position) of each intended discharge point;
(c) the total volume of fracture fluid planned to be pumped down the well, including mini- fracture treatments, and their intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
(d) the results of the reviews required by condition 14;
(e) results of modelling showing an assessment of the likely extent and dimensions of the fractures that will be generated by the discharge;
(f) the preventative and mitigation measures to be in place to ensure the discharge does not cause adverse environmental effects and complies with condition 3;
(g) the extent and permeability characteristics of the geology above the discharge point to the surface;
(h) any identified faults within the modeled fracture length plus a margin of 50%, and the potential for adverse environmental effects due to the presence of the identified faults;
(i) the burst pressure of the well and the anticipated maximum well and discharge pressures and the duration of the pressures; and
(j) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal.

Note: For the avoidance of doubt, the information provided with a resource consent application would usually be sufficient to constitute a 'Pre-fracturing discharge report' for any imminent hydraulic fracturing discharge. The Pre-fracturing discharge report provided for any later discharge may refer to the resource consent application or earlier Pre-fracturing discharge reports noting any differences.

10. The consent holder shall notify the Taranaki Regional Council of each discharge by emailing worknotification@trc.govt.nz. Notification shall include the date that the discharge is to occur and identify the 'Pre-fracturing discharge report', required by condition 9, which details the discharge. Where practicable and reasonable notice shall be given between 3 days and 14 days before the discharge occurs, but in any event 24 hours notice shall be given.

11. At the conclusion of a hydraulic fracturing programme on a given well, the consent holder shall submit a comprehensive 'Post-fracturing discharge report' to the Chief Executive. The report shall be provided within 60 days after the programme is completed and, as a minimum, shall contain:

    (a) confirmation of the interval(s) where fracturing occurred for that programme, and the geographical position (i.e. depth and lateral position) of the discharge point for each fracture interval;
    (b) the contaminant volumes and compositions discharged into each fracture interval;
    (c) the volume of return fluids from each fracture interval;
    (d) an analysis for the constituents set out in conditions 6(a)to 6(k), in a return fluid sample taken within the first two hours of flow back, for each fracture interval if flowed back individually, or for the well if flowed back with all intervals comingled;
    (e) an estimate of the volume of fluids (and proppant) remaining underground;
    (f) the volume of water produced with the hydrocarbons (produced water) over the period beginning at the start of the hydraulic fracturing programme and ending 50 days after the programme is completed or after that period of production;
    (g) an assessment of the extent and dimensions of the fractures that were generated by the discharge, based on modelling undertaken after the discharge has occurred and other diagnostic techniques, including production analysis, available to determine fracture length, height and containment;
    (h) the results of pressure testing required by condition 8, and the top hole pressure (psi), slurry rate (bpm), surface proppant concentration (lb/gal), bottom hole proppant concentration (lb/gal), and calculated bottomhole pressure (psi), as well as predicted values for each of these parameters; prior to, during and after each hydraulic fracture treatment;
    (i) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal;
    (j) details of any incidents where hydraulic fracture fluid is unable to pass through the well perforations (screen outs) that occurred, their likely cause and implications for compliance with conditions 1 and 3; and
    (k) an assessment of the effectiveness of the mitigation measures in place with specific reference to those described in the application for this consent.

12. The reports described in conditions 9 and 11 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.

13. The consent holder shall provide access to a location where the Taranaki Regional Council officers can obtain a sample of the hydraulic fracturing fluids and the return fluids.

14. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimize any actual or likely adverse effect of the activity on the environment by, as a minimum, ensuring that:

    (a) the discharge is contained within the fracture interval;
    (b) regular reviews are undertaken of the preventative and mitigation measures adopted to ensure the discharge does not cause adverse environmental effects; and
    (c) regular reviews of the chemicals used are undertaken with a view to reducing the toxicity of the chemicals used.

15. The fracture fluid shall be comprised of no less than 95% water and proppant by volume.

16. The Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review during the month of June each year, for the purposes of:

    (a) ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or

    (b) further specifying the best practicable option as required by condition 14; and/or

    (c) ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Signed at Stratford on 15 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 Biologists; Darin Sutherland and Bart Jansma
Report No	DS006
Document	1487382
Date	22 April 2015

Biomonitoring of two unnamed tributaries of the Waiau Stream in relation to drilling and hydraulic fracturing at the Mangahewa-E wellsite, May and November 2014 and January 2015

Introduction

Pre-drill, post-drill and post-frac macroinvertebrate surveys were performed at the Mangahewa-E wellsite to determine whether drilling and hydraulic fracturing ('fracking') discharges of treated stormwater, uncontaminated site water, and production water onto land had had any detrimental effects upon macroinvertebrate communities of the nearby unnamed tributary of the Waiau Stream. The pre-drill survey produced baseline results that allowed comparison with the post-drill and post-frac surveys enabling any changes in the condition of the macroinvertebrate communities to be determined. The Mangahewa-E wellsite stormwater and site production water were discharged from a skimmer pit on to land within the vicinity of two unnamed tributaries of the Waiau Stream (Figure 1).

Methods

The pre-drill survey was undertaken on 16 May 2014 at three sites (Table 1). Site 1 was the control site while site 2 was the primary impacted site and site 3 was the secondary impacted site. The subsequent post-drill survey was completed at the same three sites on 12 November 2014 and the post-frac survey was also completed at the same three sites on 13 January 2015. The altitude of the three sites was approximately 60 m asl.

Two different sampling techniques were used to collect macroinvertebrates in the unnamed tributaries of the Waiau Stream: the Council's standard 'kick-sampling' and a combination of 'kick-sampling' and a 'vegetation sweep' (Table 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). The two techniques are used depending on the situation and a combination of techniques may be used when different conditions are encountered in the same reach of stream. Furthermore, vegetation sweeps may be used when the stream is not wadeable (e.g. due to water depth and/or speed) but vegetation on the bank edges can still be sampled.

Table 1 Biomonitoring sites and sampling methods used in the two unnamed tributaries of the Waiau Stream in relation to the Mangahewa-E wellsite.

Site No.	Site code	Grid reference (NZTM)	Location	Sampling method		
				Pre Drill	Post-Drill	Post-Frac
1	WAI000084	1714201E-5678652N	10m upstream of minor tributary confluence	Sweep	Kick-sweep	Kick
2	WAI000086	1714175E-5678658N	15m upstream of confluence, 40m d/s of race	Sweep	Kick-sweep	Kick
3	WAI000089	1714183E-5678692N	15m downstream of confluence/ immediately upstream of culvert and confluence with Waiau Stream	Sweep	Kick-sweep	Kick

Figure 1 Biomonitoring sites in the two unnamed tributaries of the Waiau Stream in relation to the Mangahewa-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 difference of 11 units or more in MCI values is considered significantly different (Stark 1998).

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. A difference of 0.9 units or more in $SQMCI_s$ is considered significantly different (Stark, 1998).

Results

Site habitat characteristics

The water temperatures were moderately cool during the pre-drill and post-drill sampling but were high for sites 1 and 3 and moderate for site 2 during the post-frac survey. Water colour and clarity were uncoloured and clear for all three survey dates (Table 2). Water velocity was slow for all three sites on all sampling occasions but the flow condition were progressively lower from the pre-dill to the post-frac (Table 3).

Substrate at site 1 during the pre-drill and post-drill survey was comprised entirely of silt while during the post-frac survey it was comprised mainly of silt but with some sand and fine and coarse gravel. Substrate at site 2 for the pre-drill, post-drill and post-frac was comprised nearly entirely of silt. Substrate at site 3 for the pre-drill and post-drill was comprised nearly entirely of silt and for the post-frac a mixture of silt and sand.

At site 1 there was patchy periphyton mats and macrophytes on the bed of the stream during the pre-survey, macrophytes on the bed but no periphyton during the post-survey and no periphyton or macrophytes during the post-frac. At site 2 there were macrophytes on the bed of the stream during the pre and post-survey and no periphyton or macrophytes during the post-frac. At site 3 there were slippery periphyton mats and macrophytes on the bed of the

stream during the pre-survey, macrophytes on the bed but no periphyton during the post-survey and no periphyton or macrophytes during the post-frac. All sites on all survey occasions did not have moss, leaves or wood present and all sites were unshaded.

Table 2 Summary of time of sampling and some water quality variables collected at each site for the pre and post-drill and post-frac monitoring (May and November 2014 and January 2015) at the Mangahewa-E wellsite.

	Time (NZST)			Temperature (°C)			Water Colour			Water Clarity		
	Pre	Post-Drill	Post-Frac	Pre	Post-Drill	Post-Frac	Pre	Post-Drill	Post-Frac	Pre	Post-Drill	Post-Frac
WAI000084	1225	1130	1215	15.1	15.2	29.0	Uncoloured	Uncoloured	Uncoloured	Clear	Clear	Clear
WAI000086	1240	1105	1155	15.3	14.8	18.9	Uncoloured	Uncoloured	Uncoloured	Clear	Clear	Clear
WAI000089	1205	1040	1140	15.1	15.6	24.1	Uncoloured	Uncoloured	Uncoloured	Clear	Clear	Clear

Table 3 Summary of some additional water variables collected at each site for the pre and post-drill and post-frac monitoring (May and November 2014 and January 2015) at the Mangahewa-E wellsite.

	Flow condition			Water speed			Days since 3x Fresh			Sampling habitat		
	Pre	Post-Drill	Post-Frac	Pre	Post-Drill	Post-Frac	Pre	Post-Drill	Post-Frac	Pre	Post-Drill	Post-Frac
WAI000084	Moderate	Low	Very low	Slow	Slow	Slow	9	9	12	Pool	Run	Run
WAI000086	Moderate	Low	Very low	Slow	Slow	Slow	9	9	12	Pool	Run	Run
WAI000089	Moderate	Low	Very low	Slow	Slow	Slow	9	9	12	Pool	Run	Run

Macroinvertebrate communities

Results of the pre-drill, post-drill and post-frac surveys are summarised in Table 4 and the macroinvertebrate faunal data are presented in Table 5.

Table 4 Summary of number of taxa, MCI values and $SQMCI_S$ for the pre and post-drill and post-frac monitoring (May and November 2014 and January 2015) at the Mangahewa-E wellsite.

	Numbers of taxa			MCI values			$SQMCI_S$		
	Pre	Post-Drill	Post-Frac	Pre	Post-Drill	Post-Frac	Pre	Post-Drill	Post-Frac
WAI000084	17	23	10	72	75	70	3.9	4.5	3.3
WAI000086	16	14	9	73	71	58	3.0	2.8	2.2
WAI000089	19	25	11	78	76	75	3.1	4.4	2.8

Table 5 Macroinvertebrate fauna of two unnamed tributaries of the Waiau Stream in relation to the pre and post-drill and post-frac monitoring (May and November 2014 and January 2015) at the Mangahewa-E wellsite.

Taxa List		MCI Score	Pre-drill			Post-drill			Post-frac		
	Site Code		WAI000084	WAI000086	WAI000089	WAI000084	WAI000086	WAI000089	WAI000084	WAI000086	WAI000089
PLATYHELMINTHES (FLATWORMS)	*Cura*	3	R	C	A	R	R	-	-	-	-
NEMERTEA	Nemertea	3	C	-	C	R	-	-	-	-	-
NEMATODA	Nematoda	3	-	-	-	R	R	R	-	-	-
ANNELIDA (WORMS)	Oligochaeta	1	VA	R	-	A	C	A	R	R	A
	Lumbricidae	5	C	R	-	-	-	R	-	-	-
HIRUDINEA (LEECHES)	Hirudinea	3	-	-	-	R	-	-	-	-	-
MOLLUSCA	Lymnaeidae	3	-	-	C	-	-	R	-	-	-
	Physa	3	-	-	R	R	VA	A	-	-	-
	Potamopyrgus	4	VA	-	A	VA	-	VA	A	-	C
	Sphaeriidae	3	R	-	-	-	-	-	R	-	R
CRUSTACEA	Copepoda	5	C	C	A	-	VA	-	-	R	-
	Ostracoda	1	VA	XA	XA	A	VA	A	C	C	A
	Paracalliope	5	XA	XA	XA	XA	R	XA	-	R	A
EPHEMEROPTERA (MAYFLIES)	*Zephlebia group*	7	-	-	-	R	-	-	-	-	-
ODONATA (DRAGONFLIES)	*Ischnura*	4	-	-	-	-	-	R	-	-	-
	Xanthocnemis	4	R	R	C	C	-	A	-	-	-
HEMIPTERA (BUGS)	*Microvelia*	3	-	-	-	R	-	R	-	-	-
	Sigara	3	-	-	-	-	-	R	-	-	-
COLEOPTERA (BEETLES)	Dytiscidae	5	-	C	-	R	R	R	-	-	R
	Hydrophilidae	5	-	R	R	-	-	-	R	-	-
TRICHOPTERA (CADDISFLIES)	*Polyplectropus*	6	-	-	-	R	-	R	-	-	-
	Psilochorema	6	-	R	-	R	-	R	-	-	-
	Oecetis	4	-	-	-	-	-	R	-	-	-
	Oxyethira	2	-	C	R	R	-	-	-	C	-
	Triplectides	5	-	-	-	R	-	-	-	-	-
DIPTERA (TRUE FLIES)	Hexatomini	5	-	-	R	-	-	-	R	-	R
	Paralimnophila	6	R	-	C	-	R	R	R	R	R
	Zelandotipula	6	-	-	R	-	-	R	-	-	-
	Chironomus	1	-	-	-	-	-	C	-	R	-
	Orthocladiinae	2	R	R	C	C	VA	A	C	A	-
	Polypedilum	3	-	-	-	-	A	-	-	-	-
	Tanypodinae	5	A	R	A	A	C	C	-	-	-
	Tanytarsini	3	-	XA	C	-	-	-	C	C	R
	Ceratopogonidae	3	R	R	-	-	-	-	-	-	-
	Paradixa	4	-	-	R	R	-	C	-	-	-
	Empididae	3	R	R	-	R	-	C	-	-	-
	Muscidae	3	-	-	-	-	R	-	-	-	R
	Austrosimulium	3	R	-	-	A	-	C	-	-	-
ACARINA (MITES)	Acarina	5	R	-	C	C	C	C	R	-	C
		No of taxa	17	16	19	23	23	25	10	9	11
		MCI	72	73	78	75	75	76	70	58	75
		SQMCIs	3.9	3.0	3.1	4.5	4.5	4.4	3.3	2.2	2.8
		EPT (taxa)	0	1	0	4	4	3	0	0	0
		%EPT (taxa)	0	6	0	17	17	12	0	0	0

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

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

Site 1. 10m upstream of minor tributary confluence

A moderately low macroinvertebrate community richness of 17 taxa was found at site 1 the 'control' site during the pre-drill survey. A higher richness of 23 taxa was found in the follow-up post-drill survey while a much lower taxa richness of 10 taxa was found in the post-frac survey (Results of the pre-drill, post-drill and post-frac surveys are summarised in Table 4 and the macroinvertebrate faunal data are presented in Table 5.

Table 4).

The MCI score for all three surveys was relatively consistent, 72, 75, and 70 units for the pre-drill, post-drill and post-frac surveys respectively, which indicated communities of 'poor' biological health. The $SQMCI_S$ scores of 3.9 units and 4.5 units for the pre and post-drill survey were similar but the post-frac $SQMCI_S$ score of 3.3 units was significantly lower than the post-drill survey score.

The community at the time of the pre-drill survey was characterised by three 'tolerant' taxa (oligochaete worms, snails (*Potamopyrgus*), and ostracod seed shrimps and two 'moderately sensitive' taxa, amphipods (*Paracalliope*) and midges (Tanypodinae). The community at the time of the post-drill survey was characterised by four 'tolerant' taxa (oligochaete worms, snails (*Potamopyrgus*), ostracod seed shrimps and sandflies (*Austrosimulium*), and two 'moderately sensitive' taxa, amphipods (*Paracalliope*) and midges (Tanypodinae). The community at the post-frac survey was characterised by one 'tolerant' taxon, snails (*Potamopyrgus*) (Table 5).

Site 2. 15m upstream of confluence, 40m d/s of race

A moderately low macroinvertebrate community richness of 16 taxa was found at site 2 the 'first impacted' site during the pre-drill survey. A slightly lower taxa richness of 14 taxa was found in the follow- up post-drill survey while a low taxa richness of 9 taxa was found in the post-frac survey (Results of the pre-drill, post-drill and post-frac surveys are summarised in Table 4 and the macroinvertebrate faunal data are presented in Table 5.

Table 4).

The pre and post-drill survey MCI scores of 73 and 71 respectively indicated 'poor' biological health. The post-frac survey MCI score of 58 units indicated 'very poor' biological health. The $SQMCI_S$ score of 3.0 units and 2.8 units for the pre and post-drill survey were similar to each other but the post-frac $SQMCI_S$ score of 2.2 units was marginally lower.

The community at the time of the pre-drill survey was characterised by one 'tolerant' taxon ostracod seed shrimps and two 'moderately sensitive' taxa, amphipods (*Paracalliope*) and midges (Tanypodinae). The community at the time of the post-drill survey was characterised by four 'tolerant' taxa ostracod seed shrimps, snails (*Physa*), midges (*Orthocladiinae*), and the true fly (*Polypedium*) and one 'moderately sensitive', taxon copepods. The community at the post-frac survey was characterised by one 'tolerant' taxon, midges (*Orthocladiinae*) (Table 5).

Site 3. 15m downstream of minor confluence/ immediately upstream of culvert & confluence with Waiau Stream

A moderately low macroinvertebrate community richness of 19 taxa was found at site 3 the 'second impacted' site during the pre-drill survey. A higher richness of 25 taxa was found in the follow- up post-drill survey while a low taxa richness of 11 taxa was found in the post-frac

survey (Results of the pre-drill, post-drill and post-frac surveys are summarised in Table 4 and the macroinvertebrate faunal data are presented in Table 5.

Table 4).

The MCI score for all three surveys was relatively consistent, 78, 76, and 75 units for the pre-drill, post-drill and post-frac surveys respectively, which indicated communities of 'poor' biological health. The $SQMCI_S$ scores of 3.1 units and 2.8 units for the pre-drill and post-frac surveys were similar but the post-drill $SQMCI_S$ score of 4.4 units was significantly higher.

The community at the time of the pre-drill survey was characterised by three 'tolerant' taxa, flatworms (Platyhelminth), snails (*Potamopyrgus*) and ostracod seed shrimps and three 'moderately sensitive' taxa, copepods, amphipods (*Paracalliope*) and midges (Tanypodinae). The community at the time of the post-drill survey was characterised by five 'tolerant' taxa, oligochaete worms, snails (*Physa*) and (*Potamopyrgus*), ostracod seed shrimps and damselflies (*Xanthocnemis*), and one 'moderately sensitive' taxon, amphipods (*Paracalliope*). The community at the time of the post-frac survey was characterised by two 'tolerant' taxa, oligochaete worms and ostracod seed shrimps and one 'moderately sensitive' taxon, amphipods (*Paracalliope*) (Table 5).

Discussion and Conclusions

The Councils 'kick-sampling' technique and a combination of 'vegetation sweep' and 'kick-sampling' techniques were used at three sites to collect streambed macroinvertebrates from two unnamed tributaries of the Waiau Stream. This has provided data to assess any ongoing impacts of skimmer pit discharges to nearby land from the Mangahewa-E wellsite on the macroinvertebrate communities of two unnamed tributaries of the Waiau 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.

The May 2014 pre-drill survey, the November 2014 post-drill survey and the January 2015 post-frac survey of three sites, upstream and downstream of the skimmer pit discharge point to land near an unnamed tributary of the Waiau stream was conducted as a result of drilling and fracking at the Mangahewa-E wellsite. Taxa richness were similar among sites but varied between sampling occasions with a pattern of moderately low, moderate and low taxa richness observed indicating non wellsite related changes (e.g. water levels, temperature etc) except for the site 2 post-drill survey which had a moderately low taxa richness instead of the moderate taxa richness observed in sites 1 and 3. The taxa present at site 2 during the post-drill are characteristic of slow to very slow flowing streams that are organically rich but this does not explain the low taxa richness. Site 2 is situated on in a tributary of a different character to the tributary where sites 1 and 3 were located, which may have been a factor in the lower taxa richness observed. If site 2 was affected by a wellsite discharge then lower taxa richness would also be expected at site 3 which was not found.

MCI scores were similar for all three sites for the three surveys except for the post-frac survey at site 2 which was significantly lower than scores at sites 1 and 3. It was noted during the site visit that there was a considerable amount of iron floc present on the bed of the stream and water levels were extremely low which could have caused the reduction in MCI score. If wellsite discharges had been a factor then it would be expected that MCI values at site 3 would show the same trend as site 2 which was not found.

The trends displayed by the $SQMCI_S$ values was the same as that of taxa richnesses with a pattern of moderately low, moderate and low $SQMCI_S$ values observed for the pre-drill, post-drill and post-frac surveys respectively except for the site 2 post-drill survey which had a moderately low $SQMCI_S$ value. Higher $SQMCI_S$ values at site 1 for the post-drill survey as compared with the pre-drill survey can be solely attributed to the decrease in the abundance of the low scoring ostracod seed shrimps and oligochaete worms and for site 3 a decrease in ostracods and flatworms. Site 2 also had a decrease in the number of ostracods but it also had a decrease in higher scoring amphipods (*Paracalliope*) which was the main cause of the slight decrease in $SQMCI_S$ value from the pre-drill survey to the post-drill survey.

In general taxa richness, MCI and $SQMCI_S$ values were reasonably congruent which indicated that the two unnamed tributaries were of 'poor' health and that there were significant differences in taxa richnesses and $SQMCI_S$ values between surveys which were attributable to factors such as reduction in flows and loss of macrophytes and not wellsite discharges to nearby land. Sites 1 and 3 were also more similar in community composition to each other probably because they were in the same tributary as opposed to site 2 which was in a different unnamed tributary.

Summary

- Pre-drill, post-drill and post-frac macroinvertebrate surveys were completed at three sites near the Mangahewa-E wellsite to determine if any wellsites discharges to nearby land had impacted on the health of the macroinvertebrate communities on two unnamed tributaries of the Waiau Stream.

- Taxa richness and $SQMCI_S$ values varied between sampling dates while MCI values remained relatively consistent.

- There were some differences between sites 1 and 3 and site 2 taxa richnesses, MCI and $SQMCI_S$ scores which were probably due to sites 1 and 3 being located in the same tributary while site 2 was located in an adjacent tributary.

- The primary influences on the macroinvertebrate communities appeared to be the reduction in flows and the loss of macrophyte habitat.

- There was no evidence of wellsite discharges having had a significant impact on the macroinvertebrate communities with site 1, the 'control' site, having very similar macroinvertebrate indices compared with site 3, the 'second impacted' site.

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