BTW Company Limited
Brown Road-Wellington Landfarm
Monitoring Programme
Biennial Report
July 2011 – June 2013

Technical Report 2013–62

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Executive summary

This report describes the monitoring programme implemented by the Taranaki Regional Council for the period July 2011 – June 2013 to assess BTW Company Limited's landfarming facility located on Brown Road at Waitara, in the Waiongana catchment. The Report records the landfarm's environmental performance during the period under review, and the results and environmental effects of the Company's activities for the landfarm as a whole.

During the period under review, the Company held three consents for the landfarm. The landfarm has been progressively extended and reinstated, as requirements for additional capacity and changes in the nature of wastes to be discharged to land have arisen. The originally consented area, referred to for convenience in this report as the 'Brown Road' area, did not receive waste during the period under review. It remains under active management to ensure compliance with surrender conditions before the Council will allow consent surrender. The subsequent area of discharge and spreading (as of the end of the period under review) is located adjacent to the original area and is conveniently referred to as the 'Wellington' part of the facilities.

The original consent was first issued for the Brown Road area of the landfarm was **6867-1.** The consent covers the discharge of drilling cuttings, muds and fluids from hydrocarbon exploration drilling operations with water based muds, and drilling cuttings from hydrocarbon exploration drilling operations with synthetic based muds, onto and into land via land farming. This type of waste is commonly referred to as drilling waste. This part of the site, together with the part of the facility that was utilised under consent 7670-1 (see below), was being de-commissioned and reinstated during the period under review. The consent was last exercised in May 2011.

On 9 July 2010 discharge consent **7670-1** was granted to allow the facility to be extended onto the Wellington property. In April 2011 the Company lodged a stockpiling notification with the Council signalling its intent to store hydraulic fracturing return fluids (or fracking waste) at the Wellington site. As the discharge of this particular waste stream was not explicitly covered by the resource consent, the Council advised the Company that they should apply for an additional resource consent to explicitly provide for the disposal to land of this waste. This consent, **7884-1**, was granted 8 July 2011. All subsequent disposals at the Wellington section of the facility have been undertaken under the new discharge consent. Consent 7670-1 was surrendered on 3 August 2012, as contaminant surrender criteria had been met for the two spreading areas used under the relevant consent, and all activities were now being covered by the newer discharge consent.

The Council's monitoring programme for the period under review included twelve inspections, three intertidal inspections, the second year of a field-based study, a field-based radioactivity assessment, and reviews of monitoring data received from the Company. For the particular activities covered by consent 7884-1, the programme further included:

a) the collection of five soil samples and four surface water samples (two upstream and two downstream of the storage areas) in 2011-2012, and

b) the collection of four composite soil samples from spreading areas and fifteen groundwater samples from monitoring wells collected for physicochemical analysis, further alpha/beta radioactivity testing of fluids, and additional investigative sampling of perforated drainpipes, storage pit bases and groundwater seeps, in 2012-2013.

The monitoring indicated that there appears to be no adverse environmental effects on surface soils due to activities at the landfarming facility. Concentrations of contaminants in the soils meet the required application criteria for measured parameters as set out in consent conditions of consent 6867-1 and 7884-1. At the conclusion of the monitoring period, the Company were looking to surrender resource consent 6867-1 on the basis of soil sample results. The Council will conduct further sampling to ensure that surrender criteria are met, as part of the surrender application process.

During the period, the Company demonstrated an overall high level of environmental performance and compliance with resource consent 6867-1. There were no incidents recorded by the Council that were associated with activities under this consent at this site.

In respect of consent 7884-1, hydrocarbon concentrations for recent disposals had not yet attained the reductions that would be required at the time of ultimate surrender, but are expected to do so based on results from previous disposals. Further monitoring of the site will ensure that any consent limits potentially exceeded, are complied with prior to surrender.

Towards the end of the 2011-2012 monitoring year Council scientific staff initiated a more comprehensive investigation into the effects of activities on localised groundwater in the vicinity of the landfarming facility. The monitoring in 2011-2012 showed that effects of site activities were detected in the groundwater in the immediate vicinity of the storage area. The Council's concerns over the extent of control of wastes while in storage meant that the Company's overall performance in the 2011-2012 year was rated as 'good' rather than 'high'. Upon further investigation, these effects were found to have reached the site boundary via pre-existing artificial drainage beneath the site. Overall adverse environmental effects were less than minor, given the lack of any groundwater use, but operational shortcomings were identified and subsequently enforcement action was undertaken. There were four Unauthorised Incidents (UIs) recording non-compliance in respect of consent 7884-1 during 2012-2013. As a result, the Company was rated as demonstrating a poor performance in respect of consent 7884-1 for the 2012-2013 year, based on these failures in administrative compliance.

Therefore, for the period under review, the Company demonstrated an overall high level of environmental performance and compliance with resource consent 6867-1, a good level of environmental performance and compliance with resource consent 7884-1 in 2011-2012, and a poor performance in respect of administrative compliance with consent 7884-1 for the 2012-2013 year.

This report includes recommendations for the 2013-2014 year.

Postscript: The BTW landfarm at Brown Road is the only landfarm in Taranaki that has received hydraulic fracturing return fluids (ie fracking waste). Since the period that this report relates to (July 2011 – June 2013), the application of waste, including fracking waste, to land at the landfarm has ceased. Currently, deep well injection is the only method of fracking waste disposal in Taranaki.

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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 the Biennial Report for the period July 2011-June 2013 by the Taranaki Regional Council describing the monitoring programmes associated with the resource consents held by BTW Company Limited (BTW), to operate reception, storage, landfarming, and monitoring facilities on a landfarm situated on Brown Road at Waitara. This is the fifth Report to be prepared by the Taranaki Regional Council to cover the Company's discharges and their effects at this site. The site was extended in 2010-2011, and this is the second report to cover the activities at the expanded facility.

There has been a landfarm on Brown Road for several years. The original development of the facility ('Brown Road landfarm') was no longer used for the disposal of drilling waste since prior to the period under review. Stockpiling at this part of the site commenced in April 2006, and disposals at this site ceased in May 2011. During the 2010-2011 monitoring year, BTW were granted resource consent to expand operations into a second area to the immediate east of the original property. This second development was referred to as the 'Wellington' site, after the property owner, to distinguish it from the activities at the site as first established. The 'Wellington' part of the facilities became the primary disposal site in the 2010-2011 monitoring year, while BTW continued to manage both the original area and the area subsequently developed, in accordance with the applicable consents.

During 2011-2012, the Council required BTW to apply for an additional resource consent to explicitly provide for the disposal of well work-over and production fluids, including hydraulic fracturing return fluids, in the newer area. This consent was granted on 8 July 2011. The landfarm extension was utilised for the remainder of the monitoring period to dispose of several different types of hydrocarbon exploration and production waste, in accordance with the latest consent. The initial consent for the Wellington area was subsequently surrendered during the 2011-2012 monitoring year as surrender criteria were deemed to have been satisfied, and all further activities were covered under the new consent.[1]

Monitoring of the site will continue until the consents are either successfully surrendered or expire, at which time contaminant levels in the soils must be within limits specified in the Ministry for the Environment's 'Guidelines for assessing and managing petroleum hydrocarbon contaminated sites in New Zealand' (MfE, 1999) and 'Guidelines for the safe application of biosolids to land' (MfE, 2003).

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 Resource Management Act and the Council's

[1] Since the period that this report relates to (July 2011 – June 2013), the application of hydraulic fracturing return fluids to land at BTW landfarm at Brown Road has ceased. See the postscript to the Executive Summary.

obligations and general approach to monitoring sites through annual programmes, the resource consents held by BTW, the nature of the monitoring programmes in place for the period under review, and a description of the activities and operations conducted at the Company's landfarm.

Section 2 presents the results of monitoring during the period under review, including scientific and technical data, for the activities covered under consent 6867-1.

Section 3 presents the results of monitoring during the period under review, including scientific and technical data, for the activities covered under consent 7884-1.

Section 4 discusses the results, their interpretation, and their significance for the environment.

Section 5 presents recommendations to be implemented in the 2013-2014 monitoring year.

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

1.1.3 The Resource Management Act (1991) and monitoring

The Resource Management Act 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 Taranaki Regional Council is recognising the comprehensive meaning of `effects' inasmuch as is appropriate for each discharge source. Monitoring programmes are not only based on existing permit conditions, but also on the obligations of the Resource Management Act to assess the effects of the exercise of consents. In accordance with section 35 of the Resource Management Act 1991, the Council undertakes compliance monitoring for consents and rules in regional plans; and maintains an overview of performance of resource users against regional plans and consents. Compliance monitoring, (covering both activity and impact) monitoring, also enables the Council to continuously assess its own performance in resource management as well as that of resource users particularly consent holders. It further enables the Council to continually re-evaluate its approach and that of consent holders to resource management, and, ultimately, through the refinement of methods, and considered responsible resource utilisation to move closer to achieving sustainable development of the region's resources.

1.1.4 Evaluation of environmental performance

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

- a **high** level of environmental performance and compliance indicates that essentially there were no adverse environmental effects to be concerned about, and no, or inconsequential (such as data supplied after a deadline) non-compliance with conditions.

- a **good** level of environmental performance and compliance indicates that adverse environmental effects of activities during the monitoring period were negligible or minor at most, or, the Council did not record any verified unauthorised incidents involving significant environmental impacts and was not obliged to issue any abatement notices or infringement notices, or, there were perhaps some items noted on inspection notices for attention but these items were not urgent nor critical, and follow-up inspections showed they have been dealt with, and any inconsequential non compliances with conditions were resolved positively, co-operatively, and quickly.

- **improvement required (environmental)** or **improvement required (administrative compliance)** (as appropriate) indicates that the Council may have been obliged to record a verified unauthorised incident involving measurable environmental impacts, and/or, there were measurable environmental effects arising from activities and intervention by Council staff was required and there were matters that required urgent intervention, took some time to resolve, or remained unresolved at the end of the period under review, and/or, there were on-going issues around meeting resource consent conditions even in the absence of environmental effects. Abatement notices may have been issued.

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

For reference, in the 2012-2013 year, 35% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of environmental performance and compliance with their consents, while another 59% demonstrated a good level of environmental performance and compliance with their consents.

1.2 Process description

1.2.1 Site description

The landfarm is located on Brown Road, Waitara. The area first used, is located on the property of Papawai Holdings Limited. The extension onto the adjoining

Wellington property is to the immediate east. Both areas are identified in Figure 1. These areas are located on marginal coastal farm land situated on reworked dune fields. The predominant soil type has been identified as black loamy sand. Vegetation growth is primarily a mixture of pasture and dune grasses. Prior to the Wellington property consents (7670-1, 7884-1) being exercised there were areas of pine which have been subsequently removed and processed.

Average annual rainfall for the site is 1383mm (taken from nearby Motunui monitoring station). There are no significant surface water bodies located in the immediate vicinity of the areas that are landfarmed, other than small farm drains. Previous land use at the Wellington section of the landfarm has been a mixture of agricultural and small scale forestry. Further inland there are a number of commercial chicken sheds; one is located on the site (Figure 1).

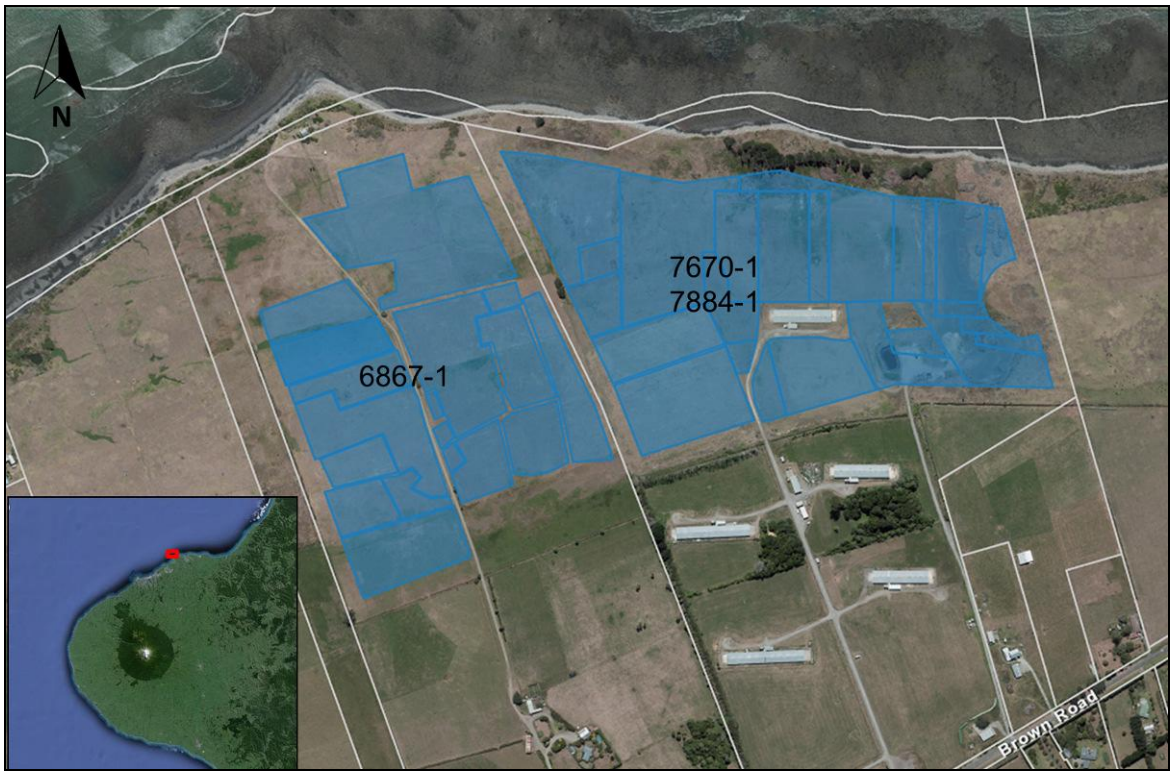

Figure 1 Aerial photograph showing the layout of the landfarming facilities on Brown Road, Waitara, and approximate regional location (inset)

The land farming operations are being used to assist the conversion of unstable shifting sands to productive pasture. Landfarming is a technology that uses natural and assisted bioremediation to reduce the concentration of petroleum compounds through degradation, while simultaneously utilising the drilling muds to stabilise poor quality sandy soils for subsequent land use. Photos 1 and 2 demonstrate the effectiveness of the landfarming process in terms of land stabilisation at this site.

Results of an independent research project conducted by AgKnowledge Ltd (2013) have indicated that the re-contoured sand dunes, after the inclusion of the drilling wastes (as per the consents), and with the addition of appropriate fertilisers and water (irrigation) are capable of producing high quality clover-based pastures and thus increasing the value of the land from about $3-4,000/ha to $30-40,000/ha (2013).

One of the landfarms sampled as part of this research project was the Brown Road landfarm. The full report is attached in Appendix IV.

Photo 1 Property prior to landfarming, showing significant areas of exposed sand

Photo 2 Spreading areas B10 and B4 post-spreading and sowing showing pasture establishment

1.3 Hydrocarbon exploration and production wastes management

1.3.1 Drilling wastes and production wastes

For the purposes of disposal to land, waste from the petroleum industry can be divided into two broad categories; exploration (drilling) wastes, and production wastes.

Drilling wastes

Waste drilling material is produced during well drilling for hydrocarbon exploration. The primary components of this waste are drilling fluids (muds) and rock cuttings. Drilling fluids are engineered to perform several crucial tasks in the drilling of a hydrocarbon well. These include: transporting cuttings from the drill bit to the well surface for disposal; controlling hydrostatic pressure in the well; supporting the sides of the hole and preventing the ingress of formation fluids; and lubricating and cooling the drill bit and drill pipe in the hole.

Drilling fluids

Oil and gas wells may be drilled with either synthetic based mud (SBM) or water based mud (WBM). As the names suggest, these are fluids with either water (fresh or saline) or synthetic oil as a base material, to which further compounds are added to modify the physical characteristics of the mud (for example mud weight or viscosity). More than one type of fluid may be used to drill an individual well. In the past, oil based muds (diesel/crude oil based) have also been used. Their use has declined since the 1980s due to their ecotoxicity; they have been replaced by SBM. SBM use olefins, paraffins or esters as a base material. While this is technically still a form of oil based fluid, these fluids have been engineered to remove polycyclic aromatic hydrocarbons, reduce the potential for bioaccumulation and accelerate biodegradation compared with OBM.

Common constituents of WBM and SBM include weighting agents, viscosifiers, thinners, lost circulation materials (LCM), pH control additives, dispersants, corrosion inhibitors, bactericides, filtrate reducers, flocculants and lubricants. Of these, the naturally occurring clay mineral barite (barium sulphate) is generally the most common additive. It is added to most drilling muds as a wetting and weighting agent.

Drilling fluids are normally recovered from return flows during the drilling of a well, for re-use after separation from rock cuttings. They may be intentionally discharged in bulk for changes to the drilling fluid programme or at the completion of drilling. Depending on operational requirements and fluid type and properties, fluids may be re-used in multiple wells.

Cuttings

Cuttings are produced as the drill bit penetrates the underlying geological formations. They are brought to the surface in the drilling fluid where they pass over a shaker screen that separates the cuttings and drilling fluids. The drilling fluids are recycled for reuse within the drilling process, but small quantities of drilling fluids remain adhered to the cuttings. The cuttings and smaller particle material from the drill fluid treatment units drain into sumps. If sumps cannot be constructed corrals or special bins are used. During drilling this material is the only continuous discharge.

Production wastes

Produced water

Produced water is subsurface water brought to the surface with oil and gas during the production of a well. It is primarily highly saline water, but its chemistry is altered through direct contact with geological formations and hydrocarbon reservoirs. The physical and chemical properties of produced water vary considerably depending on the geographic location of the field, geological formations, and the type of hydrocarbon product being produced.

Produced water is typically disposed of using deep well injection or similar disposal methods, but fixed quantities have on occasion been disposed of to land following evaluation of chemical concentrations and using different application methodologies.

Fracturing return fluids

Water and sand (proppant) make up 98% to 99.5% of the fluid used in hydraulic fracturing. In addition, chemical additives are used. The exact formulation varies depending on the well. Chemicals serve many functions in hydraulic fracturing. From limiting the growth of bacteria to preventing corrosion of the well casing, chemicals are needed to ensure that the fracturing job is effective and efficient.

The number of chemical additives used in a typical fracture treatment depends on the conditions of the specific well being fractured. A typical fracture treatment will use very low concentrations of between 3 and 12 additive chemicals, depending on the characteristics of the water and the tight sand/shale formations being fractured. Each component serves a specific, engineered purpose. For example, the predominant fluids currently being used for fracture treatments in the gas shale plays are water-based fracturing fluids mixed with friction-reducing additives (called slickwater). The addition of friction reducers allows fracturing fluids and sand, or other solid materials called proppants, to be pumped to the target zone at a higher rate and reduced pressure than if water alone were used.

In addition to friction reducers, other additives include: biocides to prevent microorganism growth which can interfere with the gel management system, and to reduce biofouling of the fractures and the production of sour gas; oxygen scavengers and other stabilisers to prevent corrosion of metal pipes; and sometimes used acids that are used to remove drilling mud damage within the near-wellbore area. These fluids are used to create the fractures in the formation and to carry a propping agent (typically silica sand), which is deposited in the induced fractures to keep them from closing up.

The fracturing fluids disposed of to land through landfarming in Taranaki have been return fluids following the completion of hydraulic fracturing jobs. The make-up of these fluids is altered during the fracturing process as these fluids interact with hydrocarbon reservoirs and varying geological formations. This material is tested for an extensive range of contaminants prior to storage and subsequent disposal.

Fracturing fluids are disposed of in Taranaki via deep well re-injection. The discharge to land through landfarming of return fluids following the completion of

hydraulic fracturing jobs in Taranaki has been explicitly consented only at the Wellington area of the Brown Road landfarm.[2]

Other waste types

Oily wastes generated from hydrocarbon exploration and production activities generally consist of: sludge and wax removed from tanks and separators; slops oil from wellhead cellars; oily formation sand; and contaminated ground material from leaks and spills.

Hydrocarbon contaminated soil may be disposed of to land via landfarming, if contaminant levels (generally hydrocarbon and heavy metals) are within range of meeting application (metals) and consent surrender (hydrocarbon) loading criteria.

1.3.2 Landfarming process description

The landfarming process has typically been used in the Taranaki region to assist the conversion of sandy coastal sites prone to erosion into productive pasture. Landfarming is a technology that uses natural and assisted bioremediation to reduce the concentration of petroleum compounds through degradation, while simultaneously utilising the drilling muds to stabilise poor quality sandy soils for subsequent land use.

Results of an independent research project conducted by AgKnowledge Ltd (2013) have indicated that the re-contoured sand dunes, after the inclusion of the drilling wastes (as per the consents), and with the addition of appropriate fertilisers and water (irrigation) are capable of producing high quality clover-based pastures and thus increasing the value of the land from about $3-4000/ha to $30-40,000/ha (2013). The full report is attached in Appendix IV.

[2] Since the period that this report relates to (July 2011 – June 2013), the application of hydraulic fracturing return fluids to land at BTW landfarm at Brown Road has ceased. See the postscript to the Executive Summary.

Photo 3 View seaward from storage area across spreading areas F7 and F5 showing pasture establishment

The landfarming process utilised at the Brown Road facility is on a single application basis. This means dedicated spreading areas receive only single applications of waste. Basic steps in the landfarming process include:

1. Waste is transported from wellsites. It may be discharged directly to land or placed in a dedicated storage pit.
2. The required area is prepared by scraping back and stockpiling existing pasture/topsoil and levelling out uneven ground.
3. Waste is transferred to the prepared area by excavator and truck and spread out with a bulldozer. Liquids may be discharged by tanker or a spray system.
4. Waste is allowed to dry sufficiently before being tilled into the soil to the required depth with a tractor and discs.
5. The disposal area is levelled with chains or harrows.
6. Stockpiled or brought in topsoil/clay is applied to aid stability and assist in grass establishment.
7. Fertiliser may be applied and the area is sown in crop or pasture at a suitable time of year, to re-instate and stabilise the site for future alternative use.

Consent 6867-1 allows for the disposal of drilling wastes. Oily wastes were added in the changes to the consent on 4 February 2010.

Consent 7670-1 allowed for the disposal of drilling wastes, and of oily wastes from hydrocarbon exploration and development activities. This consent was surrendered during the period under review, as activities at the second stage of the landfarm development are now covered by consent 7884-1.

Consent 7884-1 allows for the disposal of drilling wastes, oily wastes, contaminated soil and production fluids including hydraulic fracturing return fluids.[3]

When disposal is complete, the area will be re-instated and the consents surrendered once proven to be suitable for uses such as grazing, following stabilisation and re-grassing.

1.4 Resource consents

1.4.1 Discharges of wastes to land

Sections 15(1)(b) and (d) of the Resource Management Act 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.

BTW holds discharge permit **6867-1** to cover the discharge of drilling cuttings, muds and fluids from hydrocarbon exploration drilling operations with water based muds, and drilling cuttings from hydrocarbon exploration drilling operations with synthetic based muds, onto and into land via land farming. This permit was issued by the Taranaki Regional Council on 27 April 2006 under Section 87(e) of the Resource Management Act. It is due to expire on 1 June 2020.

Discharge permit **6867-1** was varied on 4 February 2010 to include the following changes:

- allow mixing of different waste types,
- remove the chloride and nitrogen loading limits and consequently reduce the maximum application thickness from 150 mm to 100 mm,
- reduce the buffer distance to the Tasman Sea from 100 m to 50 m,
- increase the maximum stockpiled volume from 2,000 m^3 to 6,000 m^3, and
- allow for the disposal of oily wastes,

The varied consent now outlines the discharge of drilling wastes [consisting of drilling cuttings and drilling fluids] from hydrocarbon exploration activities with water based muds and synthetic based muds, and oily wastes from hydrocarbon exploration and production activities, onto and into land via landfarming.

Condition 1 sets out definitions.

Condition 2 concerns adoption of the best practicable option.

Condition 3 requires a management plan.

Conditions 4 and 5 relate to notification and sampling requirements prior to discharge.

[3] Since the period that this report relates to (July 2011 – June 2013), the application of hydraulic fracturing return fluids to land at the BTW landfarm at Brown Road has ceased. The landfarm is now closed. See the postscript to the Executive Summary.

Conditions 6 and 7 relate to monitoring and reporting.

Conditions 8 to 14 specify discharge limits.

Conditions 15 to 23 specify receiving environment limits.

Conditions 24 and 25 concern archaeological remains and consent review.

The permit is attached to this report in Appendix I.

BTW held discharge permit **7670-1** to cover the discharge of wastes from hydrocarbon exploration drilling operations with water based muds and synthetic based muds, and oily wastes from hydrocarbon exploration and production activities, onto and into land via land farming. This permit was issued by the Taranaki Regional Council on 9 July 2010 under Section 87(e) of the Resource Management Act. This consent was superseded by consent 7884-1 during the 2011-2012 monitoring year, and was subsequently surrendered by BTW on 3 August 2012.

BTW holds discharge permit **7884-1** to cover the discharge of wastes from hydrocarbon exploration drilling operations with water based muds and synthetic based muds, and oily wastes from hydrocarbon exploration and production activities, condensate storage tank wastewater, and well work-over fluids (which includes fracturing fluids) onto and into land via land farming. This permit was issued by the Taranaki Regional Council on 8 July 2011 under Section 87(e) of the Resource Management Act. It is due to expire on 1 June 2027.

There are 30 special conditions attached to the consent.

Conditions 1 to 3 deal with definitions, best practicable option and wastes to be discharged.

Conditions 4 to 8 deal with notifications, monitoring and reporting.

Conditions 9 to 11 relate to storage of wastes.

Conditions 12 to 20 deal with discharge limits.

Conditions 21 and 22 set limits on contaminants in receiving waters.

Conditions 23 to 27 deal with contaminants in soil.

Condition 28 relates to any archaeological remains found.

Conditions 29 and 30 deal with lapse and review of the consent.

A copy of the permit is attached in Appendix I.

1.5 Monitoring programme

1.5.1 Introduction

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

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

The monitoring programme for the Brown Road landfarm consents consisted of seven primary components implemented across the entire landfarm, together with particular additional monitoring undertaken in respect of consent 7884-1.

1.5.2 Programme liaison and management

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

1.5.3 Site inspections

Four scheduled inspections of the entire landfarm facility were undertaken in the 2011-2013 period. Additional inspections were undertaken of the second stage development (Wellington), as this was the area that was continuing to receive discharges during the period under review. As aforementioned, the original site is no longer operational, so the main points of interest were the on-going effects upon soil quality and pasture cover. Five inspections were carried out at the Wellington section of the landfarm development in 2011-2012, and 7 inspections were carried out in 2012-2013. The main points of interest re consent 7884-1 were the management of stockpiling and land disposal processes, and the effects upon soil quality and pasture establishment, together with potential or actual discharges of contaminated stormwater to receiving water courses. Several additional inspections were undertaken on an investigative basis following incidents recorded at the site.

The immediate area around the entire facility was surveyed for environmental effects including any odours.

1.5.4 Chemical sampling

Five composite soil samples from disposal areas at the Wellington landfarm were collected by Council staff in 2011-2012, and four in 2012-2013. The methodology utilised was compositing 10-15 soil cores (250 mm depth) taken at 10 m intervals along transects through spreading areas. These were analysed for chloride, conductivity, hydrocarbons, pH, SAR, sodium and total soluble salts.

On two occasions in the 2011-2012 year, samples of surface water were collected upstream and downstream of the storage pits located on the Wellington property. These were analysed for barium, chloride, conductivity, hydrocarbons, pH, and total dissolved salts.

In the 2012-2013 year, three composite soil samples were taken from test pits dug at the base of the oily waste pit following spreading of material and tested for hydrocarbons as part of additional investigative sampling. A soil sample was also collected from the base of 'Pit A' following the spreading of produced water and partial reinstatement of the pit.

The ponded water located in the spreading area and investigated in 2011-2012 was re-sampled once for total hydrocarbons in 2012-2013.

Four groundwater monitoring wells were installed at the site during the 2012-2013 monitoring year. These bores were sampled on four occasions. Samples were analysed for pH, conductivity, TPH and BTEX, chloride, barium, and total dissolved solids.

Investigative sampling was also conducted of the perforated drainage pipes located on-site, and natural seeps at the site boundary.

1.5.5 Review of analytical results

The Council reviewed soil sampling results, the Company's 2011-2012 and 2012-2013 annual reports, and the surrender of consent proposal report provided by the Company (provided in place of an annual report in 2013 in respect of the original facilities covered under consent 6867-1). The Company collected receiving environment soil samples from all spreading areas post waste application. These samples were sent to an independent IANZ accredited laboratory for analysis for a wider range of contaminants. Chemical parameters tested were (all solid/sludge samples):

- pH
- chlorides
- potassium
- sodium
- total nitrogen
- barium
- heavy metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg)
- BTEX
- PAHs
- TPH (and individual hydrocarbon fractions C7-C9, C10-C14, C15-C36)

Receiving environment soil samples were also tested for electrical conductivity and sodium absorption ratio (SAR).

Liquid and oily waste predisposal samples were analysed for additional contaminants.

1.5.6 Marine ecological surveys

Three marine ecological surveys were carried out at four survey locations (3 potential impact and 1 control locations) during the monitoring period in order to assess any impacts on the shoreline caused by landfarming activities.

1.5.7 Radioactivity assessment

During the 2011-2012 monitoring period field-based assessments were conducted at and around the entire landfarm and its environs, using a handheld Thermo Electron Corp ESM FH 40 G-L Radiometer to monitor levels of radioactivity potentially associated with fracturing return fluid tracers and/or naturally occurring radioactive materials (NORMs) present in either return fluids or rock cuttings. While all measured levels were well within background/normal ranges of gamma radioactivity, it was recommended that direct sampling was conducted of return flow liquids to assess for levels of alpha/beta radioactivity to determine whether there could be any significant human or animal health risks from any potential exposure. Therefore during the 2012-2013 year under review, a sample was taken of produced water held in 'Pit A' and sent to the National Radiation Laboratory (NRL) in Christchurch for analysis.

1.5.8 Study of soil ecological state

The Council has initiated a study of the potential effects of landfarming of drilling wastes (both from drilling activities and from hydraulic fracturing of bearing formations for enhanced production) on soils' ecological communities. This study follows on from earlier studies of site productivity, which demonstrated significant environmental and economic benefits from the landfarming of drilling wastes when landfarms were subsequently returned to pasture for grazing. The new study was targeted at the microscopic level, and was to involve ongoing sampling over a three-year period of landfarming at several landfarms prior to, during, and following the application of wastes, and analysis for nematodes and soil microbes along with physicochemical analysis. The Brown Road landfarm was one of the study landfarms for this project. In the 2011-2012 monitoring year the areas of the Brown Road landfarm to which consent 7884-1 apply were also included in the project, to assess for potential effects on soil ecology specifically from the spreading of hydraulic fracturing return fluids.

In the 2011-2012 period under review, the Council implemented Year two of the three year bio-monitoring project investigating the effects of landfarming on nematode and microbe populations and pasture yield in coastal Taranaki pastures. In particular, the effects of high chloride and petroleum hydrocarbon loadings on nematode community structure and abundance as well as microbe community structure and activity were investigated. The study comprised numerous soil samples collected for soil chemistry analysis and elucidation of ecological communities of microbes, nematodes, pasture yield, and soil bulk density and other soil properties.

After the second year, the study evolved into a more specific and sensitive laboratory-based investigation of soil ecology sensitivity to waste treatment activities.

2. Results - Consent 6867-1

2.1 Inspections

Five inspections were undertaken at the original site (as first established) during the 2011-2013 monitoring period. The following observations were recorded.

11 October 2011
No objectionable odours were observed during the inspection. No recent mud application had occurred at the site to which the consent applied, and pasture had established throughout. Muds were still visible within the soil profile. All ponded water around the area was free of hydrocarbon sheen.

13 June 2012
No objectionable odours were found during the inspection. No mud storage was occurring at the site. All historical application areas were found to have good pasture growth. All ponded water around the area was free of hydrocarbon sheen.

22 November 2012
No objectionable odours were found during the inspection. All paddocks where mud has been spread had good pasture cover which appeared healthy. No mud storage was occurring and no pits were present.

18 January 2013
No mud storage was occurring, all pasture inspected appeared healthy with good cover. No mud was identified within the soil matrix and no hydrocarbon odours were noted within the soil.

17 April 2013
No objectionable odours or visible emissions were detected during the inspection. No recent disposal activity had occurred at the site and no storage pits were present. All areas where muds have been historically applied looked good and the grass growth appeared healthy. No hydrocarbon sheen was observed within any of the ponded water around the paddocks.

2.2 Notifications and provision of consent holder information

During the monitoring period there were several exchanges of correspondence between the Council and BTW over various matters, including the potential surrender of Consent 6867-1 and design and implementation of the ecological monitoring programme.

2.2.1 Annual reporting

Consent 6867-1 requires the provision of an annual report by the consent holder by 31 August each year, incorporating comprehensive details on the composition and on-site management of wastes. The report for the 2011-2012 year for the exercise of Consent 6867-1 was received on 2 August 2012. This report met the technical requirements of the consent; however, Council scientific staff advised BTW that their data provision and annual reporting formats required review. This report is attached in Appendix II.

At the conclusion of the 2012-2013 monitoring year the Company were in discussions with the Council about surrendering consent 6867-1. The Company submitted a surrender application report, which also met the technical requirements of the annual report for the 2012-2013 period. This report is included in Appendix III.

2.3 Results of receiving environment monitoring

No material was received on the first stage of the landfill site during the monitoring period, and no further material will be discharged at the site under consent 6867-1. Monitoring therefore focuses on compliance with relevant conditions that must be satisfied in order to surrender the consent. Figure 2 is a map of the completed site with all spreading areas utilised under consent 6867-1.

BTW is required to undertake and to provide the Council with results of soil sampling, to ensure compliance with consent conditions. There are requirements around the method of application and the consequent soil quality. Soil sampling was undertaken by the Company as required, on the dates as shown. Key results are summarised below in Tables 1 and 2. Full details of the sampling regime and the results are attached in Appendices II and III.

Table 1 Summary of Company's receiving environment compliance monitoring data for 2011-2012 monitoring year

	Date	03-Aug-11					11-Aug-11	15-Nov-11		23-Nov-11	10-Feb-12	
	Area	B2	B4	B15	B16	B14	B13	B5	B15	B10	B11	B10
Parameter	Surrender limit*											
C7-C9	120	<8	<8	<8	<15	<9	<9	<8	<9	<8	<8	<8
C10-C14	58	<20	21	**750**	<30	**2900**	**79**	<20	**1390**	**180**	<20	<20
C15-C36	4,000	103	220	2300	60	**8800**	650	<40	**4800**	1540	187	<40
TPH		103	241	3500	60	11700	730	<70	6200	1720	187	<70
Chloride	700	10	15	44	63	370	-	7	101	-	-	-
Total Recoverable Barium	10,000	2300	2100	2800	61	3200	1710	1240	2900	-	-	-

All units mg/kg
**These limits apply only at time of consent surrender/expiry. Highlighted figures show potential exceedance only*
The limit for C10-C14 is based on this number being used as a proxy for the possible presence of PAHs.
C7-C9: Concentration of compounds with 7, 8, or 9 carbon atoms in their molecular structure (and similarly for C10-C14, C15-C36)
TPH: total petroleum hydrocarbons

Figure 2 Usage of landfarm spreading areas B1-B16 (consent 6867-1)

Table 1 presents the results for the 2011-2012 monitoring year against surrender criteria. The results of the Company's monitoring analyses of petroleum hydrocarbons (TPH) showed that the consent limit for the lightest fraction (C7-C9) that will apply at the time of cessation of the consent was already satisfied for the areas analysed. For the middle fraction (C10-C14), the concentrations of hydrocarbons were higher than will be allowed at the time of cessation of the consent for spreading areas B15, B14 and B10. However, it should be noted that the Ministry for the Environment guidelines on which the consent limit is based, note that the C10-C14 limit is derived on the basis of ensuring protection against excessively high concentrations of BTEX and polycyclic aromatic hydrocarbons; the straight chain hydrocarbons that are also measured by a C10-C14 analysis are far less of concern environmentally.

There is no consent condition relating to barium, but it has been a contaminant of interest for the Council given its very high concentration within drilling muds. The Council has not found a New Zealand-based guideline for its application to land, and has in times past noted the Canadian Environmental Quality Guideline interim soil quality criterion for agricultural land use for barium of 750 mg/kg.

However, the Council now uses updated guidelines[4]. These guidelines stress the critical difference between soluble barium salts, and materials containing insoluble barite (such as are used in drilling muds).

The guideline value for protection of soil and flora ecological health for barite is 180,000 mg/kg, for protection for livestock grazing on pasture 30,000 mg/kg, and for protection of human health (by ingestion of crops and soil) 10,000 mg/kg.

In the 2012-2013 monitoring year, spreading areas B2, B4, B13, B14 and B15 were resampled to assess hydrocarbon concentrations. Previous sampling had verified compliance with heavy metal and chloride limits, so these were not analysed for. Table 2 presents the data for total hydrocarbons and indicates that all resampled areas have shown a reduction in concentrations to essentially background levels, well within the surrender criteria. The reductions (the almost complete degradation of hydrocarbons) occurred within 8 months.

Table 2 Summary of Company's receiving environment compliance monitoring data for 2012-2013

	Date	09-Jul-12				
	Area	B2	B4	B13	B14	B15
Parameter	Surrender limit					
C7-C9	120	<8	<11	<9	<8	<9
C10-C14	58	<20	<30	<20	<20	<20
C15-C36	4,000	82	<50	<40	<40	<40
TPH		82	<80	<70	<70	<70

All units mg/kg
The limit for C10-C14 is based on this number being used as a proxy for the possible presence of PAHs.
C7-C9: Concentration of compounds with 7, 8, or 9 carbon atoms in their molecular structure (and similarly for C10-C14, C15-C36). TPH: total petroleum hydrocarbons

2.4 Marine ecological surveys

Intertidal marine ecological surveys in the vicinity of the landfarm facility were conducted in spring and summer during the two monitoring periods. The surveys are designed to assess any potential impact of landfarming on the receiving coastal environment by recording any change in diversity, abundance and composition of intertidal reef communities.

The results of the three surveys are summarised below. The surveys were conducted to look specifically at the more recently used site, but given the close proximity, the results are applicable to both properties. Full survey results are therefore included in the reports for both stages of development, and are presented in Appendix V.

In order to assess the effects of the BTW landfarm facilities on the nearby intertidal communities, ecological surveys were conducted between 28 September and 13 October 2011 (spring survey) and 24 January and 11 February 2012 (summer survey) in the 2011-2012 year, and 19 September – 30 October 2012 in the 2012-2013 year, at four

[4] SOIL REMEDIATION GUIDELINES FOR BARITE: ENVIRONMENTAL HEALTH AND HUMAN HEALTH (Alberta Environmental, February 2009).

sites. These surveys included three potential impact sites and one control site (identified in Figure 3). Potential adverse effects of landfarming on the adjacent intertidal communities were assessed by comparing species richness and diversity at the potential impact sites relative to the control site.

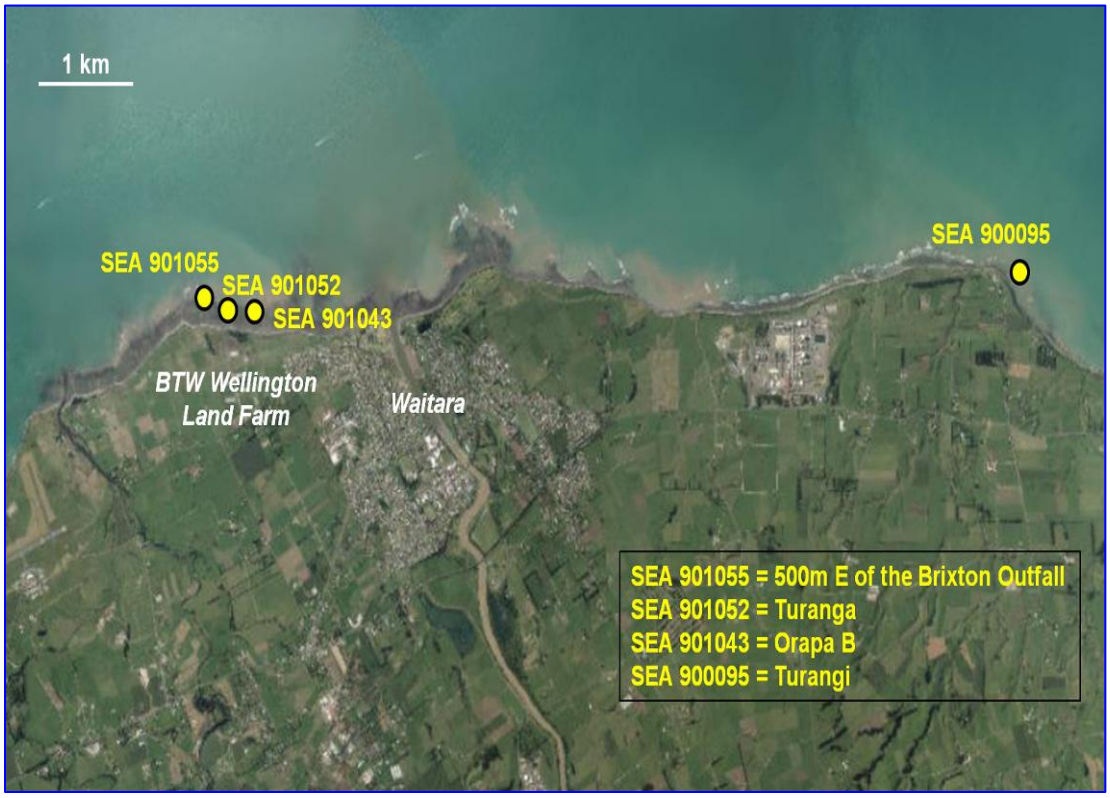

Figure 3 Ecological survey site map

During every survey it was noted that species richness and diversity were similar at the control sites and potential impact sites. The results indicate that the BTW facility was not having detectable adverse effects on the intertidal reef communities. Natural environmental factors, in particular sand inundation, appeared to be the dominant driver of species richness and diversity for the sites surveyed.

2.5 Year two of the investigation into potential effects upon soil ecology

Soils are populated by a multitude of microorganisms and invertebrates, which play an important role in the decomposition of organic matter, cycling of nutrients, energy and elemental fixation, soil metabolism and overall soil health. Among the microorganisms found in the soil are bacteria, actinomycetes, fungi, micro-algae, protozoa, nematodes, and other invertebrates (mostly arthropods). Nematodes are the most numerous multicellular animals on earth and a handful of soil will contain thousands of these microscopic worms. Many nematodes are parasites of insects, plants or animals, although free-living species are also abundant, including nematodes that feed on bacteria, fungi, and other nematodes. Thus, they are an important component of soil ecosystems and food-webs, and can therefore provide useful information on soil health and biodiversity.

The Council report on the study to date details methods and results for year one of a three year bio-monitoring project investigating the effects of land spreading/farming on nematode and microbe populations as well as pasture yield in coastal Taranaki pastures. More specifically, this study examines the effects of high chloride and petroleum hydrocarbons loadings on nematode community structure and abundance as well as microbe community structure and activity. This project builds upon and complements previous projects undertaken by the Council which have investigated the effects of land spreading on earthworm populations (as an indicator taxon for the effects on soil biota in general). These previous investigations suggested that earthworm populations are impacted upon by drilling waste application (particularly tilling, rather than the applied wastes) but that they make a slow recovery. Nematodes and microbes, being much smaller than earthworms, are likely to be substantially less vulnerable to the effects of tillage. Thus, they may be more sensitive indicators of the specific effects of contaminants on soil biota, regardless of what tilling practices were utilised. Additionally, monitoring these taxa will allow for a more comprehensive understanding of the effects of landfarming on soil biota and ecosystems.

Areas used for disposal at the Brown Road facilities were examined for evidence of effects from high chloride loading and high hydrocarbon loading (synthetic based muds). Multiple soil core samples were collected from designated areas along transits through each control and disposal area. They were then analysed for soil chemistry parameters, microbial biomass and microbial community composition by Landcare Research, and for nematode community characterisation by Lincoln University. Pasture yield was measured on-site by Council staff. Full details of methods are provided within the report.

Overall, the first year of the study found there were very few statistical differences in the parameters investigated for assessing the health of soil biota communities and soil chemical composition among control and treatment areas. Tilling a site in preparation for use appears to have the greatest effect. Initial results suggest slight changes to soil nutrient levels (carbon, nitrogen, and phosphorus), and some indicators of ecological status such as microbial biomass and respiration, after the application of drilling wastes to some treatment areas. These differences were mainly apparent in areas where synthetic-based muds had been applied (water-based muds have less impact). Nematode abundances and pasture yield were largely unaffected by drilling waste application.

In the second year of the study additional samples were taken from area F7 pre and post spreading of hydraulic fracturing return fluids, to assess whether the fracture return fluids posed any additional or specific risk. Nematode community structure and abundance, and microbe community abundance and activity were assessed along with soil parameters (total carbon and nitrogen, electrical conductivity, soil pH, phosphates and microbial biomass), and fracture return fluid constituents.

Results from the second year of this study were consistent with those in the first part of the study. It was apparent when reviewing both sets of data that there were several confounding variables that could not be accounted for in the current field based study alone. This led the Council to re-evaluate the project design and develop a laboratory based study which would complement the existing work, but focus only on the chemical effects of drilling waste on soil organisms.

The following recommendation was included in an internal memorandum, which has been included in Appendix VI.

Recommendation: That the remaining sample periods relating to the compliance monitoring programs for Consents 6867-1, 6135-1 and 7884-1 be cancelled due to lack of conclusive results arising from the environmental biases inherent in this sampling method. Results from the landfarming samples taken to date will be written up and included in the annual 2012/2013 compliance monitoring report. In place of continuing with field-based studies, lab-based tests of the toxicity of drilling muds on soil biota under controlled laboratory conditions will be initiated, and carried out under contract by Landcare Research.

A summary of the findings from the first two years of the field-based study, including a recommendation to move towards a laboratory based study, is included in Appendix VI. The laboratory based study project brief is also attached to this report in Appendix VI.

2.6 Investigations, interventions, and incidents

The monitoring programme for the period was based on what was considered to be an appropriate level of monitoring, review of data, and liaison with the consent holder. During the year matters may arise which require additional activity by the Council eg provision of advice and information, or investigation of potential or actual courses of non-compliance or failure to maintain good practices. A pro-active approach that in the first instance avoids issues occurring is favoured.

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

The Unauthorised Incident Register (UIR) includes events where the company concerned has itself notified the Council. The register contains details of any investigation and corrective action taken.

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

In the 2011-2013 period, it was not necessary for the Council to record any incidents in association with BTW's conditions in resource consent 6867-1 or provisions in Regional Plans in relation to the activities at the landfarm during the monitoring period.

However, during 2011-2012 the Council noted that some contaminants arising from the disposal of drilling wastes could be detected (at extremely low levels of no environmental significance) within the shallow groundwater beneath the site, and decided to initiate further investigation into potential impacts of this activity on localised groundwater. Therefore Council staff advised BTW that additional monitoring would be required in the 2012-2013 monitoring year. These additional investigations were conducted as indicated. BTW staff were receptive and cooperative with all Council requests and showed a high degree of professionalism at all times.

3. Results - Consent 7884-1

3.1 Inspections

Five inspections were undertaken of the areas consented by Consent 7884-1 at the landfarm during the monitoring year 2011-2012, and 7 during 2012-2013. These are discussed below.

18 August 2011
No activity was occurring on site at the time of inspection. No objectionable odours were detected during the inspection, although minor dust emissions were observed beyond the pit site boundary due to strong wind. All muds within pits were secure, and signage was present throughout. A pit along the northern perimeter that had been recently emptied had had damage to the liner and would need to be relined if used again. Earthworks were progressing and muds had been incorporated satisfactorily. Stockpiled topsoil appeared stable.

11 October 2011
A moderate wind was blowing from the north, no objectionable odours were found beyond the boundary of the site. All muds were secure in pits and plenty of freeboard was available. It was observed that one of the pit liners had considerable air pockets causing the liner to bubble in the centre. Some surface hydrocarbons were present on some of the pits and noticeable odours were present around these areas. Topsoil where muds had been applied had been re-contoured and looked good. Pasture was starting to establish nicely. Muds were still visible within the soil profile. The shoreline was inspected and no effects from site activities were observed.

25 November 2011
Strong hydrocarbon odours were noted downwind of the pits, however no objectionable odours were found beyond the site boundary. All drilling mud was found to be secure in the pits, with plenty of freeboard. A surface oily layer was present in each pit. An area of recent application had been contoured and re-sown, with pasture strike looking healthy. Signage was found to be satisfactory. An inspection of the shoreline found no effects from site activities.

11 April 2012
No objectionable odours were found beyond the site boundary, although there were localised hydrocarbon odours found around the pits containing wastes. All mud was secure within the pits. Some liners showed extensive storm damage around the fringes and these were scheduled to be replaced shortly. All pits were found to have plenty of freeboard and no evidence of overflow was found. Signage was good throughout the site. The shoreline was inspected and no effects from site activities were found. The areas where mud was last spread had been re-sown and the pasture cover appeared stable and healthy. It was noted that landfarming activities were expected to occur shortly and appropriate notifications would be given.

13 June 2012
Strong hydrocarbon odours were noted around the site from several pits, however no objectionable odours were found beyond the site boundary. All pit linings appeared to be intact and all muds were secure within their pits. Signage was good throughout. Washing of bins was occurring onto the unsealed surface of the site area, with all washings remaining localised and discharging into land.

Land-farming operations were occurring at the time of the visit and these appeared well managed. There were minor visible dust clouds around the stockpiled topsoil. A shoreline assessment was undertaken and no effects from site activities were found. All ponded groundwater downstream of the storage site appeared clear. Cattle were grazing areas of pasture which had recently been re-sown.

2012-2013

Seven scheduled inspections were undertaken at the Wellington section of the landfarm during the monitoring period. These are discussed below. Included is also an inspection that took place in August, where it was decided further investigation of site activities was required. Following this, further investigative and follow up inspections were conducted during the monitoring year. These are detailed in Section 3.6.

25 July 2012

Strong hydrocarbon/mud odours were detected downwind of the storage site. All muds were secure within pits, although the large pit on the right of the site when entering was found to have very little freeboard available. All liquids within the pits were found to have some degree of surface oiling. Some of the liners showed signs of weathering around the exposed top sections and the wind was causing an inflation effect due to the small tears. Ponded water in the vicinity of the storage area showed a hydrocarbon surface sheen. The spring beyond the seaward side of the site was inspected and found to be flowing at approximately 0.5 l/s, the liquid appeared high in iron and when disturbed the surface rainbow sheen behaved as an iron-mineral surface layer does, rather than as a hydrocarbon sheen. The shoreline was inspected and no effects were observed. Topsoil had been removed from an area recently cleared of trees to the northwest of the storage area, all stockpiled material was confined to the pits and very little dust was being mobilised in the strong wind. The water table appeared high at the time of inspection, which was attributed to the recent period of sustained rainfall.

16 August 2012

Following concerns raised by Council's scientific staff in June and July 2012, an inspection was undertaken by scientific and inspectorate management staff of the stockpiling facilities at the site. After subsequent discussion, it was decided that additional investigations (including sampling) would be undertaken into the potential impacts on localised groundwater in the vicinity of the stockpiling facilities. An incident was registered against the site. This is discussed further in Section 3.6.

22 November 2012

No objectionable odours were noted beyond the boundary of the site, strong hydrocarbon odours were detected around the lined oily waste pit and very slight drilling mud/hydrocarbon odours were found around areas where muds had been applied to the north of the storage area. Only one pit (lined) at the site contained material, another unlined pit was empty at the time of inspection. The liners previously used had been stockpiled and were stable in a pile at the east of the storage area. Pasture growth was patchy and appeared barren where small dried mud clumps were clearly visible on the soil surface.

18 January 2013
No objectionable odours were found during the inspection. Two pits were lined with acceptable liners, one appeared to contain oily wastes and the other had a dark liquid inside and a small volume of solidified surface oils, plenty of freeboard was available in both pits. Another pit on-site was lined with a substandard polythene, the small volume of liquid in the bottom appeared dark with a small volume of solidified surface oils, the liner was showing deterioration from wind/stones as several holes were present in the liner above the liquid level. Areas where muds had been applied were generally showing good pasture growth, some areas north of the storage were showing poor pasture growth and muds were visible at the surface in small clumps, these areas might need to be re-disced and re-sown in the autumn. No signage to identify specific pits was present around the pits. The main gate was unlocked. The shoreline was inspected and no adverse effects from site activities were identified.

The Company was informed that the following action was to be undertaken: Monitoring of the pasture growth in poor strike areas and remediation of the areas when weather conditions were favourable. Transferring of the liquids/oils from the pit with a substandard liner into a storage pit that was deemed fit for purpose.

27 March 2013
No objectionable odours were noted beyond the site boundary. Strong hydrocarbon odours were noted around areas where muds had been recently applied and around the storage pits. The access track was dry and dusty but less dust was being generated along the track past the house. Speed control signage was present and no traffic movements were observed during the inspection. It was outlined by the operator that muds were being spread directly from trucks to the north of the current pits. The area looked to be satisfactory and muds were well blended, although strong odours were detected around this area. Three lined storage pits were in operation at the site and all were found to have plenty of freeboard. The previous substandard liners remained on-site in piles. Areas where muds were previously spread to the northwest of the pits were showing good pasture growth and no bare mud patches were observed within the soil profile. The area directly north of the pits was showing poorer pasture strike. The shoreline was inspected and no adverse effects were observed.

17 April 2013
No objectionable odours were found at or beyond the site boundary during the inspection. Hydrocarbon odours were, however, noted in the area where muds had been applied to the northeast of the storage pits. The material had been incorporated into the soil but no grasses appeared to have been sown as of yet. Three lined pits were currently onsite containing materials: the well workover fluid in 'pit A' had a clearly visible tide line of approximately 30 cm indicating some fluid was evaporating. The liquid present in all of the pits was dark/turbid and the oily waste pits had very little surface oil. All ponded water around the paddocks was free of hydrocarbon sheen and very little mud was identifiable within the soil profile. The shoreline was inspected and no effects were observed.

20 May 2013
No objectionable odours or visible emissions were found during the inspection. Three lined pits were being used to contain drilling waste. The largest pit had a bright green material on the surface and some foam also, the other two pits both contained dark liquids with surface oils. There was freeboard available in all pits.

Historical application areas were also inspected; the majority of these areas showed good pasture growth and very little bare mud/earth was visible within the soil profile. Areas where material was recently spread looked good and had topsoil bunds surrounding the spreading area. Pasture strike in the area north of the pits looked good. The shoreline was also inspected: no effects from site activities were found.

11 June 2013

No objectionable odours or visible emissions were found during the inspection; however, intermittently noticeable hydrocarbon/mud odours were detected beyond the site boundary along the shoreline. At the time of inspection the site was unmanned and gates were unlocked, no traffic movements were occurring, and the access track was dry. Pit liners at the site appeared in good repair, 'pit C' was full with essentially no free-board available, the earth at the front of the pit had been built up slightly as a temporary bund. The operator was advised that this pit needed to have the level lowered. The oily waste pit had strong hydrocarbon odours and free-board available. The largest pit at the site was found to have plenty of free-board and surface foam across quarter of the area, the liquid inside had a slight green colour. Recent application areas were inspected. It was noted that some muds/clays had migrated to the surface and concrete boulders were present also. Additionally, plastics and ripped liner pieces were present in the soil throughout some of the spreading areas. Pasture strike looked good across the recent application area. The areas where muds previously spread had good pasture coverage in all but two places (which covered an area of approximately 5 m^2). In the bare patches unblended muds were identified on the surface. During the perimeter inspection, a perforated drainage pipe was discovered leading from the direction of the spreading area north of the storage pits. At the time of inspection this pipe was discharging water to land. The liquid discharging had a yellow tinge and a hydrocarbon odour; there was also naturally occurring iron oxide present in the discharge. The discharge was travelling several metres across land down the escarpment and onto the beach below where it was percolating into the sand. The shoreline was inspected, no other discharges were found and no effects from site activities were observed.

An incident was registered against the site and the Company were required to take the following action: cease the discharge of contaminated liquid beyond the site boundary. Remove the perforated pipe from within the spreading area. Lower the level of 'pit C'. Reincorporate muds into the soil profile which had migrated to the surface.

This incident is discussed further in Section 3.6.

3.2 Notifications and provision of consent holder information

BTW gave advice of the analysis, reception, and disposal of wastes throughout the period. There were several exchanges of correspondence over various matters, including clarification of consent conditions, provision of site layout details, receiving environment analytical results, surrender of Consent 7670-1, design and implementation of the ecological monitoring programmes (field and laboratory), incidents registered during the 2012-2013 monitoring year, groundwater monitoring, and stockpiling facility integrity.

3.2.1 Stockpiling notifications

In 2011-2012, there were 36 stockpiling notifications received for a total of 11334 m^3 of waste from several wellsites (Mangahewa A, C & D, Copper Moki, Cheal-A, B & C, KA 1,4 & 8, Talon 1 and Wingrove), McKee production station, the Pacific Chieftain, Nobel Discoverer, and the storage facilities at Omata.

In the 2012-2013 year 5,223m^3 of waste material arrived from wellsites (Mangahewa-A, -C, and –D, Copper Moki, Puka, Douglas, and Kapuni KA 2, 3, and 13) and the Maui-B platform.

Waste types received on-site during the monitoring period included WBM fluids and cuttings, SBM fluids and cuttings, oily waste, waste water, contaminated soil, produced water and well workover fluids (including fracturing return fluids). Stockpiling notifications are on a projection basis; the eventual quantity of waste received at site may vary slightly from the notification figures, but this variation is captured in the landfarming notification data, which is calculated by the operators from as-received wellsite and transport company records and verified through pit capacity. Additionally, due to operational needs, projected (and therefore notified) loads of material may be redirected to different sites.

3.2.2 Landfarming notifications and records

In the 2011-2012 year BTW landfarmed a total of 9 spreading areas exercising consents 7670-1 and 7884-1, covering a total area of 58,144m^2. These spreading areas (F3-F11) are presented in Section 2.4.2. Figure 2. BTW were generally very good at providing both landfarming and stockpiling notifications on time. Spreading calculations, predisposal results and up-to-date maps were supplied as part of the notifications, as per the requirements of their consents.

In 2012-2013 BTW landfarmed seven spreading areas areas exercising consent 7884-1, covering a total area of 52,225m^2.

3.2.3 Annual reporting

Consent 7884-1 requires the provision of an annual report by the consent holder by 31 August each year, incorporating comprehensive details on the composition and on-site management of wastes. The report for the 2011-2012 year for the exercise of Consent 7884-1 was received on 29 August 2012 and is available from the Council upon request. The 2011-2012 supplied report for Consent 7884-1 met all consent requirements. However, the presentation of data was extremely complicated, and the Council considered modification of the format would assist in ease of determining compliance. As such, Council scientific staff requested that BTW review their data provision and annual reporting formats.

The 2012-2013 report was received on 27 August 2013. The Company followed the Council's earlier recommendations and produced a more readily comprehendible landfarming report. The report for consent 7884-1 is attached in Appendix II.

3.3 Results of discharge monitoring

As required, BTW provided pre-disposal sampling results for wastes received at the landfarm during the monitoring period. These results are included in full within the consent activity report provided by the Company (Appendix II).

3.4 Results of receiving environment monitoring

3.4.1 BTW receiving soil sample results

In the 2011-2012 year BTW landfarmed a total of 9 spreading areas in the part of the site covered under consent 7884-1 (Figure 4). Receiving environment soil sample results were provided for areas F2-F10. Area F11 was completed during the monitoring year, but at the time of reporting by the Company for the 2011-2012 year only predisposal results were available. A summary of the Company's supplied results is presented in Tables 3, 4, 5 and 6.

Table 3 summarises BTW supplied data for hydrocarbons, chlorides, nitrogen and barium, allowing for comparison against contaminant limits specified in the consents.

The consent limits discussed in the table are surrender limits that apply at the time of eventual consent surrender and not at the time of deposition, meaning contaminant concentrations must be less than these limits by the time of surrender or expiry of the resource consents but do not have to be satisfied at time of application.

Figure 4 Active areas of landfarm as of June 2012 showing the location of pits and areas spread under consents 7670-1 (F1, F2), and 7884-1 (F3-11)

Table 3 Summary of receiving environment compliance monitoring data for Consents 7670-1 and 7884-1 for total petroleum hydrocarbons, chlorides, nitrogen and barium (2011-2012)

Date	Site	C7-C9*	C10-C14*	C15-C36*	TPH*	Cl*	TN*	Ba*
21-Feb-12	**F1+F2**	**<8**	**<20**	**93**	**93**	**16**	**-**	**-**
29-Sep-11	F3	<8	<20	<40	<70	310	0.14	430
10-Feb-12	F3	<8	<20	<40	<70	19	-	1,400
20-Jan-12	F4	<8	<20	<40	<70	-	0.11	19.7
	F5	<8	**390**	1,350	1,730	-	0.09	1,910
	F6	<8	<20	191	191	-	<0.05	4,800

Date	Site	C7-C9*	C10-C14*	C15-C36*	TPH*	Cl*	TN*	Ba*
29-May-12	F7	<9	<20	<40	<70	91	0.07	86
12-Jun-12	F3	< 9	< 9	< 9	< 9	< 9	-	-
	F4	< 20	< 20	< 20	< 20	< 20	-	-
	F5	< 40	< 40	129	117	< 40	-	-
	F6	< 70	< 70	129	117	< 70	-	-
10-Jul-12	F8	<8	<20	220	220	7	0.10	38
	F9	<8	**780**	**11,100**	11,900	15	0.09	760
	F10	<8	**400**	2,800	3,200	36	0.08	3,100
Consent limits[1]		**120**	**58**	**4,000**		**700**		**10,000**

**All units mg/kg*
[1] Applies only at time of expiry, cancellation, or surrender of consent, and not during the period of exercise of the consent. The limit for C10-C14 is based on this number being used as a proxy for the possible presence of PAHs. The actual levels of these particular substances found at various sites are given in Table 4.
C7-C9: Concentration of compounds with 7, 8, or 9 carbon atoms in their molecular structure (and similarly for C10-C14, C15-C36)
TPH: total petroleum hydrocarbons
Cl: chloride
TN: total nitrogen
Ba: total recoverable barium

The spreading area results used for consents 7670-1 and 7884-1 in 2011-2012 are shown to be already compliant with the surrender criteria for TPH and separate hydrocarbon fractions, with the exception of area F9 for the C15-C36 hydrocarbon fraction and areas F9, F10 and F5 for the C7-C9 hydrocarbon fraction. The concentrations of hydrocarbons are expected to reduce over time to within surrender criteria, which will be confirmed by on-going soil sampling.

There is no consent condition relating to barium, but it has been a contaminant of interest for the Council given its very high concentration within drilling muds. The Council has not found a New Zealand-based guideline for its application to land, and has previously noted the Canadian Environmental Quality Guideline interim soil quality criterion for agricultural land use for barium of 750 mg/kg. However, the Council now uses updated guidelines[5]. These guidelines stress the critical difference between soluble barium salts, and materials containing insoluble barite (such as are used in drilling muds).

The guideline value for protection of soil and flora ecological health for barite is 180,000 mg/kg, for protection for livestock grazing on pasture 30,000 mg/kg, and for protection of human health (by ingestion of crops and soil) 10,000 mg/kg.

Results for specific aromatic hydrocarbons are presented below in Table 4.

[5] SOIL REMEDIATION GUIDELINES FOR BARITE: ENVIRONMENTAL HEALTH AND HUMAN HEALTH (Alberta Environmental, February 2009).

Table 4 Summary of receiving environment compliance monitoring data for BTEX and PAHs[2] Consent 7884-1 (2011-2012)

Date	Site	Benzene*	Toluene*	Ethyl benzene*	Xylene*	Naphthalene *	Pyrene*	Benzo (a) pyrene*
9-Aug-11	F2	<0.06	<0.06	<0.06	<0.11	<0.14	<0.03	<0.03
	F4	<0.05	<0.05	<0.05	<0.10	<0.13	<0.03	<0.03
29-Sep-11	F3	<0.05	<0.05	<0.05	<0.10	<0.13	<0.03	<0.03
20-Jan-12	F4	<0.05	<0.05	<0.05	<0.10	<0.13	<0.03	< 0.03
	F5	<0.05	<0.05	<0.05	<0.10	<0.13	0.03	< 0.03
	F6	<0.05	<0.05	<0.05	<0.10	<0.13	<0.03	< 0.03
29-May-12	F7	<0.05	<0.05	<0.05	<0.10	<0.15	<0.03	<0.03
10-Jul-12	F8	0.06	0.09	<0.05	<0.10	<0.13	<0.03	<0.03
	F9	<0.05	<0.05	<0.05	<0.10	<0.12	0.05	<0.03
	F10	<0.05	<0.05	<0.05	<0.10	<0.12	0.04	<0.03
Consent limits[1]		**1.1**	**82**	**59**	**59**	**7.2**	**160**	**0.027**

[1] applying at time of surrender, not at tine of application
[2] BTEX benzene, toluene, ethyl benzene, and xylene
PAHs polyaromatic hydrocarbons
**All units mg/kg*

Monocyclic aromatic hydrocarbons (MAHs such as BTEX) and polycyclic aromatic hydrocarbons (PAHs) were well within consent limits (in fact, they were effectively at the detection limits) for all sites sampled. Area F8 showed extremely low levels of benzene and toluene, but presents no environmental risk in these concentrations.

Results for heavy metal concentrations in the receiving soils are presented in Table 5. Metals limits are taken from the "Guidelines for the Safe Application of Biosolids to Land in New Zealand"(MfE, 2003).

Table 5 Summary of receiving environment compliance monitoring data for heavy metals: Consents 7670-1 and 7884-1(2011-2012)

Date	Site	Arsenic*	Cadmium*	Chromium*	Copper*	Lead*	Mercury*	Nickel*	Zinc*
09-Aug-11	F2	<2	<0.10	9	19	3.3	<0.10	5	51
29-Sep-11	F3	< 2	< 0.10	8	16	2.4	<0.10	4	53
09-Aug-11	F4	<2	<0.10	8	17	1.8	<0.10	4	53
20-Jan-12	F4	6	<0.10	13	24	2.9	<0.10	5	73
	F5	<2	<0.10	12	24	4.4	<0.10	6	68
	F6	7	<0.10	10	17	41	0.26	5	71
21-Feb-12	F1+F2	<2	<0.10	10	19	3.2	-	5	60
29-May-12	F7	<2	<0.10	11	17	1.4	<0.10	6	75
10-Jul-12	F8	<2	<0.10	11	21	1.7	<0.10	6	79
	F9	<2	<0.10	9	15	2.1	<0.10	4	63
	F10	2	0.30	10	17	69	0.20	7	135
	Consent limits[3]	**10**	**3**	**600**	**140**	**300**	**1**	**35**	**300**

**All units mg/kg*

Heavy metal concentrations in the receiving soil samples for all spreading areas (F1-F10) sampled are well within consent limits. Given that these spreading areas are single application sites, it is not expected that concentrations will increase.
In addition to hydrocarbons, heavy metal and salt contaminant levels, general soil properties are assessed to determine whether spreading activities are negatively impacting receiving soils. Particularly the effects of salt loading can negatively impact soil structure, and impede the potential for effective bioremediation of other contaminants. Table 6 presents results for electrical conductivity, total soluble salts and the parameters used to calculate sodium absorption ratio (SAR).

Table 6 Summary of receiving environment compliance monitoring data for Consents 7670-1 and 7884-1(2011-2012)

Date	Site	Condy (mS/cm)	SAR	TSS*	Na*	P*	K*	CA*	Mg*
09-Aug-11	F2	**580**	2.3	**3,810**	157	2	1,070	253	55
	F4	90	2.4	587	43	1	135	13	7
29-Sep-11	F3	240	2.7	1571	76	<1	454	31	19
21-Feb-12	F1+ F2	80	-	<0.5	-	-	-	-	-
22-Feb-12	F5	180	1.6	1,155	57	2	355	73	13
	F6	70	1.8	436	43	<1	42	67	10
30-May-12	F7	170	8.7	1,135	218	2	104	29	11
Consent limits[3]		**400**	**18.0**	**2,500**	**460**				

**All units mg/L (samples processed as saturated paste)*
[3] Applies only at time of expiry, cancellation, or surrender of consent, and not during the period of exercise of the consent
Na: sodium *K: potassium* *Ca: calcium*
P: phosphorus *Mg: magnesium* *TSS: total soluble salts*

Area F2 was initially above the consent limits for conductivity and soluble salts. SAR, however, was well within the normal range, and subsequent sampling has shown F2 to have become compliant with conductivity and soluble salts. All other supplied results are within consent limits. The SAR for area F7 is within consent limits although somewhat elevated. This result is comparable with the Council's SAR result for F7, presented in Table 8.

3.4.2 BTW surface water sample results

On two occasions BTW sampled the shallow farm drain located inland of the storage area (Central Drain, close to TRC sampling site UND0000186, shown in Figure 5), as well as a small body of water ponding down gradient of the storage pits (Photo 3). The drain in question runs along the southern boundary of the landfarming facilities, and accordingly serves to intercept and hence reveal the nature of any groundwater flow from underneath the landfarming site. The small body of ponded water collected runoff from the site towards the coast. It had no outlet or discharge beyond the site boundary. The results are presented in Table 7.

Table 7 BTW supplied surface water results

Parameter	Ponded Water 15-Jun-2011	Central Drain 15-Jun-2011	Ponded Water 06-Jun-2012	Central Drain 06-Jun-2012	Typical fresh surface water in Taranaki
pH	7.5	6.6	6.8	6.6	6.0 - 9.5
Electrical Conductivity (EC) mS/m	41.6	28.2	332	27.0	0 - 40
Total Dissolved Solids (TDS) g/m^3	N/A	N/A	1,800	176	-
Total Potassium g/m^3	6.1	1.8	390	2.8	-
Total Sodium g/m^3	48	31	330	29	1 - 100
Chloride g/m^3	74	60	850	50	0 - 50
Total Nitrogen g/m^3	N/A	N/A	7.1.	0.22	0 - 3
Total Kjeldahl Nitrogen (TKN) g/m^3	N/A	N/A	7.1.	0.14	0 - 1
Total Arsenic g/m^3	N/A	N/A	< 0.0053	< 0.0011	0 - 0.001
Total Cadmium g/m^3	N/A	N/A	< 0.00027	< 0.000053	0 - 0.01
Total Chromium g/m^3	N/A	N/A	< 0.0027	< 0.00053	<0.0005
Total Copper g/m^3	N/A	N/A	< 0.0027	0.00082	0 - 0.02
Total Lead g/m^3	N/A	N/A	< 0.00053	< 0.00011	0 - 0.002
Total Nickel g/m^3	N/A	N/A	0.0048	< 0.00053	0 – 0.01
Total Zinc g/m^3	N/A	N/A	< 0.0053	0.0079	0 - 0.05
Benzene g/m^3	N/A	N/A	0.0113	< 0.0010	-
Toluene g/m^3	N/A	N/A	< 0.0010	< 0.0010	-
Ethylbenzene g/m^3	N/A	N/A	< 0.0010	< 0.0010	-
m&p-Xylene g/m^3	N/A	N/A	< 0.002	< 0.002	-
o-Xylene g/m^3	N/A	N/A	< 0.0010	< 0.0010	-
C7 - C9 g/m^3	N/A	N/A	< 0.10	< 0.10	-
C10 - C14 g/m^3	N/A	N/A	< 0.2	< 0.2	-
C15 - C36 g/m^3	N/A	N/A	< 0.4	< 0.4	-
Total hydrocarbons (C7 - C36) g/m^3	N/A	N/A	< 0.7	< 0.7	0

The farm drain samples have shown similar results on both occasions of sampling, with parameters falling within the ranges of typical fresh surface water in Taranaki.

Chlorides are naturally high due to the coastal location. The drain results do not show any significant impacts specific to site activities.

The results for the ponded surface water body from the 6 June 2012 sample show a significant increase in salinity, elevated nitrogen and the presence of benzene equal to the drinking water standard. (It should be noted that the pond has no discharge and is not used as a source for abstraction). The elevated salinity could potentially be a natural fluctuation given the proximity to the Tasman Sea, but the presence of benzene suggests the storage or spreading activities may also be having a detectable effect on this body of water. The Council determined that this required further attention. Additional sampling of this body of water was undertaken in the 2012-2013 monitoring year (see Section 3.4.4 below). The appearance of this ponded water raised concerns initially because of the presence of a sheen over part of the surface. On closer inspection this sheen was identified as being a naturally occurring iron oxide sheen, rather than hydrocarbon. No hydrocarbon odour was detected coming off this body of water.

Photo 3 Ponding water at landfarm showing iron oxide sheen

3.4.3 TRC receiving soil sample results

During the 2011-2012 monitoring period, the Council undertook soil sampling at several sites on 8 March 2012 and 28 March 2012. The results are presented in Table 8 below.

Table 8 Results of Council soil sampling (SOL000178)

Date	Site	Chloride (mg/kg DW)	Condy (mS/m)	HC (mg/kg)	pH	SAR	Sodium (mg/kg)	Total soluble salts (g/m^3)
8-Mar-12	F1 + F2	45.9	102	69	7.5	-	20.3	798
28-Mar-12	F4	32.2	15.0	48	6.3	0.76	11.1	117
	F7	187	90.2	41	8.2	**18.45**	204	706
	F5	188	158	570	7.9	1.16	54.5	1,236
	F6	35.7	47.6	230	7.0	0.81	26.7	372
Consent limits		**700***	**400**	**4,178***		**18**	**460***	**2,500***

** limits applies prior to surrender*
Condy conductivity
HC hydrocarbons
SAR sodium absorption ratio

The soil samples showed compliance with the surrender consent conditions is already met, with the exception of the sodium absorption ratio for area F7. SAR values for areas F4, F5 and F6 are all in the 0.5-1.5 range. The background SAR for the site as supplied by the consent holder is 1.2. A SAR result of 18.45 (while within the margin of error for the consent limit) requires further investigation. BTW's receiving environment soil sample had a SAR of 8.7, which is within the consent limit, but significantly higher than the background result. It is recommended that area F7 be resampled to confirm the SAR to assess whether further remedial action is required in area F7. A recommendation to this effect is given in Section 4.

During the 2012-2013 monitoring period there were four composite soil samples taken by the Council from spreading areas F10, 13, 14 and 16 (Figure 4, Section 3.4.1). The results are presented in Table 9.

Table 9 Composite soil monitoring results from the 7884-1 spreading areas during the 2012-2013 monitoring period

Parameter	Unit	Consent limit	Date & Sample Localities			
			25 Sep 2012 *F13*	25 Sep 2012 *F10*	29 Apr 2013 *F14*	29 Apr 2013 *F16*
Calcium	mg/kg	-	126	136	92.2	15.4
Chloride	mg/kg DW	*700*	390	66.0	255	33.1
Conductivity	mS/m@20C	*400*	197	92.9	130	46.2
Hydrocarbons (TPH)	mg/kg DW	*50,000 (4178)**	7200	5200	3300	2900
Moisture Factor	nil	-	1.135	1.166	1.103	1.258
Magnesium	mg/kg	-	10.0	13.0	12.5	5.4
Sodium	mg/kg	*460*	117	52.1	147	82.6
pH	pH	-	7.8	7.5	7.5	6.6
Sodium absorption ratio	None	*18*	2.69	1.14	3.81	4.61
Total soluble salts	mg/kg	*2500*	1541.7	727.0	1017.4	361.6

*Consent limit at time of surrender

The results of the Council sampling showed compliance with consent conditions for all parameters measured. Additionally, surrender limits were already satisfied for areas F14 and F16 for total hydrocarbon concentrations. Salinity levels were slightly elevated in areas F13 and F14, but were well within consent limits and would pose no environmental risks at these concentrations in a coastal environment with naturally elevated salinity.

3.4.4 TRC surface water sample results

During the 2011-2012 monitoring period, samples were collected on two occasions from the farm drain upstream (UND000183) and downstream (UND000186) (Figure 5) to the south of the storage pits. The results are presented in Table 10 below.

Figure 5 Surface water sampling sites in relation to storage cells, consent 7884-1 site

Table 10 Results of surface water sampling for sites UND0000183 (upstream) and UND0000186 (downstream)

Date	Site	Chloride mg/L	pH	Conductivity mS/m	TDS mg/L	Hydrocarbons g/m^3	Barium mg/L
31-Oct-11	Upstream	39.4	6.5	22.8	176	<0.5	0.008
	Downstream	41.7	6.5	31.3	242	<0.5	0.006
24-May-12	Upstream	36.1	6.5	19.7	152	<0.5	0.006
	Downstream	64.7	6.5	29.5	228	<0.5	0.047
Consent limits					**2,500**		

TDS = total dissolved solids

Upstream and downstream surface water samples collected on 31 October 2011 are indicative of the location of the site in respect to the Tasman Sea. Chlorides and total dissolved solids are very similar between sites and within the normal range for a coastal site. No hydrocarbons were detected in either sample. Soluble barium was at natural concentrations.

In the 24 May 2012 sampling run there were some notable differences between the upstream and downstream samples. Chlorides had doubled and conductivity increased. Barium increased only marginally.

The conductivity and salts results remained within the normal ranges for coastal freshwater and may be potentially accounted for by natural processes and spatial variation rather than site activities. The barium result would unlikely be naturally occurring, however, review of the analytical methods for barium in water indicates that the methodology utilised by the Council (acid soluble barium) may give a higher and less representative (and less relevant) result for readily available barium than the methodology utilised by RJ Hill Laboratories (dissolved barium through filtration). In terms of the potential for environmental effects, dissolved barium is a more meaningful measure than acid soluble barium. It is therefore recommended that the Council adopt the dissolved barium through filtration method of assessing barium levels in all subsequent water samples for this site.

During the 2012-2013 monitoring period, the ponded water noted in the 2011-2012 monitoring year was sampled once more for hydrocarbons. At the time of sampling the water was turbid and orange with an iron oxide bacterial sheen. The sample was analysed for total hydrocarbons, conductivity, pH, and total dissolved solids (TDS) at the Council laboratory. The results are presented below.

Table 11 Surface water results sample TRC122498, Wellington section of the landfarm

Parameter	Unit	Result
pH	pH	6.5
Conductivity	mS/m@20C	325
Total dissolved solids	g/m^3	**2514**
Hydrocarbons (TPH)	g/m^3	<0.5

No hydrocarbons were detected in this sample. TDS was elevated, but at the time of sampling this body of water was considered to be effectively a puddle contained in a small depression in the spreading area. The absence of hydrocarbons confirmed the sheen was bacterial in nature and unrelated to site activities.

3.4.5 TRC groundwater results

Four monitoring wells were installed during the 2012-2013 monitoring year and sampled 3-4 times each. The monitoring well locations are given in Figure 6. Samples were analysed for general water quality parameters, salinity parameters, barium, and hydrocarbons (including MAHs).

There are two special conditions in consent 7884-1 relating to groundwater quality. SC 21 sets a maximum limit for total dissolved solids of 2,500 g/m^3 in any fresh water body (surface or ground). SC 22 states that site activities must not result in contaminant concentrations in excess of background/natural levels.

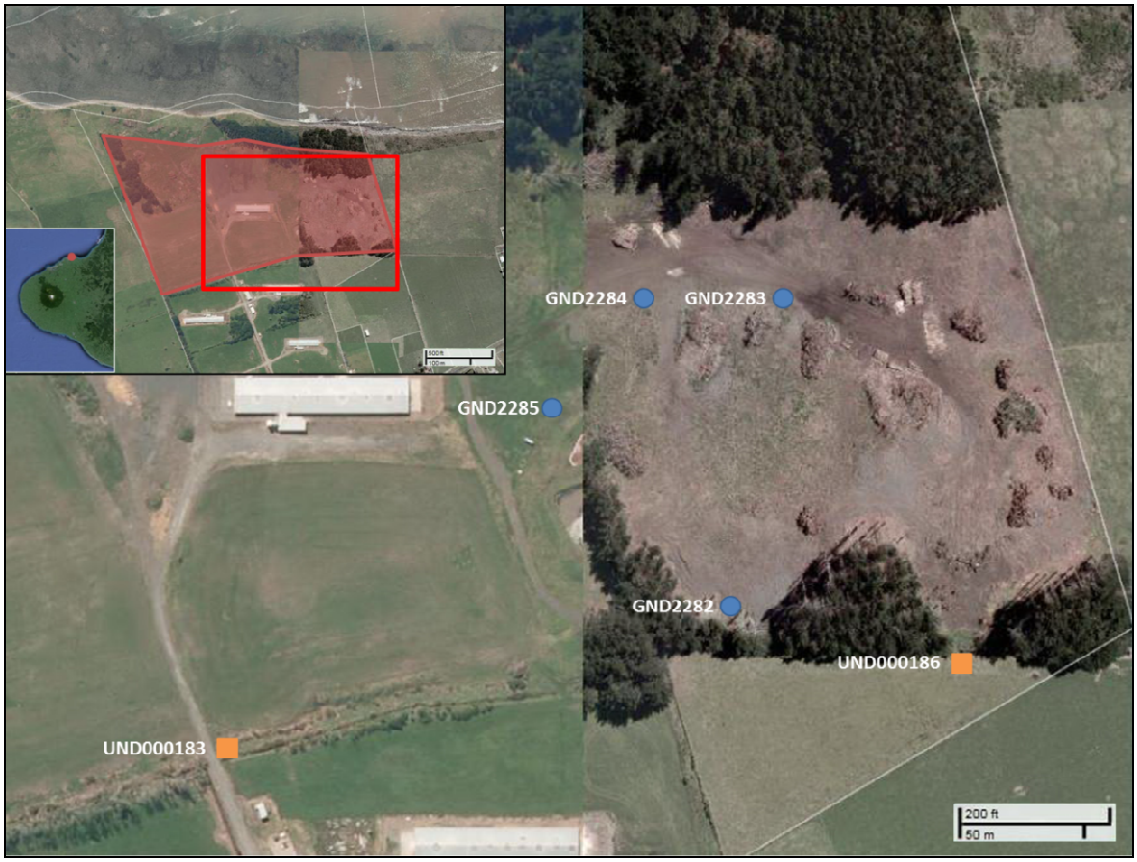

Figure 6 Groundwater and surface water sampling sites, consent 7884-1

Physicochemical results for each monitoring bore are presented in Tables 12 to 15, below.

Table 12 Groundwater monitoring results from bore GND2282 from the area of land use under consent 7884-1 during the 2012-2013 monitoring period

Parameter	Unit	04 Sep 2012	26 Sep 2012	30 Oct 2012
Static water level	m	2.250	2.334	2.481
Temperature	Deg.C	14.7	15.9	16.0
pH	pH	5.9	-	5.9
Conductivity	mS/m@20C	625	547	548
Total dissolved solids	g/m3	**4835.7**	**4232.2**	**4239.9**
Chloride	g/m3	**1740**	**1580**	**1640**
Sodium	g/m3	385	-	-
Dissolved reactive phosphorous	g/m3 P	<0.003	-	-
Sulphate	g/m3	61	-	-
Barium	g/m3	-	-	1.64
Benzene	g/m3	0.004	<0.0013	0.0014
Toluene	g/m3	0.001	<0.0010	<0.0010
Ethylbenzene	g/m3	<0.0010	<0.0010	<0.0010
Meta – xylene	g/m3	<0.002	<0.002	<0.002
Ortho – xylene	g/m3	<0.0010	<0.0010	<0.0010
Hydrocarbon (TPH)	g/m3	1.3	1.2	1.5
HC C7-C9	g/m3	<0.10	<0.10	<0.10
HC C10-C14	g/m3	<0.2	<0.2	<0.2
HC C15-C36	g/m3	**1.3**	**1.2**	**1.3**

Table 13 Groundwater monitoring results from bore GND2283 from the area of land use under consent 7884-1 during the 2012-2013 monitoring period

Parameter	Unit	04 Sep 2012	26 Sep 2012	30 Oct 2012	14 Mar 2013
Static water level	m	1.990	1.580	2.486	2.008
Temperature	Deg.C	16.1	16.7	18.2	20.6
pH	pH	7.1	-	6.7	-
Conductivity	mS/m@20C	543	448	314	343
Total dissolved solids	g/m3	**4201.2**	**3466.2**	2429.4	**2653.8**
Chloride	g/m3	**1330**	**1050**	**822**	-
Sodium	g/m3	**1210**	-	-	-
Dissolved reactive phosphorous	g/m3 P	<0.003	-	-	-
Sulphate	g/m3	<1	-	-	-
Barium	g/m3	-	-	0.37	-
Benzene	g/m3	**0.36**	**0.21**	**0.034**	**0.0197**
Toluene	g/m3	0.013	0.007	<0.0010	<0.0010
Ethylbenzene	g/m3	0.0057	0.0041	0.0018	<0.0010
Meta – xylene	g/m3	0.018	0.013	0.0029	<0.002
Ortho – xylene	g/m3	0.0148	0.0105	0.0029	<0.0010
Hydrocarbon (TPH)	g/m3	<0.7	<0.7	<0.7	<0.7
HC C7-C9	g/m3	0.10	<0.10	<0.10	<0.10
HC C10-C14	g/m3	<0.2	<0.2	0.2	<0.2
HC C15-C36	g/m3	<0.4	<0.4	<0.4	<0.4

Table 14 Groundwater monitoring results from bore GND2284 from the area of land use under consent 7884-1 during the 2012-2013 monitoring period

Parameter	Unit	04 Sep 2012	26 Sep 2012	30 Oct 2012	14 Mar 2013
Static water level	m	1.310	1.816	1.887	2.018
Temperature	Deg.C	15.3	15.9	17.5	21.9
pH	pH	6.5	-	6.3	6.0
Conductivity	mS/m@20C	176	72.2	47.5	153
Total dissolved solids	g/m3	1361.7	558.6	367.5	1183.8
Chloride	g/m3	411	149	95.0	452
Sodium	g/m3	166	-	-	-
Dissolved reactive phosphorous	g/m3 P	0.003	-	-	-
Sulphate	g/m3	<1	-	-	-
Barium	g/m3	-	-	0.049	0.31
Benzene	g/m3	0.0055	<0.0010	<0.0010	<0.0010
Toluene	g/m3	0.0054	<0.0010	<0.0010	<0.0010
Ethylbenzene	g/m3	<0.0010	<0.0010	<0.0010	<0.0010
Meta – xylene	g/m3	<0.002	<0.002	<0.002	<0.02
Ortho – xylene	g/m3	<0.0010	<0.0010	<0.0010	<0.0010
Hydrocarbon (TPH)	g/m3	<0.7	<0.7	<0.7	<0.7
HC C7-C9	g/m3	<0.10	<0.10	<0.10	<0.10
HC C10-C14	g/m3	<0.2	<0.2	<0.2	<0.2
HC C15-C36	g/m3	<0.4	<0.4	<0.4	<0.4

Table 15 Groundwater monitoring results from bore GND2285 from the area of land use under consent 7884-1 during the 2012-2013 monitoring period

Parameter	Unit	04 Sep 2012	26 Sep 2012	30 Oct 2012	14 Mar 2013
Static water level	m	0.895	1.532	1.583	1.906
Temperature	Deg.C	14.8	15.6	17.3	21.2
pH	pH	6.1	-	5.8	5.7
Conductivity	mS/m@20C	283	397	568	700
Total dissolved solids	g/m3	2189.6	**3071.6**	**4394.7**	**5416.0**
Chloride	g/m3	**891**	**1380**	**1870**	**2340**
Sodium	g/m3	212	-	-	-
Dissolved reactive phosphorous	g/m3 P	0.004	-	-	-
Sulphate	g/m3	<1	-	-	-
Barium	g/m3	-	-	**3.48**	**5.32**
Benzene	g/m3	**0.013**	**0.054**	**0.093**	**0.0067**
Toluene	g/m3	<0.0010	**0.0033**	**0.0056**	<0.0010
Ethylbenzene	g/m3	<0.0010	<0.0010	<0.0010	<0.0010
Meta – xylene	g/m3	<0.002	<0.002	<0.002	<0.002
Ortho – Xylene	g/m3	<0.0010	<0.0010	<0.0010	<0.0010
Hydrocarbon (TPH)	g/m3	<0.7	<0.7	<0.7	<0.7
HC C7-C9	g/m3	<0.10	<0.10	<0.10	<0.10
HC C10-C14	g/m3	<0.2	<0.2	<0.2	<0.2
HC C15-C36	g/m3	<0.4	<0.4	<0.4	<0.4

Monitoring wells GND2282, 2283 and 2285 all showed evidence of being affected by site activities, with consent breaches of the TDS limit of 2500 g/m^3, elevated chloride, and some of the more mobile hydrocarbons, particularly benzene and toluene. GND2284 has not shown any significant impacts from site activities.

Barium was elevated above natural background levels in bores GND2282 and GND2285, but as discussed above, the methodology utilised to analyse for barium by the Council (acid soluble barium) gives a higher and less representative (and less relevant) result for readily available barium than the methodology utilised by RJ Hill Laboratories (dissolved barium through filtration). In terms of the potential for environmental effects, dissolved barium is a more meaningful measure than acid soluble barium. It is therefore recommended that in the following monitoring period, the dissolved barium method is adopted for all samples taken from this site.

Figure 7 shows chloride concentrations in all bores over the monitoring year. Chloride is highly mobile and therefore works as an indicator contaminant, meaning elevations in chloride in ground or surface water can be used to track the movement of other contaminants potentially present.

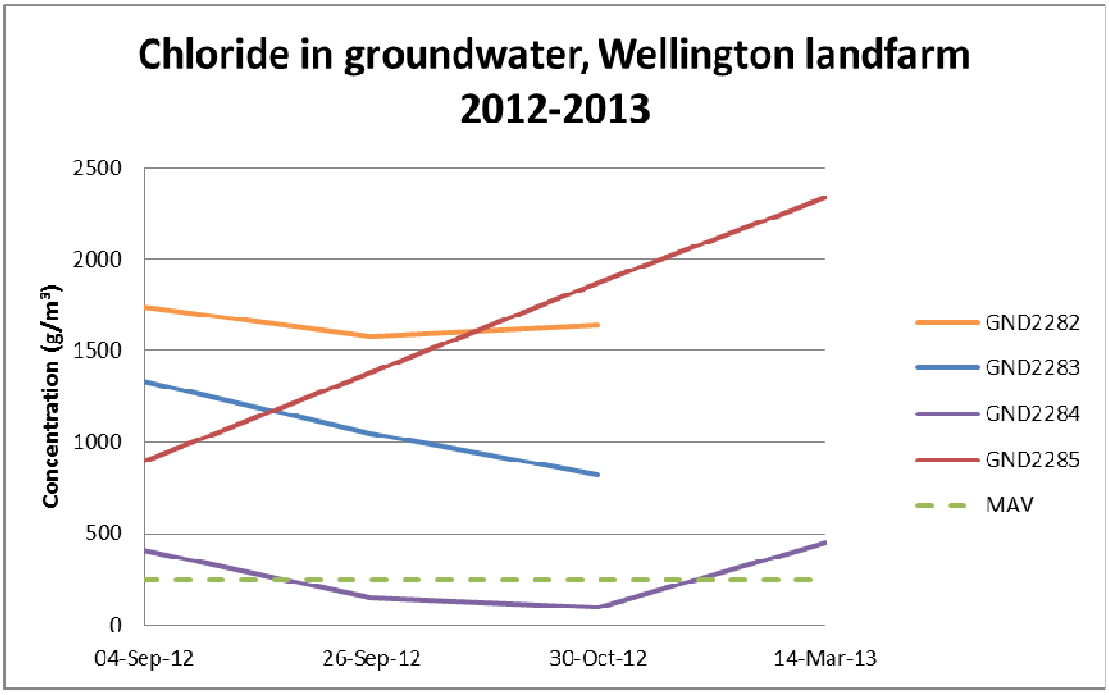

Figure 7 Chloride concentrations in GW monitoring wells 2282-2285, 2012-2013 monitoring year

Background chloride concentrations at these coastal sites naturally fluctuate depending on weather patterns and other variables (eg extent and duration of salt spray during dry weather, timing of rainfall and groundwater movement). The range of chloride concentrations naturally seen in groundwater at these coastal sites is generally 0 – 500 g/m³. Anything significantly over this range suggests an impact of site activities on groundwater. Figure 4 shows that bore GND2284 appears to be uninfluenced by site activities. Bore GND2283 was initially quite elevated in chloride, but it appears that concentrations are steadily reducing. Bores GND2282 and GND2285 show an increase in chloride concentrations over time, likely attributable to site activities (storage of muds and liquid wastes).

These results are compared in Figure 4 with the maximum allowable value (MAV) for chloride in drinking water for human consumption. The drinking water standard is only used here as a comparison point, as the consent stipulates contaminants must not be in excess of background concentrations. The groundwater at a site such as this is not utilised for consumption by humans or animals, nor are there any down-gradient water abstraction points. Any environmental effects on non-consumable, naturally saline coastal groundwater from elevated chloride at a site such as this would be negligible.

The detection of BTEX compounds in groundwater required additional consideration, as these are contaminants of concern and in the first instance could have associated potential risks depending on concentrations and exposure pathways.

Figure 8 shows only the results for wells GND2283 and GND2285, as these were the only wells where benzene was detected. The results are compared for indicative purposes in the figure with the New Zealand drinking water standard (DWS)[6], of 0.01 g/m³ for benzene.

[6] Drinking-water Standards for New Zealand 2005 (Revised 2008), Ministry of Health

It should be noted that this standard is based on lifetime consumption and is not an acute (short-term consumption) standard. All benzene concentrations were below the groundwater acceptance criteria for irrigation and stock water drinking purposes, which are more relevant at this specific location but again are provided for indicative purposes only as no such actual use of the discharge flow existed during the period under review.

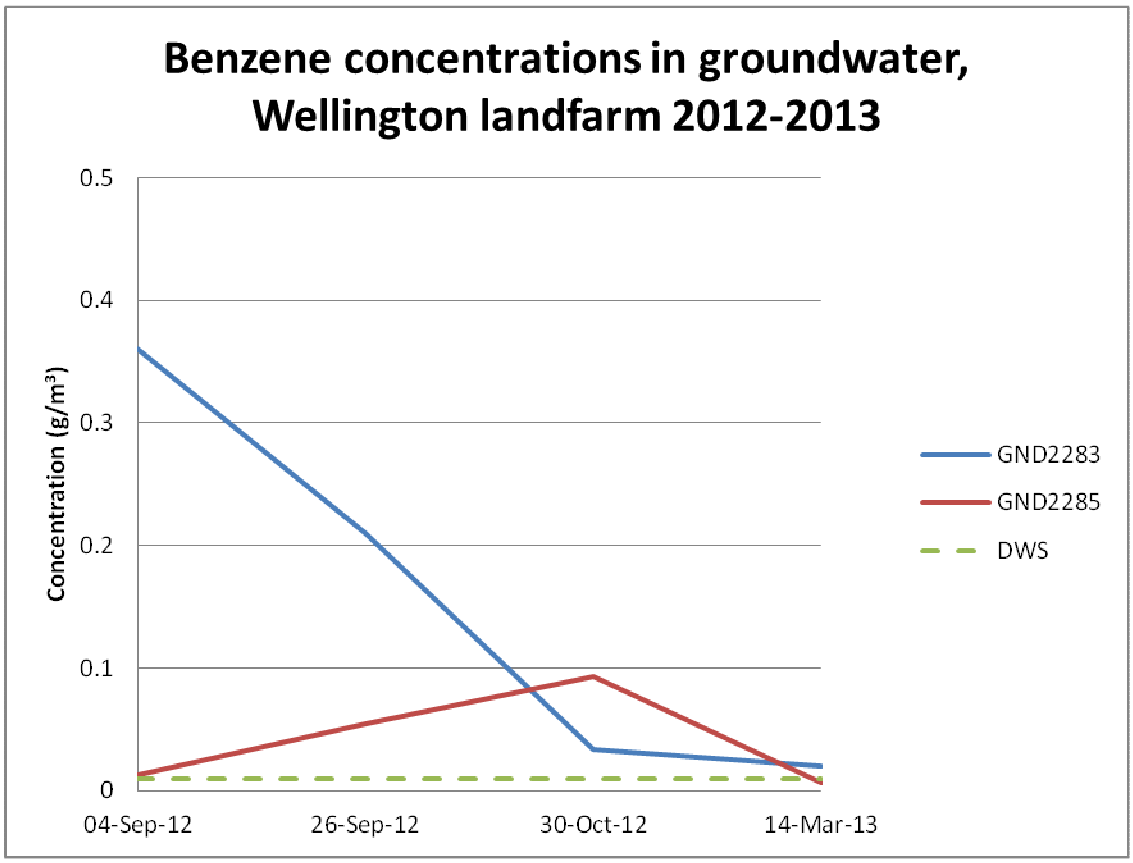

Figure 8 Benzene concentrations in monitoring wells GND2283 and GND2285

The initial sample taken from GND2283 showed elevated concentrations of benzene, which rapidly reduced over the monitoring period to slightly over the DWS. The concentrations in bore GND2285 showed an initial increase before reducing to within the DWS and close to background levels.

The DWS for toluene is 0.8 gm^{-3} and for xylene is 0.6 gm^{-3}. No sample had a concentration approaching either of these levels.

3.5 Radioactivity assessment

Concerns over perceptions of potential radioactivity associated with drilling activities have been raised on occasion by various parties. Potentially, radioactive contamination could occur from two sources:

1. Low intensity radioactive gamma tracers used in fracturing fluids to identify the size and extent of fractures and to track movement of the fluids during fracturing.

2. Naturally occurring radioactive materials (NORMs). Elements such as uranium, radium, and radon (which are present in varying concentrations in some geological formations encountered during drilling operations elsewhere) are dissolved in very low concentrations during normal reactions between water and rock or soil, if present in the parent rock. Formation water that coexists with hydrocarbon reservoirs can have higher concentrations of dissolved constituents that build up during prolonged periods of water/rock contact. Water brought to surface during production, or rock cuttings from drilling operations therefore may be a potential source of radiation.

These concerns have never been found to be substantiated, upon investigation. In the previous monitoring period (8 April 2011) the Council again undertook radiation measurements, using a Thermo Electron Corp ESM FH 40 G-L Radiometer at four areas at the landfarm located on Brown Road, Waitara. These consisted of an untreated paddock (background), the former stockpiling area (which was in the process of being reinstated), and two spreading areas, B10 SBM, and B15 WBM.

On 19 December 2011 the Council carried out a field-based radioactivity survey of the newer adjacent disposal area, testing for gamma radiation using a Thermo Electron Corp ESM FH 40 G-L Radiometer. The purpose of these surveys was to assess the potential risk to human/animal health from radiation associated with hydrocarbon production wastes.

Assessment of the potential for risk from wastes disposed of to land focusses on two aspects. Firstly, whether there are elevated levels of radiation in the material being disposed of; and secondly, if radiation levels present have the potential to be detrimental to human or animal health through relevant exposure pathways.

In the first survey, none of the readings exceeded 100 nSv/hr, which is essentially the normal background level. None of the sites showed any elevated activity by comparison with any other.

In the 19 December 2011 survey 17 sub-sites within the area used more recently for disposal (including of wastes arising from fracturing activity) were tested using a handheld radiometer. The following results were observed. None of the readings recorded exceeded 100 nSv/hr with the maximum being 86.6 nSv/hr occurring at site 1. A minimum reading of 48.9 nSv/hr occurred at site 15, with a range of 37.7 nSv/hr occurring over all readings. The fluid sample reading at site 10, of 0.62 S^{-1} (< $1S^{-1}$), equates to < 100 nSv/hr. None of the disposal site readings were significantly different from the control readings.

The readings were evaluated by the National Radiation Laboratory (NRL), who stated that any reading below 200 nSv/hr constitutes a normal background reading. In addition the NRL states that the average annual radiation dose to members of the New Zealand public is 2 mSV/y, which is equal to 228 nSv/hr. All the readings taken fall substantially below these values ie all results were within the 'normal' or background ranges for New Zealand.

The Council (with input from GNS and the National Radiation Laboratory) has prepared a technical report addressing potential radioactivity associated with

hydrocarbon exploration (Taranaki Regional Council, 2013). This included assessments undertaken at disposal sites. The main summary points were:

- The Council has sought and received assurances at all points, from the competent statutory authorities, that the use and management of radioactive materials within the hydrocarbon exploration and production sector as established in Taranaki is lawful, and is not harmful to human health;

- The Council has sought and received assurances at all points, from the competent statutory authority and expert body, that based on the samples measured to date, the release of any NORMs during hydrocarbon exploration and production as established in Taranaki is not harmful to human health

- The Council has undertaken its own surveys of radioactivity in produced fluids and radiation from soil levels at land remediation sites, to ensure from its own direct measurement that the release of radioactive materials from these sources is not harmful to human health. Measurements have confirmed that this is indeed the case, and indeed neither radioactive tracers as used in fields in Taranaki nor NORMs that are present in Taranaki fields are 'radioactive' in terms of statutory definitions, and contain levels of radioactivity orders of magnitude below those at which controls are required;

- The Council has been repeatedly advised by the competent authority and has repeatedly found on its own account, that the levels of radioactivity associated with these activities would give rise to exposures comparable to normal, everyday exposure for an average person;

In summary, the Council has found no evidence of a health or environmental issue arising from the use of radioactive tracers, the use of radioactive materials within well logging activities, disposal of drilling wastes potentially containing radioactive materials, or the release of naturally occurring radioactive materials (NORMs) during exploration or production.

Notwithstanding the above, as a complementary study the Council determined that production fluids (return fluids and/or produced water) intended for disposal to land should be analysed for alpha/beta radiation at the National Radiation Laboratory in the 2012-2013 year.

Accordingly, during the 2012-2013 monitoring period a sample of produced water was taken from 'Pit A' to be assessed for levels of alpha and beta radiation.

The alpha/beta radiation testing was conducted on produced water, as it was seen as a potential source of elevated naturally occurring radioactive material (NORM). NORMs are a concern in some specific localities overseas. A sample was taken directly from the contents of the storage pit and analysed for total alpha and total beta concentrations using liquid scintillation counting. Gamma spectrometry screening was also used to detect levels of potassium-40 and radium 226 and 228.

The sample results are presented in Table 16.

Table 16 Radioactivity results obtained August 2012

Parameter	Unit	Result
Potassium-40	(Bq/L)	8.9 ± 1.7
Radium-226	(Bq/L)	0.080 ± 0.012
Radium-228	(Bq/L)	0.051 ± 0.021
Total alpha concentration	(Bq/L)	<0.067
Total beta concentration	(Bq/L)	7.25 ± 0.43

These results show 'normal' radiation levels, with low radium results and a slight elevation in total beta concentration and potassium-40. The drinking water standard for alpha radiation is 0.10 Bq/L, which the sample easily complies with, and 0.50 Bq/L for beta radiation. The standard for beta-emitting radiation excludes beta radiation emitted from potassium-40, as the body essentially self-regulates its content of potassium-40. In simple terms, the elevated level of total beta radiation found in the sample is accounted for by the concentration of potassium-40 that was present, reducing the effective beta concentration to within drinking water standards and indicating there was no elevated human health risk.

These results were included in the technical report 'Radioactivity in hydrocarbon exploration (including fracturing activities)' (Taranaki Regional Council, 2013). This report was reviewed by the Institute of Environmental Science and Research (ESR). The findings of the report concluded there was no significant risk to human health from the levels of radioactivity encountered in production fluids or disposal site soils encountered in any of the sampling conducted (including the area where consent 7884-1 had been exercised).

More detail can be found in the full technical report available on the Council website: http://www.trc.govt.nz/Publications/ContentSearchForm?Search=radioactivity&Category=437

3.6 Investigations, interventions, and incidents

The monitoring programme for the part of the landfarm located on the Wellington property for the 2011-2013 period was based on what was considered to be an appropriate level of monitoring, review of data, and liaison with the consent holder. During each year matters may arise which require additional activity by the Council eg provision of advice and information, or investigation of potential or actual courses of non-compliance or failure to maintain good practices. A pro-active approach that in the first instance avoids issues occurring is favoured.

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

Complaints may be alleged to be associated with a particular site. If there is potentially an issue of legal liability, the Council must be able to prove by

investigation that the identified company is indeed the source of the incident (or that the allegation cannot be proven).

In the 2011-2012 period, it was not necessary for the Council to record any incidents in association with BTW's conditions in resource consents or provisions in Regional Plans in relation to the activities at the landfarming facilities covered by consent 7884-1 during the monitoring period. However, the Council noted that the drain collecting shallow groundwater along the southern boundary was the only means of monitoring potential effects upon groundwater. For the sake of greater certainty, the Council decided to initiate further investigations into potential impacts of this activity on localised groundwater, through the installation and monitoring of bores. In the monitoring period under review, Council staff advised BTW that additional groundwater monitoring would be required in the following monitoring year.

In the 2012-2013 monitoring period, the Council recorded four incidents in association with BTW's activities in the areas covered by consent 7884-1. Four abatement notices and two infringement notices were issued to the Company. These are described below.

3.6.1 Incident 23047 / Infringement notice 313

Incident summary

An incident was registered against the site on 14 August 2012 on the basis of suspected impact on groundwater from storage pits located at the landward extent of the site.

At the conclusion of the 2011-2012 monitoring year, Council scientific staff had identified some concerns about possible leaching of contaminants from stockpiling facilities being utilised at the site, and initiated additional investigations into site activities. The concerns were based on visual inspections of the stockpiling area. At the time of these inspections, housekeeping at the site was considered sub-standard. Seven storage pits were present, four of which had been lined with synthetic liners (Pits C, E, F, G), to store fracture return fluids and oily waste (Figure 9).

The Company were required to discontinue use of these pits, farm the material stored in them, install four groundwater monitoring wells in the immediate vicinity of the pits, and ensure that high density polyethylene (HDPE) (or equivalent) liners were installed in any future storage pits to be used at the site (Photo 4, below).

Investigation summary

The groundwater bores were sampled initially on 4 September 2012. The results are presented in Section 3.4.5. The results showed the presence of benzene and very low levels of toluene and xylene in two out of four bores, and low level TPH in one of the down-gradient bores. Follow-up sampling was conducted on 25 September 2012 and 30 October 2012, which confirmed the presence of benzene in two of the bores. The Council deemed it appropriate to take enforcement action in the form of an infringement notice (infringement notice 313) issued to the Company on 15 November 2012.

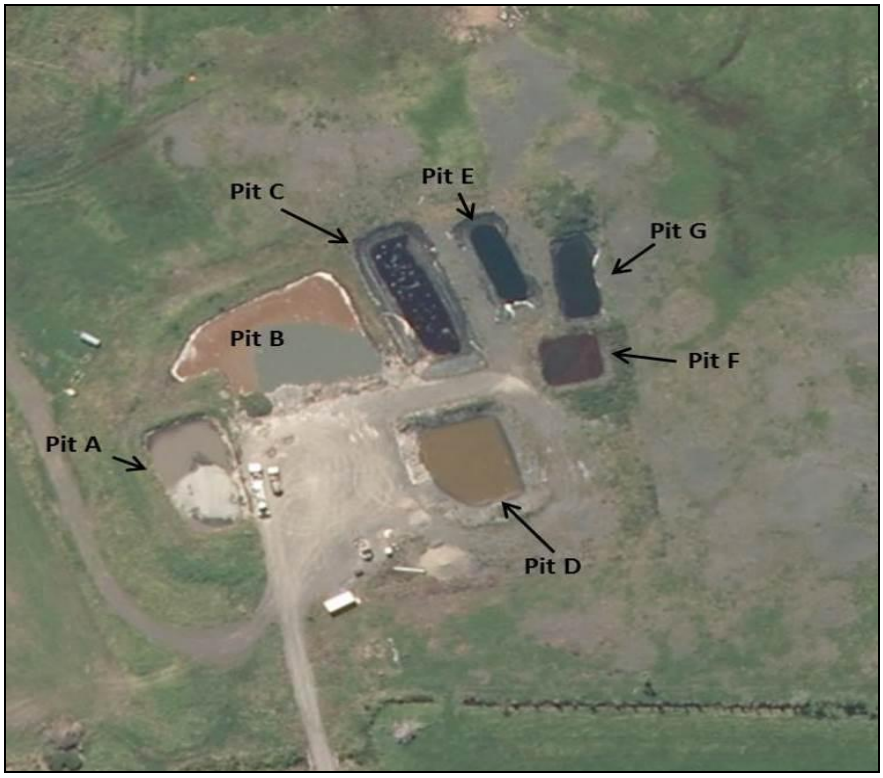

Figure 9 Map of initial storage pit, consent 7884-1 (Wellington property)

Consent 7884-1 special conditions 9 and 10 require stockpiled fracturing return fluids and oily wastes to be stored in an impermeable lined pit. At the time that the incident was registered, these materials had been being stored in lined pits, but the permeability of the liners had not been engineer-assessed. The synthetic liners in use at the time were low grade plastic liners and were in a poor state of repair at the time the incident was registered.

Perhaps of more concern was the fact that three large storage pits had been previously unlined. They had been used to store SBM and produced water. These pits initially stored WBM, relying on the sealing properties of the mud constituents (barite and bentonite) to reduce significant infiltration of liquid wastes through the pit walls and floors. However, in sandy soils, reliance on clay sealants alone was considered potentially insufficient to ensure pit base impermeability and protect shallow groundwater from wastes with higher liquid components and potentially higher hydrocarbon concentrations than WBM.

Furthermore, at the time of pit reinstatement and associated investigative sampling of the oily waste pit (pit F), material had been farmed from pit A, revealing the pit base to be roughly as deep as the groundwater table measured in bore GND2282. This suggested the possibility of direct throughflow through the pit base rather than infiltration and attenuation down from the unsaturated zone into the water table.

Photo 4 Return fluids pit showing initial sub-standard liner

Photo 5 Pit A (initially unlined) containing produced water

The Company reinstated several of the pits between September and October 2012, as instructed. Investigative sampling of the base of the former oily waste pit was conducted on 5 September 2012. Three test pits were dug at the base of the oily waste pit and soil samples were collected. The water table was encountered in the base of the test pit, so a groundwater sample was also taken from one of the test pits for analysis. Strong hydrocarbon fumes were detected in the soil and water samples, and hydrocarbon sheen was also present on the surface of the water sample.

The three test pit sample results from the oily waste pit base showed very slightly elevated BTEX, but well within guideline values for sandy soils. The other parameters assessed for were all consent-compliant for these samples.

Figure 10 Investigative sampling of previous oily waste pit following partial reinstatement showing empty pit with test pits (left) and close up of test pit showing groundwater intrusion (right)

The base of Pit A was also sampled, following farming of material and partial reinstatement, on 25 September 2012 in conjunction with the second groundwater monitoring run. The pit base sample showed elevated chloride and total hydrocarbon concentrations in excess of surrender limits but within application limits and therefore technically compliant.

The results are presented in Tables 17 and 18.

Table 17 TRC soil sample results taken from the bases of former storage pits

Parameter	Unit	Consent limit	Date & Sample Localities			
			05 Sep 2012 *OW Pit*	05 Sep 2012 *OW Pit*	05 Sep 2012 *OW Pit*	26 Sep 2012 *PW Pit*
Calcium	mg/kg	-	-	-	-	271
Chloride	mg/kg DW	*700*	143	437	404	**1160**
Conductivity	mS/m@20C	*400*	53.8	157	163	359
Moisture factor	nil	-	1.026	1.021	1.041	1.026
magnesium	mg/kg	-	-	-	-	16.9
sodium	mg/kg	*460*	75.5	193	194	376
pH	pH	-	7.1	7.3	9.1	7.1
Sodium absorption ratio	None	*18*	-	-	-	5.9
Total soluble salts	mg/kg	*2500*	-	-	-	**2809.5**
Benzene	mg/kg DW	*1.1**	0.12	0.2	0.11	<0.05
Toluene	mg/kg DW	*68**	0.37	0.56	0.15	<0.05
Ethylbenzene	mg/kg DW	*53**	<0.05	0.07	<0.05	0.06

Parameter	Unit	Consent limit	Date & Sample Localities			
			05 Sep 2012 *OW Pit*	05 Sep 2012 *OW Pit*	05 Sep 2012 *OW Pit*	26 Sep 2012 *PW Pit*
Meta - xylene	mg/kg DW	*48**	0.3	0.45	<10	0.15
Ortha - xylene	mg/kg DW	*48**	0.12	0.21	<0.05	0.6
Hydrocarbons (TPH)	mg/kg DW	*50,000 (4178)**	<70	<70	<70	<8
HC7 - C9	mg/kg DW	*120**	<9	<8	<9	440
HC10 - C14	mg/kg DW	*58**	<20	<20	<20	11900
HC15 - C36	mg/kg DW	*4000**	<40	<40	<40	12300

OW = oily waste
PW = produced water
*Consent limit to apply at time of surrender

Table 18 Water sample results from base of oily waste pit 05 September 2012

Parameter	Unit	Result
pH	pH	7.0
Conductivity	mS/m@20C	534
Total dissolved solids	g/m³	**4132**
Chloride	g/m³	**1460**
Sodium	g/m³	667
Sulphate	g/m³	9
Benzene	g/m³	**0.95**
Toluene	g/m³	**3**
Ethylbenzene	g/m³	**0.29**
Meta - xylene	g/m³	**2**
Ortha - xylene	g/m³	**0.74**
Hydrocarbons (TPH)	g/m³	**8.2**
HC C7-C9	g/m³	**2.5**
HC C10-C14	g/m³	**1.9**
HC C15-C36	g/m³	**3.8**

Relatively high concentrations of BTEX and TPH were found in the water sample taken from the test pit. The TDS limit of 2500 g/m³ was also exceeded in this sample.

Discussion

The stockpiling facilities were suspected to be the source of the change in groundwater quality, as liquid waste material was being held in concentrated form in storage pits with substandard lining. At the time of the initial non-compliance, effects were restricted to within the site boundaries, and levels of contaminants were shown to be reducing. On-going investigative monitoring continued to be conducted to determine whether environmental impacts from the site activities were reducing with the discontinuation of the use of the initial stockpiling facilities. This was shown to be the case.

Photo 6 Pit A featuring new high grade HDPE liner

3.6.2 Incident 23176 / Abatement notice 11907

Incident summary

On 28 November 2012 the Company notified the Council that produced water possibly containing fracture return fluids was being taken to the site as a contingency measure. Previous correspondence with the Company had led to the understanding that no such material would be stockpiled onsite until the pits had been reconstructed and relined with high grade liners. Following the notification, an inspection revealed the Company had constructed a makeshift pit with a low grade liner. A second incident was registered against the Company, and an abatement notice (abatement notice 11907) was issued on 4 December 2012 instructing the Company to cease all activities at the site until material was transferred into a pit deemed appropriate for storage. The Company complied with this directive and no further enforcement action was required.[7]

[7] Since the period that this report relates to (July 2011 – June 2013), the application of hydraulic fracturing return fluids to land at the BTW landfarm at Brown Road has ceased. See the postscript to the Executive Summary.

Photo 7 Produced water in makeshift pit

Investigation summary

No additional investigation was required regarding this incident. A follow-up inspection confirmed the abatement notice was being complied with.

Discussion

This was an administrative rather than environmental consent breach, and the abatement notice was an official directive to the Company to undertake works on a precautionary basis to prevent any potential impact on groundwater at the site. At the time, the material was contained within the liner, but there was concern by Council staff that the use of lower quality synthetic liners could see a repeat of the incident recorded earlier in the year (Incident 23047, discussed above).

3.6.3 Incident 23447 / Abatement 11970

Incident summary

On 6 March 2013 at 8:30 am a complaint was received regarding objectionable dust discharging beyond the boundary of a site used for landfarming of drilling wastes. An inspection of the access track during traffic movements found that dust was being generated and discharging beyond the site boundary onto a neighbouring property. An abatement notice was issued requiring that works be undertaken to prevent objectionable dust discharging beyond the site boundary. The Company applied dust suppressant to the track and also had a water cart apply water before any traffic accessed the site. A re-inspection found that the abatement notice was being complied with.

Investigation summary

No further investigation was required other than follow-up inspections.

Discussion

This incident was an operational incident with temporary and limited effects, that was quickly resolved by the Company following Council enforcement action.

3.6.4 Incident 23694 / Abatement Notices 12030 & 12031/ Infringement Notice 359

Incident summary

On 11 June 2013 at 10:00 am during a routine compliance monitoring inspection it was found that the site was not operating within resource consent conditions. A perimeter inspection revealed the end of a perforated plastic drainpipe which had been uncovered, originating from the direction of an area where drilling wastes had been spread. The discharge flowed overland and down a bank, but soaked into the sand before the beach platform. Samples were taken and sent away for analysis. Results showed the discharge to be in breach of special condition 22 of the consent. Abatement notice 12030 was issued requiring the Company to stop the discharge. Abatement notice 12031 was issued requiring the Company to remove the artificial drains from the site. Infringement notice 359 was issued to the Company for discharging contaminants to land in a manner where it was likely to enter water. Re-inspection found that the Company had complied with the abatement notices.

Investigation summary

The Council decided to conduct additional investigations into this incident due to the nature of the incident, the earlier incident regarding site groundwater, and ongoing investigations into groundwater quality at the site. At the time of this incident, following contact from the Company, the Council were investigating a groundwater seep further south along the site boundary. Both investigations are summarised below.

On 4 June 2013 the Company contacted the Council about photographs circulating on social media websites of a groundwater seep running from the site boundary onto the adjacent beachfront. The photographs showed orange staining of the escarpment, and an apparent sheen on the surface of the water flowing down the bank adjacent to the beach. Council staff had previously inspected this seep and found it to be the result of naturally occurring iron oxide bacteria (due to the lack of odour and the nature of the sheen). There are several groundwater seeps where groundwater flow converges by subsurface channelling into preferential flow paths. This is common for this area of coastline, with examples being found at regular intervals along the cliff/escarpment faces. An example is shown in Photo 8.

Photo 8 Groundwater seeps, north-eastern boundary of landfarm showing natural iron oxide staining and rainbow sheen

On 5 June 2013 (following notification from the Company) the site boundary was inspected and two discharging seeps were identified. Water samples (TRC136140 and TRC136141) were collected from these two points, and a sediment sample (TRC136142) was taken by scraping the escarpment behind the water discharge. These samples were sent away for R. J. Hill Laboratories for analysis. The sampling points are identified in blue in Figure 11. The results are presented in Table 19.

Separately, on 11 June 2013 at 10:00 am during a routine compliance monitoring inspection it was found that the site was not operating within resource consent conditions. A perimeter inspection revealed the end of a plastic perforated drainpipe which had been uncovered, originating from the area where drilling wastes had been spread (Photo 7). The discharge flowed overland and down the bank adjacent to the beach. Samples of the discharge from the pipe (TRC136291) and the discharge onto the beach (TRC136292) were taken and sent away for analysis. These sampling points are identified in pink in Figure 11. The results are presented in Table 20. Results of interest are highlighted in Tables 19 and 20.

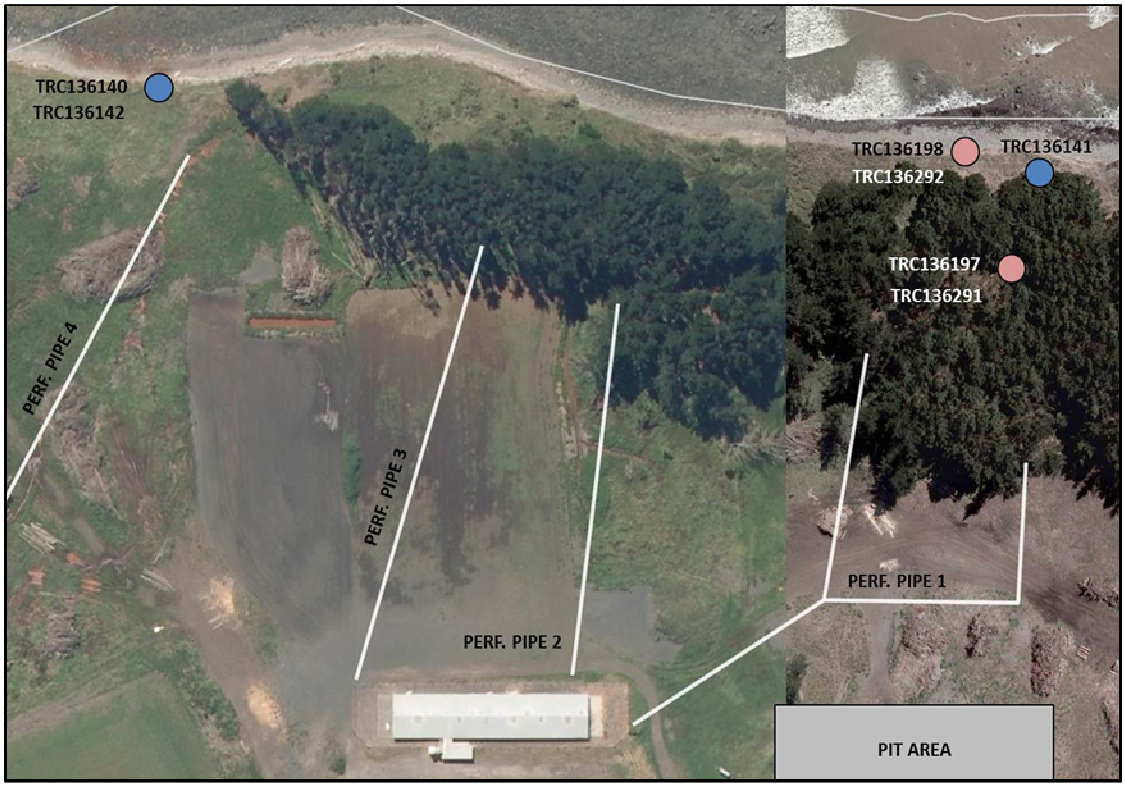

Figure 11 Schematic depicting locations of investigative sampling sites in relation to perforated pipes at landfarming facilities (Consent 7884-1)

Table 19 Additional TRC monitoring results obtained in response to incidents and investigations during the 2012-2013 monitoring period in respect of consent 7884-1

Parameter	Unit	Date and Sample Number		
		05 Jun 2013 *TRC136140*	05 Jun 2013 *TRC136141*	05 Jun 2013 *TRC136142*
pH	pH	7.4	7.2	-
Conductivity	mS/m@20C	-	-	-
Total dissolved solids	g/m³	-	-	-
Chloride	g/m³		**869**	-
Iron	g/m³	0.74	0.46	400
Total Iron	g/m³	-	-	10100
Total Nitrogen	g/m³ N	4.15	9.04	-
Potassium	g/m³	67.3	331	-
Sodium	g/m³	72.1	372	-
Sulphate	g/m³	-	-	-
Ethylene glycol	g/m³	**26**	-	-
Methanol	g/m³	<2	-	-
Chromium	g/m³	<0.03	<0.03	<0.03
Hexavalent chromium	g/m³	0.0044	-	-
Total chromium	g/m³	-	-	0.021
Benzene	g/m³	<0.0010	-	<0.0010
Toluene	g/m³	<0.0010	-	<0.0010
Ethylbenzene	g/m³	<0.0010	-	<0.0010
Meta - xylene	g/m³	<0.002	-	<0.002
Ortha - xylene	g/m³	<0.0010	-	<0.0010
Hydrocarbons (TPH)	g/m³	<0.7	<0.5	<0.7
HC C7-C9	g/m³	<0.10	-	<0.10

Parameter	Unit	Date and Sample Number		
		05 Jun 2013 *TRC136140*	05 Jun 2013 *TRC136141*	05 Jun 2013 *TRC136142*
HC C10-C14	g/m³	<0.2	-	<0.2
HC C15-C36	g/m³	<0.4	-	<0.4
Acenaphthene	g/m³	<0.00010	-	-
Acenaphthylene	g/m³	<0.00010	-	-
Anthracene	g/m³	<0.00010	-	-
Benzo[a]anthracene	g/m³	<0.00010	-	-
Benzo[a]pyrene (BAP)	g/m³	<0.00010	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m³	<0.00010	-	-
Benzo[g,h,i]perylene	g/m³	<0.00010	-	-
Benzo[k]fluoranthene	g/m³	<0.00010	-	-
Chrysene	g/m³	<0.00010	-	-
Dibenzo[a,h]anthracene	g/m³	<0.00010	-	-
Fluoranthene	g/m³	<0.00010	-	-
Fluorene	g/m³	<0.0002	-	-
Indeno(1,2,3-c,d)pyrene	g/m³	<0.00010	-	-
Napthalene	g/m³	<0.0005	-	-
Phenanthrene	g/m³	<0.0004	-	-
Pyrene	g/m³	<0.0002	-	-

The scrape sample (TRC136142) showed high levels of iron as anticipated, explaining the discolouration and sheen. No hydrocarbons were detected in either water sample; however, ethylene glycol was detected in sample TRC136140, and hexavalent chromium was detected at very low levels in the same sample. It is recommended that in 2013-2014 the groundwater sampling wells be sampled for these contaminants. A recommendation to this effect is given in Section 4.

Table 20 Additional TRC monitoring results obtained in response to incidents and investigations during the 2012-2013 monitoring period in respect of consent 7884-1

Parameter	Unit	Date and Sample Number			
		11 Jun 2013 *TRC136197*	11 Jun 2013 *TRC136198*	17 Jun 2013 *TRC136291*	17 Jun 2013 *TRC136292*
pH	pH	6.4	6.8	6.6	7.2
Conductivity	mS/m@20C	279	275	270	104
Total dissolved solids	g/m3	2158.7	2127.7	2089.0	804.7
Chloride	g/m3	**825**	**831**	**800**	170
Barium	g/m3	0.32	0.26	0.30	0.14
Ethylene glycol	g/m3	-	-	<4	<4
Hexavalent Chromium	mg/kg	-	-	<0.010	<0.010
Benzene	g/m3	**0.039**	**0.0059**	**0.040**	<0.0010
Toluene	g/m3	<0.0010	<0.0010	<0.0010	<0.0010
Ethylbenzene	g/m3	<0.0010	<0.0010	<0.0010	<0.0010
Meta - xylene	g/m3	<0.002	<0.002	<0.002	<0.002
Ortha - xylene	g/m3	<0.0010	<0.0010	0.0010	<0.0010
Hydrocarbons (TPH)	g/m3	<1.4	<0.7	-	-
HC C7-C9	g/m3	<0.15	<0.10	-	-
HC C10-C14	g/m3	<0.4	<0.2	-	-
HC C15-C36	g/m3	<0.8	<0.4	-	-

The results of the samples found that at the discharge point of the pipe (which was inside the landfarm boundary) there was benzene present at approximately four times the lifetime drinking water standard (0.039 g/m^3), but the discharge down the bank adjacent to the beach was significantly lower, at half the lifetime drinking water standard (0.0059 g/m^3).

Photo 9 Discharging perforated pipe showing iron oxide staining of substrate (Wellington property)

Follow up sampling on 17 June 2013 showed the benzene concentration at the point of discharge was unchanged, but the concentration of the flow down the bank had reduced to below the detection level. Samples were analysed for hexavalent chromium and ethylene glycol (in light of the results from the 5 June 2013 sampling). These contaminants were not detected in these samples.

Discussion

An abatement notice was issued requiring the discharge to be stopped. Another abatement notice was issued requiring the pipe to be removed to prevent any further 'fast tracking' of contaminants through the site to the coastal boundary. Discussions held with the Company revealed that the perforated pipe was one of four installed by the Company to drain excess soil moisture from the site to prevent excessive ponding following the removal of the original vegetation cover (pipe locations given in Figure 12, below).

Figure 12 BTW supplied map showing perforated pipe locations in respect of storage pits

This was treated as a separate (but related) incident to incident 23047 on the grounds that the pipes had acted to transport contaminants towards the site boundary. The initial incident only covered the presence of contaminants in groundwater directly around the storage areas. The perforated pipe responsible for discharging contaminants was removed by the Company as per compliance with the abatement notice. It is recommended that in future, additional sampling be conducted from the remaining perforated pipes (2, 3 and 4, Figure 12) and from natural groundwater seeps at the site boundary. A recommendation to this effect is given in Section 4.

4. Discussion

4.1 Discussion of site performance

The Company kept the Council well-advised, as per the consents' requirements, of the receipt of various wastes (including full characterisation), site operations, provided an updated site management plan, and carried out monitoring and annual reporting for the monitoring period.

No landfarming activity has taken place on the original site (consent 6867-1) during the monitoring period. No on-going issues have been noted in any inspections. All spread areas maintain reasonable pasture cover and the formerly exposed sand areas have been successfully stabilised.

At the 'Wellington' area (consent 7884-1) it was observed during 2011-12 that, while many aspects of the operation were aligned with best practice, there were areas where a review of operations was required.

Scheduled inspections of the Wellington development indicated that odours and dust were confined to the site, pits were not in danger of overflow, signage was generally present and no effects were observed on the foreshore immediately seaward of the site, all of which are positives that reflect the adoption of best practice.

There were some minor housekeeping issues (taking into account that it was a working site) that were raised with the Company and addressed under Council direction. The Company was co-operative in all matters and demonstrated a high level of professionalism in all dealings with the Council.

However, Council scientific staff raised questions about the management of the storage areas in regard to minimising the risk to localised groundwater. Consent 7884-1 (special condition 9) requires well work-over fluids to be stored in an impermeable liner or storage tank. Similarly, condition 10 requires liquid oily wastes to be stored in a tank or impermeable lined pit. These materials were stored in lined pits, but the permeability of the liners had not been engineer certified. At the conclusion of the 2011-12 monitoring year, as a result of initial investigations into storage pit integrity, the Council initiated a more thorough hydrogeological assessment of the site.

During the 2012-2013 monitoring year, several site improvements were implemented during the monitoring period, including the reinstatement of previous storage pits and construction of new pits lined with high-grade purpose-fit synthetic liners. The Company were generally very cooperative with all matters raised, and acted professionally at all times. There was a significant investment of time and resources by the Company to remedy the issues that had been identified at the beginning of and during the monitoring period.

Supply of information regarding site activities was good, and feedback about reporting formats was taken on board by the Company, resulting in improved annual reporting. The supplied soil results showed the Company had done a reasonable job of incorporating material, and initial pasture strike in spreading areas was good.

Notwithstanding the comments above, some aspects of the site performance were poor in 2012-2013. Improvements were made later in the monitoring period, but there were also several incidents that reflected negatively on the site's overall performance. There were less than minor adverse environmental effects associated with these incidents. They are detailed in Section 3.2.

At the beginning of the monitoring year, the physical state of the site required significant improvement, with several housekeeping issues identified, mainly concerning the stockpiling facilities. The main issues at the site concerned the installation in sandy soil of storage pits used for liquid waste, and the presence of artificial drainage pipes in close proximity to the storage area. Council staff were required to intervene in site activities, and enforcement action was undertaken on four occasions.

Investigations conducted during the monitoring period concluded that there were two operational shortcomings that had led to the incidents described in Section 2.7:

1. Insufficient consideration was given by the Company into storage pit integrity, liner type and the movement of low-viscosity fluid waste streams in porous sandy soils.
2. In an effort to control natural soil saturation, artificial drainage had been installed by the Company, which altered the natural drainage patterns of the site and inadvertently provided for the accelerated movement of contaminants towards the site boundary from the storage areas.

The actual environmental impacts of these issues were relatively minor, and are discussed below in Section 3.2.4. However, these issues do indicate that, at the time of the initial site setup, the Company did not give enough regard to the hydrogeological setting of the site and the mechanics of subsurface fluid migration.

4.2 Environmental effects of exercise of consents

4.2.1 Ecological impact

The results of the marine ecological surveys conducted as part of the monitoring programme for this consent indicate that no observable impacts on intertidal species/ecosystems have occurred as a result of site activities.

The third year of the soil biota study was discontinued in favour of a laboratory based study, which is underway at the time of reporting. The results will be included along with year two of the biota study in the 2013-2014 monitoring year.

4.2.2 Radiation effects

The produced water sample analysed for alpha/beta radiation showed normal background concentrations and demonstrate that the waste types and site presented no human or animal radiation health risk through ingestion, inhalation or direct dermal contact. This was in line with the gamma results presented in the previous monitoring year, and other work performed by the Council.

4.2.3 Receiving soil physical and chemistry effects

Levels of contaminants in the surface soil across the Wellington area already meet the required consent conditions which apply at the time of eventual site relinquishment, with the exception of hydrocarbons in some recent disposals (2011-2012) and some areas where salinity was elevated (2012-2013). It is anticipated, based on previous disposal activities, that the more recently used sites will be compliant at the relevant time.

Separate sampling by the Company and Council gave a conflicting SAR result for one sample (both results were within the consent limit). Further sampling will occur in the 2013-2014 year to resolve this discrepancy.

Hydrocarbon concentrations were within application rates (2012-2013), and in many areas within eventual surrender rates. Heavy metal levels were low in all samples. Follow-up sampling of spreading areas will confirm ongoing compliance prior to consent surrender. Monitoring of receiving soil samples from the spreading areas indicates that there appears to be no adverse environmental effects on soil due to activities at the site.

4.2.4 Groundwater physical and chemistry effects

Detection in the 2011-2012 year of a very low level of contamination of localised groundwater from the exercise of consent 7884-1 required additional investigation, which was initiated by Council scientific staff in the 2012-2013 monitoring year.

Additionally, in the BTW supplied surface water sample results for the on-site ponded water there was one sample where the presence of benzene was detected. This required verification and assessment through further investigation as described above. The surface water samples from the adjacent farm drain (both BTW and TRC samples) did not show the presence of any hydrocarbons or other contaminants of concern. One Council sample indicated a slight rise in salinity (either from natural processes or site activities), the effects of which are negligible.

Several contaminants were detected at 'above background' levels.

Firstly, there was a comparatively significant increase in salinity parameters (chloride, sodium and total dissolved solids concentrations). Several of the waste streams present at the site (potassium chloride WBM, produced water and well workover fluids) contain elevated chloride and sodium. As discussed in Section 3.4.5, elevated salinity in groundwater at a coastal site poses minimal environmental risk. The consent limits referring to salinity are to protect down-gradient water takes, freshwater aquatic ecosystems, and for irrigation water quality purposes. None of these activities/situations/environments are relevant to the area utilised for the exercise of consent 7884 on the Wellington property. Furthermore, the potential endpoint for any water moving offsite is the Tasman Sea, where chloride concentrations are naturally in the range of 20,000 g/m^3, or 5-20 times higher than the levels detected around the site.

Ethylene glycol was present in one sample taken from the discharge associated with perforated pipe 4 (Figures 11 and 12, above), at a concentration of 26 g/m^3.

It is an odourless, colourless, syrupy, sweet-tasting liquid, which is commonly used in gas production as a hydrate inhibitor. Ethylene glycol is only slightly-moderately toxic, but in larger quantities it can present a potential human/animal health risk through ingestion or inhalation. It breaks down quickly in water or soil (within weeks), and is unlikely to present any risk at the concentrations detected. To confirm there is no significant on-going issue with ethylene glycol at the site, it is recommended that the groundwater bores and other perforated pipes/groundwater seeps be tested for ethylene glycol in the following monitoring period.

Hexavalent chromium was also present in that same sample in very low concentrations (0.0044 g/m^3). Hexavalent chromium poses a significant human/animal health risk depending on concentrations and exposure pathways. The drinking water standard for hexavalent chromium is 0.02 g/m^3, and the stock-watering guideline value is 1.0 g/m^3. The sample result of 0.0044 g/m^3 is well within these values, and the water at this site is not intended for consumptive use, so the risk is essentially nil. However, hexavalent chromium is unlikely to be naturally occurring in water leaving this site, and as such is not compliant with the resource consent.

Of interest was the presence of BTEX compounds (primarily benzene) in two of the bores and in very low levels at the site boundary. Benzene is a monocyclic aromatic hydrocarbon (MAH) generally present as a colourless flammable liquid with a sweet odour. It is a natural constituent of crude oil, and could have multiple potential sources at an oil and gas disposal site. It potentially poses a significant human health risk through direct ingestion or inhalation depending on concentrations and exposure pathways. Its presence is therefore specifically regulated within consent 7884-1.

Benzene is one of the more soluble hydrocarbon compounds with a specific gravity of 0.878 and solubility in water of 1,780 ppm at 20 ^oC, meaning it can move readily through capillary action in the unsaturated zone to the water table where subsequent vertical or lateral movement depends on hydraulic conductivity, soil textural properties (eg effective porosity) and water table gradient. The relatively high mobility (compared to other hydrocarbons) is evidenced in the presence of these particular compounds in the groundwater samples.

The concentrations of BTEX in the bores have been compared with the drinking water standards, as exact limits were not set in the consent conditions. In the absence of consent limits, the conventional approach is to compare results to the most stringent guideline values. In reality, the drinking water standards are arguably not applicable at this site, as it is not water intended for consumption by humans or animals. The Tier 1 groundwater acceptance criteria for benzene are 0.8 g/m^3 for irrigation, 4 g/m^3 for stock water, and 0.3 g/m^3 for protection of aquatic ecosystems (MfE, 1999). The levels detected in the samples from the landfarming facilities are within these guideline values.

BTEX compounds are naturally attenuated in soil and groundwater through bioremediation, and concentrations are also significantly reduced through volatilization in shallow soils in the unsaturated zone. The degradation of BTEX compounds in groundwater occurs more readily in aerobic conditions, where the

biodegradation half lives can range from 10 days to 24 months depending on several variables (Howard et al, cited in MfE, 1999).

Had the perforated pipes not been influencing groundwater flow at the site, it is expected that the hydrocarbon contaminants detected in the bores would have degraded in-situ over a relatively short time frame.

Offsite effects

At the site boundary contaminants were detected at very low levels in water discharging through perforated pipes which terminated near the site boundary. It is a site with a considerable groundwater throughflow, a relatively shallow water table, and the presence of natural iron pans channelling water. The addition of the perforated pipes has both focussed and accelerated the movement of water towards the site boundary. At the low concentrations detected at the site boundary these contaminants pose negligible environmental risk. At the point of discharge onto the beach these contaminants were barely above detection level.

Due to likely high infiltration rates of beach sand at the base of the embankment, depending on flow rate, and existing soil saturation levels, any further migration of this water is likely to be subsurface into the area of tidal influence. Dilution of the already low levels of contaminants in groundwater within the high tide zone would be massive and concentrations in the receiving environment would be negligible and of no consequence.

Levels of contaminants in the surface soil across the original site (as covered by consent 6867-1) meet the required consent conditions in the supplied BTW results. Some Council data showed non-compliance with surrender conditions in particular areas (from sampling that occurred prior to the Company's monitoring), and so the Council indicated further confirmatory sampling would be undertaken by the Council in the 2013-2014 year prior to the consent being accepted for surrender. Site inspections and the results of the soil biota study indicated no on-going impacts from site activities undertaken in previous years.

Hydrogeological considerations

The additional investigations conducted at this site were necessary to determine consent compliance and quantify the environmental effects from site activities. These investigations also improved the understanding of the hydrogeological processes occurring at this site. Following the installation of the monitoring wells, groundwater contour maps were created to determine depth to groundwater, flow direction and seasonal variation, in order to model the movement of any contaminants through groundwater at the site.

GPS surveying showed the elevation of the wells to be between approximately 14-15 mASL. The water table was shown to be at elevations between 11.8 and 13.5 mASL. Groundwater flow was shown to be seaward in a NE-SW direction. Little seasonal variation in water table elevation was observed (Figure 13).

Bores GND2283 and GND2285 showed elevations in the concentrations of contaminants. GND2284 showed very little impact from site activities. Once the locations of the perforated drain pipes were surveyed in, it became apparent that 'perforated pipe 1' was possibly intercepting and redirecting flow around this bore.

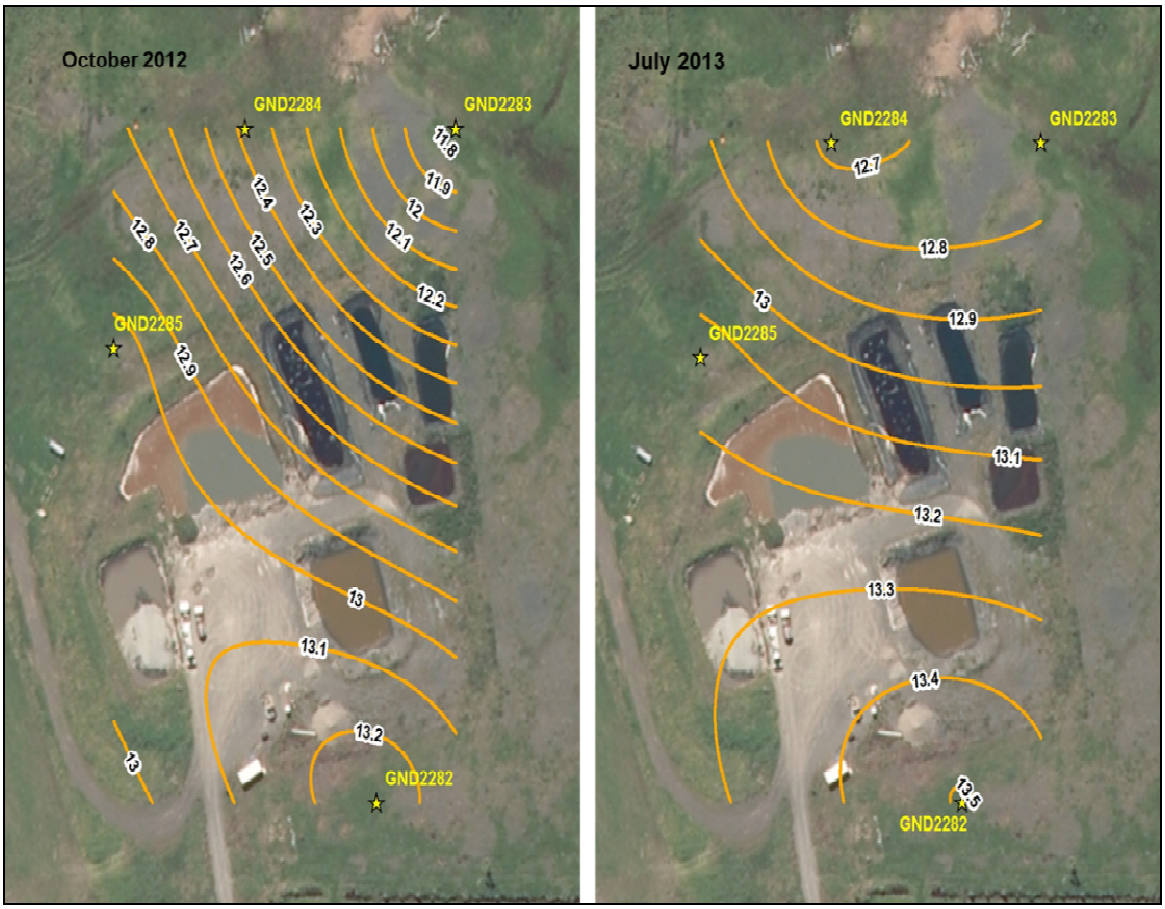

Figure 13 Groundwater contour maps of stockpiling facilities from October 2012 (left) and July 2013 (right)

This would explain the absence of contaminants in GND2284. GND2282, the 'up-gradient' bore, showed increased levels of chloride and TDS, but no hydrocarbons. Although landward of the pits it is not a true up-gradient bore and has shown some impacts from storage activities.

Following the discontinuation of the initial storage pit setup during the period under review, it is anticipated that contaminant concentrations in groundwater will continue to decrease to background. Continual groundwater sampling will be conducted to verify the reduction of these contaminant concentrations.

At the conclusion of the monitoring period the Council had begun reviewing the suitability of land disposal for liquid waste. The preferred and predominant option in the region has been and continues to be deep well injection (DWI), for wastes suitable for this technique. It is recommended that this consent be reviewed at the next available review date in 2015. A recommendation to this effect is given in Section 5.

4.3 Evaluation of performance

A tabular summary of the Company's compliance record for the years under review is set out in Tables 21-24.

Table 21 Summary of **2011-2013** performance for Consent 6867-1, to discharge drilling wastes [consisting of drilling cuttings and drilling fluids] from hydrocarbon exploration activities with water based muds and synthetic based muds, and oily wastes from hydrocarbon exploration and production activities, onto and into land via landfarming

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Definitions which apply to the consent	Not applicable	N/A
2. Best practicable option to be adopted	Inspections and liaison with consent holder	Yes
3. Current management plan in place	Current plan approved 25 March 2010	Yes
4. Notification 48 hours prior to stockpiling	No material received on site during monitoring period	N/A
5. Notification 48 hours prior to landfarming	No landfarming undertaken during monitoring period	N/A
6. Keep records relating to wastes, areas, compositions, volumes, dates, treatments and monitoring	Company records received	Yes
7. Report on records in condition 6 to Council by 31 August each year	Report	Yes
8. Discharge depth limited to 100mm for waste with hydrocarbons < 5%, or 50mm for waste with hydrocarbons > 5%	No landfarming undertaken during monitoring period	N/A
9. Single application of wastes to each area of land	No landfarming undertaken during monitoring period	N/A
10. Incorporation into soil as soon as practicable so that top 250mm layer contains less than 5% hydrocarbons	No landfarming undertaken during monitoring period	N/A
11. Re-vegetate landfarmed areas as soon as practicable	Inspection	Yes
12. No discharge within 25m of a water body, property boundary or within 50m of the Tasman Sea	No landfarming undertaken during monitoring period	N/A
13. Consent applies only to wastes generated in Taranaki	No landfarming undertaken during monitoring period	N/A
14. Maximum volume of stockpiling 6000m^3, discharge within eight months of arrival on site	No material received on site during monitoring period	N/A
15. Levels of metals in soil shall comply with guidelines	Sampling undertaken in previous years	Yes
16. Conductivity must be less than 400 mS/m. If background conductivity exceeds 400 mS/m, then increase shall not exceed 100 mS/m	Sampling undertaken in previous years	Yes
17. Sodium absorption ratio [SAR] must be less than 18.0, if background SAR exceeds 18.0 then increase shall not exceed 1.0	Sampling undertaken in previous years	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
18. Total dissolved salts in surface water or groundwater shall not exceed 2500 g/m^3	No fresh surface water in vicinity, groundwater not analysed	N/A
19. Disposal of waste shall not lead to contaminants entering surface water	No fresh surface water in vicinity	N/A
20. No adverse impacts on groundwater or surface water	No fresh surface water in vicinity, groundwater not assessed	N/A
21. Level of dissolved salts in surface water	No fresh surface water in vicinity	N/A
22. Prior to expiry, cancellation, or surrender of consent soil hydrocarbon content must comply with MfE guidelines	Sampling prior to surrender	Yes
23. Prior to expiry, cancellation, or surrender of consent these levels must not be exceeded: a) conductivity 290 mS/m b) dissolved salts 2500 g/m^3 c) sodium 460 mg/kg d) chloride 700 mg/kg	Sampling prior to surrender	Yes
24. Notification of discovery of archaeological remains	None found	N/A
25. Optional review provision re environmental effects	Next optional review in June 2014	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		**High**

Table 22 Summary of **2011-2012** performance for Consent 7670-1, to discharge drilling wastes [consisting of drilling cuttings and drilling fluids] from hydrocarbon exploration activities with water based muds and synthetic based muds, and oily wastes from hydrocarbon exploration and production activities, onto and into land via landfarming

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Definitions which apply to the consent	Not applicable	N/A
2. Best practicable option to be adopted	Inspections and liaison with consent holder	Yes
3. Current management plan in place	Current plan approved 25 March 2010	Yes
4. Notification 48 hours prior stockpiling	Notifications received	Yes
5. Notification 48 hours prior landfarming	Notifications received	Yes
6. Keep records relating to wastes, areas, compositions, volumes, dates, treatments and monitoring	Company records received	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
7. Report on records in condition 6 to Council by 31 August	Surrendered	N/A
8. Discharge depth limited to 100mm for waste with hydrocarbons < 5%, or 50mm for waste with hydrocarbons > 5%	Company records and inspection	Yes
9. Single application of wastes to each area of land	Company records and inspection	Yes
10. Incorporation into soil as soon as practicable so that top 250mm layer contains less than 5% hydrocarbons	Inspection and sampling	Yes
11. Re-vegetate landfarmed areas as soon as practicable	Company records and inspection	Yes
12. No discharge within 25m of a water body, property boundary or within 50m of the Tasman Sea	Inspection	Yes
13. Consent applies only to wastes generated in Taranaki	Company records	Yes
14. Maximum volume of stockpiling 6000$m^{3,}$ discharge within eight months of arrival on site	Company records and inspection	Yes
15. Levels of metals in soil shall comply with guidelines	Sampling	Yes
16. Conductivity must be less than 400 mS/m. If background conductivity exceeds 400 mS/m, then increase shall not exceed 100 mS/m	Sampling	Yes
17. Sodium absorption ratio [SAR] must be less than 18.0, if background SAR exceeds 18.0 then increase shall not exceed 1.0	Sampling	Yes
18. Total dissolved salts in surface water or groundwater shall not exceed 2500 g/m^3	No fresh surface water in near vicinity, groundwater not analysed	N/A
19. Disposal of waste shall not lead to contaminants entering surface water	No fresh surface water in near vicinity	N/A
20. No adverse impacts on groundwater of surface water	No fresh surface water in vicinity, groundwater not assessed	N/A
21. No adverse effects on surface water	No fresh surface water in vicinity	N/A
22. Prior to expiry, cancellation, or surrender of consent soil hydrocarbon content must comply with MfE guidelines	Sampling prior to surrender	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
23. Prior to expiry, cancellation, or surrender of consent these levels must not be exceeded: e) conductivity 290 mS/m f) dissolved salts 2500 g/m^3 g) sodium 460 mg/kg h) chloride 700 mg/kg	Sampling prior to surrender	Yes
24. Notification of discovery of archaeological remains	None found	N/A
25. Optional review provision re environmental effects	Next optional review in June 2014	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		**High**

Table 23 Summary of **2011-2012** performance for Consent 7884-1, to discharge wastes from hydrocarbon exploration, well work-over, production and storage activities, onto and into land via landfarming

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Definitions which apply to the consent	Not applicable	N/A
2. Best practicable option to be adopted	Inspections and liaison with consent holder	**No**
3. Only specified wastes to be discharged	Information provided by consent holder	Yes
4. Notification 48 hours prior stockpiling	Notifications received	Yes
5. Notification 48 hours prior landfarming	Notifications received	Yes
6. Sample of wastes from each individual source to be collected and analysed	Information provided by consent holder	Yes
7. Keep records relating to wastes, areas, compositions, volumes, dates, treatments and monitoring	Information provided by consent holder	Yes
8. Report on records in condition 7 to Council by 31 August	Report received 29 August 2012	Yes
9. Well work-over fluids to be stored in tank or pit	Inspections and information provided by consent holder	Yes
10. Liquid oily wastes to be stored in tank or mixed into pit	Inspections and information provided by consent holder	Yes
11. All wastes landfarmed ASAP or within 12 months	Inspections and information provided by consent holder	Yes
12. Well work-over fluids to be kept separate from other waste types	Inspections and information provided by consent holder	Yes
13. No waste to be discharged into F1 and F2 areas	Inspections and information provided by consent holder	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
14. Solid waste to be applied either 100mm or 50mm thick depending on hydrocarbon concentration	Inspections and information provided by consent holder	Yes
15. Parameters for rate of liquid waste application	Inspections and information provided by consent holder	Yes
16. Incorporation of solid wastes to a depth of at least 250mm ASAP	Inspections and information provided by consent holder	Yes
17. Hydrocarbon concentration shall not exceed 50,000mg/kg dry weight	Inspections and information provided by consent holder	Yes
18. Single application of wastes to each area of land	Inspections and information provided by consent holder	Yes
19. No discharge within 25m of a water body, property boundary or within 50m of the Tasman Sea	Inspections and information provided by consent holder	Yes
20. Re-vegetate landfarmed areas as soon as practicable	Inspections and information provided by consent holder	Yes
21. Total dissolved salts in surface water or groundwater shall not exceed 2500 g/m^3	Samples collected	**Surface water complies, groundwater requires verification**
22. Contaminants in surface or groundwater not to exceed background concentrations	Sampling	**Requires verification**
23. Conductivity must be less than 400 mS/m. If background conductivity exceeds 400 mS/m, then increase shall not exceed 100 mS/m	Sampling	Yes
24. Sodium absorption ratio [SAR] must be less than 18.0, if background SAR exceeds 18.0 then increase shall not exceed 1.0	Sampling	**Mostly** (1 breach in TRC results-to be verified)
25. Concentration of metals in soil to comply with guidelines	Sampling	Yes
26. Levels of contaminants prior to expiry, cancellation, or surrender of consent		N/A
27. Consent may not be surrendered until condition 26 is satisfied		N/A
28. Notification of discovery of archaeological remains	None found	N/A
29. Consent to lapse in 2016 unless given effect to	Consent exercised	N/A
30. Optional review provision re environmental effects	Next optional review in June 2015	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		**Good**

Table 24 Summary of **2012-2013** performance for Consent 7884-1, to discharge wastes from hydrocarbon exploration, well work-over, production and storage activities, onto and into land via landfarming

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Definitions which apply to the consent	Not applicable	N/A
2. Best practicable option to be adopted	Inspections and liaison with consent holder	**No**
3. Only specified wastes to be discharged	Information provided by consent holder	Yes
4. Notification 48 hours prior to stockpiling	Notifications received	Yes
5. Notification 48 hours prior to landfarming	Notifications received	Yes
6. Sample of wastes from each individual source to be collected and analysed	Information provided by consent holder	Yes
7. Keep records relating to wastes, areas, compositions, volumes, dates, treatments and monitoring	Information provided by consent holder	Yes
8. Report on records in condition 7 to Council by 31 August	Report received 27 August 2013	Yes
9. Well work-over fluids to be stored in tank or pit	Inspections and information provided by consent holder	Yes*
10. Liquid oily wastes to be stored in tank or mixed into pit	Inspections and information provided by consent holder	Yes*
11. All wastes landfarmed ASAP or within 12 months	Inspections and information provided by consent holder	Yes
12. Well work-over fluids to be kept separate from other waste types	Inspections and information provided by consent holder	Yes
13. No waste to be discharged into F1 and F2 areas	Inspections and information provided by consent holder	Yes
14. Solid waste to be applied either 100mm or 50mm thick depending on hydrocarbon concentration	Inspections and information provided by consent holder	Yes
15. Parameters for rate of liquid waste application	Inspections and information provided by consent holder	Yes
16. Incorporation of solid wastes to a depth of at least 250mm ASAP	Inspections and information provided by consent holder	Yes
17. Hydrocarbon concentration shall not exceed 50,000mg/kg dry weight	Inspections and information provided by consent holder	Yes
18. Single application of wastes to each area of land	Inspections and information provided by consent holder	Yes
19. No discharge within 25m of a water body, property boundary or within 50m of the Tasman Sea	Inspections and information provided by consent holder	Yes
20. Re-vegetate landfarmed areas as soon as practicable	Inspections and information provided by consent holder	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
21. Total dissolved salts in surface water or groundwater shall not exceed 2500 g/m^3	Samples collected	**No**
22. Contaminants in surface or groundwater not to exceed background concentrations	Sampling	**No**
23. Conductivity must be less than 400 mS/m. If background conductivity exceeds 400 mS/m, then increase shall not exceed 100 mS/m	Sampling	Yes
24. Sodium absorption ratio [SAR] must be less than 18.0, if background SAR exceeds 18.0 then increase shall not exceed 1.0	Sampling	Yes
25. Concentration of metals in soil to comply with guidelines	Sampling	Yes
26. Levels of contaminants prior to expiry, cancellation, or surrender of consent		N/A
27. Consent may not be surrendered until condition 26 is satisfied		N/A
28. Notification of discovery of archaeological remains	None found	N/A
29. Consent to lapse in 2016 unless given effect to	Consent exercised	N/A
30. Optional review provision re environmental effects	Next optional review in June 2015	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		**Poor (environmental and administrative non-compliance)**

N/A = not applicable

*Materials were stored in pits, but the liners were deemed unsuitable for the intended use

Adverse environmental effects were not observed at the original site during the monitoring period. No discharge activity (stockpiling or landfarming) occurred at the site during the monitoring period.

During the 2011-2012 year, the Company demonstrated an overall good level of environmental performance and compliance with the resource consents that applied within the second stage of development of the landfarm. However, some potential issues were noted for investigation.

During the 2012-2013 year, the Company demonstrated a poor level of environmental performance and compliance with resource consent 7884-1. There were four incidents, two of which involved minor environmental impacts. The Council was obliged to issue the Company two infringement notices and four abatement notices in relation to those incidents. Subsequently there were significant site improvements, and the administration was generally good, but there were issues with aspects of consent compliance throughout the monitoring period.

During the monitoring period, the Company demonstrated an overall good level of environmental performance and compliance with the resource consents ('high' for consents 6867-1 and 7670-1 for both years, and 'good' for consent 7884-1 for 2011-2012, but 'poor' for 2012-2013). The Company were extremely cooperative and proactively engaged the Council over all matters raised regarding the site during the monitoring period. The Company were generally very good with record keeping and data supply.

4.4 Recommendation from the 2010-2011 Annual Report

In the 2010-2011 Annual Report, it was recommended:

1. *THAT monitoring of the Brown Road Landfarm (including the Wellington property) in the 2011-2012 year be continued from that in 2010-2011, noting that (a) use of the Brown Road sites has concluded but that site monitoring will continue to establish compliance with limits that apply at time of surrender or expiry, and (b) the possible effects arising from the discharge of wastes arising from fracturing activities will be studied through a supplementary specific soil ecology monitoring programme.*

Part (a) of this recommendation was implemented, in that the individual areas used for each disposal on this part of the landfarming facilities were monitored to ensure compliance criteria were being or would be met for each spreading area; part (b) has been implemented initially in the extension to the more recently developed area (consent 7884-1) of the on-site soil ecology monitoring programme, and then through the replacement laboratory study.

4.5 Alterations to monitoring programmes for 2013-2014

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

It is proposed that for 2013-2014, the programme be modified from that for 2011-2013 in the following manner:

As of the end of the monitoring period under review, BTW have applied to surrender consent 6867-1. The Company have supplied summary compliance data for all spreading areas, including surrender sample results. To validate the supplied results, the Council will conduct independent soil sampling prior to the surrender. It can also be noted that the monitoring programme of past years was modified in 2012-2013 to include a groundwater component focussing primarily on groundwater quality in the vicinity of the stockpiling facilities.

The monitoring programme for consent 7884-1 was modified in the 2012-13 year to include a groundwater component focussing primarily on the wastes reception/storage facilities. Marine ecological surveys were reduced to one in the

2012-2013 year, reflecting the lack of observable effects observed in the initial intertidal surveys conducted in the 2011-12 monitoring year.

The effects of the exercise of consent 7884-1 will be the primary focus for monitoring during the 2013-2014 monitoring year.

The final component of the soil ecology study has been replaced with a laboratory based toxicity study.

It is proposed that the dissolved barium testing methodology is implemented as the standard for all groundwater samples.

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

5. Recommendations

1. THAT monitoring of the original disposal areas (as covered by consent 6867-1) in the 2013-2014 year be modified from that in 2011-2013, by the resumption of standard soil sampling of spread areas to assess compliance with surrender criteria.

2. THAT it be noted the monitoring of the 'Wellington' development of the landfarm (ie the area covered by consent 7884-1) has been modified to include a groundwater component focussing primarily on stockpiling facilities, this component to continue in 2013-2014.

3. THAT it be noted the soil biota programme has been extended by the addition of a laboratory based investigative programme to assess the chemical toxicity of the various wastes on microorganisms and to confirm bioactivity levels of soil health and degradation.

4. THAT barium testing in groundwater samples is by the dissolved barium test method.

5. THAT sampling is conducted of the remaining perforated pipes and natural groundwater seeps at the landfarm boundary.

6. THAT area F7 is resampled to confirm compliance for the SAR limit.

7. THAT the option for a review of resource consent 7884-1 in June 2015, as set out in condition 30 of the consent, be exercised, on the grounds that the Council are reviewing the suitability of landfarming for the disposal of wastes derived from hydraulic fracturing (ie a review of what constitutes 'best practicable option' for such wastes).

Glossary of common terms and abbreviations

The following abbreviations and terms may be 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
BTEX	MAH's benzene, toluene, ethylbenzene and xylene
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
Cumec	A volumetric measure of flow- 1 cubic metre per second (1 m^3/s)
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
MAHs	monocyclic aromatic hydrocarbons, molecules consist of a single six-sided hydrocarbon ring
MfE	Ministry for the Environment
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)
OW	Oily waste
PAHs	polycyclic aromatic hydrocarbons, molecules consist of two or more six-sided hydrocarbon rings
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 consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15)
RMA	Resource Management Act 1991 and including all subsequent amendments
SAR	Sodium absorption ratio, a measure of the sodicity of soil (also used to assess suitability of water for irrigation)
SBM	Synthetic based mud
SS	suspended solids
SQMCI	semi quantitative macroinvertebrate community index;
Temp	temperature, measured in °C (degrees Celsius)
TPH	total petroleum hydrocarbons
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
WBM	Water based mud
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.

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Appendix I

Resource consents held by BTW Company Ltd for land disposal facilities on Brown Road, Waitara

Consent 7670-1

SURRENDERED
3-08-2012

TARANAKI REGIONAL COUNCIL
CHIEF EXECUTIVE
PRIVATE BAG 713
47 CLOTEN ROAD
STRATFORD
NEW ZEALAND
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Please quote our file number on all correspondence

Discharge Permit

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

Name of Consent Holder:	BTW Company Limited P O Box 551 Taranaki Mail Centre NEW PLYMOUTH 4340
Consent Granted Date:	9 July 2010

Conditions of Consent

Consent Granted:	To discharge drilling wastes [consisting of drilling cuttings and drilling fluids from water based muds and synthetic based muds], and oily wastes, from hydrocarbon exploration and production activities, onto and into land via landfarming at or about (NZTM) 1704599E-5683484N
Expiry Date:	1 June 2027
Review Date(s):	June 2015, June 2021
ite Location:	70 Brown Road, Waitara
Legal Description:	Lot 1 DP 5462 Blk III Paritutu SD
Catchment:	Waitara

For General, Standard and Special conditions pertaining to this consent please see reverse side of this document
www.trc.govt.nz

SURRENDERED

General condition

a. The consent holder shall pay to the Taranaki Regional Council [the 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. For the purposes of this consent the following definitions shall apply:

   a) stockpiling means a discharge of drilling wastes [or oily wastes] from vehicles, tanks, or other containers onto land for the purpose of interim storage prior to landfarming, but without subsequently spreading onto, or incorporating the discharged material into the soil within 48 hours; and
   b) landfarming means the discharge of drilling wastes [or oily wastes] onto land, subsequent spreading and incorporation into the soil, for the purpose of attenuation of hydrocarbon and/or other contaminants, and includes any stripping and relaying of topsoil.

2. The consent holder shall adopt the best practicable option [as defined section 2 of the Resource Management Act 1991] to prevent or minimise any actual or potential effects on the environment arising from the discharge.

Notifications, monitoring and reporting

3. The consent holder shall notify the Chief Executive, Taranaki Regional Council, [by emailing worknotification@trc.govt.nz.] at least 48 hours prior to permitting drilling wastes onto the site for stockpiling, from each well drilled. Notification shall include the following information:

   a) the consent number;
   b) the name of the well[s] from which the waste was generated;
   c) the type of waste to be stockpiled;
   d) the volume of waste to be stockpiled; and
   e) for oily wastes the concentration of total petroleum hydrocarbons [C_6-C_9, C_{10}-C_{14}, and C_{15}-C_{36}], polycyclic aromatic hydrocarbons [PAH], and benzene, toluene, ethylbenzene and xylenes [BTEX].

4. The consent holder shall notify the Chief Executive, Taranaki Regional Council, [by emailing worknotification@trc.govt.nz.] at least 48 hours prior to landfarming stockpiled material, or material brought onto the site for landfarming within 48 hours. Notification shall include the following information:

   a) the consent number;
   b) the name of the well[s] from which the waste was generated;
   c) the type of waste to be landfarmed;
   d) the volume and weight [or density] of the waste to be landfarmed;
   e) the concentration of chlorides, nitrogen and hydrocarbons in the waste; and
   f) the specific location and area over which the waste will be landfarmed.

SURRENDERED

5. The consent holder shall keep records of the following:

   a) wastes from each individual well;
   b) composition of wastes [including concentrations of chloride, nitrogen and total petroleum hydrocarbons];
   c) stockpiling area[s];
   d) volumes of material stockpiled;
   e) landfarming area[s], including a map showing individual disposal areas with GPS co-ordinates;
   f) volumes and weights of wastes landfarmed;
   g) dates of commencement and completion of stockpiling and landfarming events;
   h) dates of sowing landfarmed areas;
   i) treatments applied;
   j) details of monitoring, including sampling locations, sampling methods and the results of analysis;

   and shall make the records available to the Chief Executive, Taranaki Regional Council.

6. The consent holder shall provide to the Chief Executive, Taranaki Regional Council, by 31 August of each year, a report on all records required to be kept in accordance with condition 5, for the period of the previous 12 months, 1 July to 30 June.

Discharge limits

7. For the purposes of landfarming, drilling wastes shall be applied to land in a layer not exceeding:

   a) 100 mm thick for wastes with a hydrocarbon concentration less than 50,000 mg/kg dry weight; or
   b) 50 mm thick for wastes with a hydrocarbon concentration equal to or greater than 50,000 mg/kg dry weight; and
   c) in a rate and manner such that no ponded liquids remain after one hour, for all wastes;

   prior to incorporation into the soil.

8. As soon as practicable following the application of drilling wastes to land in accordance with condition 7 of this consent, the consent holder shall incorporate the wastes into the soil to a depth of at least 250 mm, so that the hydrocarbon concentration at any point in the soil/waste mix is less than 50,000 mg/kg dry weight.

9. An area of land used for the landfarming of drilling wastes in accordance with conditions 7 and 8 of this consent, shall not be used for any subsequent discharges of drilling waste.

SURRENDERED

10. No discharge shall take place within 25 metres of surface water or of property boundaries.

Operational requirements

11. Liquid oily wastes shall be either:

    a) stored in an impermeable lined pit or tank; or
    b) mixed in a storage pit with a suitable volume of drilling waste in a manner that prevents the liquid oily wastes entering the ground; or
    c) landfarmed directly.

12. All material must be landfarmed as soon as practicable, but no later than twelve months after being brought onto the site.

13. As soon as practicable following landfarming, areas shall be sown into pasture [or into crop]. The consent holder shall monitor revegetation and if adequate establishment is not achieved within two months of sowing, shall undertake appropriate land stabilisation measures to minimise wind and stormwater erosion.

Receiving environment limits - water

14. The exercise of this consent shall not result in the concentration of total dissolved salts in any fresh water body exceeding 2500 g/m^3.

15. Other than as provided for in condition 14, the exercise of this consent shall not result in any contaminant concentration, within surface water or groundwater, which after reasonable mixing, exceeds the background concentration for that particular contaminant.

Receiving environment limits - soil

16. The conductivity of the soil/waste layer after landfarming shall be less than 400 mS/m, or alternatively, if the background soil conductivity exceeds 400 mS/m, the landfarming of waste shall not increase the soil conductivity by more than 100 mS/m.

17. The sodium absorption ratio [SAR] of the soil/waste layer after landfarming shall be less than 18.0, or alternatively if the background soil SAR exceeds 18.0, the landfarming of waste shall not increase the SAR by more than 1.0.

18. The concentration of metals in the soil shall at all times comply with the guidelines for heavy metals in soil set out in Table 7.1, Section 7 of the Ministry for the Environment and New Zealand Water & Wastes Assoication's Guidelines for the safe application of biosolids to land in New Zealand [2003].

SURRENDERED

19. From 1 March 2027 [three months prior to the consent expiry date], constituents in the soil shall not exceed the standards shown in the following table:

Constituent	Standard
conductivity	290 mS/m
chloride	700 mg/kg
sodium	460 mg/kg
total soluble salts	2500 mg/kg
MAHs PAHs TPH	Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand [Ministry for the Environment, 1999]. Tables 4.12 and 4.15, for soil type sand.

MAHs - benzene, toluene, ethylbenzene, xylenes
PAHs - napthalene, non-carc. [pyrene], benzo(a)pyrene eq.
TPH - total petroleum hydrocarbons [C_7-C_9, C_{10}-C_{14}, C_{15}-C_{36}]

The requirement to meet these standards shall not apply if, before 1 March 2027, the consent holder applies for a new consent to replace this consent when it expires.

20. This consent may not be surrendered at any time until the standards in condition 19 have been met.

Archaeological remains

21. In the event that any archaeological remains are discovered as a result of works authorised by this consent, the works shall cease immediately at the affected site and tangata whenua and the Chief Executive, Taranaki Regional Council, shall be notified within one working day. Works may recommence at the affected area when advised to do so by the Chief Executive, Taranaki Regional Council. Such advice shall be given after the Chief Executive has considered: tangata whenua interest and values, the consent holder's interests, the interests of the public generally, and any archaeological or scientific evidence. The New Zealand Police, Coroner, and Historic Places Trust shall also be contacted as appropriate, and the work shall not recommence in the affected area until any necessary statutory authorisations or consents have been obtained.

Lapse and review

22. This consent shall lapse on 30 September 2015, 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.

SURRENDERED

23. 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 9 July 2010

For and on behalf of
Taranaki Regional Council

Director-Resource Management

TARANAKI REGIONAL COUNCIL
CHIEF EXECUTIVE
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Please quote our file number on all correspondence

Discharge Permit

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

Name of Consent Holder:	BTW Company Limited P O Box 551 Taranaki Mail Centre NEW PLYMOUTH 4340
Decision Date:	8 July 2011
Commencement Date:	8 July 2011

Conditions of Consent

Consent Granted:	To discharge wastes from hydrocarbon exploration, well work-over, production and storage activities, onto and into land via landfarming at or about (NZTM) 1704599E-5683484N
Expiry Date:	1 June 2027
Review Date(s):	June 2015, June 2021
Site Location:	70 Brown Road, Waitara [Property owner: M Wellington]
Legal Description:	Lot 1 DP 5462 Blk III Paritutu SD [Discharge site]
Catchment:	Waitara

For General, Standard and Special conditions pertaining to this consent please see reverse side of this document
www.trc.govt.nz

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. For the purposes of this consent the following definitions shall apply:

    a) Landfarming means the discharge of wastes onto land, subsequent spreading and incorporation into the soil, for the purpose of attenuation of hydrocarbon and/or other contaminants, and includes any stripping and relaying of topsoil.
    b) Storage means a discharge of wastes from vehicles, tanks, or other containers onto land for the purpose of temporary storage prior to landfarming, but without subsequently spreading onto, or incorporating the discharged material into the soil within 48 hours.

2. The consent holder shall adopt the best practicable option [as defined section 2 of the Resource Management Act 1991] to prevent or minimise any actual or potential effects on the environment arising from the discharge.

3. Only those wastes specified in application 6815 shall be discharged.

Notifications, monitoring and reporting

4. The consent holder shall notify the Chief Executive, Taranaki Regional Council, [by emailing worknotification@trc.govt.nz.] at least 48 hours prior to permitting wastes onto the site. Notification shall include the following information:

    a) the consent number;
    b) the name of the well and wellsite, or other source, from which the waste was generated;
    c) the type of waste to be stored; and
    d) the volume of waste to be stored.

5. The consent holder shall notify the Chief Executive, Taranaki Regional Council, [by emailing worknotification@trc.govt.nz.] at least 48 hours prior to landfarming wastes. Notification shall include the following information:

    a) the consent number;
    b) the name of the well and wellsite, or other source, from which the waste was generated;
    c) the type of waste to be landfarmed;
    d) the volume of the waste to be landfarmed;
    e) the concentration of hydrocarbons in the waste; and
    f) the specific location and area over which the waste will be landfarmed.

6. The consent holder shall take a representative sample of the wastes from each individual source and have it analysed for the following:

   a) total petroleum hydrocarbons [C_6-C_9, C_{10}-C_{14}, C_{15}-C_{36}];
   b) benzene, toluene, ethylbenzene, and xylenes;
   c) polycyclic aromatic hydrocarbons screening;
   d) chloride, nitrogen, pH, potassium, and sodium; and
   e) for well work-over fluids only, ethylene glycol, gluteraldehyde, hexavalent chromium and methanol;

   and shall provide the results to the Chief Executive, Taranaki Regional Council, prior to landfarming the wastes.

7. The consent holder shall keep records of the following:

   a) composition of wastes;
   b) storage area[s];
   c) volumes of material stored;
   d) landfarming area[s], including a map showing individual disposal areas with GPS co-ordinates;
   e) volumes and weights of wastes landfarmed;
   f) dates of commencement and completion of storage and landfarming events;
   g) dates of sowing landfarmed areas;
   h) photographic evidence of pasture establishment;
   i) treatments applied;
   j) details of monitoring, including sampling locations, sampling methods and the results of analysis;

   and shall make the records available to the Chief Executive, Taranaki Regional Council.

8. The consent holder shall provide to the Chief Executive, Taranaki Regional Council, by 31 August of each year, a report on all records required to be kept in accordance with condition 7, for the period of the previous 12 months, 1 July to 30 June.

Storage

9. Well work-over fluids requiring storage prior to landfarming, shall be stored in a tank, or in a pit with an impermeable synthetic liner.

10. Liquid oily wastes shall be either:

    a) stored in a tank, or in a pit with an impermeable synthetic liner; or
    b) mixed directly into a pit containing a suitable volume of water based mud waste, in a manner that prevents the liquid oily wastes entering the ground.

11. All wastes must be landfarmed as soon as practicable, but no later than twelve months after being brought onto the site.

Discharge limits

12. Well work-over fluids shall be kept separate and distinct from other waste types.

13. No wastes shall be discharged in the F1 and F2 areas landfarmed under consent 7670-1.

14. For the purposes of landfarming, solid wastes shall be applied to land in a layer not exceeding:

    a) 100 mm thick for wastes with a hydrocarbon concentration less than 50,000 mg/kg dry weight; or
    b) 50 mm thick for wastes with a hydrocarbon concentration equal to or greater than 50,000 mg/kg dry weight.

15. For the purposes of landfarming, liquid wastes shall be applied to land:

    a) at a rate not exceeding 1 cubic metre of waste per 4 square metres of land; and
    b) at a rate such that there is no overland flow of liquids; and
    c) at a rate such that no ponded liquids remain after one hour, after application.

16. As soon as practicable following the application of solid wastes to land, the consent holder shall incorporate the wastes into the soil to a depth of at least 250 mm.

17. The hydrocarbon concentration in the soil over the landfarming area shall not exceed 50,000 mg/kg dry weight at any point where:

    a) liquid waste has been discharged; or
    b) solid waste has been discharged and incorporated into the soil.

18. Any areas of land used for the landfarming of wastes in accordance with conditons 14-16 of this consent, shall not be used for any subsequent discharges of waste.

19. No discharge shall take place within 25 metres of surface water courses or of property boundaries, or within 50 metres of Mean High Water Springs.

20. As soon as practicable following landfarming, areas shall be sown into pasture [or into crop]. The consent holder shall monitor revegetation and if adequate establishment is not achieved within two months of sowing, shall undertake appropriate land stabilisation measures to minimise wind and stormwater erosion.

Receiving environment limits - water

21. The exercise of this consent shall not result in the concentration of total dissolved salts in any fresh water body exceeding 2500 g/m^3.

22. Other than as provided for in condition 21, the exercise of this consent shall not result in any contaminant concentration, within surface water or groundwater, which after reasonable mixing, exceeds the background concentration for that particular contaminant.

Receiving environment limits - soil

23. The conductivity of the soil/waste layer after landfarming shall be less than 400 mS/m, or alternatively, if the background soil conductivity exceeds 400 mS/m, the landfarming of waste shall not increase the soil conductivity by more than 100 mS/m.

24. The sodium absorption ratio [SAR] of the soil/waste layer after landfarming shall be less than 18.0, or alternatively if the background soil SAR exceeds 18.0, the landfarming of waste shall not increase the SAR by more than 1.0.

25. The concentration of metals in the soil shall at all times comply with the guidelines for heavy metals in soil set out in Table 7.1, Section 7 of the Ministry for the Environment and New Zealand Water & Wastes Assoication's Guidelines for the safe application of biosolids to land in New Zealand [2003].

26. From 1 March 2027 [three months prior to the consent expiry date], constituents in the soil shall not exceed the standards shown in the following table:

Constituent	Standard
conductivity	290 mS/m
chloride	700 mg/kg
sodium	460 mg/kg
total soluble salts	2500 mg/kg
MAHs PAHs TPH	Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand [Ministry for the Environment, 1999]. Tables 4.12 and 4.15, for soil type sand.

MAHs - benzene, toluene, ethylbenzene, xylenes
PAHs - napthalene, non-carc. [pyrene], benzo(a)pyrene eq.
TPH - total petroleum hydrocarbons [C_7-C_9, C_{10}-C_{14}, C_{15}-C_{36}]

The requirement to meet these standards shall not apply if, before 1 March 2027, the consent holder applies for a new consent to replace this consent when it expires, and that application is not subsequently withdrawn.

27. This consent may not be surrendered at any time until the standards in condition 26 have been met.

Archaeological remains

28. In the event that any archaeological remains are discovered as a result of works authorised by this consent, the works shall cease immediately at the affected site and tangata whenua and the Chief Executive, Taranaki Regional Council, shall be notified within one working day. Works may recommence at the affected area when advised to do so by the Chief Executive, Taranaki Regional Council. Such advice shall be given after the Chief Executive has considered: tangata whenua interest and values, the consent holder's interests, the interests of the public generally, and any archaeological or scientific evidence. The New Zealand Police, Coroner, and Historic Places Trust shall also be contacted as appropriate, and the work shall not recommence in the affected area until any necessary statutory authorisations or consents have been obtained.

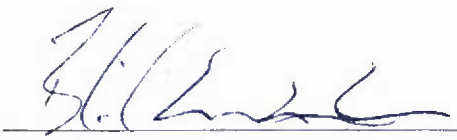
Lapse and review

29. This consent shall lapse on 30 September 2016, 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.

30. 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 8 July 2011

For and on behalf of
Taranaki Regional Council



Chief Executive

Consent 6867-1

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

Please quote our file number on all correspondence

Discharge Permit

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

Name of Consent Holder: BTW Company Limited
P O Box 551
Taranaki Mail Centre
NEW PLYMOUTH 4340

Change To Conditions Date: 4 February 2010 [Granted: 27 April 2006]

Conditions of Consent

Consent Granted: To discharge drilling wastes [consisting of drilling cuttings and drilling fluids] from hydrocarbon exploration activities with water based muds and synthetic based muds, and oily wastes from hydrocarbon exploration and production activities, onto and into land via landfarming at or about (NZTM) 1704006E-5683454N

Expiry Date: 1 June 2020

Review Date(s): June 2012, June 2014

Site Location: Brown Road, Waitara
[Property owner: Papawai Holdings Limited, C/- GL & HM Rogers]

Legal Description: Pt Sec 1 Matataiore Blk & Pt Sec 50 Papawai Blk Waitara W Dist Blk I SD

Catchment: Tasman Sea
Waiongana

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 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. For the purposes of this consent the following definitions shall apply:

   a) stockpiling means a discharge of drilling wastes from vehicles, tanks, or other containers onto land, but without subsequently spreading, or incorporating into the soil within 24 hours of such discharge; and
   b) landfarming means the discharge of drilling waste onto land, subsequent spreading and incorporation into the soil, and includes any stripping and relaying of topsoil.

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 adverse effects on the environment from the exercise of this consent.

Management plan

3. The consent holder shall maintain, to the written satisfaction of the Chief Executive, Taranaki Regional Council, a landfarming and stockpiling management plan to demonstrate the activity will be conducted to comply with all of the conditions of this consent. The management plan shall be reviewed annually and shall include as a minimum:

   a) control of site access;
   b) procedures for notification to the Taranaki Regional Council of disposal activities;
   c) procedures for the receipt and stockpiling of drilling wastes onto the site;
   d) methods used for the mixing and testing of different waste types;
   e) procedures for landfarming drilling wastes [including means of transfer from stockpiling area, means of spreading, and incorporation into the soil];
   f) procedures for sowing landfarmed areas;
   g) contingency procedures;
   h) sampling regime and methodology; and
   i) post-landfarming management, monitoring and site reinstatement.

Notification and sampling requirements prior to discharge

4. The consent holder shall notify the Chief Executive, Taranaki Regional Council, [by emailing worknotification@trc.govt.nz.] at least 48 hours prior to permitting drilling wastes onto the site for stockpiling, from each well drilled. Notification shall include the following information:

   a) the consent number;
   b) the name of the well[s] from which the waste was generated;
   c) the type of waste to be stockpiled;
   d) the volume of waste to be stockpiled; and
   e) for oily wastes the concentration of total petroleum hydrocarbons [C_6-C_9, C_{10}-C_{14}, and C_{15}-C_{36}], polycyclic aromatic hydrocarbons [PAH], and benzene, toluene, ethylbenzene and xylenes [BTEX].

5. The consent holder shall notify the Chief Executive, Taranaki Regional Council, [by emailing worknotification@trc.govt.nz.] at least 48 hours prior to landfarming stockpiled material. Notification shall include the following information:

   a) the consent number;
   b) the name of the well[s] from which the waste was generated;
   c) the type of waste to be landfarmed;
   d) the volume and weight of the waste to be landfarmed;
   e) the concentration of chlorides, nitrogen and total petroleum hydrocarbons hydrocarbons in the waste; and
   f) the specific location and area over which the waste will be landfarmed.

Monitoring and reporting

6. The consent holder shall keep records of the following:

   a) wastes from each individual well [including records of all additives used at the wellsite during the drilling process];
   b) composition of wastes, including concentrations of chloride, nitrogen and total petroleum hydrocarbons;
   c) stockpiling area[s];
   d) volumes of material stockpiled;
   e) landfarming area[s], including a map showing individual disposal areas with GPS co-ordinates;
   f) volumes and weights of wastes landfarmed;
   g) dates of commencement and completion of stockpiling and landfarming events;
   h) dates of sowing landfarmed areas;
   i) treatments applied;
   j) details of monitoring, including sampling locations, sampling methods and the results of analysis;

   and shall make the records available to the Chief Executive, Taranaki Regional Council.

7. The consent holder shall provide to the Chief Executive, Taranaki Regional Council, by 31 August of each year, a report on all records required to be kept in accordance with condition 6, for the period of the previous 1 July to 30 June.

Discharge limits

8. For the purposes of landfarming, drilling wastes shall be applied to land in a layer not exceeding:

   a) 100 mm thick for wastes with a hydrocarbon concentration less than 50,000 mg/kg dry weight; or
   b) 50 mm thick for wastes with a hydrocarbon concentration equal to or greater than 50,000 mg/kg dry weight; and
   c) in a rate and manner such that no ponded liquids remain after one hour, for all wastes;

   prior to incorporation into the soil.

9. An area of land used for the landfarming of drilling wastes in accordance with condition 8 of this consent shall not be used for any subsequent discharges of drilling waste.

10. As soon as practicable following the application of drilling wastes to land, the consent holder shall incorporate the material into the soil to a depth of at least 250 mm so that the hydrocarbon concentration at any point in the soil/waste mix is less than 50,000 mg/kg dry weight.

11. As soon as practicable following landfarming, areas shall be sown into pasture [or into crop]. The consent holder shall monitor revegetation and if adequate establishment is not achieved within two months of sowing, shall undertake appropriate land stabilisation measures to minimise wind and stormwater erosion.

12. No discharge shall take place within 25 metres of a surface water body, property boundary, or 50 metres of the Tasman Sea.

13. The exercise of this consent is limited to wastes generated within the Taranaki region.

14. The stockpiling of material authorised by this consent shall be limited to a maximum volume of 6,000 m^3 at any one time on the property. In any case all stockpiled material must be landfarmed within eight months of being brought onto the site.

Receiving environment limits

15. At any time the levels of metals in the soil shall comply with the guidelines for heavy metals in soil set out in Table 7.1, Section 7 of the "Guidelines for the safe application of biosolids to land in New Zealand" [MfE and NZWWA 2003].

16. The conductivity of the soil layer containing the discharge shall be less than 400 mSm^{-1}, or alternatively, if the background soil conductivity exceeds 400 mSm^{-1}, the application of waste shall not increase the soil conductivity by more than 100 mSm^{-1}.

17. The sodium absorption ratio [SAR] of the soil layer containing the discharge shall be less than 18.0, or alternatively if the background soil SAR exceeds 18.0, the application of waste shall not increase the SAR by more than 1.0.

18. The exercise of this consent shall not result in a level of total dissolved salts within any surface water or groundwater of more than 2500 gm^{-3}.

19. The exercise of this consent, including the design, management and implementation of the discharge [including but not limited to stockpiling on land and/or discharge onto and into land], shall not lead or be liable to lead to contaminants entering a surface water body.

20. The exercise of this consent shall not result in any adverse impacts on groundwater as a result of leaching, or on surface water including aquatic ecosystems, and/or result in a change to the suitability of use of the receiving water as determined by the Chief Executive, Taranaki Regional Council.

21. The exercise of this consent shall not result in any of the following effects on surface water:

    a) the production of any conspicuous oil or grease films, scums or foams, or floatable or suspended material;
    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.

22. At the time of expiry, cancellation, or surrender of this consent the levels of hydrocarbons in the soil shall comply with the guideline values for sandy soil in the surface layer [less than 1 metre depth] set out in Tables 4.12 and 4.15 of the Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand [Ministry for the Environment, 1999].

23. At the time of expiry, cancellation, or surrender of this consent soil parameters shall not exceed the following limits: conductivity, 290 mS/m; total dissolved salts, 2500 mg/kg; sodium, 460 mg/kg; and chloride, 700 mg/kg.

24. In the event that any archaeological remains are discovered as a result of works authorised by this consent, the works shall cease immediately at the affected site and tangata whenua and the Chief Executive, Taranaki Regional Council, shall be notified within one working day. Works may recommence at the affected area when advised to do so by the Chief Executive, Taranaki Regional Council. Such advice shall be given after the Chief Executive, Taranaki Regional Council, has considered: tangata whenua interest and values, the consent holder's interests, the interest of the public generally, and any archaeological or scientific evidence. The New Zealand Police, Coroner, and Historic Places Trust shall also be contacted as appropriate, and the work shall not recommence in the affected area until any necessary statutory authorisation or consent has been obtained.

Review

25. 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 2012 and/or June 2014, 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, or to take into account any Act of Parliament, regulations, national policy statement, and national environmental standard which is relevant to this consent.

Signed at Stratford on 4 February 2010

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Appendix II

Company Annual reports - Consent 6867-1, 7884-1

2th August 2012

Consents Manager
Taranaki Regional Council
Private Bag 713
47 Cloten Road
Stratford

Attention: Colin McLellan

RE: Resource Consent 6867-1 Brown Road Disposal Site, Waitara Monitoring and Reporting – Special Condition 7

In accordance with Special Condition 7 (SC 7) of resource consent 6867-1 it is a requirement that the consent holder provide to the Chief Executive, Taranaki Regional Council, by 31 August of each year, a report on all records required to be kept in accordance with condition 6, for the period of the previous 1 July to 30 June.

This report therefore includes all information related to activities provided for under consent 6867-1 from 1 July 2011 to 30 June 2012 as well as monitoring of previous activities undertaken and monitoring required under SC 15-17.

No material has been received on site within the last 12 month monitoring period and no further material is to be discharged under consent 6867-1. General comments are made below regarding constituent levels relevant to the surrender of the consent.

Records required – SC 6 a), d), f), g) & h)

The following information has been collated within tables and spread sheets for the purpose of demonstrating compliance with SC 7. Information will be supplied generally in order as requested within Special Condition 6 a-j (SC 6). All records required under b) & j) of SC 6 will be addressed later in the report. A map of the site showing individual disposal areas and GPS co-ordinates is located in Appendix 1 in compliance with SC 6 c) & e).

Table 1 (Appendix 2) displays information related to recording of details required within a), d), f), g), h) & i) of special condition 6 which are listed below. As no material has been discharged on site within the last 12 month period, a record of all additives used on wellsites during the drilling process has not been supplied - SC 6 a).

a) *wastes from each individual well [including records of all additives used at the wellsite during the drilling process].*
d) *volumes of material stockpiled*
f) *volumes and weights of wastes landfarmed.* (Note** Density sampling was undertaken on pre-disposal samples following consent variation)
g) *dates of commencement and completion of stockpiling and landfarming events*
h) *dates of sowing landfarmed areas*

i) treatments applied;

Records required – SC 6 b) & j) and SC 15 - 18

Information contained in Appendices 3 & 4 addresses relevant record keeping required in order to comply with SC 6 j). SC 6 b) is no longer relevant on this site as more material is being received. These monitoring results include testing to display compliance with SC 15-18. Monitoring of landfarming area's B1, B3, B6, B7, B8, B9, B12, B16 has ceased due to compliant hydrocarbon levels and other monitored constituents. Monitoring of all other areas B2, B4, B5, B7, B10, B11, B13, B14 and B15 will continue for at least one more year. A final composite sample of the site will be recovered when the consent is surrendered in order to meet standards outlined within SC 22 & 23.

b) composition of wastes, including concentrations of chloride, nitrogen and total petroleum hydrocarbons.
j) details of monirtoring, including sampling locations, sampling methods and the results of analysis.

Appendix 3	Existing environment: – Electrical conductivity – Ca, Mg, Na – Sodium Absorption ratio
Appendix 4	B2-B15 Monitoring

The following details related to monitoring and sampling are also supplied:

Monitoring:

Monitoring of landfarmed areas and pre-stockpiled material is undertaken generally as outlined within the 'Brown Road Disposal Site – Site Management Plan". One modification to this plan is when parameters reach compliant levels and relevant guidelines, monitoring ceases until consent expiry testing is proposed.

Sampling Locations:

Specific landfarmed areas are located through the use of a GPS navigational system. These co-ordinates are contained within the 'Brown Road Disposal Site – Site plan showing areas of disposal' which is updated following landfarming events. A central point is located within each area and a composite sample retrieved in a transect line from the central point. The line direction is dependent on the underlying orientation of the landfarmed material.

Methods:

Sampling involves collecting a composite of 8-10 sub-samples from a transect line running from the central point of a landfarmed area. Typically, samples are retrieved from approximately 250mm but this can vary depending on the location of the drilling mud layer.

TRC Inspection Notices:

Inspections undertaken by TRC Offices have found that storage of drilling material has ceased and all areas subject to landfarming have well established pasture. All inspection notices issued by TRC Officers have found activities on the site comply with conditions of consent 6867-1 and reporting of these inspections has also indicated compliance with special conditions 19-21.

Compliance with SC 15, 16, 17, 18, 19, 20, 21

Compliance with SC 15, 16 & 17 have been displayed within previous annual reports for the site under consent 6867-1.

Visual inspections have been undertaken to display comply with SC 19, 20 & 21. Through these inspections it can be anticipated that SC 18 is compliant as landfarming was undertaken in such a way that no contaminates may enter surface water. Therefore, compliance with SC 20 & 21 is also achieved. This compliance is also reinforced through TRC inspection notices.

If you have any queries related to this report please contact me.

Regards,

David Riley

Appendix 1

Disposal Site Map

ID	MudType	Date Farmed	WellName	Easting	Northing	Area (m²)
B1	WBM	Oct 2006	Kowhai	1704171	5683469	6802
B2	SBM	Oct 2006	Kowhai	1704192	5683371	5754
B3	WBM	Jan 2007	Kowhai	1704229	5683456	7906
B4	SBM	Jan 2007	Kowhai	1703978	5683345	3795
B5	SBM	Nov 2009	Mangahewa D	1704089	5683476	15036
B6a	WBM	Oct 2009	Mangahewa C	1704124	5683349	5151
B6b	WBM	Oct 2009	Mangahewa C	1704150	5683554	1227
B7	WBM	Oct 2009	KA 6/11	1704076	5683382	517
B8	WBM	Oct 2009	Mystone / Waitui-1	1704064	5683417	409
B9	WBM	Oct 2009	KA 8/12/15	1704087	5683354	577
B10	SBM	Jan 2010	Mangahewa C	1704016	5683392	12211
B11	WBM	Feb 2010	Waitui-1	1703991	5683418	5657
B12	Fracture Water	09-07-2010	Mangahewa C	1703933	5683489	7098
B13a	MIX	Dec 2010	McKee Production Station, Waitui-1 (SBM), Cheal B (WBM), Port Taranaki Contaminated Soil	1704054	5683635	28652
B13b	MIX	Dec 2010	McKee Production Station, Waitui-1 (SBM), Cheal B (WBM), Port Taranaki Contaminated Soil	1703922	5683513	13422
B13c	MIX	Dec 2010	McKee Production Station, Waitui-1 (SBM), Cheal B (WBM), Port Taranaki Contaminated Soil	1704028	5683235	10758
B14	MIX	Dec 2010	McKee Production Station, Cheal B	1704032	5683298	2513
B15	WBM	Dec 2010	Broadside	1703972	5683289	4532
B16a	Produced Water	Jan-May 2011	Tank Farms	1703859	5683600	7265
B16b	Produced Water	Jan-May 2011	Tank Farms	1704197	5683292	11121

1703800 1704000 1704200

5684000 5683800 5683600 5683400 5683200

N W E S

B13a B16a B13b B12 B11 B10 B4 B15 B14 B13c B5 B6b B1 B3 B8 B7 B9 B6a B2 B16b ACCESS TRACK

Legend
- Fracture Water
- Produced Water
- MIX
- SBM
- WBM
- Fence
- Track

GENERAL NOTES:
1. Coordinates are in terms of NZGD 2000 Transverse Mercator

Disclaimer:
Boundary information has been imported from external sources.
Areas and dimensions may be subject to scale error.
Use of this drawing for other purposes is at the user's risk.
Print from PDF: scale not accurate.

btw company
surveyors planners engineers land & gis services

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Web : www.btwcompany.co.nz

BROWN ROAD DISPOSAL SITE
SITE PLAN SHOWING
AREA'S OF DISPOSAL

No.	DATE	BY	CHD	DESCRIPTION
6	10/02/11	JH	DR	Add produced water areas B16a and B16b
5	25/01/11	BO	DR	Add produced water areas.
4	14/12/10	PT	DR	Add disposal areas.
3	23/07/10	PT	DR	Add labels to disposal pits.
2	11/05/10	PT	DR	Add labels to disposal pits.
1	16/02/10	PT	DR	Make changes to area calculations.

REVISIONS

DRAWN BY	THOMPSON	09/02/10
CHECKED BY	RILEY	10/02/10
PROJECT No.	09252	
LOCATION	WAITARA	
ORIGINAL SIZE	A3	
SCALE	1:2,500	

0 20 40 80 120 160 200
Meters

DRAWING No. 09252-04-GIS

REV 6

Appendix 2

Stockpiling and Landfarming Records (August 2009-2010 & 2010-2011 & 2011-2012)

Table 1: Stockpiling and landfarming records (August 2009-2010 & 2010-2011).

Well/ source	Waste	Volume (m3)	Volumes/ weight landfarmed	Commencement & completion of stockpiling	Commencement & completion of landfarming	Dates of sowing landfarmed areas	Treatments applied
Mangahewa-D	SBM	1208.4	All SBM LF'd	6/8/2009 – 16/10/2009	8/9/2009 – 10/12/2009	16/12/2009	Mangahewa D SBM and WBM became contaminated during well site storage. As a result of this contamination the material was mixed upon reaching Brown Rd and independent SBM and WBM pits were contaminated. The resulting contamination resulted in the overall dilution of hydrocarbons (non-compliance with consent). This material was spread 150mm thick as the hydrocarbon concentration was less than 50000mg/kg.
	WBM	353	All WBM LF'd	22/7/2009 – 5/8/2009	8/9/2009 – 10/12/2009	16/12/2009	See above
		246	All WBM LF'd	20/11/2009 – 9/12/2009	8/9/2009 – 10/12/2009	16/12/2009	See above
		14	All WBM LF'd	5/3/2010 – 9/3/2010	Landfarmed as Waitui-1 SBM 15/9/2010-20/12/2010		The sump at Mangahewa-D was emptied and the remaining 14m3 of WBM was blended with the Waitui-1 SBM stockpiled onsite.
	Fluids	239.5	All fluids LF'd	20/9/2009 – 25/9/2009	8/9/2009 – 10/12/2009	16/12/2009	All fluids were stockpiled within the Mangahewa-D SBM storage pit.
Mangahewa-C	SBM	1251	All SBM LF'd	19/10/2009 – 22/12/2009	10/12/2009 – 22/2/2010	1/03/2010	No blending with other material took place in regard to the landfarming of Mangahewa C SBM. This material was spread 150mm thick as the hydrocarbon concentration was less than 50000mg/kg.
	WBM	913.5	All WBM LF'd	11/10/2009 – 19/10/2009	8/9/2009 – 10/12/2009	16/12/2009	No blending with other material took place in regard to the landfarming of Mangahewa C WBM. This material was spread 150mm thick as the hydrocarbon concentration was less than 50000mg/kg.
	Fluids	1208	All fluids LF'd	8/1/2010 – 28/5/2010	15/9/2010-20/12/2010		Contaminated stormwater fluids from the Mangahewa C site were discharged into the same pits as the Waitui-1 SBM, MPS OBM, Cheal B WBM & the PTCS.
	Frac	1590	Frac water stockpiled in pits A & E spread – 384m^3	8/2/2010 – 28/4/2010	9/07/2010	Not sown	The facture water was landfarmed after being stockpiled for a minimum of two months. Over this time the water was diluted by stormwater and subject to UV treatment by sunlight. Fracture water was not tested upon arrival to the site. Prior to landfarming, testing concluded the water was appropriate to landfarm.
KA 6/11	WBM	57	All WBM LF'd	2/9/2009 – 15/9/2009	8/9/2009 – 10/12/2009	16/12/2009	No blending with other material took place in regard to the landfarming of KA 6/11 WBM. This material was spread at 150mm thick as the hydrocarbon concentration was less than 50000mg/kg.
KA 8/12/15	WBM	85	All WBM LF'd	3/10/2009 – 21/10/2009	8/9/2009 – 10/12/2009	16/12/2009	See above
Waitui-1 (Mystone)	SBM	2178	All SBM LF'd	7/1/2010 – 1/4/2010	15/9/2010-20/12/2010	28/12/2010	All Waitui-1 SBM was discharged into disposal pit D. When stormwater levels rose within pit D, pits C and B were combined with pit D. All MPS OBM, PTCS, Cheal B WBM and Waitui SBM were blended together.
	WBM	839.5	All WBM LF'd	29/12/2009 – 7/1/2010	8/1/2010 – 22/2/2010	1/03/2010	No blending with other material took place in regard to the landfarming of Waitui-1 WBM. This material was spread 150mm thick as the hydrocarbon concentration was less than 50000mg/kg.
	WBM	32	All WBM LF'd	30/07/2009 - 9/8/2010	8/9/2009-10/12/2009	16/12/2009	No blending with other material took place in regard to the landfarming of this WBM material. The WBM was spread 150mm thick as the hydrocarbon concentration was less than 50000mg/kg.
	Fluids	502.5	All fluids LF'd	18/1/2010 – 22/2/2010	15/9/2010-20/12/2010	28/12/2010	Waitui-1 fluids were stockpiled with Waitui-1 SBM material.
Mckee Production Station	OBM	298	All OBM LF'd	10/02/2010	15/9/2010-20/12/2010	28/12/2010	MPS material was stored within pit C before being blended with Waitui-1 SBM, Cheal B WBM and PTCS.
		6	All OBM LF'd	30/04/2010			
		66	All OBM LF'd	3/06/2010			

SBM - Synthetic Based Mud
WBM - Water Based Mud
Fluids - Accumulated stormwater fluids in mud tanks

OBM - Oil Based Mud
Con-soil - Contaminated Soil
Frac - Fracture water
LF'd - Landfarmed

MPS - Mckee Production Station
PTCS - Port Taranaki Contaminated Soil

Added or modified cell from 2010-2011 Annual Report.

Port Taranaki	Con-soil	91	All Soil LF'd	1/3/2010 – 4/3/2010	15/9/2010-20/12/2010	28/12/2010	PTCS was stored within pit B before being blended with Waitui-1 SBM, MPS OBM and Cheal B WBM.
Cheal B	WBM	10	All WBM LF'd	1/04/2010	15/9/2010-20/12/2010	28/12/2010	Cheal B WBM was stored within pit B before being blended with PTCS, Waitui-1 SBM and MPS OBM.
Cheal B	WBM	236	All WBM LF'd	21/7/2010 - 4/8/2010	20/12/2010 - 18/2/2011	20/11/2011	Cheal B material was stored in a separate pit to any other material, then 8m3 of MPS material was added to the pit. The material landfarmed within B14 at 100mm thickness as the combined hydrocarbon concentration were less than 50,000mg/kg
Mckee Production Station	OBM	8	All OBM LF'd	23/08/2010	20/12/2010 - 18/2/2011	20/11/2011	MPS material was stored with 236m3 of Cheal B WBM and landfarmed within B14 at 100mm thickness as the combined hydrocarbon concentration were less than 50,000mg/kg
Broadside	WBM	212	All WBM LF'd	20/9/2010 - 2/10/2010	20/12/2010 - 18/2/2011	20/11/2011	Broadside WBM was stored in an isolated pit and landfarmed within area B15 at 100mm thick as hydrocarbon concentrations were less than 50,000mg/kg
	Fluids	489	All fluids LF'd	20/9/2010 - 2/10/2010	20/12/2010 - 18/2/2011	20/11/2011	Broadsde Waste Water was stored with Broadside solids - WBM. The material was landfarmed within area B15 at 100mm thick as hydrocarbon concentrations were less than 50,000mg/kg
STOS - Tank farm	Fluids	1487	All fluids LF'd	9/2/2011 - 9/5/2011	9/2/2011 - 15/5/2011	No sowing required	STOS water was spread as it arrived to the site within area B16a and B16b. This water was not mixed with other material.

SBM - Synthetic Based Mud
WBM - Water Based Mud
Fluids - Accumulated stormwater fluids in mud tanks

OBM - Oil Based Mud
Con-soil - Contaminated Soil
Frac - Fracture water
LF'd - Landfarmed

MPS - Mckee Production Station
PTCS - Port Taranaki Contaminated Soil

Added or modified cell from 2010-2011 Annual Report.

Table 1: Stockpiling and landfarming records (August 2010-2011).

Well/ source	Waste	Volume (m3)	Volumes/ weight landfarmed	Commencement & completion of stockpiling
Cheal B	WBM Solids	265	All WBM LF'd	17/10/2010 – 5/3/2011
	SBM Solids	54	All SBM LF'd	30/10/2010 – 3/11/2010
	WBM Fluids	754	All Fluids LF'd	16/11/2010 – 7/3/2011
Sidewinder 2	WBM Solids	241	All WBM LF'd	2/2/2011 - 16/3/2011
	WBM Fluids	478	All Fluids LF'd	16/2/2011 - 16/3/2011
MPS	OBM	10	All OBM LF'd	16/12/2011
Copper-moki	WBM Solids	378	All WBM LF'd	29/1/2011 - 13/3/2011
	WBM Fluids	384	All Fluids LF'd	25/1/2011 - 19/2/2011
Sidewinder 3	WBM Solids	212	All WBM LF'd	19/3/2011 - 6/4/2011
	WBM Fluids	495	All Fluids LF'd	18/3/2011 - 6/4/2011
Sidewinder 4	WBM Solids	340	All WBM LF'd	9/4/0211 - 30/4/2011
	WBM Fluids	486	All Fluids LF'd	7/4/2011 - 30/4/2011
Cheal C	WBM Solids	107	All Fluids LF'd	28/4/2011 - 31/4/2011
	WBM Fluids	72	All Fluids LF'd	27/4/2011 - 29/4/2011

SBM - Synthetic Based Mud
WBM - Water Based Mud
OBM - Oil Based Material
Con-soil - Contaminated Soil

Commencement & completion of landfarming	Dates of sowing
20/3/2011 – 31/4/2011	Not sown
20/3/2011 – 31/4/2011	Not sown
20/3/2011 – 31/4/2011	Not sown
20/3/2011 – 31/4/2011	Not sown
20/3/2011 – 31/4/2011	Not sown
20/3/2011 – 31/4/2011	Not sown
20/3/2011 – 31/4/2011	Not sown
20/3/2011 – 31/4/2011	Not sown
5/6/2011 - 8/8/2011	Not sown
5/6/2011 - 8/8/2011	Not sown
5/6/2011 - 8/8/2011	Not sown
5/6/2011 - 8/8/2011	Not sown
5/6/2011 - 8/8/2011	Not sown
5/6/2011 - 8/8/2011	Not sown

MPS - Mckee Production Station
LF'd - Landfarmed

Treatments applied
Cheal B WBM, fluids and SBM was blended with Sidewinder-2 WBM, MPS OBM and Copper-moki WBM. The overall composition had a low hydrocarbon concentration and the material was spread at 100mm thick.
See above
See above
See above
See above
See above
See above
See above
The Sidewinder 3 & 4 WBM was blended with the Cheal C WBM
See above
See above
See above
See above
See above

Fluids - Contaminated fluids produced while drilling

Appendix 3

Existing environment

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Hamilton 3240, New Zealand

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Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	782278	svgpv1
Address:	PO Box 551	**Date Registered:**	09-Apr-2010	
	NEW PLYMOUTH 4340	**Date Reported:**	14-Apr-2010	
		Quote No:	40228	
		Order No:		
		Client Reference:		
		Submitted By:	D Riley	

Soil Analysis Results

Sample Name:		Ex - Enviro					
Lab Number:		782278.1					
Sample Type:		SOIL General, Outdoor					
Sample Type Code:		S10					
Soluble Salts (Field)	%	< 0.05	-	-	-	-	-
EC (in 1:5 Extract)	mS/cm	0.12	-	-	-	-	-
Calcium (Sat Paste)*	mg/L	62	-	-	-	-	-
Magnesium (Sat Paste)*	mg/L	31	-	-	-	-	-
Sodium (Sat Paste)*	mg/L	61	-	-	-	-	-
Sodium Absorption Ratio*		1.6	-	-	-	-	-

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Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	782278 svgpv1
Address:	PO Box 551 NEW PLYMOUTH 4340	**Date Registered:**	09-Apr-2010
		Date Reported:	14-Apr-2010
		Quote No:	40228
		Order No:	
		Client Reference:	
		Submitted By:	D Riley

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Samples
Sample Registration*	Samples were registered according to instructions received.	-	1
Soil Prep (Dry & Grind)*	Air dried at 35 - 40°C overnight (residual moisture typically 4%) and crushed to pass through a 2mm screen.	-	1
Soluble Salts (Field)	1:5 soil:water extraction followed by potentiometric determination of conductivity. Calculated by EC (mS/cm) x 0.35.	0.05 %	1
Electrical Conductivity (EC)	Electrical Conductivity measured in 1:5 Soil:Water extract.	0.01 mS/cm	1
Calcium (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1
Magnesium (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1
Sodium (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1
Sodium Absorption Ratio (SAR)*	Calculation from the sodium, calcium and magnesium determined on a Saturated Paste extract.	0.2	1

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Gordon Rajendram PhD
Senior Technologist - Agriculture Division

Appendix 4

B2-B16 Monitoring

Hill Laboratories
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ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	921931	SPv1
Contact:	D Riley	**Date Registered:**	11-Aug-2011	
	C/- BTW Company Ltd	**Date Reported:**	17-Aug-2011	
	PO Box 551	**Quote No:**	36604	
	NEW PLYMOUTH 4340	**Order No:**		
		Client Reference:	Receiving Soil 1	
		Submitted By:	D Riley	

Sample Type: Soil

Sample Name:		F4 09-Aug-2011 3:00 pm	F2 09-Aug-2011 3:00 pm	B13 09-Aug-2011 3:30 pm		
Lab Number:		921931.1	921931.2	921931.3		
Individual Tests						
Dry Matter	g/100g as rcvd	85	80	77	-	-
Total Recoverable Barium	mg/kg dry wt	18.1	189	1,710	-	-
Total Recoverable Boron	mg/kg dry wt	< 20	< 20	-	-	-
Total Recoverable Vanadium	mg/kg dry wt	147	142	-	-	-
Chloride*	mg/kg dry wt	37	750	-	-	-
Total Nitrogen*	g/100g dry wt	0.13	0.10	-	-	-
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	< 2	< 2	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	< 0.10	-	-	-
Total Recoverable Chromium	mg/kg dry wt	8	9	-	-	-
Total Recoverable Copper	mg/kg dry wt	17	19	-	-	-
Total Recoverable Lead	mg/kg dry wt	1.8	3.3	-	-	-
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	-	-	-
Total Recoverable Nickel	mg/kg dry wt	4	5	-	-	-
Total Recoverable Zinc	mg/kg dry wt	53	51	-	-	-
BTEX in Soil by Headspace GC-MS						
Benzene	mg/kg dry wt	< 0.05	< 0.06	-	-	-
Toluene	mg/kg dry wt	< 0.05	< 0.06	-	-	-
Ethylbenzene	mg/kg dry wt	< 0.05	< 0.06	-	-	-
m&p-Xylene	mg/kg dry wt	< 0.10	< 0.11	-	-	-
o-Xylene	mg/kg dry wt	< 0.05	< 0.06	-	-	-
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Acenaphthylene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Anthracene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Benzo[a]anthracene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Chrysene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Fluoranthene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Fluorene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Naphthalene	mg/kg dry wt	< 0.13	< 0.14	-	-	-

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The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Soil						
Sample Name:		F4 09-Aug-2011 3:00 pm	F2 09-Aug-2011 3:00 pm	B13 09-Aug-2011 3:30 pm		
Lab Number:		921931.1	921931.2	921931.3		
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Phenanthrene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Pyrene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	< 8	< 8	< 9	-	-
C10 - C14	mg/kg dry wt	< 20	< 20	79	-	-
C15 - C36	mg/kg dry wt	< 40	< 40	650	-	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt	< 70	< 70	730	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil			
Test	**Method Description**	**Default Detection Limit**	**Samples**
Environmental Solids Sample Preparation	Air dried at 35℃ and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-3
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	-	1-2
BTEX in Soil by Headspace GC-MS	Solvent extraction, Headspace GC-MS analysis US EPA 8260B. Tested on as received sample	-	1-2
Polycyclic Aromatic Hydrocarbons Screening in Soil	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis (modified US EPA 8270). Tested on as received sample.	-	1-2
Total Petroleum Hydrocarbons in Soil	Sonication extraction in DCM, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample	-	1-3
Dry Matter (Env)	Dried at 103℃ for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550.	0.10 g/100g as rcvd	1-3
esICextn*	Potassium phosphate extraction for Ion Chromatography. In House.	-	1-2
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-3
Total Recoverable Barium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.4 mg/kg dry wt	1-3
Total Recoverable Boron	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	20 mg/kg dry wt	1-2
Total Recoverable Vanadium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	100 mg/kg dry wt	1-2
Chloride*	Ion Chromatography determination of es potassium phosphate extraction.	3 mg/kg dry wt	1-2
Total Nitrogen*	Catalytic Combustion (900℃, O_2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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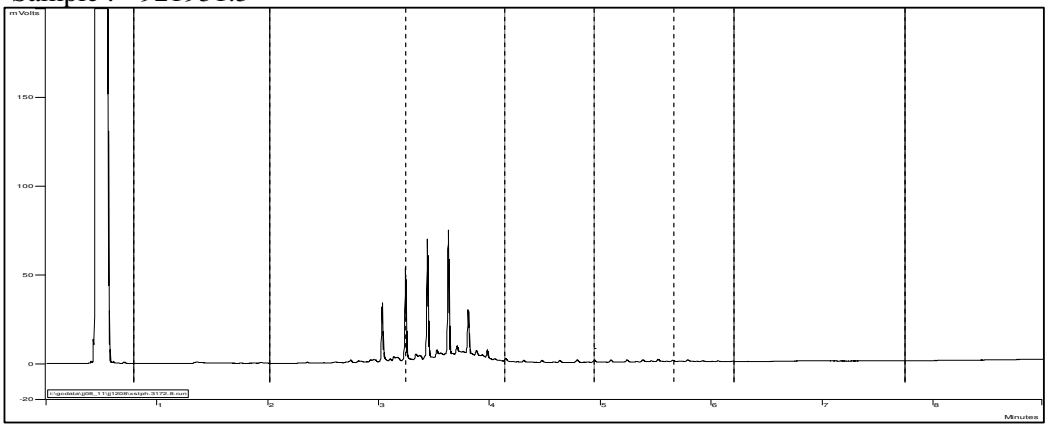
Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Sample : 921931.3



C7 C10 C15 C20 C25 C30 C34 C44

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ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	1025101	SPv1
Contact:	Michael Collins	**Date Registered:**	11-Jul-2012	
	C/- BTW Company Ltd	**Date Reported:**	16-Jul-2012	
	PO Box 551	**Quote No:**	32966	
	NEW PLYMOUTH 4340	**Order No:**		
		Client Reference:	Predisposal Sample	
		Submitted By:	BTW Company Ltd	

Sample Type: Soil

Sample Name:		B2 09-Jul-2012	B4 09-Jul-2012	B-13 09-Jul-2012	B14 09-Jul-2012	B15 09-Jul-2012
Lab Number:		1025101.1	1025101.2	1025101.3	1025101.4	1025101.5
Individual Tests						
Dry Matter	g/100g as rcvd	90	69	88	88	77
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	< 8	< 11	< 9	< 8	< 9
C10 - C14	mg/kg dry wt	< 20	< 30	< 20	< 20	< 20
C15 - C36	mg/kg dry wt	82	< 50	< 40	< 40	< 40
Total hydrocarbons (C7 - C36)	mg/kg dry wt	82	< 80	< 70	< 70	< 70

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Samples
Total Petroleum Hydrocarbons in Soil	Sonication extraction in DCM, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample	-	1-5
Dry Matter (Env)	Dried at 103℃ for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-5

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

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Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

823
365
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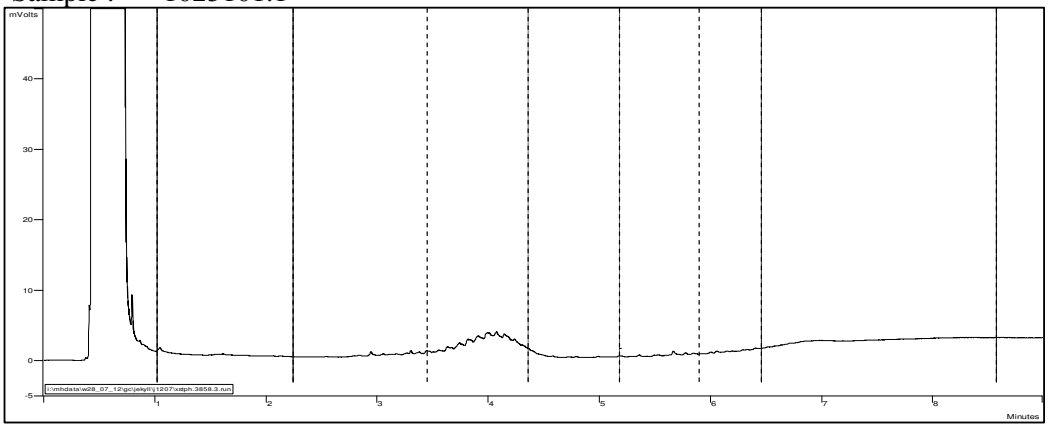
Sample : 1025101.1



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ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	953021	SPv1
Contact:	D Riley	**Date Registered:**	16-Nov-2011	
	C/- BTW Company Ltd	**Date Reported:**	22-Nov-2011	
	PO Box 551	**Quote No:**	36604	
	NEW PLYMOUTH 4340	**Order No:**		
		Client Reference:		
		Submitted By:	D Riley	

Sample Type: Soil

		Sample Name:	B5 15-Nov-2011 10:00 am	B15 15-Nov-2011 10:00 am			
		Lab Number:	953021.1	953021.2			
Individual Tests							
Dry Matter	g/100g as rcvd		88	81	-	-	-
Total Recoverable Barium	mg/kg dry wt		1,240	2,900	-	-	-
Chloride*	mg/kg dry wt		7	101	-	-	-
Total Petroleum Hydrocarbons in Soil							
C7 - C9	mg/kg dry wt		< 8	< 9	-	-	-
C10 - C14	mg/kg dry wt		< 20	1,390	-	-	-
C15 - C36	mg/kg dry wt		< 40	4,800	-	-	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt		< 70	6,200	-	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Samples
Environmental Solids Sample Preparation	Air dried at 35℃ and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-2
Total Petroleum Hydrocarbons in Soil	Sonication extraction in DCM, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample	-	1-2
Dry Matter (Env)	Dried at 103℃ for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550.	0.10 g/100g as rcvd	1-2
esICextn*	Potassium phosphate extraction for Ion Chromatography. In House.	-	1-2
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-2
Total Recoverable Barium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.4 mg/kg dry wt	1-2
Chloride*	Ion Chromatography determination of es potassium phosphate extraction.	3 mg/kg dry wt	1-2

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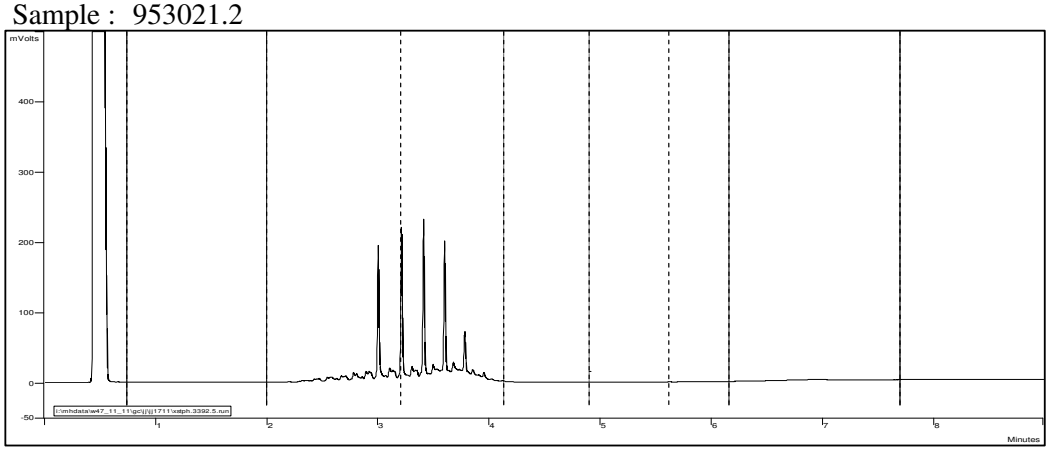
Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Sample : 953021.2



C7 C10 C15 C20 C25 C30 C34 C44

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ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	956135	SPv1
Contact:	D Riley	**Date Registered:**	25-Nov-2011	
	C/- BTW Company Ltd	**Date Reported:**	30-Nov-2011	
	PO Box 551	**Quote No:**	36604	
	NEW PLYMOUTH 4340	**Order No:**		
		Client Reference:	Receiving Soil 1	
		Submitted By:	D Riley	

Sample Type: Soil

Sample Name:		B10 23-Nov-2011 3:30 pm				
Lab Number:		956135.1				
Individual Tests						
Dry Matter	g/100g as rcvd	84	-	-	-	-
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	< 8	-	-	-	-
C10 - C14	mg/kg dry wt	180	-	-	-	-
C15 - C36	mg/kg dry wt	1,540	-	-	-	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt	1,720	-	-	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Samples
Total Petroleum Hydrocarbons in Soil	Sonication extraction in DCM, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample	-	1
Dry Matter (Env)	Dried at 103℃ for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550.	0.10 g/100g as rcvd	1

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

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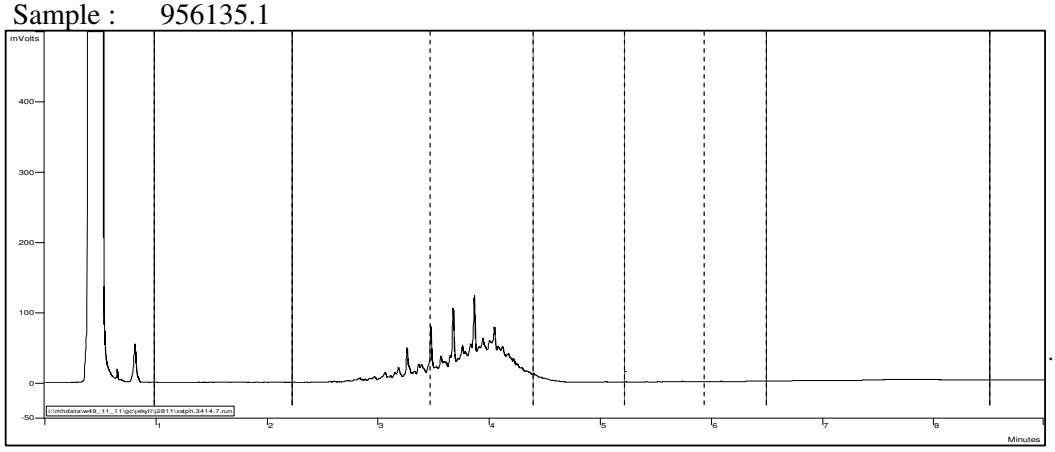
Sample : 956135.1



C7 C10 C15 C20 C25 C30 C34 C44

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ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	977090	SPv1
Contact:	D Riley	**Date Registered:**	14-Feb-2012	
	C/- BTW Company Ltd	**Date Reported:**	21-Feb-2012	
	PO Box 551	**Quote No:**	36604	
	NEW PLYMOUTH 4340	**Order No:**		
		Client Reference:	Receiving Soil 1	
		Submitted By:	D Riley	

Sample Type: Soil

Sample Name:		F3 10-Feb-2012 3:00 pm	B11 10-Feb-2012 3:30 pm	B10 10-Feb-2012 3:30 pm		
Lab Number:		977090.1	977090.2	977090.3		
Individual Tests						
Dry Matter	g/100g as rcvd	95	86	85	-	-
Total Recoverable Barium	mg/kg dry wt	1,400	-	-	-	-
Chloride*	mg/kg dry wt	19	-	-	-	-
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	< 8	< 8	< 8	-	-
C10 - C14	mg/kg dry wt	< 20	< 20	< 20	-	-
C15 - C36	mg/kg dry wt	< 40	187	< 40	-	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt	< 70	187	< 70	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Samples
Environmental Solids Sample Preparation	Air dried at 35℃ and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1
Total Petroleum Hydrocarbons in Soil	Sonication extraction in DCM, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample	-	1-3
Dry Matter (Env)	Dried at 103℃ for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550.	0.10 g/100g as rcvd	1-3
esICextn*	Potassium phosphate extraction for Ion Chromatography. In House.	-	1
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1
Total Recoverable Barium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.4 mg/kg dry wt	1
Chloride*	Ion Chromatography determination of es potassium phosphate extraction.	3 mg/kg dry wt	1

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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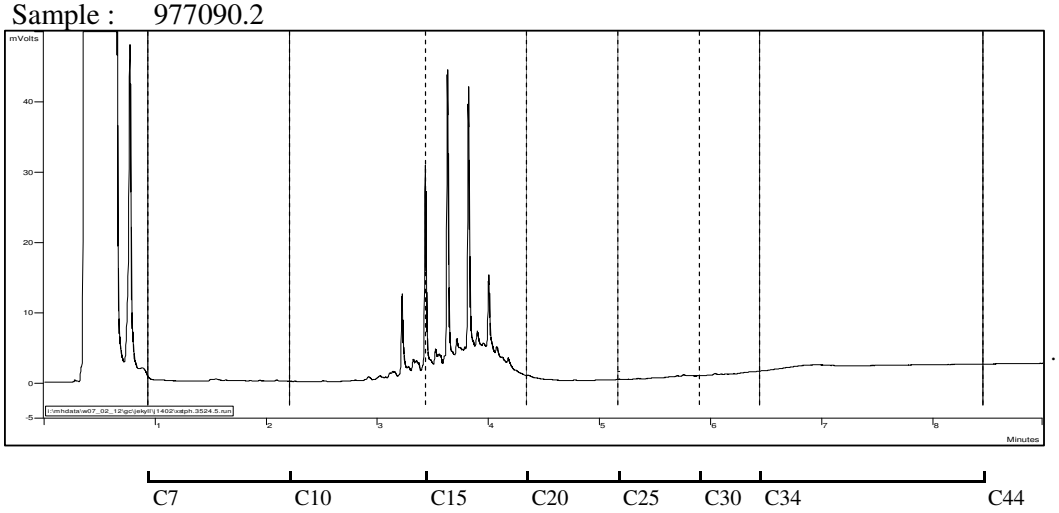
Martin Cowell - BSc (Chem)
Client Services Manager - Environmental Division

Sample : 977090.2



Annual Report

Special Condition 8 - Monitoring and Reporting

Wellington Landfarm Annual Report - Consent 7884

by BTW Company





btw company
surveyors . planners . engineers . land & g·i·s services

Wellington Landfarm Annual Report: Consent 7884

10181

	Reviewed	
Report Author	Dave Bolger	27/8/13 Date
Reviewed by	Kathryn Hooper	27/8/13 Date

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27/08/2013

CONTENTS

1 INTRODUCTION

1.1 Special Condition 8

In accordance with Special Condition 8 (SC8) of resource consent 7884 -1 it is a requirement that:

The consent holder provide to the Chief Executive, Taranaki Regional Council, by 31 August of each year, a report on all records required to be kept in accordance with Special Condition 7 (SC7), for the period of the previous 1 July to 30 June.

This report therefore includes all information related to activities provided for under consent 7884-1 from 1 July 2012 to 30 June 2013 as well as monitoring required under SC 21-27.

1.2 July 2012 to June 2013 - Summary

During the year in review BTW Company applied to surrender consent 7670-1 as monitoring analysis has demonstrated that F1 & F2 fall under consent surrender measurements. Surrender of 7670-1 was finalised on 9 August 2012. Accordingly no further reporting is required under this consent.

During the annual reporting year areas F12 to F19 have been landfarmed, these areas are shown on the attached overall landfarming plan in Appendix B. The material that has been landfarmed during the reporting period comprises water based mud, synthetic base mud, contaminated soil, oily waste and well work over fluid. Approximately 5.2 hectares of land has been landfarmed during this annual reporting year.

BTW Company has continued to work closely with the Taranaki Regional Council (TRC) over the year in review to establish best practices for landfarming operations. This has included lining all the pits and the installation of ground water monitoring bores.

1.3 Records required under Special Condition 7

The consent holder shall keep records of the following:

a) Composition of waste;
b) Storage areas;
c) Volume of material stored;
d) Landfarming areas, including a map showing individual disposal area with GPS co-ordinates;
e) Volumes and weight of wastes landfarmed;
f) dates of commencement and completion of storage and landfarming events;
g) dates of sowing landfarming areas;
h) photographic evidence of pasture establishment treatment;
i) treatment applied;
j) details of monitoring, including sampling locations, sampling methods and the results of analysis;

and shall make the records available to the Chief Executive, Taranaki Regional Council.

1.4 Report Overview

The following information has been collated for the purpose of demonstrating compliance with SC8. Information will be supplied generally in order as requested within SC7 a-j.

- Records required under SC7 condition a) Composition of waste, is provided in Appendix A of the Report. Appendix A provides a list of all chemical products and lists of possible constituents which may be added to alter the consistency of drilling mud or well work over fluids and are stored on well sites.

  Condition a) is also addressed in Section 4 of this report.

- A map of the site showing individual disposal areas, GPS co-ordinates and stockpiling areas is located in Appendix B displaying compliance with SC7 b), d) & f). This includes:
  - *Storage Area's*
  - *Landfarming areas, including a map showing individual disposal area with GPS co-ordinates;*
  - *dates and commencement and completion of storage and landfarming events.*

- Section 2 provides the information related to the recording of details required within conditions c), e), g), h) & i) of SC7 which are listed below;

  - *volumes of material stored;*
  - *volumes and weights of wastes landfarmed;*
  - *dates of sowing landfarmed areas;*
  - *photographic evidence of pasture establishment;*
  - *treatments applied.*

  Material volumes have been calculated based on the area of disposal and the thickness which disposal is undertaken. This information is available on the site map provided in Appendix B.

- Section 3 provides details of monitoring, including sampling locations and sampling methods as required by SC7, condition j.

- Section 4 provides the results of analysis as required also by SC7, condition j. Special Conditions 21-25 of Consent 7884-1 are also addressed in this section.

2 MATERIAL STORAGE AND TREATMENT

The following section provides the information related to recording of details required within c), e), g), h) & i) of SC7 which are listed below;

- *volumes of material stored;*
- *volumes and weights of wastes landfarmed;*
- *dates of sowing landfarmed areas;*
- *photographic evidence of pasture establishment;*
- *treatments applied.*

2.1 Material Volumes

As of the 30/6/13 the site contained 4 lined pits. Two pits with a maximum capacity of 1000m^3 and two smaller lined oily waste pits of maximum capacity 30m^3. The volume stored during the annual reporting year relates to the areas that have been landfarmed during this period. The volume of material stored during the reporting year is approximately 5222m^3, however this calculation is taking from the spreading areas and we always increase the required spreading areas to safe guard calculations, therefore the overall volume is likely to be considerably less than this figure. Refer to table 2.1 for a breakdown of the material landfarmed.

Table 2.1 provides the information required relating to the volumes of material landfarmed. Material volumes have been calculated based on the area of disposal and the thickness which disposal is undertaken. This information is available on the site map provided in Appendix B.

Table 2.1: Volumes of Material Landfarmed – July 2012 to June 1013

Location	Material Type	Date Landfarmed	Area of cover (m^2)	Thickness of material (mm)	Volume landfarmed (m^3)
F12	SBM	Aug 2012	18870	100	1887
F13	SBM	Aug 2012	13760	100	1376
F14	SBM	Aug 2012	5000	100	500
F15	WBM	Oct, 2012	2000	100	200
F16	CS	Mar, 2013	7500	100	750
F17	CS	May, 2013	2500	100	250
F18	WWF	May, 2013	1161	100	116.1
F19	WWF	May, 2013	1434	100	143.4

2.2 Sowing and treatments

No treatments have been applied to materials landfarmed at the Wellington Landfarm.

Sowing of grass has occurred on landfarmed areas F12 to F17. Photographic evidence of this, which is required under SC7 h), is included in Appendix D.

3 MONITORING INFORMATION

The following section provides the details of monitoring, including sampling locations, sampling methods and the results of analysis;

3.1 Monitoring

All material stockpiled on site is tested prior to arrival on site to assess its exact nature. Testing takes place prior to its arrival because on occasions it is added to other material already stored and therefore unable to be sampled separately once on-site.

When an appropriate volume of material has been stockpiled which justifies mobilising equipment for a landfarming operation, an assessment is made of all predisposal results to determine whether a composite sample needs to be taken. If hydrocarbon levels can be determined without the need for a composite sample, the landfarm area is designated, the area pegged out and landfarming commences.

Monitoring of the landfarmed area begins within the first month of topsoil being re-applied. At this point, an entire suite of tests is undertaken to assess the receiving environment against consent conditions. For WBM material, monitoring is undertaken every six months for the first year following application, and 6-monthly until compliance with consent surrender conditions is achieved. For all other material, monitoring is undertaken every three months for the first year following application , and 6-monthly after this until compliance is achieved. Within the first year, if results are compliant, monitoring ceases in the specific landfarm area.

Monitoring results have been provided in a spread sheet to assist with compliance and consent requirements for surrender (See Section 4). A number of areas identified during the monitoring year now meet the surrender limits criteria as stipulated on the consent. Areas that have met surrendering criteria are discussed in Section 4. Sampling of these areas will now cease until one last sampling composite of the site is completed as part of the surrender of this consent. BTW Company will continue to sample the remaining areas until surrender criteria limits have been meet.

All receiving environment samples are tested by an independent laboratory (Hill Laboratories) and methodology is in accordance with their requirements and the TRC.

3.2 Sampling Locations

Specific landfarmed areas are located and identified through the use of a GPS navigational system. These co-ordinates are contained within the 'Wellington Disposal Site' – Site plan (Appendix B) which shows individual areas of disposal and this is updated whenever new landfarm areas are completed. A central point is located within each area and a composite sample (15 sub samples) retrieved in a transect line from the central point. The line direction is dependent on the underlying orientation of the landfarmed material.

3.3 Methods

Sampling involves collecting a composite of 12 sub-samples which are located with GPS along a transect line running from the central point of a landfarmed area. Typically, samples are retrieved from approximately 250mm but this can vary depending on the location of the drilling mud layer. This procedure has been approved by the TRC.

3.4 Inspection Notices

As landfarming has been under the spot light in recent times we have noticed a significant increase in the inspections from TRC compliance officers. We welcome inspections to our site, however this increased monitoring has come with an ever increasing monitoring cost for landfarming operations.

Over the annual reporting year only one route inspection found a compliance issue, which was an oversight from both the TRC and BTW Company, as the issue (perforated nova coil) had been present on the site for over a year. BTW Company acted quickly to rectify the issue and to ensure no environmental effect would result. While the TRC Scientific Officer confirmed the actual effect from the non-compliance issue would be negligible, this was technically a breach of the consent, therefore compliance issued an abatement notice, refer to section 3.5 below for further details.

Overall the inspection notices have been positive and the operation has been undertaken within consent conditions and the operation has been well managed on a difficult site. The spreading areas are providing positive results, with good pasture strikes, significant constituent breakdown rates and benefits for the landowner.

3.5 Infringement Notices

An Infringement Notice was issued by the TRC on the 15th of November in regards to an authorised discharge of BTEX (Benzene) in the groundwater bores at the site. The slightly elevated level of benzene detected has now reduced and this was confirmed via the TRC monitoring programme of the groundwater bores located on the site.

An additional infringement notice was issued on the 24th of July for the discharging of contaminant (Benzene) to land, the date the infringement notice was recorded on Council records was 11 June, therefore we have included in this annual report. However the TRC at this stage have not been able to provide us with any further information on this infringement notice. No results have been provided and no information of where this sample was taken has ever been provided. It has been presumed the infringement notice was part of the abatement notice issued for the same offense, which is discussed in section 3.6 below.

3.6 Abatement Notices

An abatement notice was received on the 8th of March for objectionable dust discharging beyond the consented boundary. BTW Company acted quickly to address this issue which had been exacerbated during the warm dry summer in Taranaki. A natural dust suppressant product was applied to the access track and additionally the track was watered at regular intervals. The additional water and dust suppressant worked successfully and the adjoining neighbours were satisfied. No further dust issues have been observed.

An abatement notice was received on the 19th of June 2013 in regards to a nova coil that was discharging very low levels of Benzene (0.058g/m^3) beyond the consented boundary (Results provided in Appendix C plus additional background results). The subsequent perforated nova coil has now been removed (See Appendix B, "Novacoil Locations") and BTW Company is currently working with the TRC to achieve the best environmental outcome for the site that does have a considerable amount of natural sub soil drainage. The benzene level detected is highly likely to be from old oily waste pits that were never lined; these pits were directly up gradient of the discharge point. BTW has worked with the TRC to ensure best practices are adhered too, hence all pits are now lined which was previously not a consent requirement.

Obviously BTW Company is extremely disappointed the abatement notice was issued and works tirelessly to achieve the best environmental outcome for the site, however this abatement notice does need to be put in perspective of the level of the constituent (Benzene) that was found in the subsurface water at this location. The level of benzene found was below the acceptance criteria for irrigation & stock watering purposes under the guidelines for assessing and managing petroleum contaminated sites in New Zealand.

Therefore considering the location of the site, with no downstream users or being used as a potable water source, we do believe to meet drinking water standards of subsurface water at this location is unreasonable and unlikely.

BTW Company continues to make every effort to meet this stringent standard and will continue to work with TRC in a positive way for the environment, and it is noted that adverse effects on the environment associated with the discharge which was subject of the notice were less than minor.

3.7 Site Improvements

A collaborative approach between BTW Company and TRC has been taken to improve best practice of the landfarming operation at Brown Road, and for landfarming operations in general.

All pits on the site are now lined to ensure no uncontrolled discharge or leaching from the pits is taking place. BTW Company has also agreed to the installation of four groundwater monitoring bore to assist with the TRC monitoring programme. These bores have provided valuable data in tracking the movement of contaminates and will provide in the future value data for the surrendering of this consent and landfarming practices.

Consent condition 15 details that landfarming of well work over liquid waste at a ratio of 1 cubic metre of waste to 4 square meters. This has been identified as not workable and not the best environmental practice for the site. A proactive approach from BTW Company has seen the areas required to spread well work over fluid increased. This practice has been completely voluntary and has come at quite an expense to BTW as additional site area is required to achieve the best practices for the site.

BTW Company has improved its sampling and monitoring regime. Sampling methodology has now aligned with TRC and Hill Laboratory. Also recently a complete suite of tests were voluntarily taken for all the areas that have been landfarmed on the site to date, in order to provide more data (this information is provided in table 4.1).

Even though not exactly a site improvement, the perforated nova coils that are located through the site have indirectly provided beneficial further data of subsurface water quality. Therefore we do now have further monitoring points to ensure constituent levels are at an acceptable level. TRC and BTW Company will continue to monitor these point discharges. The first round of sampling showed the constituent levels were below background level.

BTW Company has continued to be very transparent with all its operation with the TRC and any other interested parties and will continue this practice into the next annual reporting year.

4 ANALYSIS OF RESULTS

The following Table 4.1 provides a summary of the monitoring results undertaken over the reporting period. Analysis of the results of monitoring are required by SC7, condition j. Special Conditions 21-25 of Consent 7884-1 are also addressed in this section.

Where compliant with consent surrender conditions, the fields are coloured green, where the sampling indicates the sampled constituent has not yet reached surrender limits for the receiving environment, the field is coloured red.

Analysis of the monitoring results is undertaken over the following Sections 4.1 and 4.2, with a summary proved in Section 4.3

Table 4.1: Monitoring results from Wellington Landfarm

		TRC Compliant			TRC Non-Compliant																					
	Date	Soil conductivity <290mS m-1 (see Consent if PD is greater than 400)	Sodium 460 mg/kg	SAR <18	Dissolved salts <2500gm-3	Benozene <1.1(v)	Toulene <68(4m)	Ethylbenzene (53)(4,v)	Xylenes (48) (4,m)	Naphthalene (7.2) (p)	Non-carc. (Pyrene) (160) (4p)	Benzo(a)pyrene eq.(5) (0.027)(p)	Arsenic (20mg/kg)	Cadmium (1mg/kg)	Chromium (600mg/kg)	Copper (100mg/kg)	Lead (300mg/kg)	Mercury (1mg/kg)	Nickel (60mg/kg)	Zinc (300mg/kg)	C7-C9 120 (m)	C10-C14 58 (x)	C15-C36 (4000) (7,x)	nitrogen mg/kg	Chloride 700 mg/kg	Material
F1	4/11/2012																								23	WBM
	[illegible]	90	41	1.1	804	0.05	<0.05	<0.05	<0.05	<0.12	<0.03	<0.03	<2	<0.10	11	23	3.9	<0.10	6	87	8	20	40	26	23	WBM
F2	20/01/2012					0.05	<0.05	<0.05	<0.10	<0.03	<0.03	<0.03	<2	<0.10	10	18	3.3	<0.10	6	67	8	20	40	0.05	310	WBM
	19/04/2013	250	76	2.2	1643	0.05	<0.05	<0.05	<0.10	<0.12	<0.03	<0.03	<2	<0.10	9	18	2.3	<0.10	4	53	8	20	40	2	116	WBM
F3	14/02/2012																								19	WBM
	[illegible]																				9	20	40			WBM
	19/04/2013	1	49	1.1	260	0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	<2	<0.10	12	15	2.6	<0.10	5	63	8	20	40	0.13	38	WBM
F4	[illegible]		[illegible]			<0.05	<0.05	<0.05	<0.10	<0.13	<0.03	<0.03	6	<0.10	13	24	2.9	<0.10	5	73	8	20	40	0.11	<30	WWF
	12/06/2012																				9	20	40			WWF
	19/04/2013	60	47	2.3	369	0.05	<0.05	<0.05	<0.10	<0.12	<0.03	<0.03	<2	<0.10	9	27	5.2	<0.10	5	56	8	20	40	22	27	WWF
F5	[illegible]		[illegible]			<0.05	<0.05	<0.05	<0.10	<0.13	<0.03	<0.03	<2	<0.10	12	24	4.4	<0.10	6	68	8	[illegible]	350	0.09	540	WBM
	[illegible]	180	57	1.6	1465																			6	610	WBM
	12/06/2012																				9	20	129			WBM
	[illegible]		[illegible]			0.05	<0.05	<0.05	<0.10	<0.12	<0.05	<0.03	<2	<0.10	8	15	1.8	<0.10	4	55	9	40	340	0.89	6	WBM
	19/04/2013	[illegible]	78	2	[illegible]	0.05	<0.05	<0.05	<0.10	<0.12	<0.03	<0.03	<2	<0.10	10	16	2.7	<0.10	4	56	8	20	380	1	160	WBM
F6	[illegible]		[illegible]			0.05	< 0.05	< 0.05	< 0.10	<0.13	<0.03	<0.03	7	<0.1	10	17	41	0.26	5	71	<8	<20	100	<0.05	<40	CS / WW
	18/02/2012	70	43	1.3	456																					CS / WW
	12/06/2012																				9	50	67			CS / WW
	[illegible]		480			0.05	< 0.05	< 0.05	< 0.10	<0.14	<0.03	<0.03	<2	<0.10	7	15	5.9	<0.1	4	52	[illegible]	[illegible]	630	0.15	12	CS / WW
	11/04/2013	50	43	1.7	656	0.05	< 0.05	< 0.05	< 0.05	< 0.05	[illegible]	[illegible]	[illegible]	[illegible]	10	16	3.4	< 0.10	4	68	8	20	40	2	17	CS / WW
F7	[illegible]	170	298	8.7	1965	0.05	<0.05	<0.05	<0.10	<0.015	<0.03	<0.03	<2	<0.10	11	17	1.4	0.1	6	75	9	20	40	0.07	91	WWF
	12/12/2012		[illegible]			0.05	<0.05	<0.05	<0.10	<0.13	<0.03	<0.03	<2	<0.10	7	14	1.4	<0.10	4	42	9	20	40	0.06	41	WWF
	19/04/2013	100	161	9.3	667	0.05	<0.05	<0.05	<0.10	<0.13	<0.03	<0.13	<2	<0.10	9	13	1.3	<0.10	4	56	8	20	40	9	33	WWF
F8	10/07/2012		[illegible]	0.7	564	0.06	0.09	<0.05	<0.05	<0.13	<0.03	<0.03	<2	<0.10	11	21	1.7	<0.10	6	79	8	20	200	0.1	7	WWF
	[illegible]		[illegible]			0.05	<0.05	<0.05	<0.10	<0.12	<0.03	<0.03	<2	<0.10	8	15	1.7	<0.10	[illegible]	55	8	20	40	0.06	<3	WWF
	24/04/2013	80	35	1.9	248	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<2	<0.10	8	13	1.7	<0.10	4	51	8	20	51	5	7	WWF
F9	10/07/2012		[illegible]	0.5	323	0.05	<0.05	<0.05	<0.1	<0.13	<0.03	<0.03	<2	<0.10	9	15	2.1	<0.10	4	63	8	[illegible]	[illegible]	0.09	15	SBM
	30/10/2012					0.05	<0.05	<0.05	<0.1	<0.14	0.21	<0.04	<2	<0.10	9	17	3.8	<0.10	4	72	8	[illegible]	[illegible]	0.12	50	SBM
	12/12/2012		[illegible]			0.05	<0.05	<0.05	<0.1	<0.14	0.05	<0.03	<2	<0.10	7	16	6.7	<0.10	4	48	13	[illegible]	[illegible]	0.1	27	SBM
	[illegible]	140	113	2.4	360	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<2	<0.10	8	14	2.4	<0.10	4	59	8	[illegible]	3100	3	44	SBM
F10	[illegible]		[illegible]			0.06	0.09	<0.05	<0.05	<0.12	0.04	<0.03	2	0.3	10	17	69	0.2	7	135	8	[illegible]	[illegible]	0.08	36	SBM
	[illegible]					0.05	<0.05	<0.05	<0.1	<0.13	0.12	0.04	<2	0.24	10	17	44	0.15	5	108	8	[illegible]	[illegible]	0.06	103	SBM
	12/12/2012		450			0.06	<0.06	<0.06	<0.1	[illegible]	0.06	<0.03	[illegible]	[illegible]	14	19	18.6	<0.10	8	70	12	[illegible]	[illegible]	[illegible]	108	SBM
	[illegible]	170	92	1.8	1148	0.05	<0.05	<0.05	<0.05	<0.05	[illegible]	<0.05	<2	<0.10	9	15	11.9	<0.10	4	56	9	[illegible]	1700	1	6	SBM
F11	15/11/2012	20	17	1.6	113.8	0.05	<0.05	<0.05	0.12	<0.13	0.04	<0.03	<2	<0.10	8	13	1.1	<0.10	4	65	8	20	40	0.08	3	WWF
	12/12/2012		270			0.06	<0.05	<0.05	<0.10	<0.12	<0.03	<0.03	<2	<0.10	6	10	1	<0.10	3	41	8	20	40	0.05	7	WWF
	24/04/2013	20	19	1.1	665	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<2	<0.10	8	12	1	<0.10	5	48	8	20	40	5	6	WWF
F12	[illegible]	32	[illegible]	12.9	2140	0.05	<0.05	<0.05	<0.12	<0.13	0.06	<0.03	<2	<0.10	6	22	6	<0.10	5	82	8	[illegible]	[illegible]	0.12	290	SBM
	12/12/2012		[illegible]			0.05	<0.05	<0.05	<0.10	0.08	0.19	0.05	<2	<0.10	8	19	12.6	<0.1	5	84	15	[illegible]	[illegible]	0.09	220	SBM
	[illegible]	[illegible]	245	2.6	2490	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<2	<0.10	8	14	2.4	<0.10	6	56	8	[illegible]	3600	1	63	SBM
F13	[illegible]	50	41	1.6	880	0.05	<0.05	<0.05	<0.10	<0.13	<0.03	<0.03	<2	<0.10	7	13	2.5	<0.10	3	52	8	20	40	0.09	85	SBM
	12/12/2012		[illegible]			0.05	<0.05	<0.05	<0.10	<0.14	0.06	<0.03	2	0.16	8	16	22	<0.10	5	73	9	[illegible]	[illegible]	0.11	350	SBM
	24/04/2013	[illegible]	[illegible]	6.1	[illegible]	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<2	<0.10	10	16	12.4	<0.10	6	63	8	[illegible]	[illegible]		620	SBM
F14	[illegible]	[illegible]	292	5.8	[illegible]	0.05	<0.05	<0.05	[illegible]	<0.12	0.04	<0.03	<2	<0.10	9	14	12.5	<0.1	4	73	8	[illegible]	[illegible]	0.09	370	SBM
	[illegible]		[illegible]			0.05	<0.05	<0.05	[illegible]	0.49	1.2	<0.03	<2	<0.10	8	21	3.5	<0.1	4	66	19	[illegible]	[illegible]	0.05	397	SBM
	24/04/2013	[illegible]	350	4.4	[illegible]	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<2	<0.10	11	22	7	<0.10	6	65	9	[illegible]	[illegible]	1	390	SBM
F15	11/04/2013	180	200	4.2	1185	0.05	<0.05	<0.05	<0.05	<0.12	<0.03	<0.03	<2	<0.10	12	18	2.2	<0.10	5	65	8	[illegible]	680	1	69	WBM
F16	[illegible]	50	78	[illegible]	350	0.05	<0.05	<0.05	<0.05	0.14	<0.03	<0.03	2	<0.10	17	30	4.8	<0.10	5	64	9	45	200	0.12	39	CS
F17	[illegible]	0.2	19	1.6	105.6	0.05	<0.05	<0.05	<0.05	<0.14	<0.03	<0.03	<2	<0.10	10	12	1.6	<0.10	6	42	9	20	75	1	6	CS
F18	[illegible]	0.4	51	3	271	0.05	<0.05	<0.05	<0.05	<0.12	0.06	0.05	<2	<0.10	9	16	2.5	<0.10	4	39	8	20	40		36	WWF
[illegible]	[illegible]	0.2	12	0.9	99	0.05	<0.05	<0.05	<0.05	<0.12	<0.03	<0.03	<2	<0.10	9	11	1.2	<0.10	4	41	8	20	40	1	3	WWF

* Indicates sample was "<" result provided

4.1 Compliance with SC's 21 and 22

21. The exercise of this consent shall not result in the concentration of total dissolved salts in any fresh water body exceeding 2500 g/m3

22. Other than as provided for in condition 21, the exercise of this consent shall not results in any containment concentration, within surface water or groundwater, which after reasonable mixing, exceeds the background concentration for that particular contaminant.

Historically compliance with SC's 21 & 22 has been monitored through on site testing of the open drain near the storage pits, standing water located between the storage pits and the coast. For the 2012/2013 monitoring year, water samples were obtained from the nova flow outlet drain. Compliance with SC21 is displayed within Appendix C.

4.2 Compliance with SC's 23 - 27

4.2.1 Condition 23 – Soil Conductivity

Condition 23 requires:

23. The conductivity of the soil/ waste layer after landfarming shall be less than 400 mS / m or alternatively, if the background soil conductivity exceeds 400 mS / m, the landfarming of water shall not increase the soil conductivity by more than 100 mS / m.

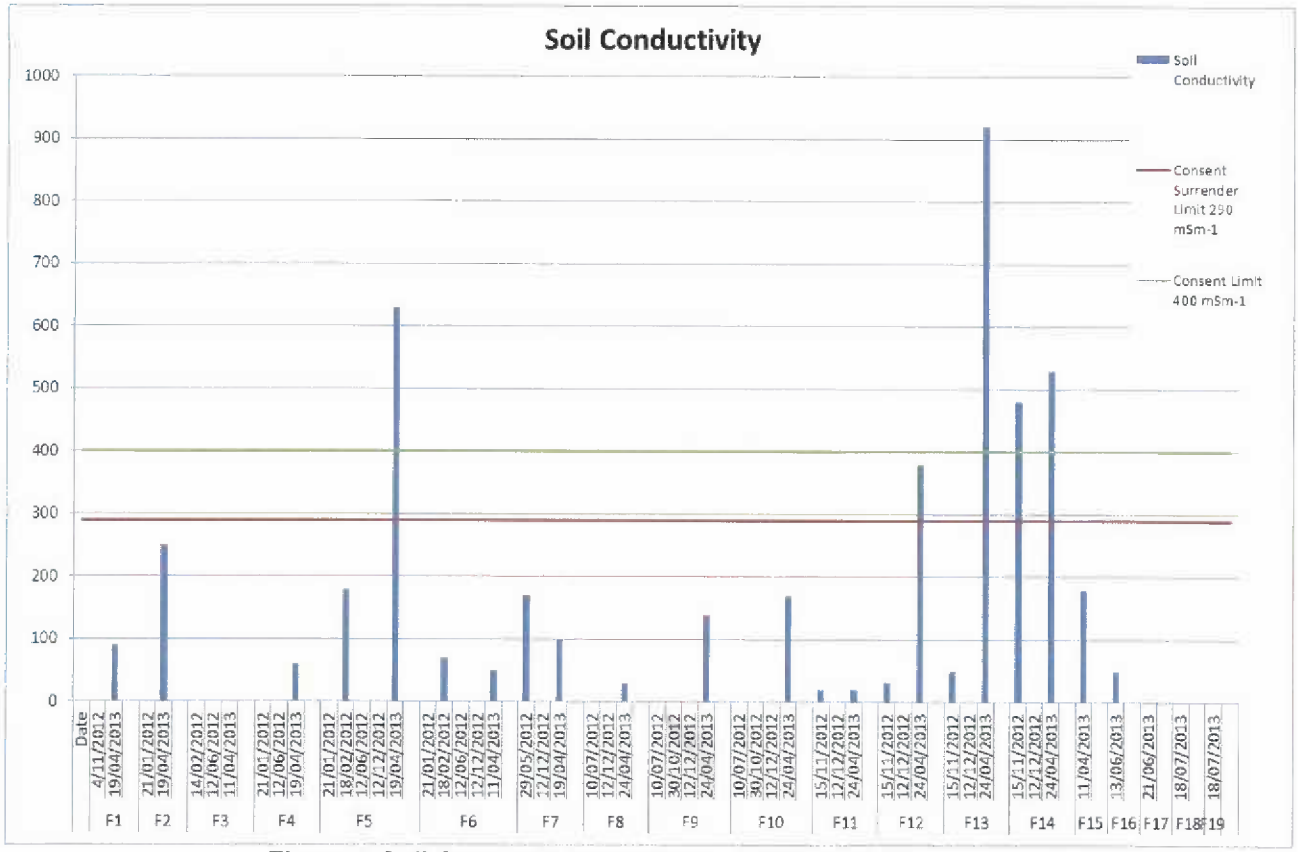


Figure 1 Soil Conductivity analysis – Wellington Disposal Site

Over the year in review, the consent limit for Soil Conductivity of 400 mS / m was exceeded at the locations F5, F13 and F14. However due to no background data on the soil we find it difficult to make any assumptions at this stage. We also note our sampling methodology has changed slightly, therefore we propose to re sample these areas in the next month and provide results to the TRC.

4.2.2 Condition 24 – SAR

Condition 24 requires:

24. The sodium absorption ratio (SAR) of the soil / waste layer after landfarming shall be less than 18.0, or alternatively if the background SAR exceeds 18.0, the landfarming of waste shall not increase the SAR by more than 1.0.

As shown in the below Figure 2, SAR has been complied with at all receiving sites at the Wellington Landfarm.

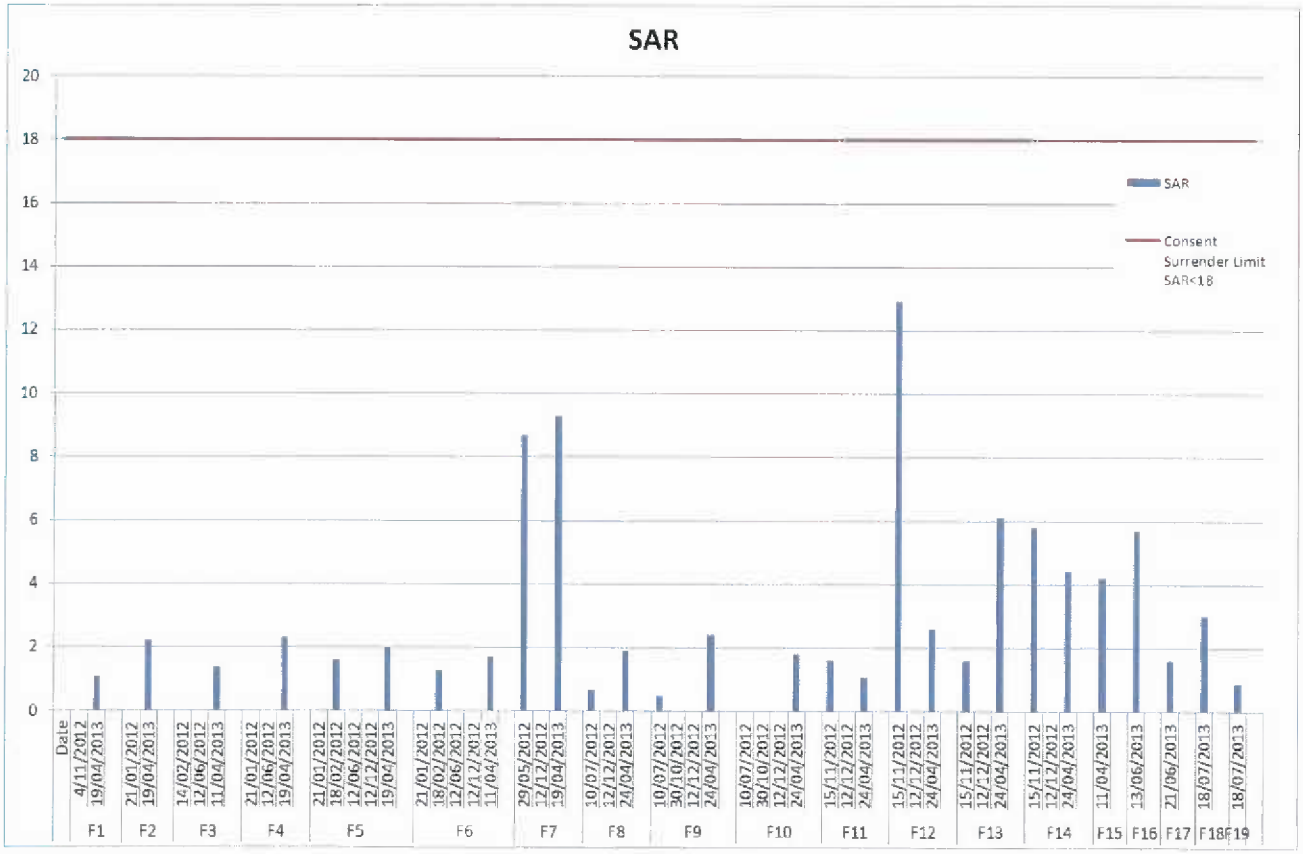


Figure 2 SAR analysis – Wellington Disposal Site

4.2.3 Condition 25 – Heavy Metals

Condition 25 requires:

25. The concentration of metals in the soil shall as all times comply with the guidelines for heavy metals in soil set out in Table 7.1, Section 7 of the Ministry of the Environment and New Zealand Water and Wastes Association's Guidelines for the safe application of biosolids to land in New Zealand (2003)

As shown in Table 4.1, all metal concentrations are complaint with Table 7.1, Section 7 of the Ministry of the Environment and New Zealand Water and Wastes Association's Guidelines for the safe application of biosolids to land in New Zealand (2003).

4.2.4 Condition 26 and 27 – Constituent Closure Criteria

Condition 26 requires:

26. From 1 March 2027 (Three months prior to the consent expiry date), constituents in the soil shall not exceed the standards shown in the following table:

Table 4.2: Consent Closure Criteria – Condition 26

Constituent	Standard
Conductivity	290 mS/m
Chloride	700 mg / kg
Sodium	460 mg /kg
Total soluble salts	2500 mg / kg
MAHs PAHs TPH	Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand (Ministry for the Environment, 1999). Tables 4.12 and 4.15, for soil type sand.

MAHs – benzene, toluene, ethylbenzene, xylenes
PAHs – naphthalene, non coarc. (Pyrene) benzo(a)pyrene eq.
TPH – Total petroleum hydrocarbons (C_7-C_9, C_{10}-C_{14}, and C15-C_{36}).

The requirement to meet these standards shall not apply if, before 1 March 2027, the consent holder applies for a new consent to replace this consent when it expires, and that application is not subsequently withdrawn.

27. This consent may not be surrendered at any time until the standards in condition 26 have been met.

The following presents series of figures detailing results from the landfarm monitoring in respect of closure criteria.

4.2.5 Conductivity

Figure 1 (above) overviews the soil conductivity results and identifies 4 sites not yet within the consent surrender limit of 290 mS / m.

Area/s not within surrender limits: F5, F12, F13 and F14.

4.2.6 Chloride

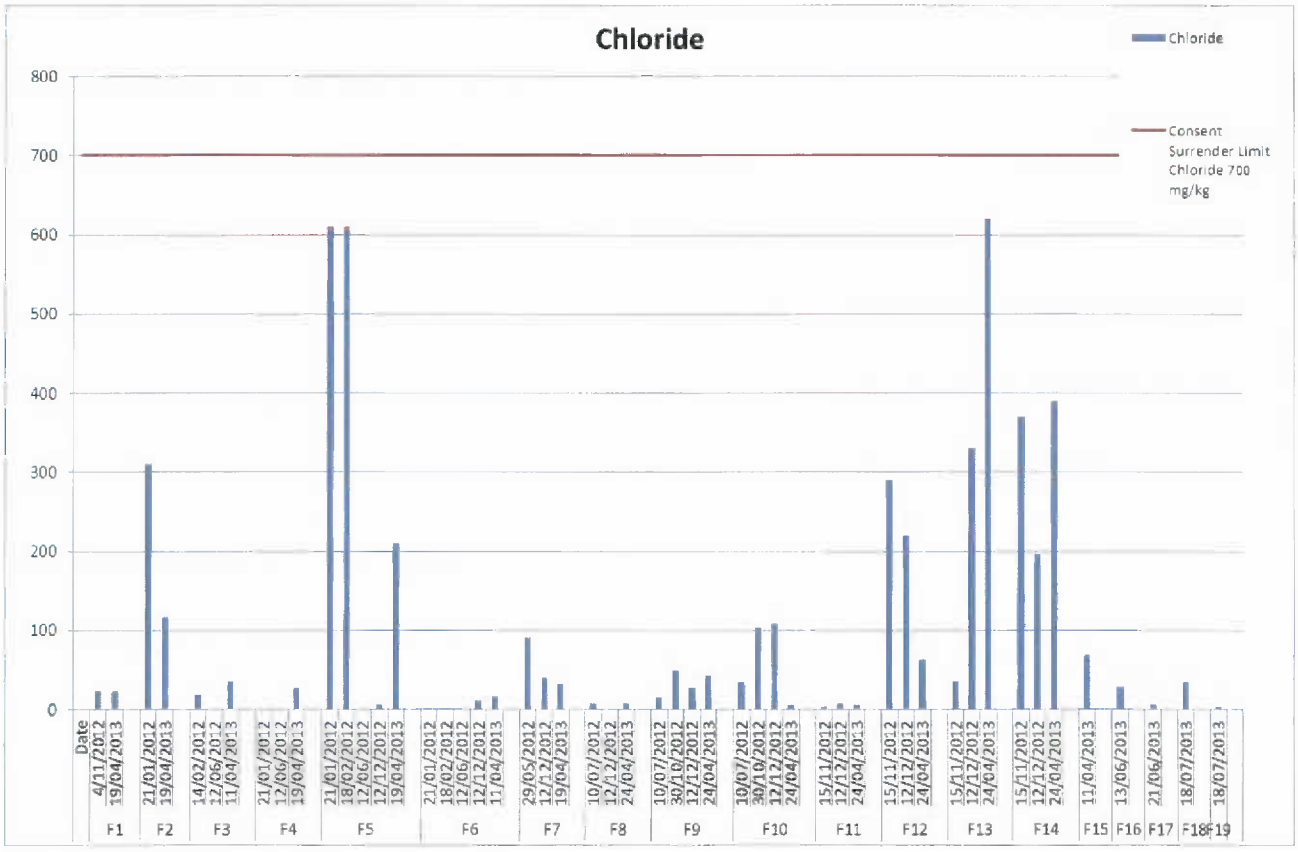


Figure 3 Chloride analysis – Wellington Disposal Site

As shown in Figure 3, consent surrender requirements for Chloride have been met for all monitored areas of the landfarm.

4.2.7 Sodium

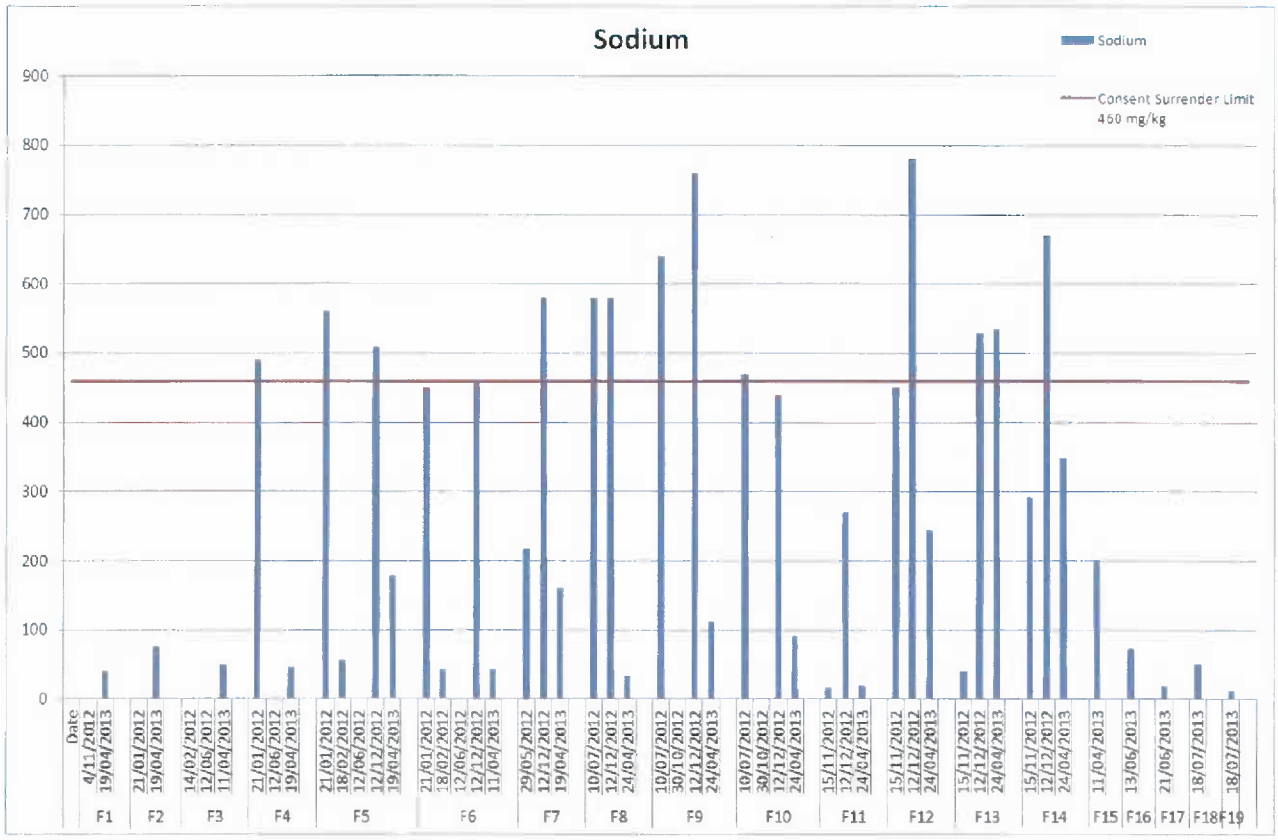


Figure 4 Sodium analysis – Wellington Disposal Site

Figure 4 provides an overview of sodium results across the landfarming areas. Exceedances of the Sodium closure criteria were experienced at F4, F5, F7, F8, F9 F10, F12, and F14 during initial/secondary monitoring however were shown to be within consent surrender limits during later monitoring events (See Table 4.2). F13 however showed an increase in sodium and therefore is not yet within surrender limits.

Table 4.3: 5 Reduction in Sodium over testing events (Initial exceedance to latest result).

Site	Time Period	Months	% Reduction
F4	21/1/2012 to 11/4/2013	15	90%
F5	21/1/2012 to 19/4/2013	15	68%
F7	12/12/12 to 19/4/2013	4	72%
F8	10/7/2012 to 24/04/13	9	94%
F9	10/7/2012 to 24/04/13	9	82%
F10	10/7/2012 to 24/04/13	9	80%
F12	15/11/12 to 24/04/13	5	45%
F14	12/12/12 to 24/04/13	4	47%

Area/s not within surrender limits: F13.

4.2.8 Dissolved Salts

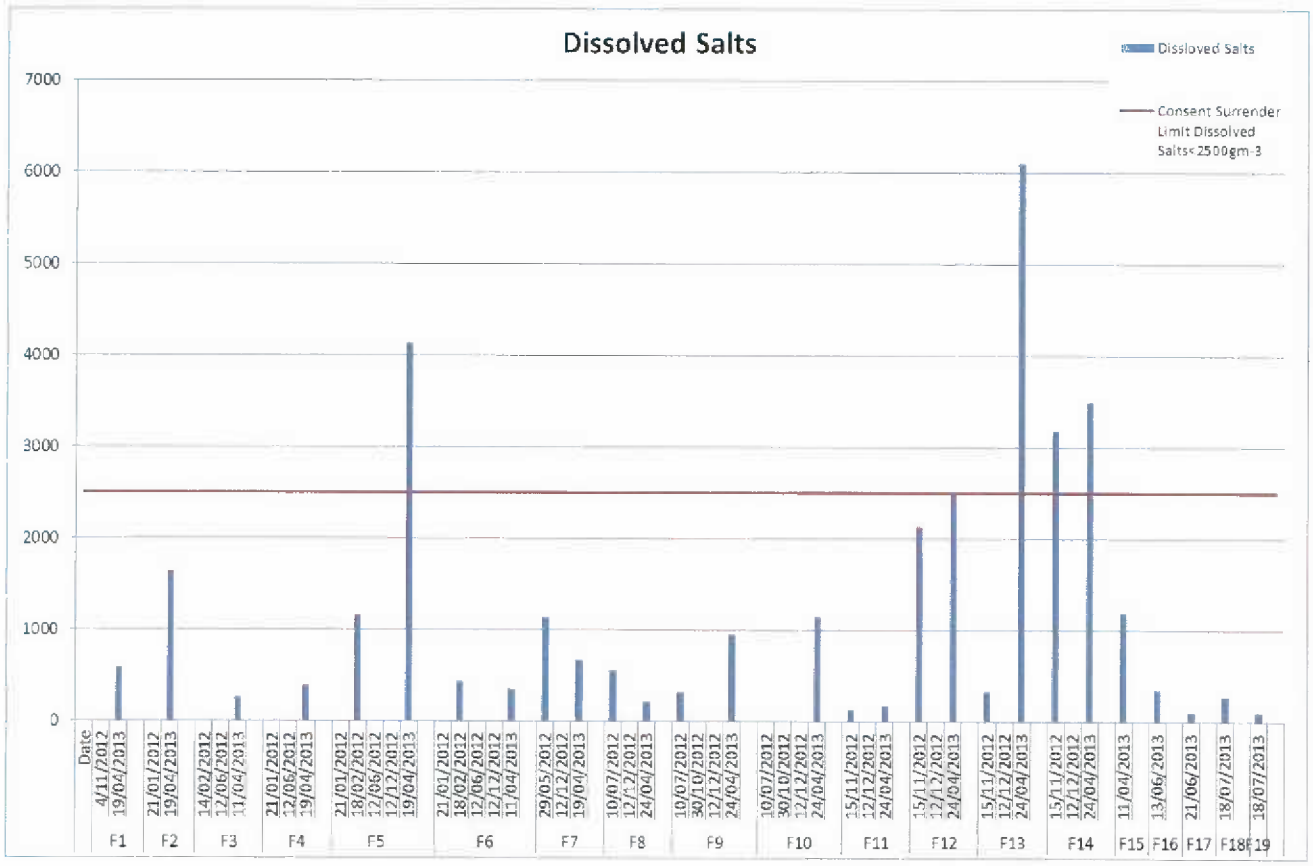


Figure 5 Dissolved Salts analysis – Wellington Disposal Site

Dissolved salt concentrations were generally within consent surrender limits, with the exception of sites F5, F13 and F14.

Area/s not within surrender limits: F5, F13, and F14.

4.2.9 TPH C7 – C9

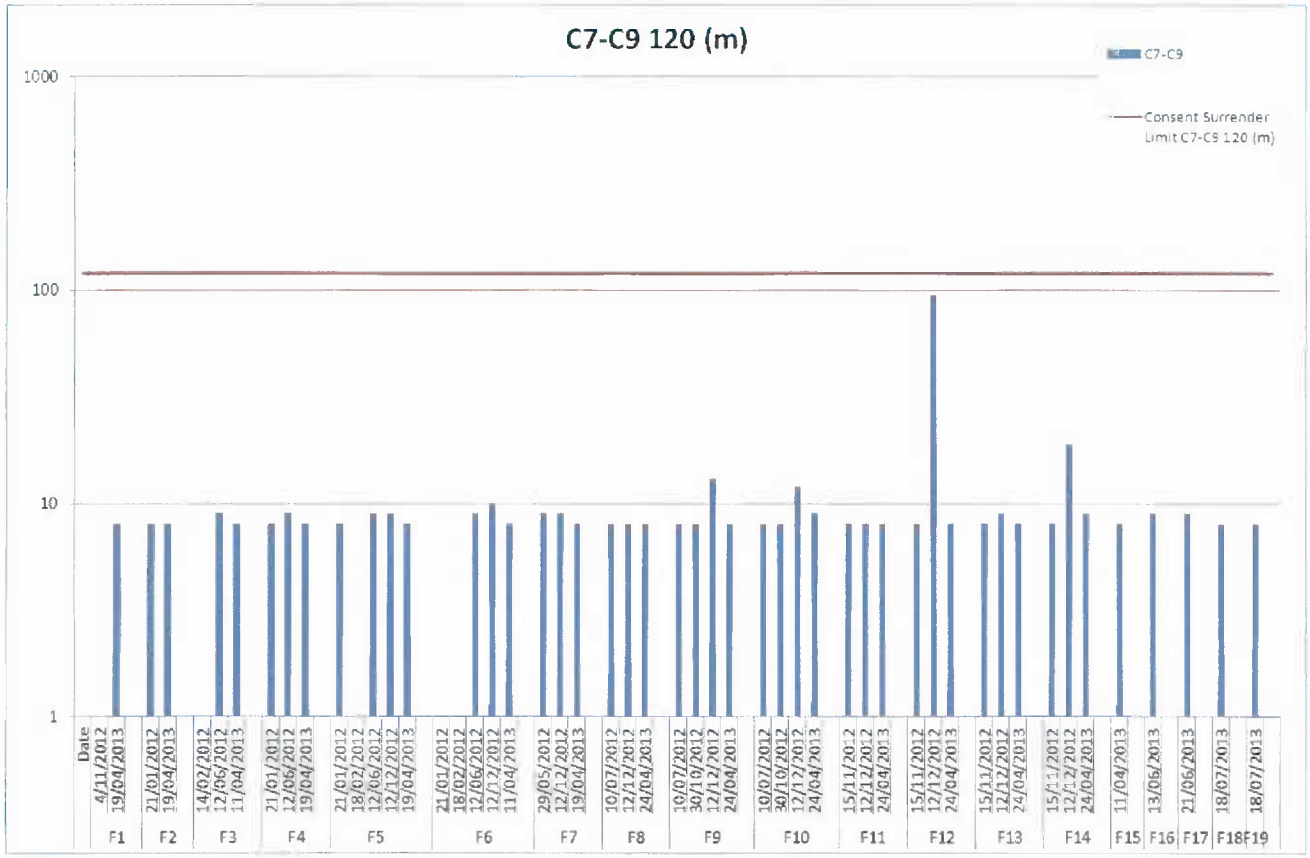


Figure 6 TPH C7-C9 – Wellington Disposal Site

TPH C7 to C9 120 (M) was compliant with consent surrender limits as shown in the above Figure 6.

4.2.10 TPH C10 – C14

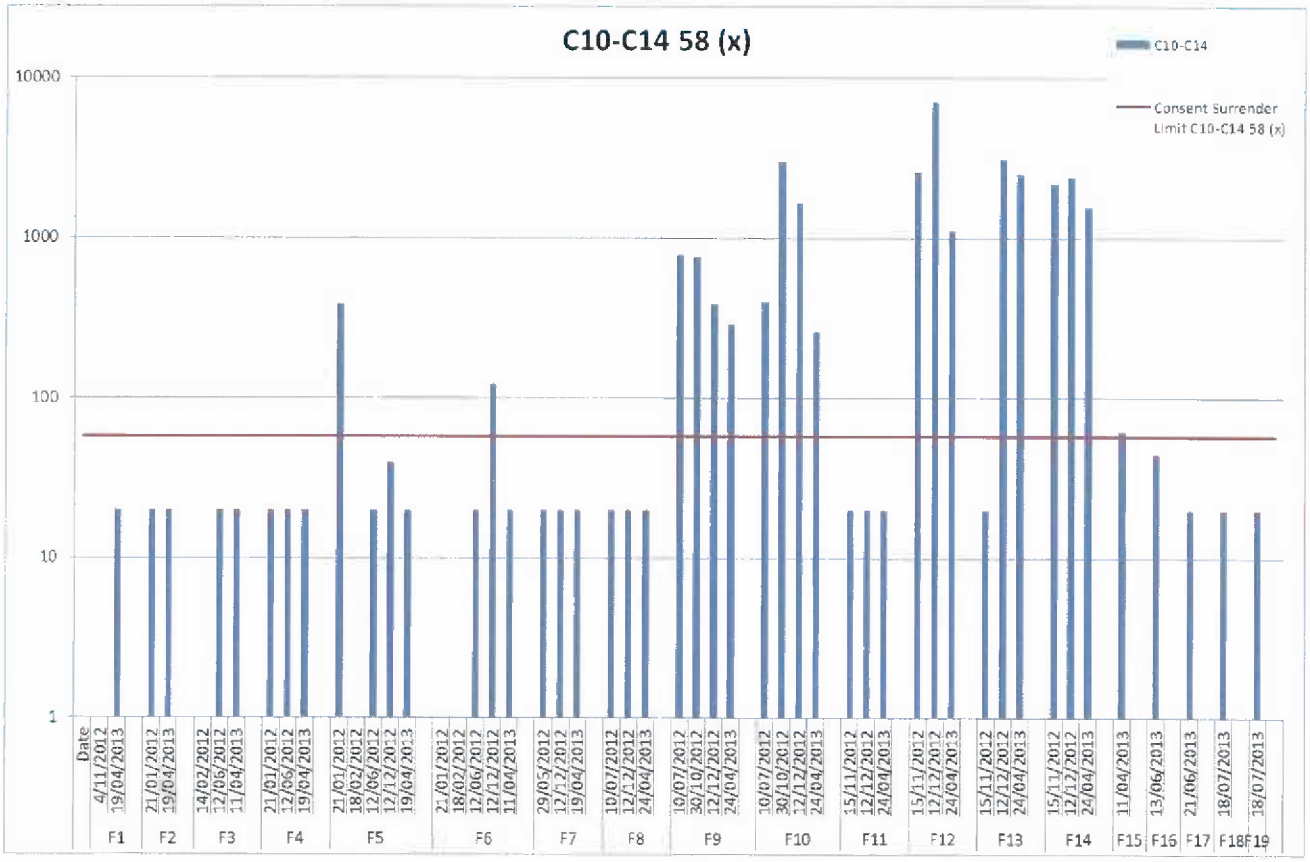


Figure 7 TPH C10-14 – Wellington Disposal Site

Results above the consent surrender limits for TPH C10 to C14 58 (x) were encountered for sites F9, F10, F12, F13, F14, and F15 and will require further monitoring. Sites F5 and F6 had exceedances during earlier monitoring however the latest results are within surrender conditions.

Area/s not within surrender limits: F9, F10, F12, F13, F14, and F15.

4.2.11 TPH C15 – C36

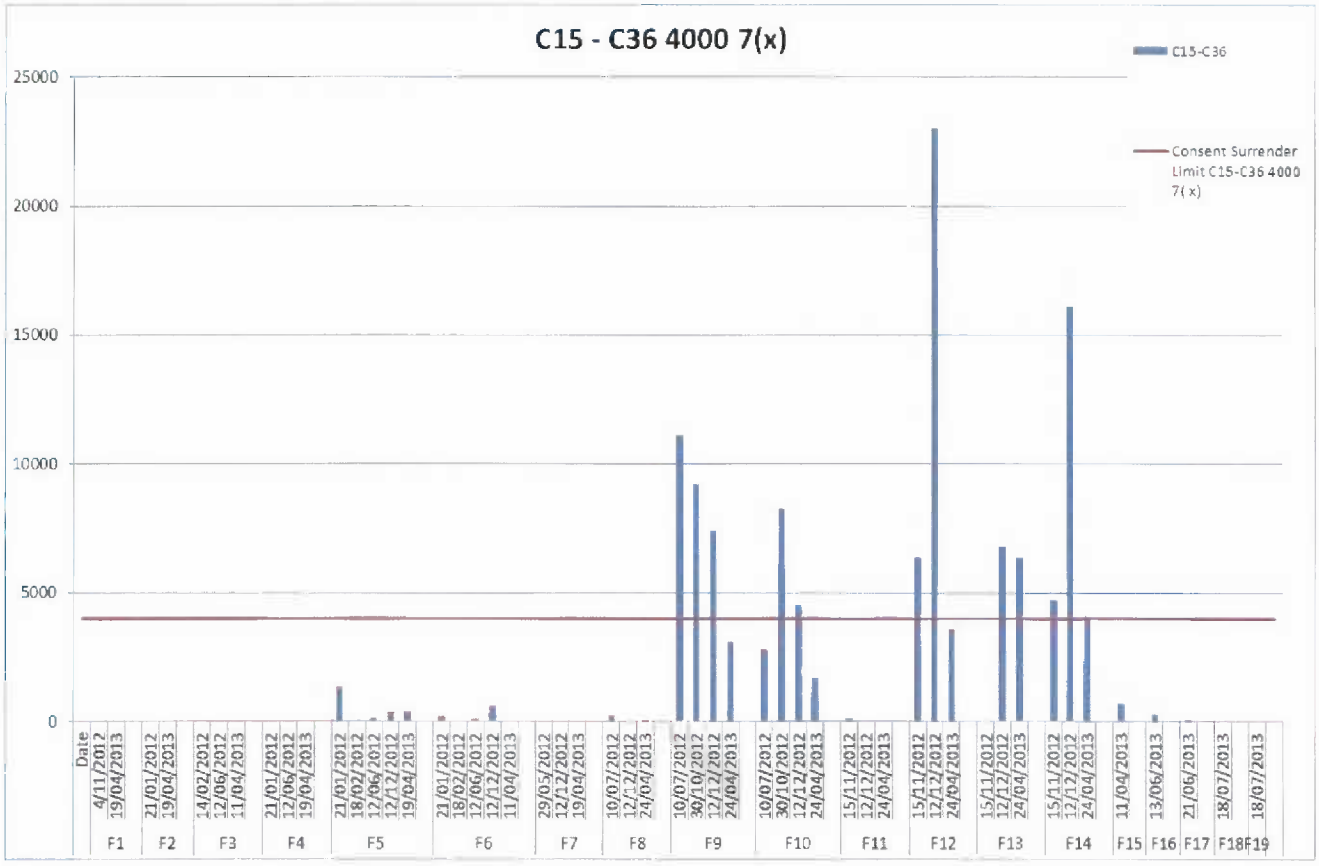


Figure 8 TPH C15-36 – Wellington Disposal Site

Of the sampled sites only F13 and F14 remain above consent surrender limits. While monitoring results for sites F9, F10, and F12 were all above the consent surrender limits during initial testing follow up monitoring had shown significant reductions in the TPH C15 – C36 results, as shown in the below Table 4.3. F13 showed an increase in TPH C15-36.

Table 4.4: 5 Reduction in TPH C15-C36 over sampling time frames.

Site	*Time Period*	*Months*	*% Reduction*
F9	10/7/2012 to 24/04/13	9	72%
F10	10/7/2012 to 24/04/13	9	80%
F12	15/11/2012 to 24/04/13	5	44%

Area/s not within surrender limits: F13, and F14.

4.2.12 Summary

Generally constituent levels within all landfarmed area have reduced considerably over the last annual year. As identified a number of areas will still require further sampling and monitoring over the next annual year. Further monitoring will be required on area F5, F9, F10, F12, F13 and F15 plus all additional new areas will be monitored.

Overall we believe we have obtained a positive result for the site and the bioremediation process would appear to be effectively breaking down constituent levels and returning soils back to background levels.

APPENDIX A COMPOSITION OF WASTE

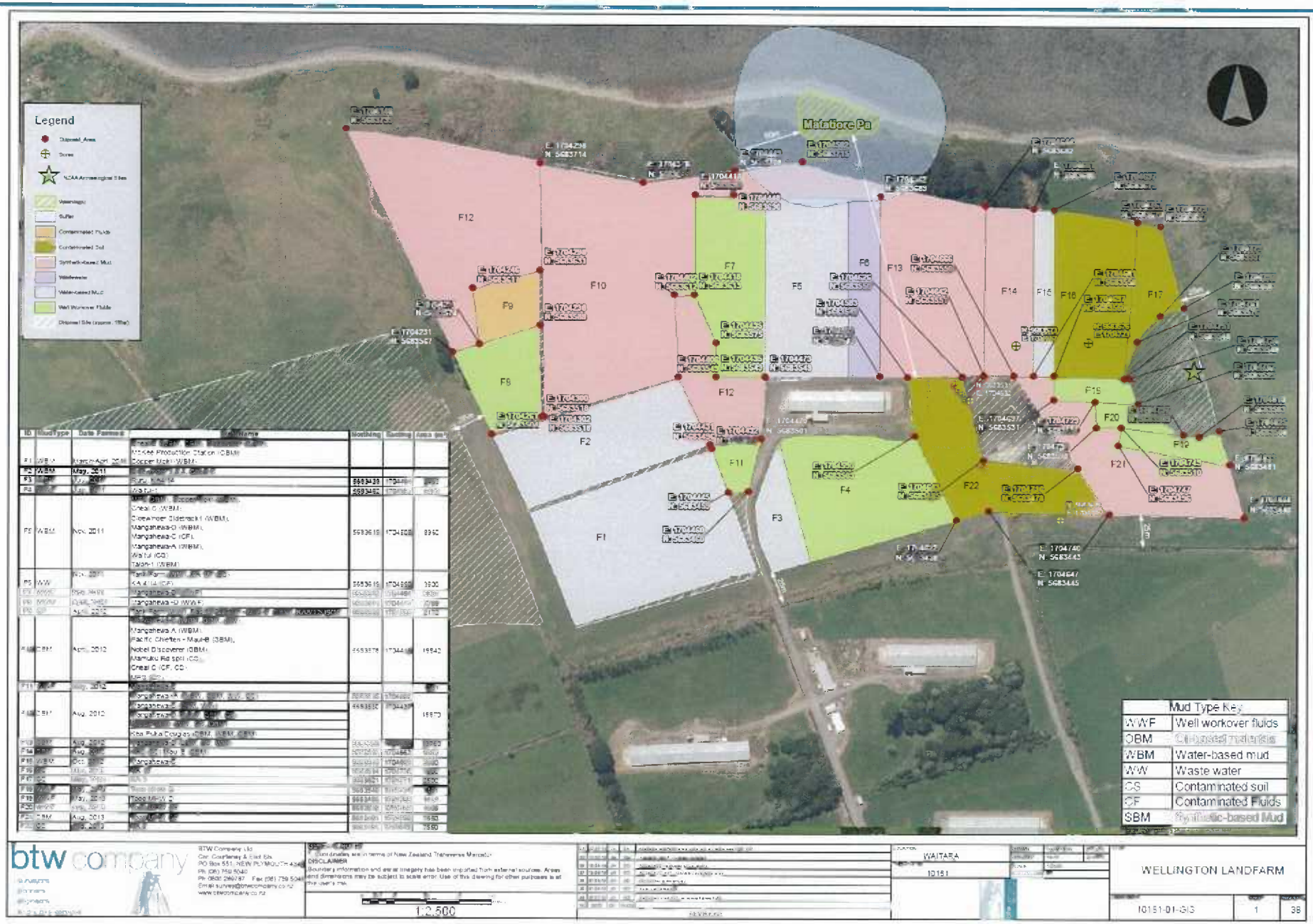
BTW COMPANY	Section of Regulations		Test Certificates					Emergency Management																Sched 4
	Sub-section		Location & Transit	Manufacture and Use	Approved Handler	Hazardous atmosphere zone	Tracking	EM Level 1	EM Level 2	EM Level 3	Fire Extinguisher	Fire Extinguisher	Documentation	Signage	Signage	Separation	Separation	Separation	Incompatibility	Disposal		Bunding
	Reference		4.2	4.2	4.3	4.4	4.5	5.2.1	5.2.2	5.2.3	5.2.5	5.2.5	5.3.1	5.3.2	5.3.2	5.4.1	5.4.1	5.4.1	5.4.1	5.5		Sched 4
	Schedule Table reference from Regulations		Table 1	Table 1	Table 2	Table 3	Table 4	Table 5	Table 6	Table 7	Table 8	Table 8	Table 9	Table 10	Table 10	Table 11	Table 11	Table 11	Table 12	Table 13	Table 14	Sched 4
	Description of what the numbers relate to in table below		Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Number of Extinguishers	Threshold level	Emergency Regulations	Identification Requirements	Low Intensity Land Use Threshold VOLUME	Low Intensity Land Use Separation Distance	Separation required from	Incompatible substances	Information Requirements	Documentation Requirements	Threshold
Asphasol (4-5% Crystalline Silica)	Solid/ Powder	6.7A Substances that are carcinogenic	0	-	-	10L	-	-	-	0.1L	1000L	-	-	0.1L	-	-	-	-	-	-	Any	0.1L	100L
		6.9A (Inhalation) Toxic to human target organs or systems		-	-	-	-	-	-	0.1L	1000L	-	-	0.1L	-	-	-	-	-	-	Any	0.1L	100L
Calcium Carbonate (Omyacal 15/100, 15 & 25)	Solid	6.4A Irritating to the eye	47500kg	-	-	-	-	-	0.1kg	50kg	10000kg	-	-	55kg	-	-	-	-	-	-	0.1kg	50kg	-
Caustic Soda	Liquid	6.1D (Oral) Acutely toxic	325kg	-	-	-	-	-	0.1kg	3.0kg	1000kg	-	-	30.kg	10000kg	10000kg	-	-	-	-	0.1kg	3.0kg	1000kg
		8.1A Metallic corrosive		-	-	-	-	-	Any	1.0kg	-	-	-	2.0kg	1000kg	1000kg	-	-	-	-	-	2.0kg	-
		8.2B Skin corrosive		-	-	-	-	-	Any	1.0kg	1000kg	-	-	1.0kg	250kg	250kg	-	-	-	-	Any	1.0kg	1000kg
		8.3A Corrosive to eyes		-	-	-	-	-	0.1kg	1.0kg	10000kg	-	-	2.0kg	1000kg	1000kg	-	-	-	-	0.1kg	2.0kg	10000kg
		9.1D Slightly harmful to the aquatic environment or otherwise designed for biocidal action.		-	-	-	-	-	1.0kg	50kg	10000kg	-	-	50kg	10000kg	10000kg	-	-	-	-	1.0kg	50kg	10000kg
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0kg	5.0kg	-	-	-	5 0kg	10000kg	10000kg	-	-	-	-	1.0kg	5.0kg	-
Ecotrol RD	Solid	3.1C Flammable (Medium hazard)		-	-	-	-	-	-	-	-	-	-	-	1000kg	1000kg	-	-	-	Class 1 Class 2 Class 3.2 Class 4 Class 5	-	-	-
		6.1C Acutely toxic (Inhalation)		-	-	Any	-	4000kg	ANY	0.5kg	100kg	-	-	0.5kg	1000kg	1000kg	-	-	-	-	Any	0.5kg	100kg
		6.1E Acutely toxic (Oral)	1225kg	-	-	-	-	-	1.0kg	50kg	-	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
		6.3B Skin irritant		-	-	-	-	-	1.0kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
		6.4A Eye irritant		-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	0.1kg	50kg	-
		6.6B Suspected human mutagen		-	-	-	-	-	-	3.0kg	-	-	-	33kg	-	-	-	-	-	-	3.3kg	3.0kg	-
		6.8B Suspected human reproductive or developmental toxicant		-	-	-	-	-	-	3.0kg	-	-	-	33kg	-	-	-	-	-	-	-	3.0kg	-
		6.9B Harmful to human target organs or systems (inhalation)		-	-	-	-	-	-	3.0kg	-	-	-	33kg	-	-	-	-	-	-	0.1kg	3.0kg	-
		9.1D Slightly harmful to the aquatic environment or otherwise designed for biocidal action.		-	-	-	-	-	3.0kg	60kg	10000kg	-	-	50kg	10000kg	10000kg	-	-	-	-	1.0kg	50kg	10000kg
Fasc Attack	Powder	TBC	5000kg																				
Glista 25	Liquid	6.1D (Oral) Acutely toxic	25L	-	-	-	-	-	0.1L	1.0L	100L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	100L
		6.5B Contact sensitiser		-	-	-	-	-	1.0L	1.0L	100L	-	-	1.0L	-	-	-	-	-	-	Any	1.0L	100L
		8.2C Corrosive to dermal tissue		-	-	-	-	-	0.1L	1.0L	1000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1kg	1.0L	1000L
		8.3A Corrosive to eyes		-	-	-	-	-	0.1L	1.0L	1000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1L	1.0L	1000L
Glydrol CC	Liquid	6.1D (Oral) Acutely toxic	0	-	-	-	-	-	0.1L	1.0L	1000L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	1000L
		6.4A Irritating to the eye		-	-	-	-	-	0.1L	1.0L	100L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	100L
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	0.1L	50L	20000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
Glydrol MC	Liquid	6.1D (Oral) Acutely toxic	0	-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1L	1.0L	100L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	100l
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
G-Seal	Solid/ Powder	6.1E Acutely toxic	4000kg	-	-	-	-	-	-	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-
		6.3B Mildly irritating to the skin		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-
		6.4A Irritating to the eye		-	-	-	-	-	1.0kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
		9.1D Slightly harmful to the aquatic environment or otherwise designed for biocidal action.		-	-	-	-	-	1.0kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
HRP	Liquid	6.3A Skin irritant	825L	-	-	-	-	-	1.0kg	50kg	10000kg	-	-	50kg	20000kg	10000kg	-	-	-	-	1.0kg	50kg	10000kg
Kleen Up	Liquid	6.3A Skin irritant	1875L	-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
Lime	Powder/ Dust	8.2C Corrosive to dermal tissue	2000kg	-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
		8.3A Corrosive to eyes		-	-	-	-	-	0.1kg	1.0kg	10000kg	-	-	2.0kg	1000kg	2000kg	-	-	-	-	-	2.0kg	10000kg
		9.1D Slightly harmful to the aquatic environment or otherwise designed for biocidal action.		-	-	-	-	-	0.1kg	1.0kg	10000kg	-	-	2.0kg	1000kg	2000kg	-	-	-	-	0.1kg	2.0kg	10000kg
M-I Barite	Powder	6.1D (Oral) Acutely toxic	45000kg	-	-	-	-	-	1.0kg	50kg	10000kg	-	-	50kg	10000kg	10000kg	-	-	-	-	1.0kg	50kg	10000kg
		6.7A Substances that are carcinogenic		-	-	-	-	-	0.1kg	3.0kg	1000kg	-	-	30.kg	10000kg	10000kg	-	-	-	-	0.1kg	3.0kg	1000kg
		6.9A (Inhalation) Toxic to human target organs or systems		-	-	10kg	-	-	-	0.5kg	1000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	1000kg
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	-	0.5kg	10000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	10000kg
M-I Gel Supreme (Bentonite)	Powder	6.7A Substances that are carcinogenic	25tkg	-	-	10kg	-	-	1.0kg	5.0kg	-	-	-	5.0kg	10000kg	10000kg	-	-	-	-	1.0kg	5.0kg	-
		6.9A (Inhalation) Toxic to human target organs or systems		-	-	-	-	-	-	0.5kg	1000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	1000kg
MIX II (Coarse & Fine)	Powder	6.7A Substances that are carcinogenic	4000kg	-	-	-	-	-	-	0.5kg	10000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	10000kg
		6.9A (Inhalation) Toxic to human target organs or systems		-	-	10kg	-	-	-	0.5kg	1000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	10000kg
Novamul	Liquid	3.1D Flammable liquids: low hazard	3700L	-	-	-	-	-	5.0L	50L	10000L	50CL	2	50L	10000L	10000L	-	-	-	Class 1 Class 2 Class 3.1 Class 4 Class 5	5 CL	50L	10000L
Novatec F	Liquid	6.1D (Oral) Acutely toxic	4095L	-	-	-	-	-	0.1L	1.0L	100L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	1000L
		6.5A Respiratory sensitiser		-	-	-	-	-	1.0L	1.0L	1000L	-	-	1.0L	-	-	-	-	-	-	Any	1.0L	1000L
		6.5B Contact sensitiser		-	-	-	-	-	1.0L	1.0L	1000L	-	-	1.0L	-	-	-	-	-	-	Any	1.0L	1000L
		8.2C Corrosive to dermal tissue		-	-	-	-	-	0.1L	1.0L	100DL	-	-	1.0L	1000L	1000L	-	-	-	-	0.1kg	1.0L	1000L
		8.3A Corrosive to eyes		-	-	-	-	-	0.1L	1.0L	100DL	-	-	1.0L	1000L	1000L	-	-	-	-	0.1L	1.0L	1000L
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-
KCL	Powder	6.1E Acutely toxic	240750kg	-	-	-	-	-	1.0kg	50kg	-	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
		6.3B Mildly irritating to the skin		-	-	-	-	-	1.0kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	0.1kg	50kg	-
		9.3B Ecotoxic to terrestrial vertebrates		-	-	-	-	-	0.2kg	5.0kg	-	-	-	5.0kg	10000kg	10000kg	-	-	-	-	0.2kg	5.0kg	-

BTW COMPANY		Section of Regulations		Test Certificates					Emergency Management					Documentation	Signage	Signage	Separation	Separation	Separation	Incompatibility	Disposal		Sched 4 Bunding
		Sub-section		Location & Transfer	manufacture & end Use	Approved Handler	Hazardous Atmospheres zones	Tracking	EM Level 1	EM Level 2	EM Level 3	Fire Extinguisher	Fire Extinguisher										
		Reference		4.2	4.2	4.3	4.4	4.5	5.2.1	5.2.2	5.2.3	5.2.5	5.2.5	5.3.1	5.3.2	5.3.2	5.4.1	5.4.1	5.4.1	5.4.1	5.5		
		Schedule Table reference from Regulations		Table 1	Table 1	Table 2	Table 3	Table 4	Table 5	Table 6	Table 7	Table 8	Table 8	Table 9	Table 10	Table 10	Table 11	Table 11	Table 11	Table 12	Table 13	Table 14	Sched 4
		Description of what the numbers relate to in table below		Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Number of fire extinguishers	Threshold level	Emergency Regulation	Identification Requirements	Low Intensity Land Use Threshold VOLUME	Low Intensity Land Use Separation Distance	Separation required from	Incompatible substances	Information Requirements	Document ation Requirements	Threshold
Safe Cide	Liquid	6.1D (Oral) Acutely toxic	0	-	-	-	-	-	0.1L	1.0L	1000L	-	-	1.0L	10000L	10000L	-	-	+	-	0.1L	1.0L	1000L
		6.5B Contact sensitiser		-	-	-	-	-	1.0L	1.0L	1000L	-	-	1.0L	-	-	-	-	+	-	Any	1.0L	1000L
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	+	-	-	-	1.0L	5.0L	-
Safe Solv E	Liquid	6.1 E Acutely toxic	835L	-	-	-	-	-	1.0L	50L	-	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
		6.5A Respiratory Sensitiser		-	-	-	-	-	11.0L	1.0L	1000L	-	-	1.0L	-	-	-	-	-	-	Any	1.0L	1000L
		6.5B Contact sensitiser		-	-	-	-	-	1.0L	1.0L	1000L	-	-	1.0L	-	-	-	-	-	-	Any	1.0L	1000L
		8.2C Corrosive to dermal tissue		-	-	-	-	-	0.1L	1.0L	10000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1kg	1.0L	10000L
		8.3A Corrosive to eyes		-	-	-	-	-	0.1L	1.0L	10000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1L	1.0L	10000L
		9.1D Slightly harmful to the aquatic environment or otherwise designed for biocidal action.		-	-	-	-	-	1.0L	50L	10000L	-	-	50L	10000L	10000L	-	-	-	-	1.0L	50L	10000L
Safe Surf O	Liquid	6.1D (Oral) Acutely toxic	835L	-	-	-	-	-	0.1L	1.0L	1000L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	1000L
		6.3A Skin Irritant		-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
		8.3A Corrosive to eyes		-	-	-	-	-	0.1L	1.0L	10000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1L	1.0L	10000L
		9.1D Slightly harmful to the aquatic environment or otherwise designed for biocidal action.		-	-	-	-	-	1.0L	50L	10000L	-	-	50L	10000L	10000L	-	-	-	-	1.0L	50L	10000L
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-
Safe PVD	Solid	6.1E Acutely toxic	4200kg	-	-	-	-	-	1.0kg	50kg	-	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	0.1kg	50kg	-
Saraline 185V	Liquid	3.1B Flammable Liquids: high hazard	8	50L	-	-	1.0L	-	1.0L	1.0L	1000L	250L	2	1.0L	250L	250L	-	-	-	Class 1 Class 2 Class 3.2 Class 4 Class 5	1.0L	1.0L	1000L
		6.1E Acutely toxic		-	-	-	-	-	1.0L	50L	-	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
		6.3B Mildly irritating to the skin		-	-	-	-	-	1.0L	50L	1000L	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
Soda Ash	Solid	6.1B Acutely toxic	450KG	-	-	Any	-	REQUIRED	ANY	any	100kg	-	-	Any	250kg	250kg	-	-	-	-	Any	Any	100kg
		6.3A Skin Irritant		-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	0.1kg	50kg	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	0.1kg	50kg	-
		6.9B Toxic to human target organs or systems		-	-	-	-	-	-	3.0kg	-	-	-	30.kg	-	-	-	-	-	-	0.1kg	3.0kg	-
Sodium Formate	Liquid	6.1E Acutely toxic.	10000L	-	-	-	-	-	1.0L	50L	-	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
Sodium Formate	Solid	6.1E Acutely toxic.	1500kg	-	-	-	-	-	1.0kg	50kg	-	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
Versawet	Liquid	6.9B Toxic to human target organs or systems	1892L	-	-	-	-	-	-	1.0L	-	-	-	1.0L	-	-	-	-	-	-	0.1L	1.0L	-
		8.3A Corrosive to eyes		-	-	-	-	-	0.1L	1.0L	1000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1L	1.0L	10000L
		9.1D Slightly harmful to the aquatic environment or otherwise designed for biocidal action.		-	-	-	-	-	1.0L	50L	10000L	-	-	50L	10000L	10000L	-	-	-	-	1.0L	50L	10000L
		9.2B Ecotoxic in the soil environment		-	-	-	-	-	0.2L	5.0L	-	-	-	5.0L	18921	18921	-	-	-	-	0.2L	5.0L	-
		9.3B Ecotoxic to terrestrial vertebrates		-	-	-	-	-	0.2L	5.0L	-	-	-	5.0L	18921	18921	-	-	-	-	0.2L	5.0L	-
HALLIBURTON CHEMICALS																							
A3-L	Liquid	6.1D Acutely Toxic	1000L	-	-	-	-	-	0.1L	1.0L	1000L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	2000L
		8.2C Corrosive to skin		-	-	-	-	-	0.1L	1.0L	10000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1kg	1.0L	10000L
		8.3A Corrosive to eyes		-	-	-	-	-	0.1L	1.0L	10000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1L	1.0L	10000L
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-
A5-S	Liquid	6.1D (oral) Acutely toxic	1000L	-	-	-	-	-	0.1L	1.0L	1000L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	10000L
		3.1B Flammable Liquids: high hazard		50L	-	-	1.0L	-	1.0L	1.0L	1000L	250L	2	1.0L	250L	250L	-	-	-	Class 1 Class 2 Class 3.2 Class 4 Class 5	1.0L	1.0L	1000L
		6.1F (oral) Acutely toxic		-	-	-	-	-	1.0L	50L	-	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
		6.3A Irritating to the skin		-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
		6.3B Mildly irritating to the skin		-	-	-	-	-	1.0L	50L	10000L	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
		8.3A Corrosive to ocular tissue		-	-	-	-	-	0.1L	1.0L	10000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1L	1.0L	10000L
		9.1D (fish, crustacea, algae) Slightly harmful in the aquatic environment or are otherwise designed for biocidal action		-	-	-	-	-	1.0L	50L	10000L	-	-	50L	10000L	10000L	-	-	-	-	1.0L	50L	10000L
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-
Calcium Chloride	Solid	6.1D (oral) Acutely toxic	1000kg	-	-	-	-	-	0.1kg	3.0kg	1000kg	-	-	30.kg	10000kg	10000kg	-	-	-	-	0.1kg	3.0kg	1000kg
		6.3A Irritating to the skin		-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	0.1kg	50kg	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	0.1kg	50kg	-
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0kg	5.0kg	-	-	-	5.0kg	10000kg	10000kg	-	-	-	-	1.0kg	5.0kg	-
CFR -3	Solid	6.1E Acutely toxic (oral)	2000kg	-	-	-	-	-	1.0kg	50kg	-	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
CFR-3L	Liquid	6.3A Irritating to the skin	1000L	-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	1.0kg	50kg	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
Class G Cement	Solid	6.1D(oral) Acutely toxic	1000kg	-	-	-	-	-	0.1kg	2.0kg	1000kg	-	-	20.kg	10000kg	10000kg	-	-	-	-	0.1kg	2.0kg	1000kg
		6.5A Respiratory sensitisers		-	-	-	-	-	1.0kg	3.0kg	1000kg	-	-	30.kg	-	-	-	-	-	-	Any	3.0kg	1000kg
		6.5B Contact sensitisers		-	-	-	-	-	1.0kg	3.0kg	1000kg	-	-	30.kg	-	-	-	-	-	-	Any	3.0kg	1000kg
		8.2C Corrosive to dermal tissue		-	-	-	-	-	0.1kg	1.0kg	10000kg	-	-	2.0kg	1000kg	1000kg	-	-	-	-	-	2.0kg	10000kg
		8.3A Corrosive to eyes		-	-	-	-	-	0.1kg	1.0kg	10000kg	-	-	2.0kg	1000kg	1000kg	-	-	-	-	0.15kg	2.0kg	10000kg
Clearbore_B	Liquid	6.1D (oral) Acutely toxic	1000L	-	-	-	-	-	0.1L	1.0L	1000L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	10000L
		6.3A Irritating to the skin		-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
		8.3A Corrosive to ocular tissue		-	-	-	-	-	0.1L	1.0L	10000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1L	1.0L	10000L
		9.1D (fish, crustacea, algae) Slightly harmful in the aquatic environment or are otherwise designed for biocidal action		-	-	-	-	-	1.0L	50L	10000L	-	-	50L	10000L	10000L	-	-	-	-	1.0L	50L	10000L
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-
D-AY 3000	Liquid	6.3B Mildly irritating to the skin	1000L	-	-	-	-	-	1.0L	50L	10000L	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
Econolite Liquid	Liquid	6.1D (oral) Acutely toxic	1000L	-	-	-	-	-	0.1L	1.0L	1000L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	1000L
		8.2C Corrosive to dermal tissue		-	-	-	-	-	0.1L	1.0L	10000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1kg	1.0L	10000L
		8.3A Corrosive to ocular tissue		-	-	-	-	-	0.1L	1.0L	10000L	-	-	1.0L	1000L	1000L	-	-	-	-	0.1L	1.0L	10000L
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-

BTW COMPANY	Section of Regulations		Test Certificates					Emergency Management																Sched 4
	Sub-section		Location & Transfer	manufacture and Use	Approved Handler	Hazardous atmosphere zone	Tracking	EM Level 1	EM Level 2	EM Level 3	Fire Extinguisher	Fire Extinguisher	Documentation	Signage	Signage	Separation	Separation	Separation	Incompatibility	Disposal			Bonding
	Reference		4.2	4.2	4.3	4.4	4.5	5.2.1	5.2.2	5.2.3	5.2.5	5.2.5	5.3.1	5.3.2	5.3.2	5.4.7	5.4.1	5.4.1	5.4.1	5.5			
	Schedule Table reference from Regulations		Table 1	Table 1	Table 2	Table 3	Table 4	Table 5	Table 6	Table 7	Table 8	Table 8	Table 9	Table 10	Table 10	Table 11	Table 11	Table 11	Table 12	Table 13	Table 14	Sched 4
	Description of what the numbers relate to in table below		Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Number of Extinguishers	Threshold level	Emergency Regulations	Identification Requirements	Low Intensity Land Use Threshold VOLUME	Low Intensity Land Use Separation Distance	Separation required from	Incompatible substances	Information Required and	Declaration Requirements	Threshold
Fly Ash	Solid	6.1E Acutely toxic (oral)		-	-	-	-	-	1.0kg	50kg	-	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	0.1kg	50kg	-
		6.7A Substances that are carcinogenic	1000kg	-	-	10kg	-	-	-	0.5kg	1000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	1000kg
		6.9A (Inhalation) Toxic to human target organs or systems		-	-	-	-	-	-	0.5kg	10000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	10000kg
		8.2C Corrosive to dermal tissue		-	-	-	-	-	0.1kg	1.0kg	10000kg	-	-	2.0kg	1000kg	1000kg	-	-	-	-	-	2.0kg	10000kg
		9.1D (fish, crustacea, algae) Slightly harmful in the aquatic environment or are otherwise designed for biocidal action		-	-	-	-	-	1.0kg	50kg	10000kg	-	-	50kg	10000kg	10000kg	-	-	-	-	2.0kg	50kg	10000kg
Gascon 469	Liquid	6.1E (oral) Acutely toxic		-	-	-	-	-	1.0L	50L	-	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
		6.3A Irritating to the skin		-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
		6.4A Irritating to the eye	1000L	-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
		6.7A Substances that are carcinogenic		-	-	10L	-	-	-	0.1L	1000L	-	-	0.1L	-	-	-	-	-	-	Any	0.1L	1000L
		6.9A (inhalation) Toxic to human target organs or systems		-	-	-	-	-	-	0.1L	10000L	-	-	0.1L	-	-	-	-	-	-	Any	0.1L	10000L
Goldseal Bentonite	Liquid	6.7A Substances that are carcinogenic	1000L	-	-	10L	-	-	-	0.1L	1000L	-	-	0.1L	-	-	-	-	-	-	Any	0.1L	1000L
		6.9B Toxic to human target organs or systems		-	-	-	-	-	-	1.0L	-	-	-	1.0L	-	-	-	-	-	-	0.1L	1.0L	-
HAI 404	Liquid	3.1B Flammable liquids: high hazard		50L	-	-	1.0L	-	1.0L	1.0L	1000L	250L	2	1.0L	250L	250L	-	-	-	Class 1 Class 2 Class 3.2 Class 4 Class 5	1.0L	1.0L	1000L
		6.1D (oral) Acutely toxic	1000L	-	-	-	-	-	0.1L	1.0L	1000L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	1000L
		6.3B Mildly irritating to the skin		-	-	-	-	-	1.0kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
		6.8B Suspected human reproductive or developmental toxicants		-	-	-	-	-	-	1.0L	-	-	-	1.0L	-	-	-	-	-	-	-	1.0L	-
		6.9A (inhalation) Toxic to human target organs or systems		-	-	-	-	-	-	0.1L	10000L	-	-	0.1L	-	-	-	-	-	-	Any	0.1L	10000L
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-
Halad 344	Solid	6.1C (oral) Acutely toxic		-	-	Any	-	Hazard	ANY	0.5kg	200kg	-	-	0.5kg	1000kg	1000kg	-	-	-	-	Any	0.5kg	100kg
		6.1D (dermal & inhalation) Acutely toxic		-	-	-	-	-	0.1kg	3.0kg	1000kg	-	-	30kg	10000kg	10000kg	-	-	-	-	0.1kg	3.0kg	1000kg
		6.3A Irritating to the skin		-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	0.1kg	50kg	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	0.1kg	50kg	-
		6.5B (contact) Contact sensitisers	1000kg	-	-	-	-	-	2.0kg	3.0kg	1000kg	-	-	30kg	-	-	-	-	-	-	Any	3.0kg	1000kg
		6.6A Known or presumed human mutagens		-	-	-	-	-	-	0.5kg	1000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	100000kg
		6.7A Known or presumed human carcinogens		-	-	10kg	-	-	-	0.5kg	1000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	1000kg
		6.8B Suspected human reproductive or developmental toxicants		-	-	-	-	-	-	3.0kg	-	-	-	30kg	-	-	-	-	-	-	-	3.0kg	-
		6.9A Toxic to human target organs or systems		-	-	-	-	-	-	0.5kg	10000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	10000kg
		9.3B Ecotoxic to terrestrial vertebrates		-	-	-	-	-	0.2kg	5.0kg	-	-	-	5.0kg	1000kg	1000kg	-	-	-	-	0.2kg	5.0kg	-
Halad 693	Solid	6.1D (oral) Acutely toxic		-	-	-	-	-	0.1kg	3.0kg	1000kg	-	-	30kg	10000kg	10000kg	-	-	-	-	0.1kg	3.0kg	1000kg
		6.7A Known or presumed human carcinogens		-	-	10kg	-	-	-	0.5kg	1000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	1000kg
		6.9A (inhalation) Toxic to human target organs or systems		-	-	-	-	-	-	0.5kg	10000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	10000kg
		8.1A Corrosive to metals	1000kg	-	-	-	-	-	Any	1.0kg	-	-	-	2.0kg	1000kg	1000kg	-	-	-	-	-	2.0kg	-
		8.2C Corrosive to dermal tissue		-	-	-	-	-	0.1kg	1.0kg	10000kg	-	-	2.0kg	1000kg	1000kg	-	-	-	-	-	2.0kg	10000kg
		8.3A Corrosive to ocular tissue		-	-	-	-	-	0.1kg	1.0kg	10000kg	-	-	2.0kg	1000kg	1000kg	-	-	-	-	0.1kg	2.0kg	10000kg
		9.1C Harmful in the aquatic environment		-	-	-	-	-	1.0kg	5.0kg	-	-	-	5.0kg	1000kg	1000kg	-	-	-	-	1.0kg	5.0kg	1000kg
		9.3B Ecotoxic to terrestrial vertebrates		-	-	-	-	-	0.2kg	5.0kg	-	-	-	5.0kg	1000kg	1000kg	-	-	-	-	0.2kg	5.0kg	-
HIS500M	Liquid	6.1E (oral) Acutely toxic		-	-	-	-	-	1.0L	50L	-	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
		6.4A Irritating to the eye	1000L	-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	0.1kg	50kg	-
		6.9A (oral) Toxic to human target organs or systems		-	-	-	-	-	-	0.5kg	10000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	10000kg
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-
Microsilica 600	Solid	6.7A Carcinogenic	1000kg	-	-	10kg	-	-	-	0.5kg	1000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	1000kg
		6.9A Target Organ Toxicant		-	-	-	-	-	-	0.5kg	10000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	10000kg
SSA-1 Silica Flour	Powder	6.7A Carcinogenic	1000kg	-	-	10kg	-	-	-	0.5kg	1000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	1000kg
		6.9A Target Organ Toxicant		-	-	-	-	-	-	0.5kg	10000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	10000kg
Super CLB	Solid	4.3B Flammable Solids - Dangerous when wet	1000kg	25kg	-	100kg	-	-	0.5kg	0.5L	1000L	250kg	2	0.5kg	250kg	250kg	10 000 2000 Litres 10000 100000 m3 100000-5000 000 1000000 L+	1m 3m 4m 6m 8m Not Applic	Low Intensity Land Use	Class 1 Class 2 Class 3 Class 4.1.1, 4.1.2, 4.1.3 & 4.2 Class 5 Class 8 Water	0.5kg	0.5kg	1000kg
		6.9B Toxic to human target organs or systems		-	-	-	-	-	-	3.0kg	-	-	-	30kg	-	-	-	-	-	-	0.1kg	3.0kg	-
		9.1D (fish, crustacea, algae) Slightly harmful in the aquatic environment or are otherwise designed for biocidal action		-	-	-	-	-	1.0kg	50kg	20000kg	-	-	50kg	10000kg	10000kg	-	-	-	-	1.0kg	50kg	10000kg
Tuned Spacer III	Powder	6.7A Carcinogenic	1000L	-	-	10kg	-	-	-	0.5kg	1000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	1000kg
		6.9A Target Organ Toxicant		-	-	-	-	-	-	0.5kg	10000kg	-	-	0.5kg	-	-	-	-	-	-	Any	0.5kg	10000kg
Versaset	Solid	6.3A Irritating to the skin	1000kg	-	-	-	-	-	2.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	2.1kg	50kg	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	2.1kg	50kg	-
Well life 684	Solid	4.2C Flammable Solids - spontaneously combustible (self heating)	1000kg	25kg	-	-	-	-	1.0kg	3.0kg	10000kg	500kg	2	3.0kg	10000kg	10000kg	10 000 2000 Litres 10000 100000 m3 100000-5000 000 1000000 L+	1m 3m 4m 6m 8m Not Applic	Low Intensity Land Use	Class 1 Class 3 Class 3 Class 4.1.1, 4.1.2, 4.1.3 & 4.2 Class 5 Class 8 Water Hydrogen	1.0kg	-	10000kg
Zoneseslant 2000	Liquid	3.1B Flammable Liquids: high hazard	1000L	50L	-	-	1.0L	-	1.0L	1.0L	1000L	250L	2	1.0L	250L	250L	-	-	-	-	1.0L	1.0L	1000L
		6.1E Acutely toxic		-	-	-	-	-	1.0L	50L	-	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
		6.3B Mildly irritating to the skin		-	-	-	-	-	1.0L	50L	10000L	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
		6.4A Irritating to the eye		-	-	-	-	-	0.1L	50L	10000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-

BTW COMPANY		Section of Regulations		Test Certificates					Emergency Management															Sched 4
		Sub-section		Location & Transfer	manufacture and Use	Approved Handler	Hazardous atmospheres zone	Tracking	EM Level 1	EM Level 2	EM Level 3	Fire Extinguisher	Fire Extinguisher	Documentation	Signage	Signage	Separation	Separation	Separation	Incompatibility	Disposal		Bunding
		Reference		4.2	4.2	6.9	4.4	4.5	5.2.1	5.2.2	5.2.3	5.2.5	5.2.5	5.3.1	5.3.2	5.3.2	5.4.1	5.4.1	5.4.1	5.4.1	5.5		
		Schedule Table reference from Regulations		Table 1	Table 1	Table 2	Table 3	Table 4	Table 5	Table 6	Table 7	Table 8	Table 8	Table 9	Table 10	Table 10	Table 11	Table 11	Table 11	Table 12	Table 13	Table 14	Sched 4
		Description of what the numbers relate to in table below		Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Threshold level	Number of Extinguishers	Threshold level	Emergency Regulations	Identification Requirements	Low Intensity Land Use Threshold VOLUME	Low Intensity Land Use Separation Distance	Separation required from	Incompatible substances	Information Requirements	Documentation Requirements	Threshold
GENERAL CHEMICALS																							
Methanol	Liquid	6.1B Flammable Liquids: high hazard		50L	-	-	1.0L	-	1.0L	1.0L	10001	250L	2	1.0L	250L	250L	-	-	-	Class 1 Class 2 Class 3.2 Class 4 Class 5	1.0L	1.0L	1000L
		6.1D (oral) Acutely toxic	1500L	-	-	-	-	-	0.1L	1.0L	3500L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	1000L
		6.4A Irritating to the eye		-	-	-	-	-	0.1L	50L	100000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
		6.8B Suspected human reproductive or developmental toxicants		-	-	-	-	-	-	1.0L	-	-	-	2.0L	-	-	-	-	-	-	-	1.0L	-
		6.9A (Inhalation) Toxic to human target organs or systems		-	-	-	-	-	-	0.1L	10000L	-	-	0.1L	-	-	-	-	-	-	Any	0.1L	10000L
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-
LPG	Gas	2.1.1A Flammable Gases : high hazard	200m3	100m3	-	100m3	38m3	-	0.2m3	0.2m3	200m3	38m3	1	0.2m3	100m3	100m3	-	-	-	Class 2	0.2m3	0.2m3	-
Diesel	Liquid	3.1D Flammable liquids: low hazard.	20000L	-	-	-	-	-	5.0L	50L	100001	500L	2	50L	10000L	10000L	-	-	-	Class 1 Class 2 Class 3.2 Class 4 Class 5	5.0L	50L	10000L
		6.1E Acutely toxic		-	-	-	-	-	1.0L	50L	-	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
		6.3B Mildly irritating to the skin.		-	-	-	-	-	1.0kg	50kg	10000kg	-	-	50kg	-	-	-	-	-	-	1.0kg	50kg	-
		6.7B Carcinogenic		-	-	-	-	-	-	1.0L	1000001	-	-	1.0L	-	-	-	-	-	-	Any	1.0L	10000L
		9.1B Harmful to aquatic ecosystems		-	-	-	-	-	0.2L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	0.2L	5.0L	10000L
Produced Hydrocarbons	Liquid	3.1B Flammable Liquids: high hazard	150000L	50L	-	-	2.0L	-	1.0L	1.0L	10000L	250L	2	1.0L	250L	250L	-	-	-	Class 1	1.0L	1.0L	10000L
		6.1E Acutely toxic		-	-	-	-	-	1.0L	50L	-	-	-	50L	-	-	-	-	-	-	1.0L	50L	-
		6.6A Mutagenic properties		-	-	-	-	-	-	0.1L	10000L	-	-	0.1L	-	-	-	-	-	-	Any	0.1L	10000L
		6.7A Substances that are carcinogenic		-	-	20L	-	-	-	0.1L	10001	-	-	0.1L	-	-	-	-	-	-	Any	0.1L	10000L
		6.9B Toxic to human target organs or systems		-	-	-	-	-	-	1.0L	-	-	-	1.0L	-	-	-	-	-	-	0.1L	1.0L	-
		9.1C Harmful to aquatic ecosystems		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	10000L
Monoethylene Glycol	Liquid	6.1D Toxic	1500L	-	-	-	-	-	0.1L	1.0L	10000L	-	-	1.0L	10000L	10000L	-	-	-	-	0.1L	1.0L	10000L
		6.4A Irritating to the eye		-	-	-	-	-	0.1L	50L	100000L	-	-	50L	-	-	-	-	-	-	0.1L	50L	-
		6.9A Target Organ		-	-	-	-	-	-	0.1L	100000L	-	-	0.1L	-	-	-	-	-	-	Any	0.1L	10000L
		9.3C Harmful to terrestrial vertebrates		-	-	-	-	-	1.0L	5.0L	-	-	-	5.0L	10000L	10000L	-	-	-	-	1.0L	5.0L	-

APPENDIX B SITE MAPS


Legend
Disposal_Areas
Bores
NZAA Archaeological Sites
Waterways
Buffer
Contaminated Fluids
Contaminated Soil
Synthetic-based Mud
Wastewater
Water-based Mud
Well Workover Fluids
Disposal Site (approx. 15ha)
Matatiore Pa
F1
F2
F3
F4
F5
F6
F7
F8
F9
F10
F11
F12
F13
F14
F15
F16
F17
F18
F19
F20
F21
F22
Mud Type Key
WWF Well workover fluids
OBM Oil-based muds
WBM Water-based mud
WW Waste water
CS Contaminated soil
CF Contaminated Fluids
SBM Synthetic-based Mud
btw company
WELLINGTON LANDFARM
WAITARA
10181
1:2,500


Novacoil 4
Novacoil 3
Novacoil 2
Pipe
Novacoil 1
Legend
Existing Lined Storage Pit
Old Oily Waste Storage Pits
Sampling Bores
Manhole
Water Pipes
Wellington Disposal Site Boundaries
btw company
1:2,000
WAITARA
10181
WELLINGTON DISPOSAL SITE
NOVACOIL LOCATIONS
10151-104-GIS

APPENDIX C NOVAL COIL MONITORING RESULTS

Hill Laboratories
BETTER TESTING BETTER RESULTS

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	1148146	SPv1
Contact:	Dave Bolger	**Date Registered:**	21-Jun-2013	
	C/- BTW Company Ltd	**Date Reported:**	01-Jul-2013	
	PO Box 551	**Quote No:**	45045	
	NEW PLYMOUTH 4340	**Order No:**		
		Client Reference:	Tank Water	
		Submitted By:	Dave Bolger	

Sample Type: Aqueous

Sample Name:		Nova Outlet 4 - Brown 19-Jun-2013 11:00 am	Nova Outlet 2 - Brown 19-Jun-2013 10:00 am			
Lab Number:		1148146.1	1148146.2			
Individual Tests						
pH	pH Units	6.1	6.5	-	-	-
Electrical Conductivity (EC)	mS/m	125.4	25.4	-	-	-
Total Dissolved Solids (TDS)	g/m³	770	159	-	-	-
Specific Gravity*	20°C/20°C	1.00	1.00	-	-	-
Total Potassium	g/m³	170	23	-	-	-
Total Sodium	g/m³	82	12.7	-	-	-
Chloride	g/m³	167	39	-	-	-
Total Nitrogen	g/m³	11.7	1.06	-	-	-
Nitrate-N + Nitrite-N	g/m³	7.9	0.33	-	-	-
Total Kjeldahl Nitrogen (TKN)	g/m³	3.8	0.73	-	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m³	< 0.0011	< 0.0011	-	-	-
Total Cadmium	g/m³	0.000158	< 0.000053	-	-	-
Total Chromium	g/m³	< 0.00053	< 0.00053	-	-	-
Total Copper	g/m³	0.0092	0.0031	-	-	-
Total Lead	g/m³	< 0.00011	0.00012	-	-	-
Total Nickel	g/m³	0.0026	< 0.00053	-	-	-
Total Zinc	g/m³	0.0095	0.43	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	< 0.0010	-	-	-
Toluene	g/m³	< 0.0010	< 0.0010	-	-	-
Ethylbenzene	g/m³	< 0.0010	< 0.0010	-	-	-
m&p-Xylene	g/m³	< 0.002	< 0.002	-	-	-
o-Xylene	g/m³	< 0.0010	< 0.0010	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	< 0.10	-	-	-
C10 - C14	g/m³	< 0.2	< 0.2	-	-	-
C15 - C36	g/m³	< 0.4	< 0.4	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	< 0.7	-	-	-

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples

823 365
This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Samples**
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	-	1-2
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1-2
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-2
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-2
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21st ed. 2005.	10 g/m³	1-2
Specific Gravity*	Calculation: weight of sample / weight of equivalent volume of water at 20°C. Gravimetric determination.	0.01 20°C/20°C	1-2
Total Potassium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.053 g/m³	1-2
Total Sodium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.021 g/m³	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m³	1-2
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N.	0.05 g/m³	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 21st ed. 2005.	0.002 g/m³	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 21st ed. 2005.	0.10 g/m³	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental Division

APPENDIX D PHOTOGRAPHIC RECORD OF LANDFARMING

January 2013

July 2013

Appendix III

Consent surrender application report for consent 6867-1

29/7/2013

Chief Executive
Taranaki Regional Council
Private Bag 713
Stratford 4352

RE: Surrender of Consent 6867-1(Discharge Permit)

We request that resource consent 6867-1 by surrendered from the consent holder BTW Company Limited.

Material was received at the Brown Road Land Farming site under consent 6867-1 between the dates of 27/4/2006 and 1/5/2011. All material was land farmed within the consented areas F1 to F16b as shown on the attached map in Appendix 1. Twenty individual areas have been land farmed within the consented area and include a variety of drilling waste material from water based muds to produced water; some areas include a mixture of products as shown in the schedule on the attached site plan.

Consent 6867-1 is being surrendered as the site has not been operational for some time now and there are no further areas to land farmed within the confines of this consent. The last area to be land farmed was F16a & b which was between the period of January 2011 and May 2011.

The receiving environment areas which have been land farmed has been actively monitored by BTW Company and the Taranaki Regional Council (TRC) since the first area was land farmed. All areas have shown the material has bio remediated to meet surrender requirements of the consent. The last area to meet surrender criteria was B15, which was in July 2012. We have provided all our sampling results to the TRC to demonstrate compliance with surrender limits of the consent. These results are also contained in Appendix 2.

After consultation with David Olson (Senior Scientist with TRC and Job Manager) it was concluded that to complete the surrender requirements of the consent BTW would undertake one last round of sampling to ensure compliance with surrender limits. The sampling required taking a transect through the sampling area. Two transects were taken on either side of the access track with approximately 20 sub samples taking per transect. The sub samples were then homogenised and a composite sample taken. The samples were sent to Hill Laboratory and a complete suite of tests were completed to analyse constituent levels with the soils. The following table from the latest analysis report shows compliance with constituent surrender limits specified in special conditions 22 & 23 of consent 6867-1. A complete copy of the analysis report is contained in Appendix 3.

Table 1: Analysed composite sample vs consent surrender criteria

Constituent	Surrender criteria	Transect 1	Transect 2
	Table 7.1 Section 7 MfE, NZWWG (2003)		
Arsenic	20	3	4
Cadmium	1	<0.10	0.10
Chromium	600	11	11
Copper	100	17	19
Lead	300	3.4	2.6
Mercury	1	<0.10	<0.10
Nickel	60	5	4
Zinc	300	57	56
Conductivity	290mS/m	30	30
Chloride	700mg.kg	13	13
Sodium	460mg/kg	20	23
Total soluble salts	2500mg/kg	184.8	198
	Sand <1m, Table 4.12 Section 4 MfE, GfAMPHCSNZ (1999)		
Benzene	1.1	<0.05	<0.05
Toulene	68	<0.05	<0.05
Elthylbenzene	53	<0.05	<0.05
Xylenes	48	<0.05	<0.05
Natphthalene	7.2	<0.14	<0.13
Non-carc (pyrene)	160	<0.03	<0.03
Benzo (a) pyrene eq	0.027	<0.03	<0.03
	Sand <1m, Table 4.15 Section 4 MfE, GFAMPHCSNZ (1999)		
C7-C9	120	<8	<8
C10-C14	58	<20	<20
C15-C36	4000	<40	167

We conclude that from sampling results previously we have demonstrated that all land farmed area have meet surrender criteria limits, however to give greater certainty and more data we undertook further sampling of the site. As shown from the table above the last round of sampling has also demonstrated compliance with surrender limit criteria of consent 6867-1. We now believe we have sufficient data to ensure consent 6867-1 meets surrender conditions criteria and the consent can now be surrendered.

I look forward to receiving confirmation from the TRC that consent 6867-1 has been surrendered.

Kind Regards,

Dave Bolger
Land Farming Manager

Appendix 1

Site Map

ID	MudType	Date Farmed	WellName	Easting	Northing	Area (m²)
B1	WBM	Oct 2006	Kowhai	1704171	5683469	6802
B2	SBM	Oct 2006	Kowhai	1704192	5683371	5754
B3	WBM	Jan 2007	Kowhai	1704229	5683456	7906
B4	SBM	Jan 2007	Kowhai	1703978	5683345	3795
B5	SBM	Nov 2009	Mangahewa D	1704089	5683476	15036
B6a	WBM	Oct 2009	Mangahewa C	1704124	5683349	5151
B6b	WBM	Oct 2009	Mangahewa C	1704150	5683554	1227
B7	WBM	Oct 2009	KA 6/11	1704076	5683382	517
B8	WBM	Oct 2009	Mystone / Waitui-1	1704064	5683417	409
B9	WBM	Oct 2009	KA 8/12/15	1704087	5683354	577
B10	SBM	Jan 2010	Mangahewa C	1704016	5683392	12211
B11	WBM	Feb 2010	Waitui-1	1703991	5683418	5657
B12	Fracture Water	09-07-2010	Mangahewa C	1703933	5683489	7098
B13a	MIX	Dec 2010	McKee Production Station, Waitui-1 (SBM), Cheal B (WBM), Port Taranaki Contaminated Soil	1704054	5683635	28652
B13b	MIX	Dec 2010	McKee Production Station, Waitui-1 (SBM), Cheal B (WBM), Port Taranaki Contaminated Soil	1703922	5683513	13422
B13c	MIX	Dec 2010	McKee Production Station, Waitui-1 (SBM), Cheal B (WBM), Port Taranaki Contaminated Soil	1704028	5683235	10758
B14	MIX	Dec 2010	McKee Production Station, Cheal B	1704032	5683298	2513
B15	WBM	Dec 2010	Broadside	1703972	5683289	4532
B16a	Produced Water	Jan-May 2011	Tank Farms	1703859	5683600	7265
B16b	Produced Water	Jan-May 2011	Tank Farms	1704197	5683292	11121

1703800 1704000 1704200

5684000 5683800 5683600 5683400 5683200

N W E S

B13a B16a B13b B12 B11 B10 B4 B15 B14 B13c B5 B6b B1 B3 B8 B7 B9 B6a B2 B16b ACCESS TRACK

Legend
- Fracture Water
- Produced Water
- MIX
- SBM
- WBM
- Fence
- Track

GENERAL NOTES:
1. Coordinates are in terms of NZGD 2000 Transverse Mercator

Disclaimer:
Boundary information has been imported from external sources.
Areas and dimensions may be subject to scale error.
Use of this drawing for other purposes is at the user's risk.
Print from PDF: scale not accurate.

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BROWN ROAD DISPOSAL SITE
SITE PLAN SHOWING
AREA'S OF DISPOSAL

No.	DATE	BY	CHD	DESCRIPTION
6	10/02/11	JH	DR	Add produced water areas B16a and B16b
5	25/01/11	BO	DR	Add produced water areas.
4	14/12/10	PT	DR	Add disposal areas.
3	23/07/10	PT	DR	Add labels to disposal pits.
2	11/05/10	PT	DR	Add labels to disposal pits.
1	16/02/10	PT	DR	Make changes to area calculations.

REVISIONS

DRAWN BY	THOMPSON	09/02/10
CHECKED BY	RILEY	10/02/10
PROJECT No.	09252	
LOCATION	WAITARA	
ORIGINAL SIZE	A3	
SCALE	1:2,500	

0 20 40 80 120 160 200
Meters

DRAWING No. 09252-04-GIS

REV 6

Appendix 2

Complete sampling Results

	Brown Road Anaylsis against surrender consent conditions			2010 Annual Report									
	Contaminant	**sand at <1m**	**Limit**	07-Aug-08				13-Aug-09				08-Sep-09	
				B1	B2	B3	B4	B1	B2	B3	B4	B5	B6
TPH	**C7-C9 (4)**	**120 (m)**	**120**		<8.0	<8.0	8.1	<8.4	<8.0	<8.0	<8.1	<8.0	<8.2
	C10-C14	**58 (x)**	**58**		<20	<20	4600	<20	1500	<20	2500	<20	<20
	C15-C36	**(4,000) (7,x)**	**4000**		220	35	11000	<30	4800	33	8400	<30	<30
	Total				240	<60	16000	<60	6300	<60	11000	<60	<60
MAHs	**Benzene**	**1.1 (v)**	**1.1**					<0.050	<0.050	<0.050	<0.050	<0.05	<0.05
	Toluene	**(68) (4,v)**	**68**					<0.050	<0.050	<0.050	<0.050	<0.05	<0.05
	Ethylbenzene	**(53) (4,v)**	**53**					<0.050	<0.050	<0.050	<0.050	<0.05	<0.05
	Xylenes	**(48) (4,v)**	**48**					<0.1	<0.1	<0.1	<0.1	<0.10	<0.10
PAHs	**Naphthalene**	**7.2 (p)**	**7.2**				<0.14	<0.14	<0.12	<0.12	<0.14	<0.14	<0.14
	Non-carc. (Pyrene)	**(160) (4,p)**	**160**				0.28	<0.028	0.076	<0.024	0.23	<0.027	<0.028
	Benzo(a)pyrene eq.	**0.027 (p)**	**0.027**					<0.028	<0.024	<0.024	<0.027	<0.027	<0.028
	Conductivity,	**290 mS/m**	**290**										
	Total dissolved salts,;	**2500 mg/kg**	**2500**										
	Sodium,	**460 mg/kg**	**460**										
	Chloride,	**700 mg/kg**	**700**					7.3	18	10	350	11	9.4
	Soluble Salts (Field)	%											
	EC (IN 1:5 Extract)	mS/m											
	Total soluble salts	mg/L											
	EC (Sat Paste)	mS/m											
	Calcium (Sat Paste)	mg/L		162	21	5	369	44	44	52	132		
	Magnesium	mg/L		11	2	2	14	5	5	5	11		
	Sodium	mg/L		86	10	7	32	11	12	8	21		
	SAR			1.8	0.5	0.7	0.4	0.4	0.5	0.3	0.5		
	Total Nitrogen	g/100g dry wt						0.1	0.091	<0.050	0.091	0.12	0.11
	Dry Matter	g/100g as rcvd			90	87	86	85	88	92	88	82	80
Metals	Total Recoverable Barium	mg/kg dry wt			1400	-	2500						
	Total Recoverable Arsenic	mg/kg dry wt	10					2.9	<2	<2	2.4	4.3	2.2
	Total Recoverable Cadmiun	mg/kg dry wt	3					<0.1	<0.1	<0.1	<0.1	<0.1	0.13
	Total Recoverable Chromium	mg/kg dry wt	600					15	16	13	19	13	12
	Total Recoverable Copper	mg/kg dry wt	140					22	26	20	26	19	41
	Total Recoverable Lead	mg/kg dry wt	300					4.7	6.6	2.6	3.4	2.2	8.4
	Total Recoverable Mecury	mg/kg dry wt	1					<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Total Recoverable Nickel	mg/kg dry wt	35					9.9	8.5	7.3	8.2	5.9	6.7
	Total Recoverable Zinc	mg/kg dry wt	300					87	120	86	120	75	110

19-Nov-09					17-Feb-10		10-May-10						03-Aug-10				
B5	B 6a & b	B7	B8	B9	B5	B10	B5	B6	B7	B8	B9	B10	**B2**	B3	**B4**	**B5**	**B10**
<8	<8	<8	<8.1	<8	<8	<8	<8	<8	<8	<8	<8	<8	<9	<8	<8	<9	11
820	<20	<20	1300	<20	3500	3700	2300	<20	<20	<20	<20	700	1570	<20	5500	400	2400
3200	<30	<30	3000	31	7700	1300	6000	<40	<40	<40	<40	2800	8600	<40	13500	1250	9000
4000	<60	<60	4200	<60	1100	1700	8200	<60	<60	<60	<60	3500	10100	<60	19000	1660	11400
<0.079	<0.079	<0.080	<0.079	<0.072	<0.050	<0.050	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05					
<0.079	<0.079	<0.080	<0.079	<0.072	<0.050	<0.050	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05					
<0.079	<0.079	<0.080	<0.079	<0.072	<0.050	<0.050	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05					
<0.16	<0.16	<0.16	<0.16	<0.16	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1					
<0.13	<0.12	<0.12	<0.14	<0.12	<0.12	<0.13	<0.13	<0.13	<0.12	<0.13	<0.12	<0.14					
<0.025	<0.024	<0.024	<0.027	<0.023	<0.024	<0.025	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03					
<0.025	<0.024	<0.024	<0.027	<0.023	<0.024	<0.025	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03					
200	550	39	32	19	130	150	200	210	7.8	23	5.9	44					
0.11	0.097	0.13	0.13	<0.050	0.11	0.12	0.144	0.121	0.083	0.076	0.064	0.019					
89	88	89	88	94	93	90	88	90	90	76	93	90	82	84	89	82	87
<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.5	<2.0	<2.0	<2.0	<2.0	<2.0					
<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1					
13	12	8.8	9.6	9.9	14	12	9.1	8.9	6.6	7.7	7.6	9.1					
19	20	22	23	16	19	19	15.4	16.2	18	32	14.5	15.8					
1.9	2.6	2.6	2.4	1.4	1.9	2.5	2.3	3.7	2.2	2.6	1.49	2.6					
<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1					
6.4	6.1	5	5.7	5.1	7.7	6.2	4.8	5.3	3.8	5.6	4.6	4.6					
91	84	66	68	59	100	83	61	60	49	50	55	63					

2011 Annuual Report																
09-Mar-11	22-Jun-10	02-Feb-11	01-Nov-10					10-Jan-11	13-May-11				03-Aug-11				
B11	B12	**B10**	B5	B6a & b	B7	B8	B9	**B13**	B13	**B14**	**B15**	B16	B2	B4	**B15**	B16	B14
<8	<10	<8	<8	<8	<8	<8	<8	<8	<9	<10	16	<13	<8	<8	<8	<15	<9
<20	<20	4200	<20	<20	<20	34	<20	3300	270	2800	4400	<30	<20	21	750	<30	2900
78	<40	12800	140	<40	<40	210	<50	9800	1540	7800	13,400	<60	103	220	2300	60	8800
								<0.05	<0.05	<0.06	<0.08	<0.16					
								<0.05	<0.05	<0.06	<0.08	<0.16					
								<0.05	<0.05	<0.06	<0.08	<0.16					
								0.21/0.24	<0.10	<0.12	<0.16	<0.16					
								<0.13	<0.14	<0.17	<0.18	<0.3					
								0.09	0.03	<0.04	<0.04	<0.05					
								<0.03	<0.03	<0.04	<0.04	<0.05					
	62								15	72	141	33	10	15	44	63	370
			<0.05	<0.05	<0.05	<0.05	<0.05										
			0.08	0.05	<0.01	0.13	0.12										
			647	416	99	832	779	1888		1241	1043	205					
			1	0.6	0.2	1.3	1.2	2.9		1.9	1.6	0.3					
			68	33	12	152	91	58		120	123	14					
			10	5	3	15	10	7		9	10	4					
			95	34	9	57	128	530		174	116	34					
			2.8	1.5	0.6	1.2	3.4	17.5		4.1	2.7	2					
	0.24							1300	1800	2200	2300	6800					
	71							87	84	75	62	52	87	90	84	50	74
								2000	1370	1480	2800	40	2300	2100	2800	61	3200
								2	<2	2	3	5					
								<0.1	<0.10	<0.10	<0.10	0.27					
								9	9	11	12	15					
								16	15	20	27	20					
								2.8	2.9	4.3	6.2	2.7					
								<0.1	<0.1	<0.1	<0.1	<0.1					
								5	5	7	7	4					
								52	54	55	64	62					

2012 Annual Report										
11-Aug-11	15-Nov-11		23-Nov-11	10-Feb-12		09-Jul-12				
B13	B5	B15	B10	B11	B10	B2	B4	B13	B14	B15
<9	<8	<9	<8	<8	<8	<8	<11	<9	<8	<9
79	<20	1390	180	<20	<20	<20	<30	<20	<20	<20
650	<40	4800	1540	187	<40	82	<50	<40	<40	<40
730	<70	6200	1720	187	<70	82	<80	<70	<70	<70
	7	101								
77	88	81	84	86	85	90	69	88	88	77
1710	1240	2900								

Appendix 3

Analysis Reports– Final Sampling

Hill Laboratories
BETTER TESTING BETTER RESULTS

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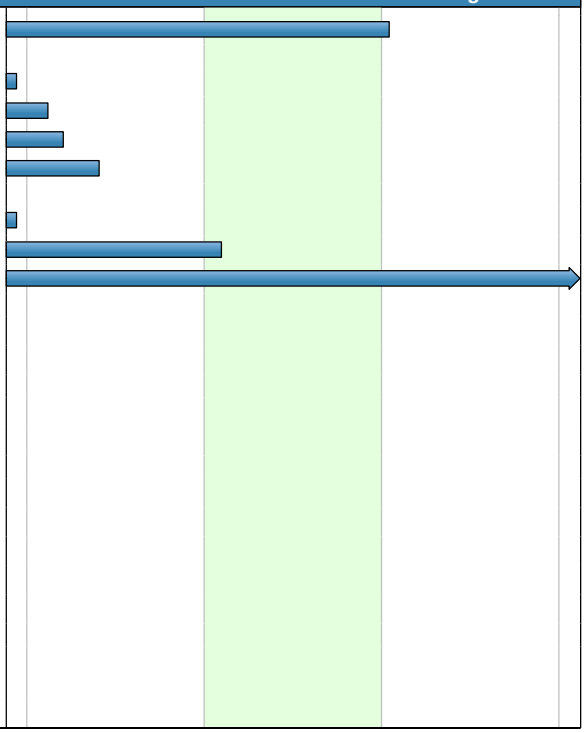
ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	1157746	shpv2
Address:	PO Box 551 NEW PLYMOUTH 4340	**Date Registered:**	19-Jul-2013	
		Date Reported:	26-Jul-2013	
		Quote No:	36604	
		Order No:	09252	
		Client Reference:		
Phone:	06 759 5040	**Submitted By:**	Dave Bolger	

Sample Name: Final - Brown Rd - 1 **Lab Number:** 1157746.1
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.3	5.8 - 6.3
Potassium	me/100g	0.13	0.50 - 0.80
Calcium	me/100g	2.5	6.0 - 12.0
Magnesium	me/100g	0.44	1.00 - 3.00
Sodium	me/100g	0.08	0.20 - 0.50
CEC	me/100g	6	12 - 25
Total Base Saturation	%	53	50 - 85
Volume Weight	g/mL	1.46	0.60 - 1.00
Total Soluble Salts*	mg/L	184.8	
Electrical Conductivity (Sat Paste)*	mS/cm	0.3	
Nitrate-N (Sat Paste)*	mg/L	4	
Ammonium-N (Sat Paste)*	mg/L	2	
Phosphorus (Sat Paste)*	mg/L	1	
Potassium (Sat Paste)*	mg/L	16	
Calcium (Sat Paste)*	mg/L	18	
Magnesium (Sat Paste)*	mg/L	4	
Sodium (Sat Paste)*	mg/L	20	
Sodium Absorption Ratio*		1.1	
Lime Requirement (7.5cm)	tonne/ha	0.6	



The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information.
IANZ Accreditation does not apply to comments and interpretations, i.e. the 'Range Levels' and subsequent graphs.

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Hill Laboratories
BETTER TESTING BETTER RESULTS

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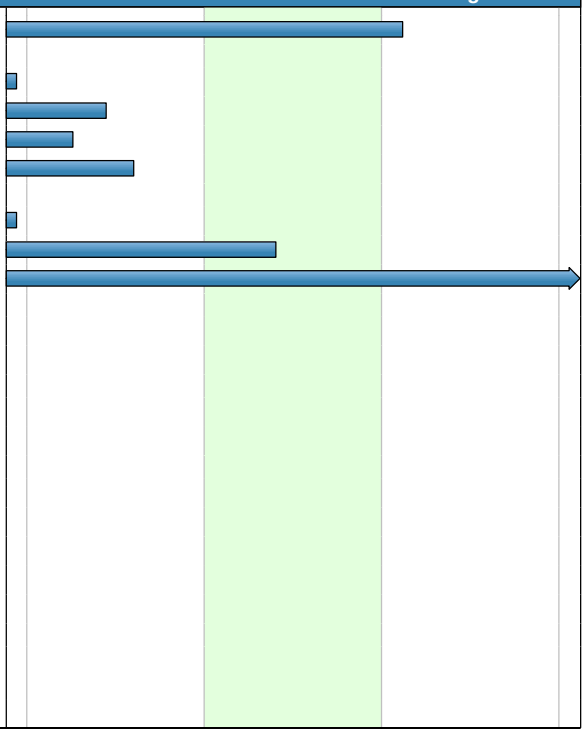
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	1157746 shpv2
Address:	PO Box 551	**Date Registered:**	19-Jul-2013
	NEW PLYMOUTH 4340	**Date Reported:**	26-Jul-2013
		Quote No:	36604
		Order No:	09252
		Client Reference:	
Phone:	06 759 5040	**Submitted By:**	Dave Bolger

Sample Name: Final - Brown Rd - 2 **Lab Number:** 1157746.2
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.4	5.8 - 6.3
Potassium	me/100g	0.14	0.50 - 0.80
Calcium	me/100g	3.8	6.0 - 12.0
Magnesium	me/100g	0.48	1.00 - 3.00
Sodium	me/100g	0.12	0.20 - 0.50
CEC	me/100g	7	12 - 25
Total Base Saturation	%	64	50 - 85
Volume Weight	g/mL	1.39	0.60 - 1.00
Total Soluble Salts*	mg/L	198.0	
Electrical Conductivity (Sat Paste)*	mS/cm	0.3	
Nitrate-N (Sat Paste)*	mg/L	5	
Ammonium-N (Sat Paste)*	mg/L	2	
Phosphorus (Sat Paste)*	mg/L	< 1	
Potassium (Sat Paste)*	mg/L	15	
Calcium (Sat Paste)*	mg/L	17	
Magnesium (Sat Paste)*	mg/L	4	
Sodium (Sat Paste)*	mg/L	23	
Sodium Absorption Ratio*		1.3	
Lime Requirement (7.5cm)	tonne/ha	0.2	



The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information.
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ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	1157746	shpv2
Address:	PO Box 551	**Date Registered:**	19-Jul-2013	
	NEW PLYMOUTH 4340	**Date Reported:**	26-Jul-2013	
		Quote No:	36604	
		Order No:	09252	
		Client Reference:		
Phone:	06 759 5040	**Submitted By:**	Dave Bolger	

Analyst's Comments

Samples 1-2 Comment:
The lime requirement shown above is based on achieving a total base saturation of 70%, assuming 90% pure limestone and a sampling depth of 7.5cm.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Samples
Sample Registration*	Samples were registered according to instructions received.	-	1-2
Soil Prep (Dry & Grind)*	Air dried at 35 - 40°C overnight (residual moisture typically 4%) and crushed to pass through a 2mm screen.	-	1-2
pH	1:2 (v/v) soil:water slurry followed by potentiometric determination of pH.	0.1 pH Units	1-2
Total Soluble Salts*	Saturated Paste extraction followed by potentiometric conductivity determination (25°C).	1.0 mg/L	1-2
Electrical Conductivity (Sat Paste)*	Saturated Paste extraction followed by potentiometric conductivity determination (25°C).	0.1 mS/cm	1-2
Nitrate-N (Sat Paste)*	Saturated Paste extraction followed by Salicylate colorimetry.	1 mg/L	1-2
Ammonium-N (Sat Paste)*	Saturated Paste extraction followed by Berthelot colorimetry.	1 mg/L	1-2
Phosphorus (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1-2
Potassium (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1-2
Calcium (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1-2
Magnesium (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1-2
Sodium (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1-2
Sodium Absorption Ratio (SAR)*	Calculation from the sodium, calcium and magnesium determined on a Saturated Paste extract.	0.2	1-2
Lime Requirement 7.5cm	Lime requirement based on 7.5cm depth.	0.1 tonne/ha	1-2
Potassium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.01 me/100g	1-2
Calcium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.5 me/100g	1-2
Magnesium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.04 me/100g	1-2
Sodium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.05 me/100g	1-2
Potassium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.1 %BS	1-2
Calcium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 %BS	1-2
Magnesium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.2 %BS	1-2
Sodium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.1 %BS	1-2
CEC	Summation of extractable cations (K, Ca, Mg, Na) and extractable acidity.	2 me/100g	1-2
Total Base Saturation	Calculated from Extractable Cations and Cation Exchange Capacity.	5 %	1-2
Volume Weight	The weight/volume ratio of dried, ground soil.	0.01 g/mL	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Andrew Whitmore BSc (Tech)
Technologist - Agriculture Division

Hill Laboratories
BETTER TESTING BETTER RESULTS

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ANALYSIS REPORT

Client:	BTW Company Ltd	**Lab No:**	1157854	SPv2
Contact:	Dave Bolger	**Date Registered:**	19-Jul-2013	
	C/- BTW Company Ltd	**Date Reported:**	29-Jul-2013	
	PO Box 551	**Quote No:**	36604	
	NEW PLYMOUTH 4340	**Order No:**	09252	
		Client Reference:	Receiving Environment -Soil	
		Submitted By:	Dave Bolger	

Sample Type: Soil

Sample Name:		Final - Brown Rd - 1 18-Jul-2013 12:00 pm	Final - Brown Rd - 2 18-Jul-2013 12:00 pm			
Lab Number:		1157854.1	1157854.2			
Individual Tests						
Dry Matter	g/100g as rcvd	82	83	-	-	-
Total Recoverable Barium	mg/kg dry wt	1,130	870	-	-	-
Total Recoverable Boron	mg/kg dry wt	< 20	< 20	-	-	-
Total Recoverable Vanadium	mg/kg dry wt	141	147	-	-	-
Chloride*	mg/kg dry wt	13	13	-	-	-
Total Nitrogen*	g/100g dry wt	0.16	0.24	-	-	-
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	3	4	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	0.10	-	-	-
Total Recoverable Chromium	mg/kg dry wt	11	11	-	-	-
Total Recoverable Copper	mg/kg dry wt	17	19	-	-	-
Total Recoverable Lead	mg/kg dry wt	3.4	2.6	-	-	-
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	-	-	-
Total Recoverable Nickel	mg/kg dry wt	5	4	-	-	-
Total Recoverable Zinc	mg/kg dry wt	57	56	-	-	-
BTEX in Soil by Headspace GC-MS						
Benzene	mg/kg dry wt	< 0.05	< 0.05	-	-	-
Toluene	mg/kg dry wt	< 0.05	< 0.05	-	-	-
Ethylbenzene	mg/kg dry wt	< 0.05	< 0.05	-	-	-
m&p-Xylene	mg/kg dry wt	< 0.10	< 0.10	-	-	-
o-Xylene	mg/kg dry wt	< 0.05	< 0.05	-	-	-
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Acenaphthylene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Anthracene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Benzo[a]anthracene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Chrysene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Fluoranthene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Fluorene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Naphthalene	mg/kg dry wt	< 0.14	< 0.13	-	-	-

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Soil						
Sample Name:		Final - Brown Rd - 1 18-Jul-2013 12:00 pm	Final - Brown Rd - 2 18-Jul-2013 12:00 pm			
Lab Number:		1157854.1	1157854.2			
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Phenanthrene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Pyrene	mg/kg dry wt	< 0.03	< 0.03	-	-	-
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	< 8	< 8	-	-	-
C10 - C14	mg/kg dry wt	< 20	< 20	-	-	-
C15 - C36	mg/kg dry wt	< 40	167	-	-	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt	< 70	167	-	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Samples
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-2
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	-	1-2
BTEX in Soil by Headspace GC-MS	Solvent extraction, Headspace GC-MS analysis US EPA 8260B. Tested on as received sample [KBIs:5782,26687,3629]	-	1-2
Polycyclic Aromatic Hydrocarbons Screening in Soil	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis (modified US EPA 8270). Tested on as received sample. [KBIs:5786,2805,2695]	-	1-2
Total Petroleum Hydrocarbons in Soil	Sonication extraction in DCM, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample [KBIs:5786,2805,10734]	-	1-2
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-2
esICextn*	Potassium phosphate extraction for Ion Chromatography. In House.	-	1-2
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-2
Total Recoverable Barium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.4 mg/kg dry wt	1-2
Total Recoverable Boron	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	20 mg/kg dry wt	1-2
Total Recoverable Vanadium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	100 mg/kg dry wt	1-2
Chloride*	Ion Chromatography determination of es potassium phosphate extraction.	3 mg/kg dry wt	1-2
Total Nitrogen*	Catalytic Combustion, separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-2

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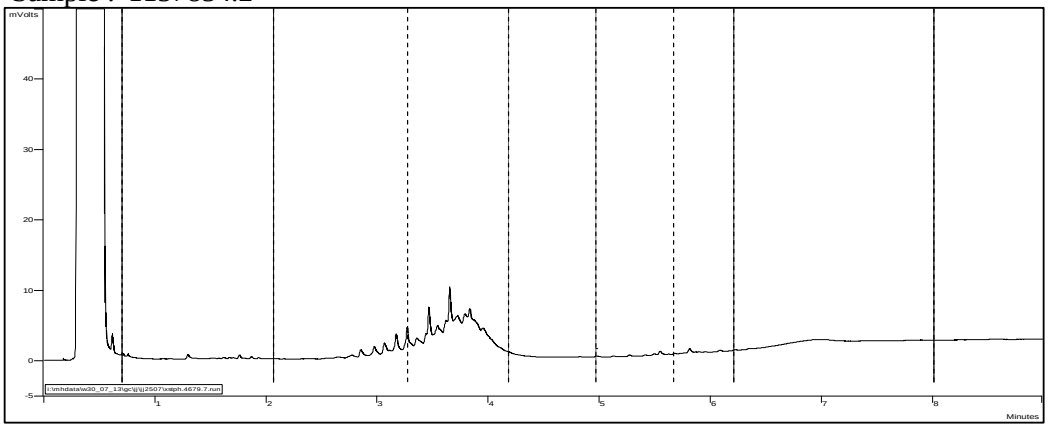
Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental Division

Sample : 1157854.2



C7 C10 C15 C20 C25 C30 C34 C44

Appendix IV

AgKnowledge Landfarm review report

The Taranaki Landfarms

are they

"Fit for Purpose"

A report

Commissioned by Taranaki Regional Council

Undertaken by

Dr D C Edmeades
agKnowledge Ltd
PO Box 9147, Hamilton, 3240.

September 2013

EXECUTIVE SUMMARY

1. Waste products (rock cuttings and drilling muds) from the oil exploration industry in Taranaki are being incorporated into re-contoured formed sand dunes and re-sown back to pasture (a process referred to as Landfarming). This process is controlled by resource consents issued by the Taranaki Regional Council. Three Landfarms have been completed to date and are now being farmed commercially (2 under irrigation).

2. The drilling muds contain potential contaminants: petrochemical residues, barium, heavy metals and salts. The question arises: are these reformed soils 'fit-for-purpose' - in this case pastoral farming and especially dairy farming.

3. As required by the consents regular soil samples were collected and analysed during the disposal process. These results were summarised and examined relative to the permitted limits for the various potential contaminants.

4. The completed sites were visited and the pasture and soils inspected. Soil and pasture samples were collected and analysed for all potential contaminants. These results were compared to the properties of normal New Zealand pastorals soils.

5. It is concluded from this body of evidence that these modified soils are 'fit –for-purpose". The concentrations of: nutrients (macro and micro), heavy metals and soluble salts in these soils and pasture are similar to normal New Zealand soils. The form of barium present is as environmentally benign barite, and there is no evidence of accumulation of petrochemical residues.

6. The process of Landfarming these otherwise very poor soils, together with appropriate management (irrigation, fertiliser and improved pastures) has increased the agronomic value of the land from about $3-5000/ha to $30-40,000/ha.

BRIEF

1. The Taranaki Regional Council (TRC) has consented several oil exploration companies to dispose of 'drilling muds' at several sites on coastal sands around the region.

2. The drilling muds are initially stored at the sites and, after the sand dunes have been levelled, this material is applied to the surface (at < 100mm thick) and then incorporated into the re-contoured sandy soils (at a minimum depth of 250mm depth). Once this process is completed the modified soils are fertilised (not more the 200 kg N/ha) and sown down to clover–based pasture. This whole process is controlled by criteria set out in resource consents.

3. Three sites (referred to as landfarms) have been completed to date and are currently being used for pastoral farming. One site (Browns, commenced 2006, completed 2011) is not irrigated and runs dry stock. The other 2 sites (Schrider, commenced 2004, completed 2010, and Geary, commenced 2001, completed 2006) are under pivot irrigation and used for dairy farming. Note there is a small area at the Geary site, which is not irrigated.

4. The TRC has retained agKnowledge Ltd to determine whether these landfarms are "fit for purpose", in this case fit for pastoral farming and in particular dairying.

5. Specifically this brief excludes any consideration as to the off-site effects of the landfarms (possible movement of contaminants via runoff or leaching) and does not consider whether the compliance criteria set out in the consents were met or otherwise.

METHODOLOGY

6. Drilling muds consist of a) the cuttings (mainly solid) of the underlying strata of rocks from the drill bit b) drilling fluids (bentonite based mud and slurry including proprietary additives used to either lubricate the drilling process or to control the in-well pressure and conditions. This includes barium sulphate which is used as a wetting and weighting agent and c) drilling wastes (liquid) containing well water and petrochemical residues. There are 3 classes of drilling fluids: water-based, (WBM), oil based (OBM) and synthetic (SBM) (Taranaki Regional Council, undated, ref: PCDOCS\FRODO\98943\1).

7. Given the general composition of the drilling muds, this report investigates the following aspects of the completed landfarms:

    a. What is the current soil fertility of the modified soils with respect to growing clover-based pasture for ruminants and in particular dairy cows?

b. What are the heavy metal and barium concentrations in the soils and pastures and are there any implications for soil, pasture and animal health and production?
c. Are there any petrochemical residues in the soils and pasture, which may affect soil, plant and animal health?

8. Two sites, Geary and Schrider, were visited on July 4 2013 and soils samples (0-75mm – the standard depth for determining soil fertility) and mixed-pasture samples were collected for an initial investigation, using the standard sampling protocols.

9. The 3 completed landfarms were visited on 5 August 2013 and on this occasion two sets of soil (0-75mm) and mixed pasture samples were collected from the following sites: Schrider (irrigated), Geary (irrigated and non-irrigated) and Brown (non-irrigated). One set were sealed in clip-tight plastic bags for analysis of petroleum hydrocarbon (PCH) residues and the other set were used to determine the concentrations of the full suit of elements including the macro, micro and heavy metals plus barium.

10. The TRC provided the full records of the soil tests (0-250mm) undertaken as per the consents, during the process of disposal of the drilling muds, at each site. This data was summarized.

11. Throughout this the report the criteria for the safe disposal of heavy metals, barium and petroleum hydrocarbons (as set down by a number of authorities) are used as part (other matters are also considered) of the assessment process. In applying these criteria it is assumed that they have been set at levels to ensure the protection of soil, pasture, animal and human health.

RESULTS

Pasture Assessment

At the time of the second site visit (5 August 2013) the pastures were assessed as follows:

Table 1: Visual assessment of the pastures at the three sites.

Site	Assessment	Rating
Schrider (irrigated)	Ryegrass dominant pasture, vigorous. Very little clover some showing signs of potassium deficiency. Excreta patches obvious. Some flats weeds and poor pasture grasses.	6/10
Geary (irrigated)	Vigorous ryegrass pasture with about 20% clover. Excreta patches not apparent. Very few weeds.	8/10
Geary (non-irrigated)	Assorted weeds abundant, excreta patches prominent, Some low value browntop and Yorkshire fog. Ryegrass and clover only in excreta patches.	2/10
Brown (non-irrigated)	Assorted weeds abundant, excreta patches prominent, Ryegrass and clover only in excreta patches.	2/10

Importantly, there were abundant earthworm casts on all sites indicating considerable soil biological activity. The earthworm can be regarded as the 'canary in the mine' with respect to soil biological activity.

Soil Properties

The general properties of the modified soils (0-75mm, the standard depth for soil fertility assessment) are given in Table 2 and indicate low levels of cation exchange capacity (CEC), anion storage capacity (ASC), organic matter (OM) and organic nitrogen (ON), reflecting their sandy nature and past history (low quality pasture). The amounts of soluble salts (SS) and the exchangeable sodium percentage (referred to in the documentation incorrectly as the sodium absorption, SAR) are low and the soil calcium (Ca) and sodium (Na) levels are consistent with the normal levels found in pastoral soils.

Table 2: Soil chemical properties (0-75mm) at the three landfarms sites.

Site	CEC (me/100 gm)	ASC (%)	OM (%)	ON (%)	SS (%)	Ca (MAF units)	Na (MAF units)	SAR (%)
Schrider	9	11	2.6	0.13	0.01	7	7	1.1
Geary Irrigated	7	11	2.2	0.16	0.02	5	10	2.0
Geary Non irrigated	9	16	3.5	0.21	0.02	6	7	1.2
Brown	9	34	3.4	0.14	0.01	6	4	0.6
Typical	*10-30*	*20-80*	*5-20*	*0.1-0.4*	*0.05-0.30*	*5-20*	*3-10*	*1-2*

As required by the consent agreements, routine soil testing (0-250mm) was undertaken on all three sites during the process of disposal of the drilling muds. The results for each site are summarized in Tables 3 a,b,c:

Table 3a. Chemical characteristics of the soil (0-250mm) at the Schrider site during disposal.

Soil Property	No. samples	Average	Max	Min	Limit[1] & units	No. over limit
Conductivity (disposal)	51	32 <0.02	0.13	<0.02	400 mS/m	0
Conductivity (expiry)	53	44 < 0.02	1.3	<0.02	290 mS/m	0
Soluble salts	53	43 <0.05	0.46	<0.05	0.25 %	2
SAR	47	1.1	3.1	0.3	18	0
Sodium	31	482	790	310	460 g/m3	14
Chloride	50	145	1360	4	700g/m3	3

Note 1) Taranaki Regional Council, undated, ref: PCDOCS\FRODO\98943\1.

Table 3b. Chemical characteristics of the soil (0-250mm) at the Geary site during disposal.

Soil Property	No. samples	Average	Max	Min	Limit[1]& units	No. over limit
Conductivity (disposal)	33	30 <0.02	0.37	<0.02	400 mS/m	0
Conductivity (expiry)	33	29 <0.02	0.37	<0.02	290 mS/m	0
Soluble salts	33	32 <0.05	0.13	<0.05	0.25 %	0
SAR	38	1.0	3.7	0.1	18	0

Sodium	13	481	600	310	460 g/m3	7
Chloride	36	28	356	4	700 g/m3	0

Note 1) Taranaki Regional Council, undated, ref: PCDOCS\FRODO\98943\1.

Table 3c. Chemical characteristics of the soil (0-250mm) at the Brown site during disposal.

Soil Property	No. samples	Average	Max	Min	Limit[1]& units	No. over limit
Conductivity (disposal)		No given			400 mS/m	0
Conductivity (expiry)		No given			290 mS/m	0
Soluble salts	5	all < 0.05	<0.05	-	0.25 %	0
SAR	17	2.4	18	0.3	18	0
Sodium	17	80	530	7	460 g/m3	7?
Chloride	31	98	550	5.9	700 g/m3	0

Note 1) Taranaki Regional Council, undated, ref: PCDOCS\FRODO\98943\1.

The soil property which most frequently exceeded the limit was the soil Na concentrations. The limit of 460 gm/m^3 soil, is (assuming a soil bulk density of about 1) equivalent to a MAF soil Na reading of about 20. Thus, while some elevated soil Na levels were recorded during the disposal process the current levels (0-75 mm) are normal (Table 2). This is also apparent in the SAR levels. The likely reason for this is that Na (and the same applies to chloride) are very mobile and will readily leach out of soils, especially sandy soils with a good rainfall and under irrigation, noting that in the New Zealand situation Na and Cl are environmentally benign.

In any case note that the problems that occur when soil Na levels are elevated (loss of soil structure and impeded drainage together with plant sensitivity to salinity) normally arise on heavy soils in arid climates. Furthermore, higher than normal soil Na levels and hence better than normal pasture Na concentration (see later) can only be beneficial to animal health in the New Zealand setting.

Soil Fertility

Soils

The soil tests (Table 4) indicate that, in terms of optimizing production from clover-based pastures, the sites are deficient with respect to potassium (K) and sulphur (S). The site with the best overall soil fertility is 'Geary irrigated' and this is reflected in the superior pasture on this site (Table 1). The poor pasture on the 2 non-irrigated sites (Brown, Geary non-irrigated) can be explained by the lack of irrigation resulting in moisture stress together with the poor underlying soil fertility.

Table 4: Soil nutrient levels (0-75mm) at the three landfarms sites (units are as used in the standard MAF soil testing protocol)

Site	pH	Olsen P	K	Sulphate S	Organic S	Mg
Schrider	6.0	24	2	4	3	23
Geary Irrigated	6.3	28	5	12	3	37
Geary Non irrigated	6.2	38	7	6	3	22

Brown	6.6	22	2	8	4	13
Optimal[1]	*5.8-6.0*	*35-40*	*7-10*	*10-12*	*10-12*	*8-10*

Notes 1) assuming a high producing dairy farm

Pasture

The concentrations of macro (Table 5a) and micro (Table 5b) nutrients in the mixed-pasture samples from the 4 sites are given below. Mixed-pasture analysis provides information relating to the nutrient value of the pastures for, in this case, ruminants.

Table 5a: Macronutrient concentrations (%) in mixed-pasture from the three sites for samples collected 5 August 2013 (Figures in parenthesis are from samples collected 4 July 2013).

Site	**Pasture macronutrient concentration (%)**						
	N	**P**	**K**	**S**	**Mg**	**Ca**	**Na**
Schrider	4.43 (2.66)	0.44 (0.43)	2.51 (1.69	0.37 (0.40)	0.29 (0.38)	0.57 (0.64)	0.79 (1.11)
Geary Irrigated	4.44	0.47	3.59	0.40	0.33	0.38	0.55
Geary non-irrigated	3.92 (4.11)	0.46 (0.45)	3.62 (2.73)	0.37 (0.41)	0.30 (0.31)	0.39 (0.39)	0.54 (0.45)
Brown	4.15	0.40	3.51	0.36	0.24	0.64	0.47
Typical	*4.5-5.5*	*0.30-0.40*	*2.0-4.00*	*0.25-0.35*	*0.15-0.22*	*0.25-0.50*	*0.1-0.3*

Table 5b: Micronutrient concentrations (ppm) in mixed-pasture from the three sites for samples collected 5 August 2013 (Figures in parenthesis are from samples collected 4 July 2013).

Site	**Pasture micronutrient concentrations (ppm)**							
	Mn	**Zn**	**Cu**	**Fe**	**Co**	**Mo**	**Se**	**B**
Schrider	54 (58)	31 (33)	6.4 (6.3)	230 (818)	0.16 (0.27)	0.34 (<0.05)	0.31 (0.48)	6.0 (7.3
Geary Irrigated	86	32	7.6	2057	0.87	0.59	0.14	9.7
Geary non-irrigated	79 (84)	28 (34)	9.2 (10.9)	1124 (930)	0.46 (0.23)	0.46 (0.41)	0.02 (0.02)	7.7 (7.5)
Brown	65	31	9.3	351	0.18	2.38	<0.01	6.9
Typical	*20-50*	*10-20*	*5-10*	*45-65*	*0.04-0.10*	*0.1-1.0*	*>0.03*	*13-16*

These results indicate that the nutrient levels in the pastures from these landfarm sites are typical of New Zealand pastures except that:

a) The pasture sodium (Na) levels are elevated due to enrichment from the soils either from sea sprays or from the drilling muds. Either way this is of no consequence and can only be a benefit to animal health.
b) The manganese (Mn) and zinc (Zn) levels appear to the greater than normal but are nevertheless not sufficiently high to give rise to animal health problems.
c) The iron (Fe) levels are elevated. This is most likely due to contamination from the soil as frequently occurs on 'normal' soils and in any case is of little practical consequence.
d) The cobalt (Co) and molybdenum (Mo) are above the minimum levels for optimal health.

e) The selenium (Se) levels on 2 sites are below the minimum level for optimal animal production as is frequently the case for many New Zealand soils. This can be readily corrected with fertiliser Se.

The combined soil and pasture results suggest that there is nothing unusual about the soils and pastures at these landfarms, relative to normal conditions, which occur routinely throughout New Zealand. Furthermore, they indicate that providing the soil fertility is optimised and there is little moisture stress (i.e. they are irrigated), high quality productive and healthy clover-based pastures can be grown on these landfarms.

If the constraints (soil fertility and moisture) were removed it should be possible to grow at least 15 tonnes DM/ha annually, and assuming they are used for dairying, would put the value of the landfarms at about $30-40,000/ha. In their natural state (i.e. before land farming) they were growing low-quality feed and used for dry-stock farming only. There original value would be about $3-4000/ha.

Heavy Metals

Soil (Routine Sampling 0-250mm)

The results from the monitoring of the soils (0-250mm) during the process of disposal of the drilling muds, as required under the consents, are summarized for each site in Table 6 a, b, c:

In all cases the heavy metal concentrations were well below the guideline limits set by the Ministry for the Environment (2003) for the disposal of biosolids.

Table 6a: Summary of heavy metal concentrations (ppm) in the soil (0-250mm) at the Schrider site.

Element	No. samples	Average	Max.	Min.	Limit[1]
As	47	46 < 2[2]	4	< 2	20
Cd	47	all < 0.10[2]	< 0.10	-	1
Cr	50	15	23	8	600
Cu	50	13	25	9	100
Pb	50	3	23	1	300
Ni	50	8	11	5	60
Zn	50	71	100	33	300
Hg	41	all < 0.01[2]	< 0.10	-	1

Note 1) from the Ministry for the Environment 2003
2) for some elements and on some occasions the results were reported at being less than a given limit. It is not realistic in such cases to give an arithmetic mean and hence some indication of the distribution of the results is recorded.

Table 6b: Summary of heavy metal concentrations (ppm) in the soil (0-250mm) at the Geary site.

Element	No. samples	Average	Max.	Min.	Limit[1]
As	33	all < 2[2]	<2	-	20
Cd	33	all < 0.1[2]	<0.10	-	1
Cr	33	15	20	8	600
Cu	33	17	32	7	100
Pb	33	14	48	1	300
Ni	33	7	11	5	60
Zn	33	72	113	33	300
Hg	33	all < 0.1[2]	<0.10	-	1

Note 1) from the Ministry for the Environment 2003
2) for some elements and on some occasions the results were reported at being less than a given limit. It is not realistic in such cases to give an arithmetic mean and hence some indication of the distribution of the results is recorded.

Table 6c: Summary of heavy metal concentrations (ppm) in the soil (0-250mm) at the Brown site.

Element	No. samples	Average	Max.	Min.	Limit[1]
As	24	17 < 2[2]	5	< 2	20
Cd	24	22 < 0.10[2]	0.27	< 0.10	1
Cr	24	11	19	7	600
Cu	24	21	41	15	100
Pb	24	3	8	1	300
Ni	24	6	10	4	60
Zn	24	74	120	49	300
Hg	24	all < 0.01[2]	<0.10	-	1

Note 1) from the Ministry for the Environment 2003
2) for some elements and on some occasions the results were reported at being less than a given limit. It is not realistic in such cases to give an arithmetic mean and hence some indication of the distribution of the results is recorded.

The heavy metal concentrations in the soils (0-250mm), as measured during the process of disposal, were all much less than the set limits, at all three sites.

Soil (normal pastoral soil levels)

The heavy metal concentrations in soils (0-100mm) from surveys conducted from various regions of New Zealand under pasture and non-farmed land uses are summarized in Appendix 1. The Table below (Table 7) compares these typical concentrations (0-100mm) with those found at the three landfarm sites (0-75mm).

Table 7: Comparison of the heavy metal concentrations (ppm) in typical New Zealand pastoral and non-farmed soils (0-100mm) and in the soils (0-75mm) at the three sites; Schrider, Geary and Brown.

Element	Range in mean/median values in NZ farmed or (non-farmed) soils)[1]	Site					
		Schrider		Geary			Brown[2]
				Sample 1[2]	Sample 2[2]		
		Sample 1[2]	Sample 2[2]	Non-irrigated	Non irrigated	Irrigated	Sample 1
Arsenic (As)	3-9 (3-5)	<2	<2	<2	<2	<2	2
Cadmium (Cd)	0.1-0.8 (0.1-0.14)	<0.1	0.11	<0.1	<0.1	<0.1	<0.1
Chromium (Cr)	8-18 (12-18)	nd	11	nd	11	11	8
Copper (Cu)	10-20 (10-16)	nd	11	nd	20	13	21
Lead (Pb)	6-16 (9-16)	1.6	1.8	3.2	3	1.4	3.6
Nickel (Ni)	4-14 (4-14)	nd	5	nd	5	5	4
Zinc (Zn)	7-79 (28-66)	nd	55	nd	53	57	57
Mercury (Hg)	0.07-0.20 (0.11-0.19)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Notes 1) from Appendix 1.
2) samples 1 collected 4 July 2013, samples 2 collected 8 August 2013.

The samples collected on the three landfarms (Schrider, Geary and Brown), were from the depth 0-75mm (the normal depth for testing soil nutrients). The range in the median and mean above, from the surveys, are for soils to a depth of 0-100mm. Data from Waikato survey (Waikato Regional Council 2011) shows that top-soils (0-100mm) are enriched relative to the sub-soils (100-200mm) for Cd, Cr, Cu, Ni but not for the other heavy metals. Thus, the results above for the landfarms (0-75mm) are likely to be elevated to some extend relative to the typical ranges given in Table 7.

These results indicate that the soil heavy metal concentrations are at the low end of the ranges for both farmed (dairying) and non-farmed soils (referred to in the respective reports as either native, indigenous and background).

Pasture (normal levels)

The available information on the heavy metal concentrations in pastures in New Zealand is summarized in Appendix 2.

Table 8: Heavy metal concentrations (ppm) in mixed-pasture from the three sites for samples collected 5 August 2013 (Figures in parenthesis are from samples collected 4 July 2013).

Site	Pasture heavy metal and barium concentrations (ppm)						
	As	**Cd**	**Hg**	**Pb**	**Cr**	**Ni**	**Ba**
Schrider	<0.1 (<0.1)	0.022 (0.033)	0.013 (0.028)	0.039 (0.079)	0.460 (<0.1)	<1 (<1)	42 (33)
Geary Irrigated	<0.1	0.011	<0.01	0.072	0.750	<1	74
Geary non-irrigated	<0.1 (<0.10)	0.025 (0.027)	0.011 (0.029)	0.102 (0.112)	0.600 (0.160)	<1 (<1)	>100 (97)
Brown	<0.1	0.073	0.011	0.104	0.520	<1	71
***Typical*[1]**	*0.07-0.24*	*0.03-0.29*	*na*	*0.10-1.8*	*0.31-0.49*	*0.10-0.20*	*na*

Note 1) see Appendix 2

Consistent with the soil data, these results indicate that there is nothing unusual about the heavy metal concentrations in the pastures from these landfarms relative to normal levels reported for New Zealand pastures.

Barium

Barium sulphate (Barite) is used during the drilling process (Alberta Environment 2009), as noted. This chemical form of barium is practically insoluble and therefore environmentally benign, unlike other barium salts (e.g. barium chloride and nitrate) (Menzies et al 2008). There are currently no guidelines in New Zealand for the disposal of biosolids containing barite. The Canadian Authorities (Alberta Environment 2009) have set remediation guidelines for agricultural land at 10,000 ppm (Barite containing sites) and 750 ppm (non-barite sites).

Table 9 summarizes the soil barium (Ba) data (0-250mm) collected during the disposal phase for the three sites.

Table 9: Total barium (Ba) concentrations (ppm) in the soils (0-250mm) at the three sites during the disposal phase.

Site	No. samples	Average	Max	Min	Limit[1]	No. over limit
Schrider	54	528	5500	17	750 ppm	6
Geary	39	1265	5400	90	750 ppm	11
Brown	15	1860	3200	40	750 ppm	13

Note 1) Taranaki Regional Council, undated, ref: PCDOCS\FRODO\98943\1.

This data suggests that the Ba limit (assuming a non-barite source of Ba) was exceeded at some times, however none of the sites reached levels of 10,000 ppm the guideline for barite sites.

The Alberta Environment (2009) guidelines specify a simple procedure to determine whether barite is present at a specific site. If the extractable Ba (in 0.1M Calcium chloride at a 1:10 ratio) exceeds 250 ppm then it is assumed it is a non-barite site. The results below show that the extractable Ba levels are well below the 250-ppm limit leading to the conclusion that the only source of Ba at these sites is the environmentally benign barite form.

Table 10. The concentrations of extractable and total barium (Ba) in soils and in pastures at the 3 landfarm sites

Site	Extractable Ba (ppm)	Total Ba (ppm)	Pasture Ba (ppm)
Schrider	24	7800	42 (33)
Geary (irrigated)	36	760	74
Geary (non-irrigated)	46	2400	>100 (97)
Brown	31	930	71

This being so, the limit for safe disposal (viz. < 10,000 ppm) applies and this was never exceeded during the disposal process. This is consistent with the measured Ba concentrations in the pastures (Table 8) which indicate levels in the ppm range and not in the percent (%) range as might be expected for a divalent cation such as calcium (Ca) or magnesium (Mg) (c.f. table 5a and 8). This is consistent with the view that barite is not considered bioavailable (Alberta Environment 2009).

Petroleum Hydrocarbons

Soils

The guidelines for the management of petrochemical hydrocarbons (PHC) (Ministry for the Environment 2011) require the monitoring of 3 representative types of PHCs:

a) TPH (Total Petroleum Hydrocarbons) in three classes: C7-C9, C10-C14 and C15-36.
b) BTEX: which includes benzene, toluene, ethyl-benzene and xylene.
c) PAH (Polycyclic aromatic hydrocarbons).

Levels of each PHC are set for screening purposes, meaning that if these levels are exceeded, further investigation is recommended.

The measured concentrations of these classes of PHC in the soil (0-250mm) collected during the disposal process for each site are given in tables 11a,b,c below:

Table 11a. Concentrations of various petroleum hydrocarbons (PHC) in the soils (0-250mm) at the Schrider site.

PHC		No. samples	Average	Max.	Min	Limit[1]	No. over limit
TPH	C7-C9	55	50< 8	12	<8	120	0
	C10-C14	55	44< 20	5020	<10	58	3
	C15-C36	55	21<30	19000	<30	4000	4
BTEX	Benzene	43	13<0.05	0.26	<0.03	1.1	0
	Toluene	43	35<0.06	3.23	<0.03	68	0
	Ethylbenzene	43	35<0.05	1.93	<0.03	53	0
	o-xylene	43	23<0.05	4.68	<0.03	48	0
	m&p-xylene	43	31<0.09	13	<0.05	48	0
PAH	Benzo[a]pyrene	37	12<0.02	0.07	<0.02	0.027	1
	Napthelene	37	13<0.10	7.1	<0.10	7.2	0
	Pyrene	37	30<0.09	0.72	<0.02	160	0

Note 1) screening limit set by Ministry for the Environment 2011

Table 11b. Concentrations of various petroleum hydrocarbons (PHC) in the soils (0-250mm) at the Geary site.

PHC		No. samples	Average	Max.	Min	Limit[1]	No. over limit
TPH	C7-C9	32	all<8	<8	-	120	0
	C10-C14	32	29<20	49	<10	58	0
	C15-C36	32	17<30	1400	<30	4000	0
BTEX	Benzene	28	25<0.05	0.20	<0.05	1.1	0
	Toluene	28	25<0.06	0.20	<0.05	68	0
	Ethylbenzene	28	25<0.05	0.20	<0.05	53	0
	o-xylene	28	21<0.05	0.13	<0.02	48	0
	m&p-xylene	28	25<0.09	<0.20	<0.05	48	0
PAH	Benzo[a]pyrene	19	16<0.02	0.40	<0.02	0.027	1
	Napthelene	19	18<0.10	0.12	<0.02	7.2	1
	Pyrene	19	18<0.09	0.19	<0.02	160	0

Note 1) screening limit set by Ministry for the Environment 2011

Table 11c. Concentrations of various petroleum hydrocarbons (PHC) in the soils (0-250mm) at the Brown site.

PHC		No. samples	Average	Max.	Min	Limit[1]	No. over limit
TPH	C7-C9	57	36<8	16	<8	120	0
	C10-C14	57	28<20	5500	<20	58	23
	C15-C36	57	5<30	13500	<30	4000	14
BTEX	Benzene	26	16<0.05	0.08	<0.05	1.1	0
	Toluene	26	16<0.06	0.08	<0.05	68	0
	Ethylbenzene	26	16<0.05	0.16	<0.05	53	0
	xylene	26	14<0.10	0.24	<0.10	48	0
PAH	Benzo[a]pyrene	26	8<0.025	0.028	<0.025	0.027	2
	Napthelene	26	8<0.12	0.30	<0.12	7.2	0
	Pyrene	26	23<0.09	0.28	<0.09	160	0

Note 1) screening limit set by Ministry for the Environment 2011

During the process of disposal there were some occasions when the limits, particularly of TPHs, and particularly on the Brown site, were exceeded. Despite this the BTEX and PAH screening limits were rarely exceeded.

Petrochemical hydrocarbons are biodegradable (Ministry for the Environment 2011) under aerobic soil conditions (as is the case on these sandy soils) and it is likely that the higher rate of exceedances on the Brown site is because this is the most recently completed site. It is anticipated that with time these levels will decline noting that the numerous earthworm casts at all sites indicated an active biomass. This is confirmed by the fact that the TPH concentrations (0-75mm) measured in August 2013 (Table 12) were below the levels of detection on all sites (Table 12).

Table 12: Concentrations of total petrochemical hydrocarbons (TPH) in the soils (0-75mm) at the three landfarm sites (samples collected 5 Aug 2013).

Site	Total Petrochemical Hydrocarbon[1] (TPH) (ppm)			
	C7-C9	C10-C14	C15-C36	Total (C7-C36)
Schrider	<8	<20	<40	<70
Geary Irrigated	<10	<20	<40	<70
Geary non-irrigated	<8	<20	<40	<70
Brown	<8	<20	<40	<70

Note 1) see Appendix 3 for the full results including BTEX and PAH.

The possibility that the TPH levels in these topsoils (0-75mm) underestimate the concentrations in the full profile (i.e. 0-250mm), either due to uneven placement of the drilling wastes in the profile, or their movement down the profile, can be set aside because of the method of disposal required under the consents (surface applied not more than 100mm and incorporated to a depth > 250 mm) and the fact that TPHs are not water soluble.

Pasture

The measured concentrations of these classes of PHCs in the pasture from each site are given in table 13 below:

Table 13: Concentrations of total petrochemical hydrocarbons (TPH) in the pastures at the three landfarm sites (samples collected 5 Aug 2013).

Site	Total Petrochemical Hydrocarbon[1] (TPH) (ppm)			
	C7-C9	C10-C14	C15-C36	Total (C7-C36)
Schrider	<8	<20	58	58
Geary Irrigated	<8	<20	86	86
Geary non-irrigated	<8	<20	71	71
Brown	<8	<20	81	81

1) see Appendix 3 for the full results including BTEX and PAH.

Once again the levels of C7-C9 and C10-C14 TPHs are below the detection limits, as for the soils, but there are higher order TPHs (C15-C36) in the pasture, which

are not present in the soil. The likely explanation for this is that plants manufacture waxes, which are represented in the C15-C36 group of TPH (*pers. comm*. Jo Cavanagh, Landcare Research Ltd)

The concentrations of individual PAHs in the pasture are given in Appendix 3 and for most, the levels are below the detection limit. Plants do not manufacture these compounds and hence any levels above the limit of detection are likely due to plant uptake. However the levels are so low that it is unlikely they would cause a problem in terms of pasture growth, animal health or food quality.

This is consistent with the results from monitoring the concentrations of these compounds in milk from these farms. None have been found (*pers. com*. Mr Andy Fowler, Fonterra, Hamilton).

CONCLUSIONS

Based on the available evidence it is concluded that the Taranaki 'Landfarms' are 'fit for purpose' in terms of pastoral farming and particular dairy farming. This conclusion is based on considering the concentrations of nutrients (both macro and micro), heavy metals, barium and petrochemical hydrocarbons residues in both the soils and pastures at 3 sites.

The re-contoured sand dunes, after the inclusion of the drilling wastes (as per the consents), and with the addition of appropriate fertilisers and water (irrigation) are capable of producing high quality clover-based pastures and thus increasing the value of the land from about $3-4000/ha to $30-40,000/ha.

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Appendix 1a: Heavy metal concentrations (ppm) in non-farmed soils (0-100mm).

Heavy metal	Source of data			
	Rural Auckland[1] (indigenous)	Waikato[2] (background)	Wellington[3] (native)	Range in mean/median values
Arsenic (As)	3.3	5.1 (1-25)	3 (<2-10)	3-5
Cadmium (Cd)	0.14	0.11 (0.03-0.30)	0.10 (<0.1-0.30)	0.10-0.14
Chromium (Cr)	12.5	18 (1-50)	12 (6-18)	12-18
Copper (Cu)	10.1	16 (4-55)	12 (6-22)	10-16
Lead (Pb)	15.8	11 (3-32)	9 (3-15)	9-16
Nickel (Ni)	4.8	3.9 (0.56-21)	14 (16-2-22)	4-14
Zinc (Zn)	40.2	28 (11-58)	66 (40-104)	28-66
Mercury (Hg)	0.11	0.19 (0.19-0.5)	ng	0.11-0.19

Notes 1) Concentrations of Selected Trace Elements for Various Land Uses and Soil Orders within Rural Auckland. Auckland Council Technical Report 2012/021

2) Soil Quality and Trace Element Monitoring in the Waikato Region. Waikato Regional Council Technical Report 2011/13

3) Soil quality and stability in the Wellington Region. State and Trends. Great Wellington Regional Council. 2012

Appendix 1b: Heavy metal concentrations (ppm) in dairy or farmed soils (0-100mm).

Heavy metal	Source of data					
	Auckland (dairying) [1]	Bay of Plenty (dairying) [2]	Waikato[3] (farmed)	Wellington[4] (dairying)	Malborough [6] (dairying)	Range in mean/ median values
Arsenic (As)	3.3	4.9 (SE 1.2)	8.6 (0.70-94)	4 (<2-30)	5.1	3-9
Cadmium (Cd)	0.59	0.75 (SE 0.09)	0.71 (0.10-2.0)	0.5 (0.23-1.3)	0.42	0.1-0.8
Chromium (Cr)	13.1	7.6 (SE 0.8)	14 (1-220)	17 (9.8 – 50)	27	8-18
Copper (Cu)	16	16.1 (SE 3.7)	24 (3-250)	13 (6.8-35)	20	10-20
Lead (Pb)	14.7	5.6 (SE 0.6)	16 (3-95)	16 (7.3-32)	15	6-16
Nickel (Ni)	5.5	6.1 (SE 1.0)	6 (1-34)	12 (4-24)	13	4-14
Zinc (Zn)	43.1	72 (SE 17.8)	62 (1-258)	79 (33-120)	81	7-79
Mercury (Hg)	0.2	0.07 (SE 0.01)	0.16 (0.03-0.5)	ng	ng	0.07-0.20

Appendix 2: Heavy metal concentrations (ppm) in pasture reported in the literature and the Maximum Permissible Levels (MPL) in complete rations.

Heavy metal	**Longhurst[1]**	**Quin[2]**	**Typical**	**MPL[3]**
As	0.07-0.24	ng[4]	0.07-0.24	2
Cd	0.03-0.29	0.05 – 0.08	0.03-0.29	1
Cr	ng	0.34-0.46	0.31-0.49	ng
Cu	9-14	5.4-11.7	5.4-14	ng
Pb	0.10-0.35	0.76-1.80	0.10-1.8	5
Ni	ng	< 0.10-0.20	0.10-0.20	ng
Zn	6.5-40	22-37	6.5-37	ng
Hg	ng	ng	ng	0.10

Notes
1) Longhurst et. al. 2004. Range in mean concentrations across soil groups and plant species
2) Quin and Syers 1978. Range in values for control treatment
3) Maximum permitted levels in complete rations for ruminants (Suttle N. F. 2010)
4) ng = not given

Appendix 3: Laboratory results showing the concentrations of all petrochemical hydrocarbons in 4 soils samples and 4 pasture samples.

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ANALYSIS REPORT

Client:	Eurofins NZ Laboratory Services Ltd	**Lab No:**	1168389	SPv2
Contact:	S Stiles-Jones	**Date Registered:**	17-Aug-2013	
	C/- Eurofins NZ Laboratory Services Ltd	**Date Reported:**	29-Aug-2013	
	PO Box 281	**Quote No:**	56330	
	HAMILTON 3240	**Order No:**	168833HM	
		Client Reference:	3256047	
		Submitted By:	S Stiles-Jones	

Amended Report

This report replaces an earlier report issued on the 26 Aug 2013 at 1:33 pm
Sample IDs have been amended at the client's request.

Sample Type: Soil

		Sample Name:	13508240 (Brown) 09-Aug-2013	13508241 (Geary Unirrig) 09-Aug-2013	13508242 (Geary irrig) 09-Aug-2013	13508243 (Schrider) 09-Aug-2013	
		Lab Number:	1168389.1	1168389.2	1168389.3	1168389.4	
Individual Tests							
Dry Matter	g/100g as rcvd		80	84	75	84	-
BTEX in Soil by Headspace GC-MS							
Benzene	mg/kg dry wt		< 0.05	< 0.05	< 0.06	< 0.05	-
Toluene	mg/kg dry wt		< 0.05	< 0.05	< 0.06	< 0.05	-
Ethylbenzene	mg/kg dry wt		< 0.05	< 0.05	< 0.06	< 0.05	-
m&p-Xylene	mg/kg dry wt		< 0.10	< 0.10	< 0.12	< 0.10	-
o-Xylene	mg/kg dry wt		< 0.05	< 0.05	< 0.06	< 0.05	-
Polycyclic Aromatic Hydrocarbons Screening in Soil							
Acenaphthene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Acenaphthylene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Anthracene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Benzo[a]anthracene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Benzo[a]pyrene (BAP)	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Benzo[g,h,i]perylene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Benzo[k]fluoranthene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Chrysene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Dibenzo[a,h]anthracene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Fluoranthene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Fluorene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Naphthalene	mg/kg dry wt		< 0.14	< 0.14	< 0.16	< 0.13	-
Phenanthrene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Pyrene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Total Petroleum Hydrocarbons in Soil							
C7 - C9	mg/kg dry wt		< 8	< 8	< 10	< 8	-
C10 - C14	mg/kg dry wt		< 20	< 20	< 20	< 20	-
C15 - C36	mg/kg dry wt		< 40	< 40	< 40	< 40	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt		< 70	< 70	< 70	< 70	-

823 365 laboratory

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil			
Test	**Method Description**	**Default Detection Limit**	**Samples**
TPH + PAH + BTEX profile	Sonication extraction, SPE cleanup, GC & GC-MS analysis	-	1-4
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-4

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

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ANALYSIS REPORT

Client:	Eurofins NZ Laboratory Services Ltd	**Lab No:**	1165426	SPv1
Contact:	K Rhodes	**Date Registered:**	09-Aug-2013	
	C/- Eurofins NZ Laboratory Services Ltd	**Date Reported:**	23-Aug-2013	
	PO Box 281	**Quote No:**		
	HAMILTON 3240	**Order No:**	168833HM	
		Client Reference:	9640618	
		Submitted By:	K Rhodes	

Sample Type: Plant Material

Sample Name:		13P02588	13P02589	13P02590	13P02591	
Lab Number:		1165426.1	1165426.2	1165426.3	1165426.4	
Polycyclic Aromatic Hydrocarbons in Biomatter						
Acenaphthene	mg/kg	0.0009	0.0007	0.0006	0.0010	-
Acenaphthylene	mg/kg	< 0.0005	< 0.0005	< 0.0005	0.0006	-
Anthracene	mg/kg	0.0009	0.0023	0.0005	0.0014	-
Benzo[a]anthracene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Benzo[a]pyrene (BAP)	mg/kg	0.0003	< 0.0002	0.0003	< 0.0002	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg	0.0004	0.0003	0.0003	0.0002	-
Benzo[g,h,i]perylene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Benzo[k]fluoranthene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Chrysene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Dibenzo[a,h]anthracene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Fluoranthene	mg/kg	0.0008	0.0004	0.0004	0.0004	-
Fluorene	mg/kg	0.0014	0.0013	0.0010	0.0015	-
Indeno(1,2,3-c,d)pyrene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Naphthalene	mg/kg	0.006	0.007	0.005	0.011	-
Phenanthrene	mg/kg	0.0028	0.0021	0.0016	0.0018	-
Pyrene	mg/kg	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-
Total Petroleum Hydrocarbons in Biota						
C7 - C9	mg/kg as rcvd	< 8	< 8	< 8	< 8	-
C10 - C14	mg/kg as rcvd	< 20	< 20	< 20	< 20	-
C15 - C36	mg/kg as rcvd	81	71	86	58	-
Total hydrocarbons (C7 - C36)	mg/kg as rcvd	81	71	86	< 60	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.2 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Plant Material

Test	Method Description	Default Detection Limit	Samples
Homogenisation of Biological samples for Organics Tests	Mincing, chopping, or blending of sample to form homogenous sample fraction.	-	1-4
Polycyclic Aromatic Hydrocarbons in Biomatter		-	1-4
Total Petroleum Hydrocarbons in Biota	Sonication extraction, Alumina cleanup, GC-FID analysis	-	1-4

Sample Type: Plant Material			
Test	**Method Description**	**Default Detection Limit**	**Samples**
TPH in Biota extraction by Sonication (Instrument Vial)	Sonication extraction, Silica cleanup, GC-FID analysis.	-	1-4
TPH in Biota extraction by Sonication (Storage Vial)	Sonication extraction, Silica cleanup, GC-FID analysis.	-	1-4

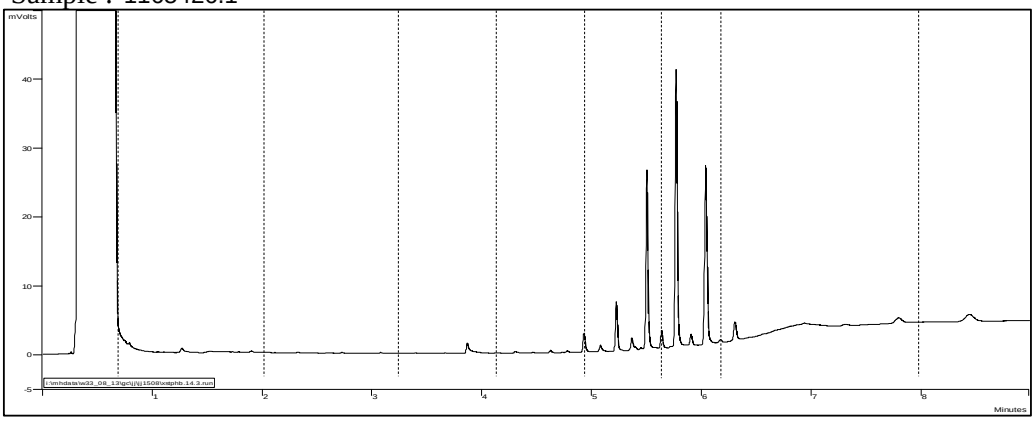
These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

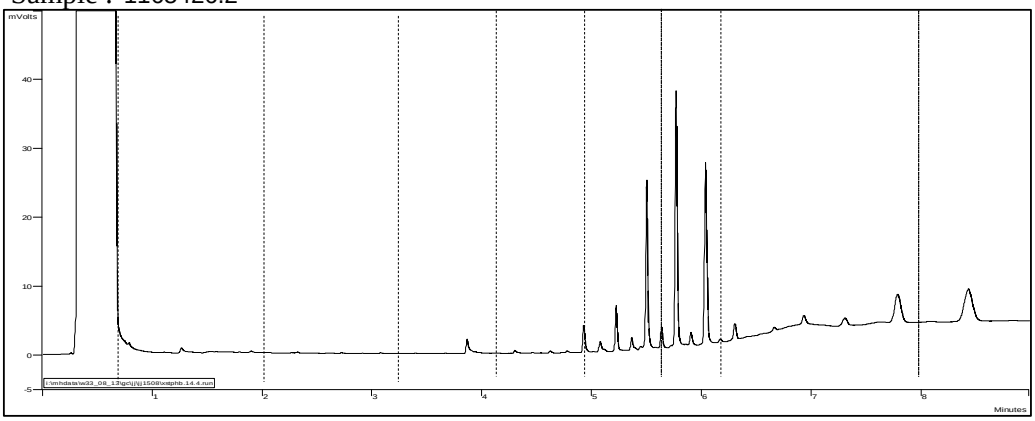
This report must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

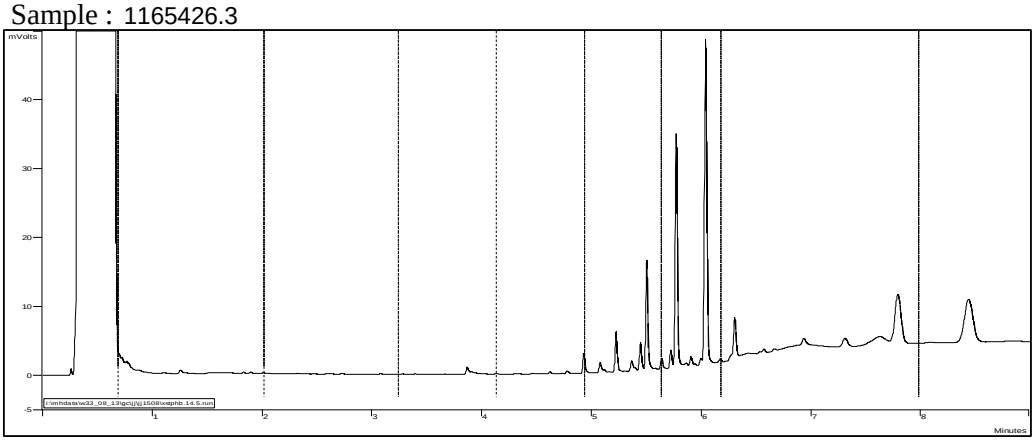
Sample : 1165426.1



Sample : 1165426.2

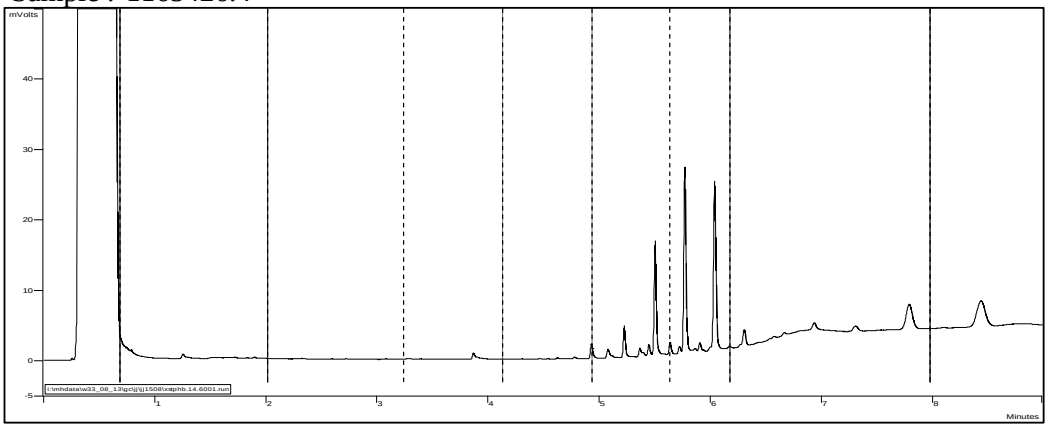


Sample : 1165426.3



C7 C10 C15 C20 C25 C30 C34 C44

Sample : 1165426.4



C7 C10 C15 C20 C25 C30 C34 C44

Appendix V

Marine ecological surveys

Internal Memorandum

To	Environmental Monitoring Manager, Keith Brodie
From	Scientific Officer, Emily Roberts
File	1209956
Date	14 June 2013

BTW Wellington Land Farm – Marine Ecological Survey September-October 2012

1.0 Introduction

A marine ecological survey was carried out at four sites as part of the 2012-2013 monitoring programme for the BTW Wellington Land Farm. The survey was carried out at three potential impact sites in the vicinity of the land farm, and one control sites between 19 September and 30 October 2012. The objective of the survey was to determine any change in species abundance and community structure attributable to the presence of the BTW Wellington Land Farm.

2.0 Methods

2.1 Field Work

The survey was conducted at four sites. The potential impact sites were: Orapa B (SEA 901043), Turanga Reef (SEA 901052), and 500m E of the Brixton Outfall (SEA 901055). The control site was at Turangi Reef (SEA 900095).

At each site, a 50 m transect was laid parallel to the shore. This transect was used to establish five 5 m x 3 m blocks. Within each block, 5 random 0.25 m^2 quadrats were laid giving a total of 25 random quadrats. For each quadrat the percentage cover of algal and encrusting animal species was estimated using a grid. For all other animal species, individuals larger than 3 mm were counted. Under boulder biota was counted where rocks and cobbles were easily overturned.

2.2 Data Analysis

For the data collected during the spring 2012 survey the following analyses was undertaken: The mean number of species per quadrat and Shannon-Weiner diversity indices per quadrat were calculated at each site. Assumptions of normality were tested using the Lilliefors test. One-way analysis of variance (ANOVA) was used to determine any significant differences between means. The Tukey's multiple comparison test was used to determine which means were significantly different from one another.

3.0 Results

The mean number of species per quadrat and the mean Shannon-Weiner diversity index per quadrat are presented in Table 1. 500m E (potential impact) had the highest number of species, followed by Turanga (potential impact) and Turangi (control). Orapa B (potential impact) had the lowest number of species. 500m E had the highest diversity, followed by Turanga, Turangi and Orapa B respectively.

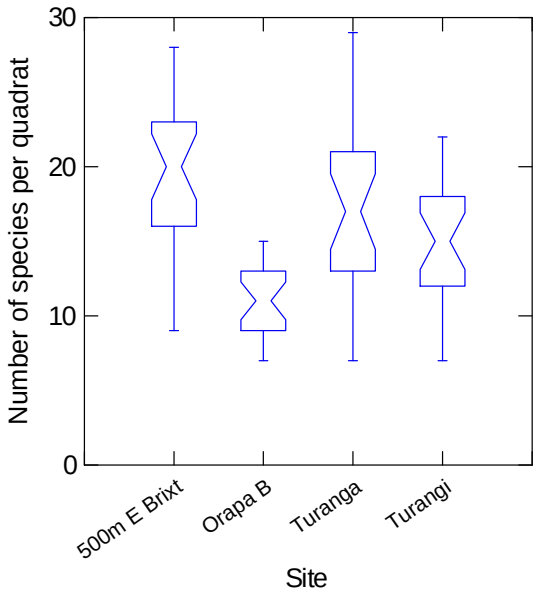
Table 1 Mean results for the summer 2012 survey. The Shannon-Weiner diversity index ($H^{|}$) incorporates the abundance of individual species in addition to the number of species present, providing a measure of diversity.

Site	No. of Quadrats	Mean number of species per quadrat			Mean Shannon Weiner Index per quadrat		
		Algae	Animals	Total Species (Algae & Animals)	Algae	Animals	Total Species (Algae & Animals)
Turangi Reef	25	4.20	10.97	15.16	0.47	0.70	0.83
Orapa B	25	4.28	6.80	11.08	0.50	0.62	0.77
Turanga Reef	25	5.76	11.64	17.40	0.56	0.86	1.00
500m E	25	5.96	13.72	19.68	0.59	0.91	1.06

3.1 Number of Species per Quadrat

Figure 1 shows the total number of species per quadrat at each site as a box and whisker plot. The notched area of the box represents the median plus and minus the 95% confidence interval. This form of graphical representation allows a quick comparison to be made between sites. Generally, if the notched areas of the boxes for the different sites do not overlap you would expect to obtain a significantly different result with ANOVA.

Figure 1 Box and whisker plot of total number of species per quadrat



For all sites, there was no significant deviation from normal distribution at the 95% confidence level (Lilliefors test, n = 25, P >0.05). There was a significant difference in species number per quadrat between sites (ANOVA, n = 25, F = 17.22, P <0.001).

Table 2 Tukey's multiple comparison test of total number of species per quadrat

Site	Turangi Reef	Orapa B	Turanga Reef
Orapa B	SIG		
Turanga Reef	NS	SIG	
500m E	SIG	SIG	NS

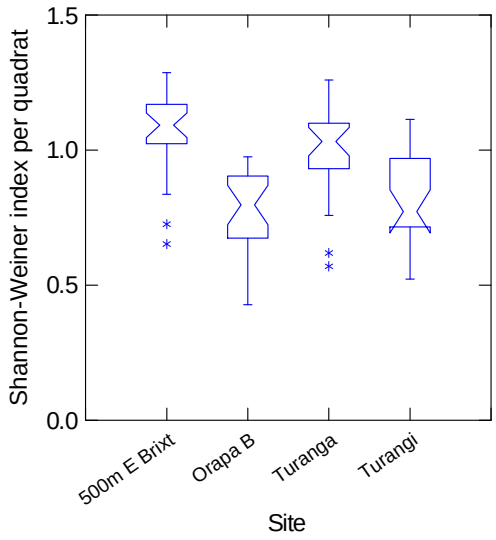
Key - SIG = significant difference at 95% confidence level
NS = no significant difference at 95% confidence level

Significant differences between sites were determined using Tukey's multiple comparison test (Table 2). At Orapa B the mean number of species per quadrat was significantly lower than at all other sites (P <0.05). The mean number of species per quadrat at 500m E was significantly higher than at both Turangi and Orapa B (P <0.05).

3.3 Shannon-Weiner Diversity Index

Figure 2 shows the Shannon-Weiner index per quadrat at each site as a box and whisker plot.

Figure 2 Box and whisker plots of mean Shannon-Weiner index per quadrat



500m E was the only site with a significant deviation from normal distribution at the 95% confidence level (Lilliefors test, n = 25, P = 0.047). There was a significant difference in the Shannon-Weiner index per quadrat between sites (ANOVA, n = 25, F = 17.66, P <0.001). Significant differences between sites were determined using Tukey's multiple comparison test (Table 3). At 500m E and Turanga, the mean Shannon-Weiner index per quadrat was significantly higher than at Orapa B and Turangi (P <0.05).

Table 3 Tukey's multiple comparison test of Shannon Weiner Index per quadrat

Site	Turangi Reef	Orapa B	Turanga Reef
Orapa B	NS		
Turanga Reef	SIG	SIG	
500m E	SIG	SIG	NS

Key - SIG = significant difference at 95% confidence level
NS = no significant difference at 95% confidence level

3.4 Sand Cover

The percent cover of sand was recorded (Table 4) because high sand levels can significantly impact marine communities.

Table 4 Mean percent cover of sand per quadrat

Site	% sand and silt per quadrat*
Turangi Reef	1
Orapa B	31
Turanga Reef	35
500m E	10

* *Sand coverage >30% can significantly impact marine communities.*

Both Turangi and 500m E had relatively low sand levels, which would not have adversely affected ecological diversity of the reefs. At Orapa B and Turanga, the mean sand cover per quadrat was 31% and 35% respectively. Although there appeared to be no noticeable effects of sand cover at Turanga, sand cover might have contributed to the significantly lower number of species recorded at Orapa B. At the Orapa B site, there was a high density of the colonial polychaete worm, *Neosabellaria kaiparaensis* (previously *Sabellaria kaiparaensis*). This species traps sand to build a worm case, preventing most other species from growing on either the substrate or the worm cases.

Photo 1 Polychaete worm *Neosabellaria kaiparaensis*

5.0 Discussion

The concept of ecological diversity consists of two basic components; *species richness* (the number of different species present in an ecological community) and the *relative abundance* of species. These two measures of ecological diversity are used in this report to assess the effect of the BTW Wellington land farm on the local intertidal community. The first measure used is the mean number of species per quadrat and this is essentially a measure of species richness. The second diversity measure used is the mean Shannon-Weiner diversity index per quadrat. This statistic incorporates both the number of different species present (species richness) and the relative abundance of those species into one statistic.

As this was only the third survey undertaken for this programme, potential impact of the BTW Wellington land farm on the local intertidal community was assessed through comparing the results from potential impact sites with those from the control site.

Impacts of the BTW Wellington Land Farm on the local intertidal community were not evident from the spring 2012 survey results. There was no significant difference in Shannon-Weiner index per quadrat between the control site Turangi and potential impact site Orapa B. Potential impact sites 500m E and Turanga had significantly higher Shannon-Weiner indecies per quadrat than the control site Turangi.

The most evident factor impacting the intertidal communities at the sites surveyed was sand inundation. Sand can cause smothering and scouring of intertidal communities and significant volumes of sand can be deposited as a result of storm events or seasonal oceanographic processes. Within Taranaki, sand deposition appears to be a dominant driver of species richness and diversity amongst intertidal reef communities. Long term monitoring of intertidal rocky reefs around the Taranaki coastline has revealed the abundance and diversity of these communities can be adversely affected when sand levels exceed 30% coverage. However, historical results from certain sites around the Waitara area (e.g. Orapa A and Airedale Reef) indicate that Tranaki intertidal communities can recover relatively rapidly (within the year) from heavy sand inundation providing that high sand deposition is not continuous.

At Orapa B the sand percentage coverage has remained >20% since 2007 (see Waitara Marine Outfall Annual Report 2010, TRC 2011-41). Over this period, both mean number of species per quadrat and mean Shannon-Weiner index per quadrat have steadily declined. This reef has become dominated by the colonial tube worm *Neosabellaria kaiparaensis* (Photograph 1). Although generally uncommon in New Zealand, large colonies of this endemic polychaete occur around the Taranaki coastline. *Neosabellaria kaiparaensis* thrives in sand rich environments, and domination of this species can prevent other rock dwelling organisms from colonising the area. The factors driving temporal variation in community composition at Orapa B require further investigation. It must be stressed, however, that there is no evidence that the increase in sand cover and lower species richness and diversity at this site is in anyway related to the BTW Wellington Land Farm.

6.0 Conclusions

In order to assess the effects of the BTW Wellington Land Farm on the nearby intertidal communities, ecological surveys were conducted between 19 September and 30 October 2012 at four sites. These surveys included three potential impact sites and one control sites. Potential adverse effects of the BTW Wellington Land Farm on the intertidal communities were assessed by comparing species richness and diversity at the potential impact sites relative to the control site.

As both species richness and diversity were similar at the control sites and potential impact sites, the results indicate that the BTW Wellington Land Farm was not having detectable adverse effects on the intertidal reef communities. Natural environmental factors, in particular sand inundation, appeared to be the dominant driver of species richness and diversity for the sites surveyed.

Emily Roberts
Marine Ecologist

Internal Memorandum

To	Environmental Monitoring Manager, Keith Brodie
From	Scientific Officer, Emily Roberts
File	1209841
Date	14 June 2013

BTW Wellington Land Farm – Marine Ecological Survey January-February 2012

1.0 Introduction

A marine ecological survey was carried out at four sites as part of the 2011-2012 monitoring programme for the BTW Wellington Land Farm. The survey was carried out at three potential impact sites in the vicinity of the land farm, and one control sites between 24 January and 11 February 2012. The objective of the survey was to determine any change in species abundance and community structure attributable to the presence of the BTW Wellington Land Farm.

2.0 Methods

2.1 Field Work

The survey was conducted at four sites. The potential impact sites were: Orapa B (SEA 901043), Turanga Reef (SEA 901052), and 500m E of the Brixton Outfall (SEA 901055). The control site was at Turangi Reef (SEA 900095).

At each site, a 50 m transect was laid parallel to the shore. This transect was used to establish five 5 m x 3 m blocks. Within each block, 5 random 0.25 m^2 quadrats were laid giving a total of 25 random quadrats. For each quadrat the percentage cover of algal and encrusting animal species was estimated using a grid. For all other animal species, individuals larger than 3 mm were counted. Under boulder biota was counted where rocks and cobbles were easily overturned.

2.2 Data Analysis

For the data collected during the summer 2012 survey the following analyses was undertaken: The mean number of species per quadrat and Shannon-Weiner diversity indices per quadrat were calculated at each site. Assumptions of normality were tested using the Lilliefors test. One-way analysis of variance (ANOVA) was used to determine any significant differences between means. The Tukey's multiple comparison test was used to determine which means were significantly different from one another.

3.0 Results

The mean number of species per quadrat and the mean Shannon-Weiner diversity index per quadrat are presented in Table 1. 500m E (potential impact) had the highest number of species, followed by Turangi (control) and Turanga (potential impact). Orapa B (potential impact) had the lowest number of species. 500m E had the highest diversity, followed by Turangi, Turanga and Orapa B respectively.

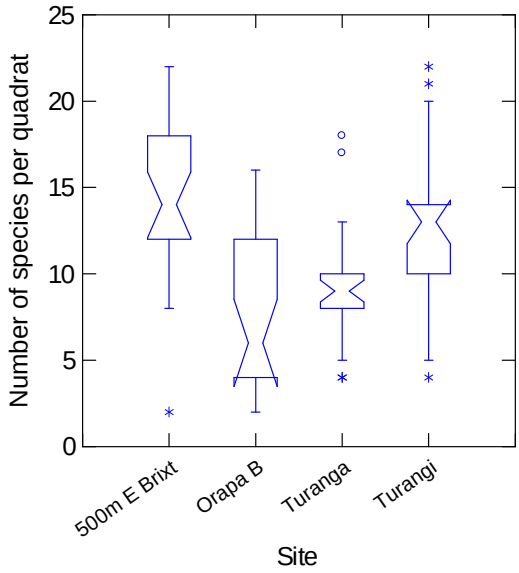
Table 1 Mean results for the summer 2012 survey. The Shannon-Weiner diversity index ($H^{|}$) incorporates the abundance of individual species in addition to the number of species present, providing a measure of diversity.

Site	No. of Quadrats	Mean number of species per quadrat			Mean Shannon Weiner Index per quadrat		
		Algae	Animals	Total Species (Algae & Animals)	Algae	Animals	Total Species (Algae & Animals)
Turangi Reef	25	3.64	9.12	12.76	0.41	0.51	0.68
Orapa B	25	2.08	5.88	7.96	0.19	0.50	0.59
Turanga Reef	25	3.04	6.28	9.32	0.36	0.52	0.65
500m E	25	4.20	10.12	14.32	0.51	0.82	0.97

3.1 Number of Species per Quadrat

Figure 1 shows the total number of species per quadrat at each site as a box and whisker plot. The notched area of the box represents the median plus and minus the 95% confidence interval. This form of graphical representation allows a quick comparison to be made between sites. Generally, if the notched areas of the boxes for the different sites do not overlap you would expect to obtain a significantly different result with ANOVA.

Figure 1 Box and whisker plot of total number of species per quadrat



Orapa B was the only site with a significant deviation from normal distribution at the 95% confidence level (Lilliefors test, n = 25, P = 0.016). There was a significant difference in species number per quadrat between sites (ANOVA, n = 25, F = 11.90, P <0.001).

Table 2 Tukey's multiple comparison test of total number of species per quadrat

Site	Turangi Reef	Orapa B	Turanga Reef
Orapa B	SIG		
Turanga Reef	SIG	NS	
500m E	NS	SIG	SIG

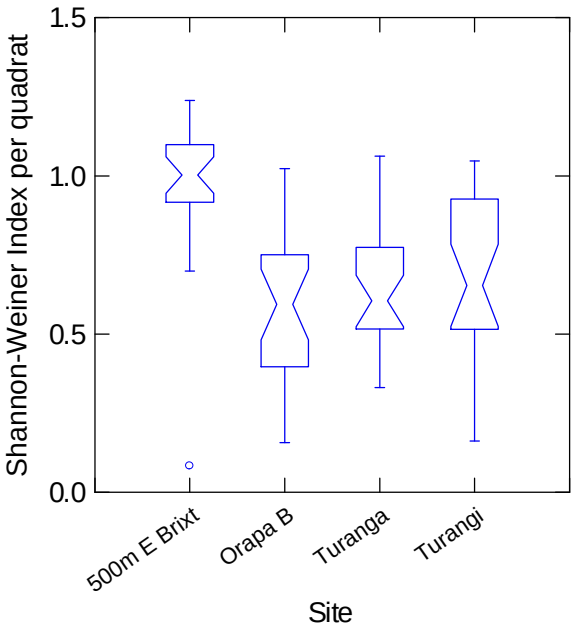
Key - SIG = significant difference at 95% confidence level
NS = no significant difference at 95% confidence level

Significant differences between sites were determined using Tukey's multiple comparison test (Table 2). At Orapa B and Turangi the mean number of species per quadrat was significantly higher than at Orapa B and Turanga (P <0.05).

3.3 Shannon-Weiner Diversity Index

Figure 2 shows the Shannon-Weiner index per quadrat at each site as a box and whisker plot.

Figure 2 Box and whisker plots of mean Shannon-Weiner index per quadrat



500m E was the only site with a significant deviation from normal distribution at the 95% confidence level (Lilliefors test, n = 25, P = 0.011). There was a significant difference in the Shannon-Weiner index per quadrat between sites (ANOVA, n = 25, F = 15.13, P <0.001). Significant differences between sites were determined using Tukey's multiple comparison test (Table 3). At 500m E, the mean Shannon-Weiner index per quadrat was significantly higher than at all other sites (P <0.05).

Table 3 Tukey's multiple comparison test of Shannon Weiner Index per quadrat

Site	Turangi Reef	Orapa B	Turanga Reef
Orapa B	NS		
Turanga Reef	NS	NS	
500m E	SIG	SIG	SIG

Key - SIG = significant difference at 95% confidence level
NS = no significant difference at 95% confidence level

3.4 Sand Cover

The percent cover of sand was recorded (Table 4) because high sand levels can significantly impact marine communities.

Table 4 Mean percent cover of sand per quadrat

Site	% sand and silt per quadrat*
Turangi Reef	8
Orapa B	26
Turanga Reef	12
500m E	22

* *Sand coverage >30% can significantly impact marine communities.*

Both Turangi and Turanga had relatively low sand levels, which would not have adversely affected ecological diversity of the reefs. At Orapa B and 500m E, the mean sand cover per quadrat was 26% and 22% respectively. Although there appeared to be no noticeable effects of sand cover at 500m E, sand cover might have contributed to the significantly lower number of species recorded at Orapa B. At the Orapa B site, there was a high density of the colonial polychaete worm, *Neosabellaria kaiparaensis* (previously *Sabellaria kaiparaensis*). This species traps sand to build a worm case, preventing most other species from growing on either the substrate or the worm cases.

Photo 1 Polychaete worm *Neosabellaria kaiparaensis*

5.0 Discussion

The concept of ecological diversity consists of two basic components; *species richness* (the number of different species present in an ecological community) and the *relative abundance* of species. These two measures of ecological diversity are used in this report to assess the effect of the BTW Wellington land farm on the local intertidal community. The first measure used is the mean number of species per quadrat and this is essentially a measure of species richness. The second diversity measure used is the mean Shannon-Weiner diversity index per quadrat. This statistic incorporates both the number of different species present (species richness) and the relative abundance of those species into one statistic.

As this was only the second survey undertaken for this programme, potential impact of the BTW Wellington land farm on the local intertidal community was assessed through comparing the results from potential impact sites with those from the control site.

Impacts of the BTW Wellington Land Farm on the local intertidal community were not evident from the summer 2012 survey results. There was no significant difference in Shannon-Weiner index per quadrat between the control site Turangi and potential impact sites Turanga and Orapa B. Potential impact site 500m E had a significantly higher Shannon-Weiner index per quadrat than all other sites.

The most evident factor impacting the intertidal communities at the sites surveyed was sand inundation. Sand can cause smothering and scouring of intertidal communities and significant volumes of sand can be deposited as a result of storm events or seasonal oceanographic processes. Within Taranaki, sand deposition appears to be a dominant driver of species richness and diversity amongst intertidal reef communities. Long term monitoring of intertidal rocky reefs around the Taranaki coastline has revealed the abundance and diversity of these communities can be adversely affected when sand levels exceed 30% coverage. However, historical results from certain sites around the Waitara area (e.g. Orapa A and Airedale Reef) indicate that Tranaki intertidal communities can recover relatively rapidly (within the year) from heavy sand inundation providing that high sand deposition is not continuous.

At Orapa B the sand percentage coverage has remained >20% since 2007 (see Waitara Marine Outfall Annual Report 2010, TRC 2011-41). Over this period, both mean number of species per quadrat and mean Shannon-Weiner index per quadrat have steadily declined. This reef has become dominated by the colonial tube worm *Neosabellaria kaiparaensis* (Photograph 1). Although generally uncommon in New Zealand, large colonies of this endemic polychaete occur around the Taranaki coastline. *Neosabellaria kaiparaensis* thrives in sand rich environments, and domination of this species can prevent other rock dwelling organisms from colonising the area. The factors driving temporal variation in community composition at Orapa B require further investigation. It must be stressed, however, that there is no evidence that the increase in sand cover and lower species richness and diversity at this site is in anyway related to the BTW Wellington Land Farm.

6.0 Conclusions

In order to assess the effects of the BTW Wellington Land Farm on the nearby intertidal communities, ecological surveys were conducted between 24 January and 11 February 2012 at four sites. These surveys included three potential impact sites and one control sites. Potential adverse effects of the BTW Wellington Land Farm on the intertidal communities were assessed by comparing species richness and diversity at the potential impact sites relative to the control site.

As both species richness and diversity were similar at the control sites and potential impact sites, the results indicate that the BTW Wellington Land Farm was not having detectable adverse effects on the intertidal reef communities. Natural environmental factors, in particular sand inundation, appeared to be the dominant driver of species richness and diversity for the sites surveyed.

Emily Roberts
Marine Ecologist

Internal Memorandum

To	Environmental Monitoring Manager, Keith Brodie
From	Scientific Officer, Emily Roberts
File	1206050
Date	5 June 2013

BTW Wellington Land Farm – Marine Ecological Survey September-October 2011

1.0 Introduction

A marine ecological survey was carried out at four sites as part of the 2011-2012 monitoring programme for the BTW Wellington Land Farm. The survey was carried out at three potential impact sites in the vicinity of the land farm, and one control sites between 28 September and 13 October 2011. The objective of the survey was to determine any change in species abundance and community structure attributable to the presence of the BTW Wellington Land Farm.

2.0 Methods

2.1 Field Work

The survey was conducted at four sites. The potential impact sites were: Orapa B (SEA 901043), Turanga Reef (SEA 901052), and 500m E of the Brixton Outfall (SEA 901055). The control site was at Turangi Reef (SEA 900095).

At each site, a 50 m transect was laid parallel to the shore. This transect was used to establish five 5 m x 3 m blocks. Within each block, 5 random 0.25 m^2 quadrats were laid giving a total of 25 random quadrats. For each quadrat the percentage cover of algal and encrusting animal species was estimated using a grid. For all other animal species, individuals larger than 3 mm were counted. Under boulder biota was counted where rocks and cobbles were easily overturned.

2.2 Data Analysis

For the data collected during the spring 2011 survey the following analyses was undertaken: The mean number of species per quadrat and Shannon-Weiner diversity indices per quadrat were calculated at each site. Assumptions of normality were tested using the Lilliefors test. One-way analysis of variance (ANOVA) was used to determine any significant differences between means. The Tukey's multiple comparison test was used to determine which means were significantly different from one another.

3.0 Results

The mean number of species per quadrat and the mean Shannon-Weiner diversity index per quadrat are presented in Table 1. 500m E (potential impact) had the highest number of species, followed by Turangi (control) and Turanga (potential impact). Orapa B (potential impact) had the lowest number of species. 500m E had the highest diversity, followed by Turanga. Turangi and Orapa B had the lowest diversity.

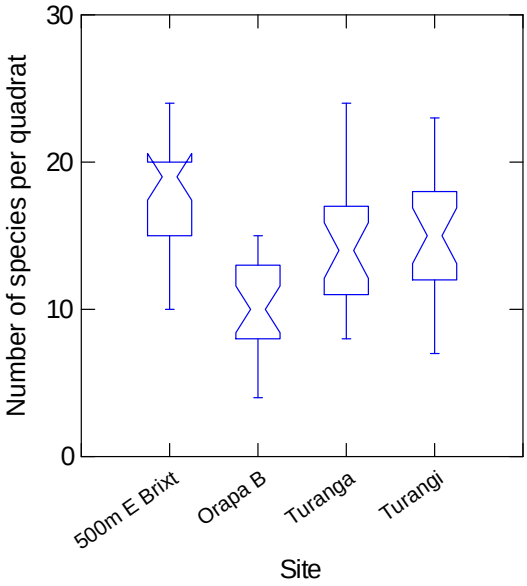
Table 1 Mean results for the spring 2011 survey. The Shannon-Weiner diversity index ($H^{|}$) incorporates the abundance of individual species in addition to the number of species present, providing a measure of diversity.

Site	No. of Quadrats	Mean number of species per quadrat			Mean Shannon Weiner Index per quadrat		
		Algae	Animals	Total Species (Algae & Animals)	Algae	Animals	Total Species (Algae & Animals)
Turangi Reef	25	3.84	11.40	15.24	0.38	0.73	0.83
Orapa B	25	3.12	7.04	10.16	0.52	0.59	0.73
Turanga Reef	25	4.24	10.64	14.88	0.48	0.82	0.96
500m E	25	5.88	11.76	17.64	0.62	0.87	1.04

3.1 Number of Species per Quadrat

Figure 1 shows the total number of species per quadrat at each site as a box and whisker plot. The notched area of the box represents the median plus and minus the 95% confidence interval. This form of graphical representation allows a quick comparison to be made between sites. Generally, if the notched areas of the boxes for the different sites do not overlap you would expect to obtain a significantly different result with ANOVA.

Figure 1 Box and whisker plot of total number of species per quadrat



For all sites, there was no significant deviation from normal distribution at the 95% confidence level (Lilliefors test, n = 25, P >0.05). There was a significant difference in species number per quadrat between sites (ANOVA, n = 25, F = 15.73, P <0.001).

Table 2 Tukey's multiple comparison test of total number of species per quadrat

Site	Turangi Reef	Orapa B	Turanga Reef
Orapa B	SIG		
Turanga Reef	NS	SIG	
500m E	NS	SIG	NS

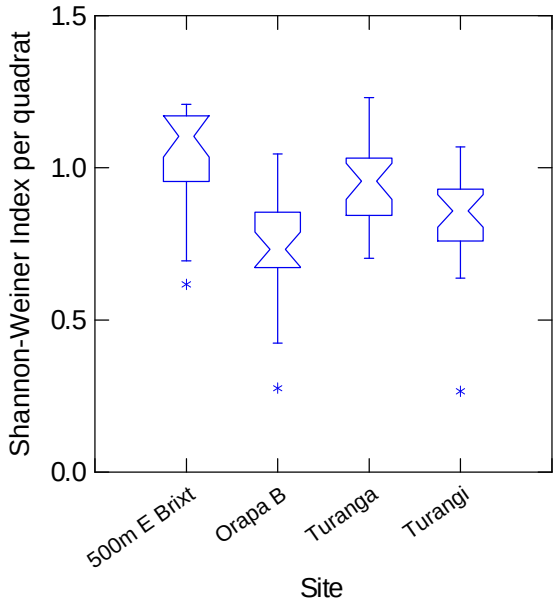
Key - SIG = significant difference at 95% confidence level
NS = no significant difference at 95% confidence level

Significant differences between sites were determined using Tukey's multiple comparison test (Table 2). At Orapa B the mean number of species per quadrat was significantly lower than at all other sites (P <0.05).

3.3 Shannon-Weiner Diversity Index

Figure 2 shows the Shannon-Weiner index per quadrat at each site as a box and whisker plot.

Figure 2 Box and whisker plots of mean Shannon-Weiner index per quadrat



For all sites, there was no significant deviation from normal distribution at the 95% confidence level (Lilliefors test, n = 25, P >0.05). There was a significant difference in the Shannon-Weiner index per quadrat between sites (ANOVA, n = 25, F = 17.91, P <0.001). Significant differences between sites were determined using Tukey's multiple comparison test (Table 3). At Turanga and 500m E, the mean Shannon-Weiner index per quadrat was significantly higher than at Turangi Reef and Orapa B (P <0.05).

Table 3 Tukey's multiple comparison test of Shannon Weiner Index per quadrat

Site	Turangi Reef	Orapa B	Turanga Reef
Orapa B	NS		
Turanga Reef	SIG	SIG	
500m E	SIG	SIG	NS

Key - SIG = significant difference at 95% confidence level
NS = no significant difference at 95% confidence level

3.4 Sand Cover

The percent cover of sand was recorded (Table 4) because high sand levels can significantly impact marine communities.

Table 4 Mean percent cover of sand per quadrat

Site	% sand and silt per quadrat*
Turangi Reef	16
Orapa B	23
Turanga Reef	8
500m E	8

* *Sand coverage >30% can significantly impact marine communities.*

Both Turanga and 500m E had low sand levels, which would not have adversely affected ecological diversity of the reefs. At Orapa B and Turangi, the mean sand cover per quadrat was 23% and 16% respectively, which might have contributed to the significantly lower Shannon-Weiner index recorded at these two sites. At the Orapa B site, there was a high density of the colonial polychaete worm, *Neosabellaria kaiparaensis* (previously *Sabellaria kaiparaensis*). This species traps sand to build a worm case, preventing most other species from growing on either the substrate or the worm cases.

Photo 1 Polychaete worm *Neosabellaria kaiparaensis*

5.0 Discussion

The concept of ecological diversity consists of two basic components; *species richness* (the number of different species present in an ecological community) and the *relative abundance* of species. These two measures of ecological diversity are used in this report to assess the effect of the BTW Wellington land farm on the local intertidal community. The first measure used is the mean number of species per quadrat and this is essentially a measure of species richness. The second diversity measure used is the mean Shannon-Weiner diversity index per quadrat. This statistic incorporates both the number of different species present (species richness) and the relative abundance of those species into one statistic.

As this was the first survey undertaken for this programme, potential impact of the BTW Wellington land farm on the local intertidal community was assessed through comparing the results from potential impact sites with those from the control site.

Impacts of the BTW Wellington Land Farm on the local intertidal community were not evident from the spring 2011 survey results. Certain potential impact sites (500m E and Turanga) had a significantly higher Shannon-Weiner index per quadrat than the control site Turangi Reef.

The most evident factor impacting the intertidal communities at the sites surveyed was sand inundation. Sand can cause smothering and scouring of intertidal communities and significant volumes of sand can be deposited as a result of storm events or seasonal oceanographic processes. Within Taranaki, sand deposition

appears to be a dominant driver of species richness and diversity amongst intertidal reef communities. Long term monitoring of intertidal rocky reefs around the Taranaki coastline has revealed the abundance and diversity of these communities can be adversely affected when sand levels exceed 30% coverage. However, historical results from certain sites around the Waitara area (e.g. Orapa A and Airedale Reef) indicate that Tranaki intertidal communities can recover relatively rapidly (within the year) from heavy sand inundation providing that high sand deposition is not continuous.

At Orapa B the sand percentage coverage has remained >20% since 2007 (see Waitara Marine Outfall Annual Report 2010, TRC 2011-41). Over this period, both mean number of species per quadrat and mean Shannon-Weiner index per quadrat have steadily declined. This reef has become dominated by the colonial tube worm *Neosabellaria kaiparaensis* (Photograph 1). Although generally uncommon in New Zealand, large colonies of this endemic polychaete occur around the Taranaki coastline. *Neosabellaria kaiparaensis* thrives in sand rich environments, and domination of this species can prevent other rock dwelling organisms from colonising the area. The factors driving temporal variation in community composition at Orapa B require further investigation. It must be stressed, however, that there is no evidence that the increase in sand cover and lower species richness and diversity at this site is in anyway related to the BTW Wellington Land Farm.

6.0 Conclusions

In order to assess the effects of the BTW Wellington Land Farm on the nearby intertidal communities, ecological surveys were conducted between 28 September and 13 October 2011 at four sites. These surveys included three potential impact sites and one control sites. Potential adverse effects of the BTW Wellington Land Farm on the intertidal communities were assessed by comparing species richness and diversity at the potential impact sites relative to the control site.

As both species richness and diversity were similar at the control sites and potential impact sites, the results indicate that the BTW Wellington Land Farm was not having detectable adverse effects on the intertidal reef communities. Natural environmental factors, in particular sand inundation, appeared to be the dominant driver of species richness and diversity for the sites surveyed.

Emily Roberts
Marine Ecologist

Appendix VI

Soil ecology investigation

Memorandum

To GK Bedford, Director-Environment Quality
K Brodie, Environmental Monitoring Manager
D Olson, Scientific Officer
From R Martin, Scientific Officer - Biodiversity
Document 1042066
Date 8 May 2012

Changes to landfarming soil biodiversity monitoring methods – Consents 6867-1, 6135-1 and 7884-1

In response to Point 4 of Origin Energy's letter of the 26th January 2012 (FRODO # 1042180), I have reviewed the results to date for the Compliance Monitoring Programmes relating to the above consents, and spoken to the relevant ecotoxicologists at Landcare Research regarding best practice soil toxicology testing. In their letter, Origin queried the validity of the current biological soil compliance monitoring programme at Schrider Landfarm, and whether it is viable to continue with the sampling methodologies used to date due to the biases inherent in those methods, and the lack of definitive/conclusive results thus far. However, this query applies to all soil monitoring associated with landfarming practices.

As discussed at our meeting on the 23rd April 2012, field-based sampling and analyses of soil microbes and nematodes have not shown any definitive significant results or long-term trends for microbes/nematodes (see Annual Technical Report 2011 – 35, FRODO # 894052). Additionally, the initial round of 2011/2012 sample results for all landfarming compliance programmes show no significant results (including those for synthetic- and water-based drilling wastes at Brown Road and Schriders landfarms, as well as fracturing fluid wastes at the Wellington landfarm).

This lack of conclusive results is due to the large number of environmental effects/biases and variation in application methods. In particular, mechanical manipulation and disturbance of soil is a major issue in the landfarming process. During the landfarming process, large amounts of topsoil are stripped and replaced using heavy machinery, and the disturbance and soil compaction this creates may be masking any toxic effects the application of drilling muds may be having on soil biota. Additionally, spatial variability and large differences in soil microclimates even within the same sample plot create large ranges for each of the soil parameters analysed, which complicates any meaningful interpretation of statistical results.

As the objective of the Council's compliance monitoring programme for the above consents is to specifically quantify the toxic effects (or otherwise) of applying drilling wastes to soil (landfarming) and the biota inhabiting this soil, a lab-based study will be more suitable to assess the potential toxicity of application of drilling muds to soil biota as it will eliminate the environmental biases inherent in field sampling.

This lab-based study will be designed and carried out by peer-reviewed ecotoxicologists at Landcare Research, and will involve investigating the toxicity (or otherwise) of drilling mud application to earthworms and soil microbial biota (these taxa are widely used as bioindicators of soil health), using the application rates/methods specified in the above consents. Replication levels for treatment and control soil samples for these toxicity tests will comply with international best practice. Additionally, drilling wastes will be applied to some samples at much higher application rates than actually allowed by the Council's consent conditions to assess the levels required to achieve high soil toxicity and negative impacts on soil biota over long time periods. Lab-based studies will complement the work already carried out during the field-based studies, and results from the two study types will provide a clear overall picture of the effects of landfarming on soil biota in Taranaki.

Recommendation: That the remaining sample periods relating to the compliance monitoring programs for Consents 6867-1, 6135-1 and 7884-1 be cancelled due to lack of conclusive results arising from the environmental biases inherent in this sampling method. Results from the landfarming samples taken to date will be written up and included in the annual 2012/2013 compliance monitoring report. In place of continuing with field-based studies, lab-based tests of the toxicity of drilling muds on soil biota under controlled laboratory conditions will be initiated, and carried out under contract by Landcare Research.

Rebecca Martin

Scientific Officer - Biodiversity

Project Brief

Project Title: **Land farming of drilling wastes: Toxicity impacts on soil biota within sandy soils in Taranaki**

Project Manager: David Olson (Scientific Officer)

Project Team: David Olson (Scientific Officer),
Rebecca Martin (Scientific Officer – Biodiversity)
Jo Cavanagh (Landcare Research),

Job Number: Consent No. 6187-1 (BTW at Brown Road landfarm)
Consent No. 6135-1 (Origin Energy at Schrider landfarm)
Consent No. 7884-1 (BTW at Wellington landfarm)
Future landfarming consents

Document: 1052392

Date: 15 April 2013

Project objective

To investigate the possible toxic effects of landfarming of drilling wastes (synthetic-based drilling muds, water-based drilling muds and fracking fluids) on soil and freshwater biota within Taranaki, using earthworms and microbes as bioindicators for soil taxa, and algae and *Daphnia* as bioindicators for freshwater taxa.

Project overview & description

This laboratory-based project builds upon and complements previous field-based soil monitoring studies undertaken by the Council, which investigated the effects of earthworm, nematode and microbe populations *in situ* where landfarming was being carried out (Project Briefs, FRODO # 754606 and 930194 and Technical Report 2011/35, FRODO # 894052). These investigations suggested that although some soil biota variables may have been impacted upon by land spreading operations, it was impossible to tease out the physical effects of landfarming operations and environmental biases inherent in the field-based sampling from any potential toxic effects due to the application of the drilling muds themselves. Therefore, this project will address this issue by specifically investigating whether the application of drilling wastes to land from (a) synthetic-based drilling muds, (b) water-based drilling muds, and (c) fracturing fluids has a toxic effect on soil biota, under controlled laboratory conditions (see Memo, FRODO # 1042066 for details).

Eliminating the variability in the field-based results caused by the physical processes of landfarming and environmental biases will allow for a more specific understanding of the

possible effects of land farming on soil biota and ecosystems. Results from the lab-based studies will be combined with results from the Council's field-based programs to date (that will be terminated on 30 June 2012), which will provide a comprehensive report on the various elements of landfarming and their effects on soils in Taranaki. Thus, this study aims to assess the possible toxic effects of fluid disposal on earthworm and microbial community structure and activity in a controlled laboratory environment. This study will also assess the possible toxic effects of fluid disposal on freshwater biota (using green algae growth and *Daphnia* survival tests), should there ever be an incident where wastes enter waterways. The soil testing component of the work will be carried out by Landcare Research, while the freshwater component will be carried out by NIWA. This survey is particularly motivated by a need to examine the potential implications of recent changes to consent conditions relating to the disposal of fracking fluids at landfarms.

This study will assess the toxicity of drilling mud samples disposed of at 3 sites under the following resource consents:

Held by BTW for Brown Road Landfarm:

6187-1 To discharge drilling wastes [consisting of drilling cuttings and drilling fluids] from hydrocarbon exploration activities with water-based muds and synthetic-based muds, and oily wastes from hydrocarbon exploration and production activities, onto and into land via landfarming.

Held by Origin Energy Resources New Zealand Ltd. for Schrider landfarm:

6135-1 To discharge drilling cuttings and fluids from drilling operations with water-based muds, drilling cuttings from wells drilled with synthetic-based muds, and drilling cuttings and oily wastes from wells drilled with oil-based muds, onto and into land via landfarming.

Held by BTW for the Wellington Landfarm (70, Brown Road, property owner: M. Wellington)

7884-1 To discharge wastes from hydrocarbon exploration, well work-over, production and storage activities, onto and into land via land farming.

Soil biota testing

Earthworm and microbial populations will be used as indicators of soil health, and will be used to demonstrate whether the application of drilling muds at various application rates have toxic effects on soil biota. To examine the effect of drilling waste disposal on soil health and earthworm and microbe communities/populations, effect size (the magnitude of difference between treatment and control) will be compared between soils subject to drilling waste application (treatment samples) and the same soils with no drilling wastes applied (control samples).

Sampling strategy/design

1. Earthworm testing:

Chronic laboratory testing using earthworms will provide an indication of the long-term toxicity of drilling muds and fracking fluids on the reproductive capabilities of the test species. Chronic earthworm tests will be run over a period of 56 days (8 weeks), using the following protocol:

1) Mix a bulk quantity of 2 standard test soil types with each of the 3 muds or fluids at the application rate currently specified under consent conditions (current consented application rate is a maximum of 50 000 mg hydrocarbon/kg dry weight in soil/waste mix).
2) Undertake chronic earthworm toxicity testing (exposed worms are examined at 4 days, 28 days and 56-days to look at effects on mortality, cocoon production and hatching) (see Table 1 for further details).

2. Microbe testing:

1) Using 2 representative soil types, mix soil at a single dose-level (maximum consented) with 3 drilling fluids, place into replicate jars, and incubate alongside worm tests (see Table 1 for further details).
2) Undertake measurement of microbial biomass, aerobic N-mineralisation, basal respiration at selected time points.

Aquatic biota testing

Green algae growth and *Daphnia* species survival will be used as indicators of the possible toxicity of drilling wastes to freshwater biota, and three types of drilling muds at various dilution rates will be applied to populations of these species. To examine the effect of drilling waste disposal on freshwater biota, effect size (the magnitude of difference between treatment and control) will be compared between biota subject to drilling waste application (treatment samples) and the same biota with no drilling wastes applied (control samples).

Table 1 Parameters to be measured

Parameter measured	Party Responsible	Details	Comment
Chronic Earthworm test (56 day toxicity testing)	**Landcare Research**	Cost for testing 2 soil types (each with 5 replicates of a treatment and control soil) for 3 muds/fluids at time 0, 4 days, 28 days, 56 days	Five replicates suggested as variability relatively high and statistical power low with 3 replicates
Microbial testing (Microbial Biomass C, N-min, Basal respiration etc.)		Cost for testing 2 soil types (each with 5 replicates of a treatment and control soil) for 3 muds/fluids at time 0, 28 days, 56 days, and 6 months	
Landcare Research data analysis and reporting			
Ecotoxicity testing on aquatic organisms	**NIWA**	Cost for assessing possible toxicity to aquatic organisms of 3 muds/fluids at varying dilutions	Possible toxicity effects will be assessed on populations of green algae (growth rates) and *Daphnia* species (survival rates)

Background information

Land spreading (also known as land farming, land disposal and land treatment) is the process whereby drilling wastes (cuttings and mud) are disposed of via application to land. Applying drilling wastes to the land is a form of bioremediation – it allows the soil's naturally occurring microbial population to degrade the waste constituents (particularly hydrocarbons, other organic compounds and nitrogen) drilling cuttings and muds contain.

Taranaki Regional Council has granted consents for land spreading of drilling wastes at several locations around the region, with conditions stipulating maximum loading limits and application depths based on Canadian standards.

In Taranaki to date, land spreading has consisted only of single applications of drilling wastes. Basic steps in the land treatment process include;

1. Drilling waste is transported from wellsites by truck (cuttings) or tanker (liquids), and may be discharged directly to land or placed in a dedicated storage pit (for individual well and mud type).

2. Required area is prepared by removing any existing pasture/topsoil and leveling out uneven ground.
3. Waste may be blended with additional materials such as sawdust.
4. Waste is transferred to prepared area by excavator and truck and spread out with a bulldozer. Liquids may be discharged by tanker or spray system.
5. Waste is allowed to dry sufficiently before being tilled into the soil to the required depth with a tractor and discs.
6. Area is leveled with chains or harrows.
7. Removed topsoil/clay is applied to aid stability and assist in grass establishment.
8. Fertiliser may be applied and the area is sown in crop or pasture at a suitable time of year.

Optimal land spreading techniques balance additions of waste against a soil's capacity to assimilate waste constituents. This is important to avoid detrimental effects on soil integrity, subsurface soil contamination problems, or other adverse environmental impacts. Taranaki loading limits and maximum application rates are dictated by resource consents. The preparation of these consents is informed by national guidelines and criteria for soil and water quality and local research into biodegradation and attenuation rates and environmental effects associated with drilling wastes.

Studies elsewhere have indicated that if wastes are applied correctly, land spreading does not adversely affect soils. Furthermore, some studies as well as anecdotal evidence have suggested that land spreading may even benefit certain sandy soils by increasing their water-retaining capacity and reducing fertilizer losses.

Taranaki Regional Council Guidelines relating to land spreading in Taranaki suggest that land spreading operations should ideally be located on relatively flat sandy country prone to wind erosion as this is where the greatest environmental benefits are likely to be obtained. Additionally, Council Monitoring Programme Technical Reports for land spreading operations in Taranaki have stated that such operations are being used to assist the conversion of unstable shifting sands to productive pasture.

In the past however, monitoring of bioremediation at contaminated sites has usually been limited to chemical analysis of pollutants in the soil (Wilson & Jones 1993, Hubalek 2007). Some studies have been carried out assessing the effects of hydrocarbons on soil biota but these have predominantly been conducted in a laboratory setting and do not account for site specific factors such as soil characteristics, environmental conditions and species.

Chemical analysis is not enough to evaluate the impacts of soil contamination on soil biota, nor the efficiency of clean up techniques (Molina-Barahona *et al* 2005, Paton *et al* 2005, Smith *et al* 2006), and cannot provide a full picture of the bioremediation process (Hubalel *et al* 2007). Reduction in contamination is not always accompanied by reduced soil toxicity, in fact in some cases incomplete degradation and the formation of intermediary metabolites can lead to increased soil toxicity (Phillips *et al* 2000, Hubalek *et al* 2007). For example, a study by Hubalek *et al* (2007) found that inhibition of earthworm reproduction in hydrocarbon

contaminated soil remained reasonably steady across the study period (17 months) despite total hydrocarbon concentrations decreasing by 65.5%.

Another reason why chemical analysis is inadequate for assessing the impacts of land spreading on soil biota is that factors beside toxicity of contaminants can have negative effects on biota at land spreading sites. For example, the method of incorporating or applying drilling wastes to the soil may in some cases be more important than the contaminants within the waste. In Taranaki, drilling wastes are tilled into the soil to a greater or lesser extent. Studies have shown that tillage can sometimes negatively impact on earthworm abundance. Such impacts are most likely to result from mechanical damage to individuals or damage to habitats but the exact processes responsible have seldom been investigated (Chan 2001).

Because so little attention has been paid to the effects application of contaminants has on soil biodiversity and ecosystems, there is a scarcity of studies that demonstrate elevated risks or which provide information on "safe" concentrations and practices for terrestrial organisms in the field. Investigations of the impacts of land spreading on soil organisms and ecosystems has been rated overall as a very high priority by the National Science Strategy Committee in their "*Sustainable Land Management Strategy*" (1997). Additionally, the MAF report *"Towards Safeguarding New Zealand's Agricultural Biodiversity: Research gaps, Priorities and Potential Case Studies"* states that: *"In New Zealand, little is known about…the influence of waste/sewage spreading on ecosystems".*

Thus there is a lack of information to inform local authorities' decisions regarding the granting of resource consents, the surrender of consents and the formulation of consent conditions, best practice and standards relating to the application of drilling wastes to land. For this reason, and because biodiversity in agricultural ecosystems is important for maintaining essential ecosystem goods and services (nutrient cycling, maintenance of soil structure and fertility, degradation of pollutants, soil carbon sequestration, pollination), studies of the effects of land treatment of drilling wastes on soil ecology and biodiversity in Taranaki are prudent and valuable.