Origin Energy Resources NZ Limited
Drilling Waste Landfarms
Monitoring Programmes
2011-2013
Biennial Report
Technical Report 13-83

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Executive summary

Origin Energy Resources NZ Limited (Origin Energy) took over the three drilling waste landfarming sites of Swift Energy NZ Ltd in 2008. The sites are located on Geary Road at Manutahi, in the Waikaikai catchment (Geary and Schrider sites); and on Spence Road, Kakaramea, in the Kaikura catchment. Disposals at the Geary site were completed in March 2006 and the area has since been reinstated to productive dairy farmland. Disposals at the Schrider site were completed in 2011. At the time of reporting the only active site is the Spence site, however all three sites are continually monitored and reported on annually, as consents have not expired or been surrendered.

This report for the period July 2011-June 2013 describes the monitoring programmes implemented by the Taranaki Regional Council to assess Origin Energy's environmental performance during the period under review, and the results and environmental effects of Origin Energy's activities.

Origin Energy holds two resource consents, which include a total of 56 conditions setting out the requirements that the Company must satisfy. AR Geary holds one resource consent, which includes a total of 27 conditions setting out the requirements that the consent holder must satisfy. AR Geary held an additional resource consent that expired during the monitoring period. These consents allow for the discharge of drilling waste onto and into land via landfarming.

The Council's monitoring programme for the period under review included 12 inspections, 8 soil samples collected for analysis, and the review of records provided by Origin Energy.

Monitoring indicates that there are no adverse environmental effects occurring as a result of activities at the sites. Levels of contaminants in the surface soil meet the required consent conditions in most cases. Further monitoring of the sites will ensure that all criteria are complied with prior to surrender of the consents.

During the monitoring period, Origin Energy demonstrated a high level of environmental performance and compliance with the resource consents. There were no incidents recorded by the Council in relation to the Company's landfarming operations.

This report includes recommendations for the 2013-2014 year.

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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 1 July 2011 – 30 June 2013 by the Taranaki Regional Council describing the monitoring programmes associated with resource consents held by Origin Energy Resources NZ Limited (Origin Energy) and AR Geary. Origin Energy operates drilling waste landfarms situated on Geary Road at Manutahi (Schrider Landfarm), and Spence Road at Kakaramea. They also monitor the Geary Landfarm site to ensure that consent conditions are met prior to surrender. The consents for this site are held by the landowner AR Geary.

This report covers the results and findings of the monitoring programmes implemented by the Council in respect of the consents held by Origin Energy and AR Geary, to discharge drilling waste onto and into land via landfarming. This is the 4th combined Technical Report and the 17th report across the three sites, to be prepared by the Taranaki Regional Council to cover the Company's discharges and their effects.

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

Sections 2 - 4 each cover one of the three landfarming sites, setting out the site location, details of the resource consents, presenting the results of monitoring during the period under review (including scientific and technical data), and an evaluation of compliance with the resource consents.

Section 5 discusses the results, their interpretation, and their significance for the environment.

Section 6 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 Drilling waste

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 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.

1.2.2 Landfarming

The landfarming process as implemented in Taranaki has typically been shown to assist the conversion of sandy coastal sites prone to erosion into productive pasture. 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 VII.

Landfarming uses natural and assisted bioremediation to reduce the concentration of petroleum compounds through degradation. Basic steps in the landfarming process include:

1. Drilling waste is transported from wellsites by truck (cuttings) or tanker (liquids). 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 leveling 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 leveled 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.

The landfarming process utilized at the Geary, Schrider and Spence Road sites are on a single application basis. This means dedicated spreading areas each receive only a single application of waste.

When disposal is complete, the area will be suitable for use for grazing following stabilisation and re-grassing.

Photograph 1 Landfarming equipment at the Schrider site

1.3 Resource consents

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.

Details of the consents covered by this report are summarised in Table 1.

Table 1 Summary of landfarming consents covered by this report

Site	Consent holder	Consent number	Purpose of consent	Issue date	Next review	Expiry
Geary	AR Geary	5325-1	Discharge drilling waste (SBM, WBM & OW)	28/5/1998	-	2016
		6297-2	Discharge drilling waste (Kauri E OBM & OW)	9/6/2006	-	2012*
Schrider	Origin	6135-1	Discharge drilling waste (SBM, WBM, OBM & OW)	6/3/2003	2016	2022
Spence Rd	Origin	5935-1	Discharge drilling waste (SBM, WBM & OW)	7/12/2001	2012	2016

OBM = oil based mud
OW = oily waste
SBM = synthetic based mud
WBM = water based mud
*expired during monitoring period

These permits are attached to this report in Appendix I.

1.4 Monitoring programme

1.4.1 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 Origin Energy landfarms consisted of five primary components.

1.4.2 Programme liaison and management

There is generally a significant investment of time and resources by the Taranaki Regional Council in ongoing liaison with resource consent holders over consent conditions and their interpretation and application:

- in discussion over monitoring requirements
- preparation for any reviews
- renewals
- new consents
- advice on the Council's environmental management strategies and content of regional plans and
- consultation on associated matters.

1.4.3 Site inspections

A total of twelve inspections were made of the landfarm sites during the monitoring period, with regard to the consents for the discharge of drilling waste. The main point of interest was to assess the ongoing effects upon soil quality of the land disposal process.

The inspections occurred as follows:

Geary Landfarm	15 May 2012 6 June 2013
Schrider Landfarm	15 May 2012 17 January 2013 6 June 2013
Spence Road Landfarm	28 July 2011 24 November 2011 15 May 2012 19 June 2012 17 January 2013 2 April 2013 6 June 2013

1.4.4 Chemical sampling

During the monitoring period the Council collected six composite soil samples from the Spence Road site and another two composite soil samples from the Geary site. For each sample, 12-15 cores were taken from a diagonal transect at 10m intervals to a depth of 250mm, and composited in the field. The samples were analysed for chloride, conductivity, hydrocarbons, pH, sodium and total soluble salts.

1.4.5 Review of analytical results

The Council reviewed results provided by Origin Energy. Origin Energy are required by their consents to take predisposal and receiving environment samples and supply analyses results to the Council to ensure that waste application loading and surrender limits are met for the areas used for disposal.

1.4.6 Soil biology

The second year of a three year study into the impacts of landfarming drilling waste on soil biota was completed in 2011-2012. As in the previous year, 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. Following the review of the first two years of monitoring data, it was decided that the remaining year of field based study is replaced with a laboratory based eco-toxicity study. This re-designed programme will complement the field based monitoring, but can focus exclusively on the chemical effects of drilling waste application on soil biota, as opposed to the collective effects of the waste application and the physical effects of re-contouring paddocks and tilling. The 2011-2012 field-based results will be included in a biennial report combining the final two years of monitoring, which will also include the laboratory results from the third year of the study.

2. Geary Landfarm

2.1 Site location

Swift Energy New Zealand Limited (Swift) operated a drilling waste landfarm off Geary Road, Manutahi which is shown in Figure 1. This site is located on marginal coastal farm land situated on reworked dune fields. The Waikaikai Stream flows approximately through the centre of the site. The proximity of the site to this recognised ecosystem has been taken into account in the setting of buffer distances and location of the stockpiling facilities.

The predominant soil type has been identified as black loamy sand and vegetation growth is primarily pasture. Average annual rainfall for the site is 1043 mm (taken from the nearby 'Patea' monitoring station). As with the other South Taranaki coastal sites, the Geary site is subject to strong winds.

Site data

Location	
Word descriptor:	Geary Road, Manutahi, Taranaki
Map reference:	E 1718754
(NZTM)	N 5606372
Mean annual rainfall:	1043 mm
Mean annual soil temperature:	~15.1°C
Mean annual soil moisture:	~32.9%
Elevation:	~40 m
Geomorphic position:	Cliffed coast / dune backslope
Erosion / deposition:	Erosion
Vegetation:	Pasture, dune grasses
Parent material:	Aeolian deposit
Drainage class:	Free / well draining
Land use:	Grazing stock

Disposals at the site were completed in March 2006 and the area has since been reinstated to productive farmland. Origin Energy took over Swift's operations in 2008; they now monitor the site to ensure that the conditions are met prior to surrender. The two consents were held by AR Geary. One of the consents expired during the period under review.

Oil based cuttings and wastes from the Kauri E wellsite, located in the southeast corner of the property, were landfarmed at the site in 2004 and 2005.

No disposals occurred during the period under review.

The site is adjacent to a remote cliffed coast with little to no public access.

Figure 1 Aerial photograph of Geary Landfarm highlighting spreading areas and approximate regional location (inset)

2.2 Resource consents

AR Geary holds discharge consent **5325-1**, to discharge: drilling mud, fluids and cuttings from well drilling operations with water based muds; drilling cuttings from wells drilled with synthetic based muds; and oily waste material from hydrocarbon exploration and production activities; onto and into land. This consent was issued by the Taranaki Regional Council on 28 May 1998 as a resource consent under Section 87(e) of the Resource Management Act. Changes to conditions were made on 2 July 2002, 18 September 2002 and 16 June 2003. It is due to expire on 1 June 2016.

Condition 1 relates to compliance with information supplied.

Condition 2 relates to best practicable option.

Conditions 3, 4, 5 and 7 relate to notification and supply of information to the Council.

Conditions 6 and 8-26 relate to operational and technical requirements.

Condition 27 is a review condition.

The permit is attached to this report in Appendix I.

AR Geary held discharge permit **6297-1**, to cover the discharge of oil based drilling cuttings and oily wastes from the Kauri E wellsite onto and into land via landfarming. This permit was issued by the Taranaki Regional Council on 18 March 2004 as a resource consent under Section 87(e) of the Resource Management Act. It was varied on 23 June 2004 and renewed on 9 June 2006. It expired on 1 June 2012, at which time surrender criteria had been met.

Condition 1 related to compliance with information supplied.

Condition 2 related to best practicable option.

Conditions 3-18 listed a range of operational and technical requirements which must be complied with.

Condition 19 was a review condition.

The permit is attached to this report in Appendix I.

Photograph 2 View east from sand dunes across Geary site showing spreading area 39

Photograph 3 Spreading area G38 showing successful pasture establishment following landfarming

2.3 Results

2.3.1 Inspections

There were a total of two scheduled inspections of the Geary site conducted during the monitoring period. Summaries of compliance inspections are provided below.

15 May 2012
At the time of inspection a light breeze was occurring from the west and no objectionable odours were detected. No recent disposal activities had occurred and all pasture where muds had previously been applied appeared stable and healthy.

6 June 2013
The inspection found that the majority of pasture where muds have been applied looked healthy. The pasture around spreading area G14-15 appeared to have 'browned-off' in patches. Discussions with farm staff outlined that no spraying had occurred, but recent heavy rains had caused ponding in the area which affected pasture appearance, some new growth coming through appeared green. The culvert was inspected and was found to be in good order and no flow resistance or scouring was observed. The Waikaikai Stream was running clear at the time of inspection. It was recommended that these patches be sampled. Samples were taken on 12 June 2013. The results are presented in Section 2.3.2.

2.3.2 Results of receiving environment monitoring

2.3.2.1 TRC soil results

Two composite soil samples were collected by sub-sampling to a depth of 250mm in landfarmed areas. The results of this sampling are presented in Table 2.

Table 2 Soil samples taken on 12 June 2013 at Geary Landfarm

Parameter	Unit	Sample 1	Sample 2
Chloride	mg/kg DW	21.5	23.6
Conductivity	mS/m@20C	24.4	65.4
Total petroleum hydrocarbons	mg/kg DW	26	73
Moisture Factor	nil	1.189	1.022
pH	pH	6.1	7.6
Sodium absorption ratio	None	2.14	0.63
Total soluble Salts	mg/kg	191	512

The Council soil samples for landfarmed areas demonstrate compliance with all of the limits stipulated in the conditions of consent 5325-1. The levels of hydrocarbons detected are low. This would suggest that the browning off of these areas is unlikely to be a result of the material farmed here in previous years, and may be attributable to the ponding of rainwater over parts of the site.

2.3.2.2 Origin supplied soil results 2011-2012

Origin supplied the results of one soil sample during the monitoring period, from the spreading area G24. The results are shown below in Table 3. The results from this sample complied with the conditions set out in the consent; including polycyclic aromatic hydrocarbons (PAH's) and volatile aromatic compounds (BTEX) results which were all below the limits of detection (Appendix II).

Table 3 Origin supplied soil results from the Geary site during the 2011 – 2012 monitoring period

Parameter	Unit	Consent Limit	Spreading Areas Sampled
			G24
Benzene	mg/kg	*1.1*	<0.02
Toluene	mg/kg	*68*	<0.02
Ethylbenzene	mg/kg	*53*	<0.02
m & p xylene	mg/kg	*48*	<0.02
o xylene	mg/kg	*48*	<0.02
Benzo(a)pyrene	mg/kg	*0.027*	<0.02
Napthalene	mg/kg	*7.2*	<0.01
Pyrene	mg/kg	*160*	<0.03
Hydrocarbon (TPH)	mg/kg	-	<50
C7 – C9	mg/kg	*120*	<7
C10 – C14	mg/kg	*58*	<10
C15 – C36	mg/kg	*4000*	<30
Arsenic	mg/kg	*20*	<2
Cadmium	mg/kg	*1*	<0.1
Chromium	mg/kg	*600*	9
Copper	mg/kg	*100*	12
Lead	mg/kg	*300*	9.2
Mercury	mg/kg	*1*	<0.1
Nickel	mg/kg	*60*	5
Zinc	mg/kg	*300*	37
Barium*	mg/kg	*(10,000)*	370
Chloride	mg/kg	*700*	10

Parameter	Unit	Consent Limit	Spreading Areas Sampled
Conductivity	mSm-1	*290*	<0.02
Sodium	mg/kg	*460*	370
Soluble salts	g/100g	*2500*	<0.05
Sodium absorption ratio	-	*18*	<0.05

*Alberta agricultural limit for barium, not a consent condition.

Previous sampling has shown that the majority of the site complied with the surrender criteria, with the exception being for sodium in several areas. This has led to discussion between Origin Energy and the Council regarding the appropriateness of the consent limit for this element.

Two soil remediation guidelines for barium have been developed by the Canadian authorities, one is for barium (CCME, 1999; CCME, 2006) and the other is for barite (AENV, 2009). The CCME guidelines are not applicable to barite as they were developed using literature on soluble barium salts. Soluble forms of barium have a very different fate, transport and toxicological behaviour than those of insoluble barite (BaSO4).

Barium occurs in drilling mud in the form of barium sulphate (barite) which is highly insoluble and therefore has low mobility through soil. The soil guidelines developed by Alberta Environment (AENV, 2009) are shown below in Table 4 and have been developed specifically for sites which are known to be contaminated with barite (barium sulphate), they are therefore applicable as guidelines for landfarms, nevertheless the Alberta guidelines state that before barite guidelines can be applied it is necessary to demonstrate:

1. Barium is still in an immobile/unavailable form; and
2. That the barium would not be expected to become mobile/available in the future.

Table 4 Soil guideline values for barium and barite

		LANDUSE				
		Natural Area (mg/kg)	Agricultural (mg/kg)	Residential/ Parkland (mg/kg)	Commercial (mg/kg)	Industrial (mg/kg)
A	Guideline for Extractable Barium	250	250	250	450	450
B	Guideline for True Total Barium at Barite Sites	10,000	10,000	10,000	15,000	140,000
C	Alberta Tier 1 Guideline for Barium at Non-Barite Sites	750	750	500	2,000	2,000

All samples taken from the Geary landfarm site fall within the agricultural guideline for true total barium at barite sites of 10,000mg/kg (Table 2; guideline B). This is deemed to be the most appropriate guideline for use at this site for the reasons outlined above. The consent surrender limit for sodium is 460 g/m^3 (no method specified). The units show that this value applies to an aqueous sample and not to soil (mg/kg).

The TRC "Guidelines for the control of disposal of drilling wastes onto and into land" in Appendix III, indicate that the consent limit is based on the irrigation water upper limit for moderately tolerant crops. Origin samples have been analysed for Total Recoverable Sodium, while TRC samples have been analysed for soluble sodium. Section 3.3.3 of the 2010-2011 annual report states that "Soluble sodium may be a more appropriate test to reflect potential adverse effects on the environment." Soluble sodium results are an order of magnitude below the consent limit. Background samples collected from Origin landfarms have returned results at or above the consent limit for total recoverable sodium.

Results for SAR (a measure of sodicity, the effect of sodium) are well below (more than 10 times lower than) the consent limit of 18.

2.3.2.3 Origin supplied soil results 2012-2013

Origin provided the results to the Council from six soil samples obtained during the 2012 – 2013 monitoring period. The results are shown below in Table 5.

Table 5 Origin supplied soil results from the Geary site during the 2012 – 2013 monitoring period

Parameter	Unit	Consent Limit	Spreading Areas Sampled					
			G9	G22	G23	G26	G36	G40
Benzene	mg/kg	*1.1*	<0.05	<0.03	<0.04	<0.02	<0.04	<0.04
Toluene	mg/kg	*68*	<0.05	<0.03	<0.04	<0.02	<0.04	<0.04
Ethylbenzene	mg/kg	*53*	<0.05	<0.03	<0.04	<0.02	<0.04	<0.04
m & p xylene	mg/kg	*48*	<0.10	<0.6	<0.08	<0.02	<0.07	<0.08
o xylene	mg/kg	*48*	<0.05	<0.03	<0.04	<0.02	<0.04	<0.04
Benzo(a)pyrene	mg/kg	*0.027*	<0.03	<0.02	<0.03	<0.03	<0.02	<0.03
Napthalene	mg/kg	*7.2*	<0.12	<0.1	<0.12	<0.13	<0.1	<0.13
Pyrene	mg/kg	*160*	<0.03	0.06	<0.03	<0.03	0.21	<0.03
Hydrocarbon	mg/kg	-	<50	1200	<60	140	<60	<60
C7 – C9	mg/kg	*120*	<7	<8	<7	<7	<7	<8
C10 – C14	mg/kg	*58*	<10	23	<10	<10	<10	<20
C15 – C36	mg/kg	***4000***	<30	1200	<30	140	<30	<30
Arsenic	mg/kg	*20*	<2	<2	<2	<2	<2	<2
Cadmium	mg/kg	*1*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/kg	*600*	14	13	13	13	14	17
Copper	mg/kg	*100*	12	10	12	21	12	23
Mercury	mg/kg	*1*	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	mg/kg	*60*	7	6	6	7	6	9
Lead	mg/kg	*300*	1.2	1.0	3	2.70	13.9	4
Zinc	mg/kg	*300*	68	61	58	59	50	66
Barium*	mg/kg	*(10,000)**	284	610	388	159	123	140
Chloride	mg/kg	*700*	9	20	23	5	9	22
Conductivity	mSm-1	*290*	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Sodium	mg/kg	*460*	420	440	410	440	390	280
Soluble salts	g/100g	*2500*	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sodium absorption ratio	-	*18*	0.5	0.9	1.7	0.90	0.50	0.70

*Alberta agricultural limit for barium, not a consent condition.

All parameters complied with the consent.

2.4 Evaluation of performance

A tabular summary of the Company's compliance record for the year under review is set out in Tables 6 and 7.

Table 6 Summary of performance for Consent 5325-1 to discharge: drilling mud, fluids and cuttings from well drilling operations with water based muds; drilling cuttings from wells drilled with synthetic based muds; and oily waste material from hydrocarbon exploration and production activities; onto and into land

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Comply with documentation submitted for application	No disposals during monitoring period	N/A
2. Prevent or minimise any likely adverse effects on the environment	Inspection	Yes
3. Notify TRC in writing prior to waste disposal	No disposals during monitoring period	N/A
4. Notify TRC prior to disposal of stockpiled waste	No disposals during monitoring period	N/A
5. Provide written notice and a chemical analysis for disposal of waste with greater than 5% hydrocarbon content	No disposals during monitoring period	N/A
6. Keep areas of disposal of water based drilling wastes separate from synthetic mud based drilling waste. Keep disposal areas for individual wells separate	No disposals during monitoring period	N/A
7. Maintain records of wastes for: a. each well b. stockpiling and disposal areas c. composition and volume of waste d. times of discharge e. treatments applied	No disposals during monitoring period	N/A
8. Limited to wastes generated within Taranaki	No disposals during monitoring period	N/A
9. No discharge within 25m of surface water or property boundaries, or within 6m of pipelines	No discharges during monitoring period	N/A
10. No destabilisation of neighbouring land	Site reinstated	Yes
11. Discharge depth limited to 150mm for waste with less than 5% hydrocarbons, or 50mm for waste with greater than 5% hydrocarbons	No discharges during monitoring period	N/A
12. If waste has greater than 5% hydrocarbons, incorporate waste into the soil so that the surface 250mm contains less than 5% hydrocarbons	No discharges during monitoring period	N/A

Condition requirement	Means of monitoring during period under review	Compliance achieved?
13. Electroconductivity must be less than 400 mSm^{-1}. If background soil has an electroconductivity of greater than 400 mSm^{-1}, then electroconductivity after disposal shall not exceed original electroconductivity by more than 100 mSm^{-1}	Sampling and records	Yes
14. Sodium absorption ratio [SAR] must be less than 18.0. If background soil has an SAR of greater than 18.0, then SAR after disposal shall not exceed original SAR by more than 1.0	Sampling and records	Yes
15. Maximum rate of chloride application after discharge must not exceed 800 kgCl/ha/yr	No discharges during monitoring period	N/A
16. Maximum rate of nitrogen application after discharge must not exceed 200 kgN/ha/yr	No discharges during monitoring period	N/A
17. Prior to expiry/cancellation of consent soil hydrocarbon content must comply with Ministry for the Environment guidelines	Sampling and records	Yes
18. Levels of metals must comply with Ministry of Health guidelines	Sampling and records	Yes
19. Total dissolved salts shall not exceed 2500 g/m^3	Sampling and records	Yes
20. Prior to expiry/cancellation of consent these levels must not be exceeded: a. conductivity, 290 mSm^{-1} b. dissolved salts, 2500 g/m^3 c. sodium, 460 g/m^3 d. chloride, 700 g/m^3	Council and Company soil samples	Yes
21. Discharge area shall be tilled and resown to pasture/crop as soon as possible after completion	No discharges during monitoring period. Pasture has been re-established.	N/A
22. Disposal of waste shall never lead to contamination of any surface water	Inspection - no effects noted	Yes
23. Disposal of waste shall never result in any adverse effects on ground or surface water	Inspection - no effects noted	Yes
24. Stockpiling limited to 5000 cubic metres and discharged within 2 months	No stockpiling or discharges during monitoring period	N/A
25. No offensive dust beyond the site boundary	Site reinstated	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
26. No offensive odour beyond the site boundary	Site reinstated	Yes
27. Optional review provision re environmental effects	No further options for review prior to expiry	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		**High**

Table 7 Summary of performance for Consent 6297-2 to discharge drilling cuttings and oily wastes from the Kauri-E well site drilled with oil based muds onto and into land via land farming (**EXPIRED 1-JUN-12)**

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Comply with documentation submitted for application	No discharges during monitoring period	N/A
2. Minimise adverse effects on the environment	Inspection	Yes
3. Consent applies only to the Kauri E4, E5 and E6 wells, no discharges after 1 June 2005	No discharges during monitoring period	N/A
4. Keep areas of disposal of water based drilling wastes separate from synthetic mud based drilling waste separate from oil based drilling waste separate from oily waste. Keep disposal areas for individual wells separate	No discharges during monitoring period	N/A
5. No stockpiling of cuttings drilled with oil based muds No discharge within 25 m of surface water or property boundaries	No stockpiling or discharges during monitoring period	N/A
6. No destabilisation of land	Site reinstated	Yes
7. Disposal of waste shall never lead to contamination of any surface water	Inspection - no effects noted	Yes
8. Disposal of waste shall never result in any adverse effects on groundwater	Inspection - no effects noted	Yes
9. Discharge shall not alter surface water in the way of films, foams or suspended materials, change colour or visibility, objectionable odour, or harm aquatic or farm animals	Inspection - no effects noted	Yes
10. Electroconductivity must be less than 400 mSm^{-1}. If background soil has an electroconductivity of greater than 400 mSm^{-1}, then electroconductivity after disposal shall not exceed original electroconductivity by more than 100 mSm^{-1}	Sampling and records	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
11. Sodium absorption ratio [SAR] must be less than 18.0. If background soil has an SAR of greater than 18.0, then SAR after disposal shall not exceed original SAR by more than 1.0	Sampling and records	Yes
12. Area used for disposal is limited to 25,000 m^2 per well Maximum rate of chloride application after discharge must not exceed 800 kgCl/ha/yr	No disposals during monitoring period	Yes
13. Maximum rate of nitrogen application after discharge must not exceed 200 kgN/ha/yr	No discharges during monitoring period	N/A
14. Levels of metals must comply with Ministry of Health guidelines	Sampling and records	Yes
15. Discharge of drill cuttings limited to a depth of 20 mm Total dissolved salts shall not exceed 2500 g/m^3	No discharges during monitoring period	N/A
16. Prior to expiry/cancellation of consent these levels must not be exceeded: a) conductivity, 290 mSm^{-1} b) dissolved salts, 2500 g/m^3 c) sodium, 460 g/m^3 d) chloride, 700 g/m^3	Sampling and records	Yes
17. Prior to expiry/cancellation of consent soil hydrocarbon content must comply with Ministry for the Environment guidelines	Sampling and records	Yes
18. Record all details, compositions, treatments and movements of waste material	Company records and sampling	N/A
19. Optional review provision re environmental effects	No further options for review prior to expiry	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		**High**

3. Schrider Landfarm

3.1 Site location

The Schrider Landfarm is located off Geary Road, Manutahi and adjoins the Geary Landfarm, as seen in figure 2. Schrider landfarm is located on marginal coastal farm land situated on reworked dune fields and also consists predominately of black loamy sand, with vegetation growth primarily consisting of pasture. Average annual rainfall for the site is 1043 mm (taken from the nearby 'Patea' monitoring station). As with the other South Taranaki coastal sites, the Schrider site is subject to strong winds.

Site data

Location

Word descriptor:	Lower Manurau Road, Manutahi, Taranaki
Map reference:	E 1719054
(NZTM)	N 5605073
Mean annual rainfall:	1043 mm
Mean annual soil temperature:	~15.1°C
Mean annual soil moisture:	~32.9%
Elevation:	~30 m
Geomorphic position:	Cliffed coast / dune backslope
Erosion / deposition:	Erosion
Vegetation:	Pasture, dune grasses
Parent material:	Aeolian deposit
Drainage class:	Free / well draining
Land use:	Grazing stock

Previously part of the site was used to dispose of cuttings from the Kauri F well. The site was initially used for the disposal of water based and synthetic based muds. Later, consent was granted for the disposal of oil based mud on a trial basis and then oily wastes were also included.

Disposals at the site were completed in March 2011 and the area has since been reinstated. No disposals occurred during the period under review.

Figure 2 Aerial photograph of Schrider Landfarm highlighting spreading areas and approximate regional location (inset)

3.2 Resource consent

Origin Energy holds discharge consent 6135-1 to discharge drilling cuttings and fluids from drilling operations with water based muds, drilling cuttings from wells drilled with synthetic based muds, drilling cuttings from wells drilled with oil based muds, and oily wastes, onto and into land via land farming. This consent was issued by the Taranaki Regional Council on 6 March 2003 to Swift Energy NZ Ltd, as a resource consent under Section 87(e) of the Resource Management Act. Changes to conditions were made on 19 March 2004, 16 April 2004, 10 June 2004, 23 June 2004, 9 August 2006 and 10 February 2010. The consent was transferred to Origin Energy on 11 April 2008 and is due to expire on 1 June 2022.

Conditions 1 and 2 concern definitions and adoption of the best practical option.

Conditions 3 to 5 relate to notification and sampling requirements prior to discharge.

Conditions 6 to 18 relate to discharge limits and operational requirements.

Conditions 19 to 29 relate to receiving environment limits.

Conditions 30 and 31 concern monitoring and reporting.

Conditions 32 and 33 provide for optional review of the consent.

The consent is attached to this report in Appendix I.

3.3 Results

3.3.1 Inspections

There were a total of three inspections of the Schrider site during the monitoring period, all of which were scheduled. Summaries of compliance inspections are provided below.

15 May 2012
There was a light westerly wind blowing on the day of the inspection. No recent mud storage activities had occurred and there were no objectionable odours detected. Historic application areas appeared stable and the pasture looked good. All ponded water throughout appeared free of hydrocarbon sheen and no muds could be identified within the soil profile. No follow-up action was required to be taken.

17 January 2013
No recent disposal had occurred and no mud pits were present. All pasture inspected appeared healthy and good coverage was present. No ponded water was observed and no muds were identified within the soil profile.

6 June 2013
No recent disposal had occurred and no mud pits were present. It was noted that fencing had also been reinstated in the pit area. All pasture inspected appeared healthy and no muds were identified within the soil profile. Ponded water around the lowest application area was free of hydrocarbon sheen and no hydrocarbon odours were noted.

Photograph 4 View across spreading areas H63/H64 from site visit on 15-May-12

3.3.2 Results of receiving environment monitoring

It was agreed that the regular programme of collecting soil samples from disposal areas would be suspended while the three year soil biology project was implemented, as it has a soil chemistry component. During the monitoring period, the soil biota programme was discontinued in favour of a complementary laboratory-based programme. In the following monitoring period it is recommended that standard soil sampling resumes.

A recommendation to this effect is given in Section 6.

Origin Energy collected eight soil samples over the monitoring period and provided the Council with the results of soil sampling. The results are shown below in Tables 8 and 9; further results are detailed in Appendix IV.

Table 8 Origin supplied soil results from the Schrider site during the 2011 – 2012 monitoring period

Parameter	Unit	Consent Limit	Spreading Areas Sampled			
			H33	H37	H38	H57
Benzene	mg/kg	*1.1*	<0.05	<0.03	<0.1	<0.05
Toluene	mg/kg	*68*	<0.05	<0.03	<0.1	<0.05
Ethylbenzene	mg/kg	*53*	<0.05	<0.03	<0.1	<0.05
m & p xylene	mg/kg	*48*	<0.1	<0.07	<0.1	<0.10
o xylene	mg/kg	*48*	<0.05	<0.03	<0.1	<0.05
Benzo(a)pyrene	mg/kg	*0.027*	<0.03	<0.02	<0.02	<0.02
Napthalene	mg/kg	*7.2*	<0.1	<0.1	<0.11	<0.12
Pyrene	mg/kg	*160*	<0.03	<0.02	0.33	<0.024
Hydrocarbon	mg/kg	*-*	<60	<50	<60	510
C7 – C9	mg/kg	*120*	<8	<7	<8	<8
C10 – C14	mg/kg	*58*	<20	<10	<20	25
C15 – C36	mg/kg	*4000*	<40	<30	<30	490
Arsenic	mg/kg	*20*	<0.2	<2	<2	<2
Cadmium	mg/kg	*1*	<0.1	<0.1	<0.1	<0.1
Chromium	mg/kg	*600*	16	15	20	19
Copper	mg/kg	*100*	10	12	15	15
Lead	mg/kg	*300*	0.9	1.3	4.0	1.4
Mercury	mg/kg	*1*	<0.1	<0.1	<0.1	<0.1
Nickel	mg/kg	*60*	7	8	9	9
Zinc	mg/kg	*300*	67	69	90	92
Barium*	mg/kg	*(10,000)*	30	234	270	470
Chloride	mg/kg	*700*	13	23	160	42
Conductivity	mSm-1	*290*	<0.02	<0.02	<0.02	<0.02
Sodium	mg/kg	*460*	370	370	360	320
Soluable salts	g/100g	*2500*	<0.05	<0.05	<0.05	<0.05
Sodium absorption ratio	-	*18*	1	0.6	1.80	3.1

*Alberta agricultural limit for barium, not a consent condition.

Table 9 Origin supplied soil results from the Schrider site during the 2011 – 2012 monitoring period

Parameter	Unit	Consent Limit	Spreading Areas Sampled			
			H62	H63	H64	H66
Benzene	mg/kg	*1.1*	<0.05	<0.05	<0.05	<0.05
Toluene	mg/kg	*68*	<0.05	<0.05	<0.05	<0.05
Ethylbenzene	mg/kg	*53*	<0.05	<0.05	<0.05	<0.05
m & p xylene	mg/kg	*48*	<0.10	<0.10	<0.10	<0.10
o xylene	mg/kg	*48*	<0.05	<0.05	<0.05	<0.05
Benzo(a)pyrene	mg/kg	*0.027*	<0.03	<0.03	<0.03	<0.03
Napthalene	mg/kg	*7.2*	<0.12	<0.12	<0.12	<0.12
Pyrene	mg/kg	*160*	<0.03	<0.03	<0.03	<0.03
Hydrocarbon	mg/kg	-	<70	100	<60	<70
C7 – C9	mg/kg	*120*	<8	<8	<8	<8
C10 – C14	mg/kg	*58*	<20	<20	<20	<20
C15 – C36	mg/kg	*4000*	<40	100	<40	<40
Arsenic	mg/kg	*20*	<2	4.1	2.9	<2
Cadmium	mg/kg	*1*	<0.10	0.26	<0.10	<0.10
Chromium	mg/kg	*600*	14	16	25	14
Copper	mg/kg	*100*	13	34	21	10
Lead	mg/kg	*300*	1.4	13	16	1
Mercury	mg/kg	*1*	<0.10	<0.10	<0.10	<0.10
Nickel	mg/kg	*60*	6	19	22	6
Zinc	mg/kg	*300*	57	57	64	59
Barium*	mg/kg	*(10,000)*	56	690	35	57
Chloride	mg/kg	*700*	9	<3	1.1	6
Conductivity	mSm-1	*290*	<0.2	1.3	1.1	<0.2
Sodium	mg/kg	*460*	360	400	310	-
Soluable Salts	g/100g	*2500*	<0.05	0.46	0.39	<0.05
Sodium absorption ratio	-	*18*	1.2	0.6	0.7	1.2

*Alberta agricultural limit for barium, not a consent condition.

It is noted that previous background samples had sodium concentrations at, and above, the consent limit (which has effect only at time of expiry - 2022). While the consent does not stipulate a method to be used, samples were analysed for total recoverable sodium. Soluble sodium may be a more appropriate test to reflect potential adverse effects on the environment. Results for soluble sodium would be much lower than for total recoverable sodium. All sodium results meet the required consent conditions in any case.

There is no consent condition relating to barium but it is a contaminant of concern. The Canadian Environmental Quality Guideline interim soil quality criteria for agricultural land use of 750 mg/kg, was previously considered the most appropriate reference. However this guideline has been effectively superseded by the Alberta guidelines detailed in Table 4. All of the samples to date have been compliant with the Alberta guidelines.

3.4 Evaluation of performance

A tabular summary of the Company's compliance record for the year under review is set out in Table 10.

Table 10 Summary of performance for Consent 6135-1 to discharge drilling cuttings and fluids from drilling operations with water based muds, drilling cuttings from wells drilled with synthetic based muds, drilling cuttings from wells drilled with oil based muds, and oily wastes, onto and into land via land farming

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Definitions	Not applicable	N/A
2. Adoption of best practicable option	Inspection and sampling	Yes
3. Notify TRC 48 hrs prior stockpiling	No disposals during monitoring period under review	N/A
4. Notify TRC 48 hrs prior to landfarming	No disposals during monitoring period under review	N/A
5. Provide specified data for OBM disposals	Provision of data - no OBM disposals	N/A
6. Rate of discharge/application depths	Inspection, sampling and Company records	Yes
7. Incorporate wastes ASAP so that hydrocarbon content in top 250mm is: a) < 5 % for WBM & SBM b) < 1.5 % for oily wastes & OBM	Sampling	Yes
8. Resow into pasture ASAP	Inspection	Yes
9. Wastes from individual wells to be kept separate & distinct	Inspection and Company records	Yes
10. Oily waste & OBM's to be kept separate & distinct	Inspection and Company records	Yes
11. No discharge near surface water, boundaries or pipelines	Inspection	Yes
12. Wastes restricted to Taranaki Region	Inspection and Company records	Yes
13. Max stockpiled volume of 2,000 m^3 & must be discharged within 8 mths	Inspection and Company records	Yes
14. No stockpiling of oily wastes or OBM's	Inspection and Company records	Yes
15. OBM only from certain wells	No OBM disposals	N/A
16. Limited area for disposal of OBM	No OBM disposals	N/A
17. Limit on nitrogen application rates	No disposals during monitoring period	N/A
18. No destabilisation of neighbouring land	Inspection	Yes
19. Electroconductivity limits	Sampling	Yes
20. Sodium absorption ratio limits	Sampling	Yes
21. Limits on concentration of metals	Sampling	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
22. Hydrocarbon levels prior to expiry	Sampling	N/A
23. Conductivity, TDS, sodium and chloride limits prior to expiry	Sampling	N/A
24. Level of total dissolved salts in surface and groundwater	Sampling – surface water not sampled, groundwater not assessed.	Not tested during period under review
25. No contamination of surface water bodies	No surface water	N/A
26. No impacts upon groundwater or surface water	Sampling	Not tested during period under review
27. No effects on surface water	No surface water	N/A
28. Limits on dust generation	Inspection	Yes
29. No offensive or objectionable odour	Inspection and complaint register	Yes
30. Monitoring requirements	Provision of data	Yes
31. Post application analysis for OBM's	Provision of results – no OBM disposals	N/A
32. Consent review		N/A
33. Consent review	Next option for review in June 2016	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		**High**

4. Spence Road Landfarm

4.1 Site location

The Spence Road (Kauri C) Landfarm is located on Spence Road, Kakaramea and is shown in Figures 3. As with other South Taranaki coastal sites, Spence Road landfarm is located on marginal coastal farm land amongst reworked dune fields, and consists predominately of black loamy sand. Average annual rainfall for this site is 1043 mm (taken from the nearby 'Patea' monitoring station) and is subject to strong winds.

Site data

Location	
Word descriptor:	Spence Road, Kakaramea, Taranaki
Map reference:	E 1722014
(NZTM)	N 5601830
Mean annual rainfall:	1043 mm
Mean annual soil temperature:	~15.1°C
Mean annual soil moisture:	~32.9%
Elevation:	~40 m
Geomorphic position:	Backslope
Erosion / deposition:	Erosion
Vegetation:	Pasture, dune grasses
Parent material:	Aeolian deposit
Drainage class:	Free / well draining
Land use:	Grazing stock

Previously part of the site was used to dispose of cuttings from the Kauri C well, however during the monitoring period Spence Road landfarm was intermittently used for small quantities of material from other alternate sources.

Figure 3 Aerial photograph of Spence Road Landfarm highlighting spreading areas and approximate regional location (inset)

4.2 Resource consent

Origin Energy holds discharge permit **5935-1**, to discharge waste drilling cuttings, muds and fluids from wells drilled with water based muds, waste drilling cuttings from wells drilled with synthetic based muds and oily wastes, from hydrocarbon exploration and production operations onto and into land. This permit was issued to Swift Energy NZ Ltd by the Taranaki Regional Council on 7 December 2001, as a resource consent under Section 87(e) of the Resource Management Act. It was varied on 16 April 2004, 30 September 2008 and 10 February 2010. It was transferred to Origin Energy on 11 April 2008 and is due to expire on 1 June 2016.

Resource consent 5935-1 provides for an optional review of the consent in June 2012. A recommendation was made in the 2010-11 Annual Report that this option would not be exercised on the grounds that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of the consents.

Origin Energy applied to vary the consent on 3 February 2012. The variation requested that condition 12 be deleted. This condition required that oily wastes are kept separate from other waste types (SBM and WBM). As volumes of oily waste are typically small (less than $10m^3$) Origin Energy considered it uneconomic to landfarm such small volumes and requested that the condition be removed. The variation also requested that condition 13 be amended to allow for the time period for stock piling

wastes on site to be extended from eight months to twelve months. The consent was varied on 7 March 2012.

Conditions 1 and 2 set out definitions and a requirement for adoption of the best practicable option.

Conditions 3 to 6 set out the requirements for a management plan, notifications, monitoring and reporting.

Conditions 7 and 8 specify discharge limits.

Conditions 9 to 13 are operational requirements.

Conditions 14 to 17 relate to effects on groundwater and surface water.

Conditions 18 to 22 set limits on certain parameters in the soil.

Condition 23 allows for an optional review.

The permit is attached to this report in Appendix I.

4.3 Results

4.3.1 Inspections

There were a total of seven scheduled inspections of the Spence Road site during the monitoring period. Summaries of compliance inspections are provided below.

28 July 2011

At the time of inspection a light breeze was occurring from the south west and no objectionable or visible emissions were noted. Only three pits were left at the site, two of which appeared free of muds, and the third contained oils and a turbid orange/brown liquid with plenty of free-board still available. Extensive re-contouring works had been undertaken around the areas where muds had been applied and incorporated into the soil matrix, which looked very good. Patches of muds were sighted on the surface in only two locations and the lumps were very small, none of which was found within the soil profile when excavation occurred. Ponded water located around the excavated area was free of surface sheen and pasture was to be resown. Very little dust was being generated by the wind on the exposed area. Works were being continued on the boom irrigator.

24 November 2011

A strong westerly breeze was present upon inspection and no objectionable odours were noted. Downwind of the third (and newest) oily waste pit, a very strong hydrocarbon odour was noted. This pit is unlined and no tideline was observed which is indicative that the contents were remaining within the pit. All the other pits containing drilling muds were secure and no further odours were present. Application and contouring works had been completed and blending/incorporation of the muds into the soil had been achieved as the resown pasture appeared healthy. A boom irrigator had been installed at the site. Limited signage for only one pit at the storage area was also noted.

15 May 2012
A light westerly breeze was present at the time of inspection and no objectionable odours were noted. All muds were secure within their pits with clear signage present and the integrity of the pits looked good. Historical application areas were inspected. Pasture appeared stable and no muds were identified within the soil profile. Waste oil tanks were observed to have plenty of free-board.

19 June 2012
At the time of inspection a light breeze was present from the north and no objectionable odours or emissions were detected. All pits were essentially emptied of muds and the oily wastes tank integrity appeared good with plenty of free-board available. All historical application areas showed good pasture growth and all vegetation appeared healthy with drilling mud well incorporated into the soil matrix. Signage throughout the site was excellent.

17 January 2013
A light westerly breeze was present at the time of inspection and no objectionable odours were detected. However, strong hydrocarbon odours were noted around the location of the oil waste tank, which had plenty of freeboard still available. Hydrocarbon odours were also detectable around a pile of contaminated soil adjacent to mix pit 1. Pits 1-3 are unlined and all featured a small volume of turbid liquid inside, essentially no mud was located within the pits. Inspected areas where muds had been applied had good pasture established throughout.

2 April 2013
Localised hydrocarbon odours were noted in the direct proximity of the storage area. No recent disposal had occurred at the site and all unlined pits were free of material. All test pits featured very little drilling mud identifiable within the soil profile and all pasture inspected appeared healthy. The D-bin (metal tank for temporary storage) was found to have plenty of free-board.

6 June 2013
No recent storage or disposal activities had occurred at the site. All mud pits were free of muds and only clear stormwater in the bottom of each pit was present. The oily waste bin had plenty of freeboard available and hydrocarbon odours remained localised. All pasture inspected where muds had previously been applied appeared healthy. No mud was identified within the soil profile and no hydrocarbon odours were noted.

4.3.2 Results of discharge monitoring

One area was landfarmed during the monitoring period. Details are shown in Table 11. The area landfarmed is shown in Appendix V.

Table 11 Summary of discharges at the Spence Road Landfarm

Date	Area	Waste description	Source	Volume (m^3)	Area (m^2)	Application depth (mm)	Hydrocarbons (mg/kg)
January 2012	S31	Water based mud	Manutahi D 2/3/4	250	3,032	100	9,000

The disposal area complied with the application depth limits.

4.3.3 Results of receiving environment monitoring

4.3.3.1 TRC soil results

Five composite soil samples were collected on two separate occasions by sub-sampling to a depth of 250mm in landfarmed areas. The results of this sampling are presented in Table 12.

Table 12 Results of Council soil sampling at Spence Road during the 2011 - 2013 monitoring period

Parameter	Unit	Date & Spreading area					
		30 Jun 11 *S29*	27 Mar 12 *S29*	10 Jun 13 *S27/S28*	10 Jun 13 *S20*	10 Jun 13 *S31*	10 Jun 13 *S26*
Chloride	Mg/kg DW	16.7	21	12.9	8.8	17.9	7.6
Conductivity	mS/m	37.8	-	16.9	15.2	28.3	13.8
Hydrocarbons	Mg/kg DW	<4	37	23	<3	<3	<3
Moisture Factor	-	1.013	-	1.017	1.018	1.014	1.012
pH	pH	8.1	7.1	6.5	6.4	6.6	6.4
Sodium absorption ratio	-	-	-	1.76	1.95	1.35	1.52
Total soluble salts	Mg/kg	296	193	132.3	119	221.5	108.0

4.3.3.2 Origin supplied soil results 2011-2012

Origin Energy collected four soil samples over the 2011-2012 monitoring period and provided the Council with the results of soil sampling. The results are shown below in Table 13. Compliance with the analytical consent limits, for each disposal area for the 2011-2012 monitoring period, is shown in Appendix VI. The most recent results listed for each parameter are the most relevant, given that concentrations in the soil will typically reduce over time.

Table 13 Origin supplied soil results from the Spence Road site during the 2011 – 2012 monitoring period

Parameter	Unit	Consent Limit	Spreading areas sampled			
			S24/25	S27/28	S29	S31
Benzene	mg/kg	*1.1*	<0.05	<0.05	<0.05	<0.05
Toluene	mg/kg	*68*	<0.05	<0.05	<0.05	<0.05
Ethylbenzene	mg/kg	*53*	<0.05	<0.05	<0.05	<0.05

Parameter	Unit	Consent Limit	Spreading areas sampled			
m & p xylene	mg/kg	*48*	<0.10	<0.10	<0.10	<0.10
o xylene	mg/kg	*48*	<0.05	<0.05	<0.05	<0.05
Benzo(a)pyrene	mg/kg	*0.027*	<0.03	<0.03	<0.03	<0.03
Napthalene	mg/kg	*7.2*	<0.13	<0.12	<0.12	<0.12
Pyrene	mg/kg	*160*	<0.03	<0.03	<0.03	<0.03
Hydrocarbon	mg/kg	-	<70	<70	<70	<70
C7 – C9	mg/kg	*120*	<8	<8	<8	<8
C10 – C14	mg/kg	*58*	<20	<20	<20	<20
C15 – C36	mg/kg	*4000*	<40	<40	<40	<40
Arsenic	mg/kg	*20*	<2	<2	<2	<2
Cadmium	mg/kg	*1*	<0.10	<0.10	<0.10	<0.10
Chromium	mg/kg	*600*	11	12	13	13
Copper	mg/kg	*100*	11	14	11	11
Lead	mg/kg	*300*	1.8	2.1	1.1	1.1
Mercury	mg/kg	*1*	<0.10	<0.10	<0.10	<0.10
Nickel	mg/kg	*60*	6.0	6.0	6	7
Zinc	mg/kg	*300*	47.0	57	58	59
Barium*	mg/kg	*(10,000)*	93	450	49	17
Chloride	mg/kg	*700*	2	22	22	11
Conductivity	mSm-1	*290*	<0.2	<0.2	<0.2	<0.2
Sodium	mg/kg	*460*	28	350	320	250
Soluable salts	g/100g	*2500*	<0.05	<0.05	<0.05	<0.05
Sodium absorption ratio	-	*18*	0.9	1.1	1.5	1.1

*Alberta agricultural limit for barium, not a consent condition.

Most disposal areas comply with the limits specified in the consent. While compliant with application criteria, site S31 exceeded the surrender criteria limits for recoverable hydrocarbons C10 to C14 and hydrocarbons C 15-C36, as shown in Table 14 below, however subsequent sampling of the area in June 2012 showed the area to be compliant with all consent limits (including surrender criteria limits).

Table 14 Exceedence of surrender criteria limits for consent 5935-1

Parameter	Consent Limit	Monitoring Result
Hydrocarbons C10 – C14	58 mg/kg dry wt	2,300
Hydrocarbons C15 – C36	4,000 mg/kg dry wt	6,700

Photograph 5 View across Spence Road Landfarm on 01 July 2011

Photograph 6 View NW across S24/25b at Spence Road Landfarm on 27 July 2011

4.4 Evaluation of performance

A tabular summary of the Company's compliance record for the year under review is set out in Table 15.

Table 15 Summary of performance for Consent 5935-1 To discharge waste drilling cuttings, muds and fluids from wells drilled with water based muds and waste drilling cuttings from wells drilled with synthetic based muds from hydrocarbon exploration and production operations onto and into land

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Definitions	Not applicable	N/A
2. Best practicable option to be adopted	Inspections and liaison with consent holder	Yes
3. Management plan	Site management information provided	Yes
4. Notification of Council prior to any discharge	Notification received	Yes
5. Notification of Council prior to discharging stockpiled material	Notification received	Yes
6. Records to be kept and made available to Council	Consent holder's records	Yes
7. Limit on application depth of waste	Inspection and consent holder's records	Yes
8. Incorporation of wastes	Inspection and sampling	Yes
9. Buffer distances	Inspection	Yes
10. Only wastes generated in Taranaki to be disposed of	Consent holder's records	Yes
11. Discharge not to cause destabilisation of neighbouring land	Inspection	Yes
12. Stockpiling and disposal areas for oily wastes to be kept separate	Inspection and consent holder's records	Yes
13. Material to be incorporated within 8 months	Inspection and consent holder's records	Yes
14. Discharge area to be tilled and resown as soon as practicable after discharge	Inspection	Yes
15. No contaminants to enter a surface water body	Inspection	Yes
16. There are to be no adverse effects on groundwater or surface water	Inspection - no surface water, groundwater not assessed	Yes
17. Discharge not to give rise to certain effects in receiving waters	Inspection	Yes
18. Limit on level of total dissolved salts in surface or groundwater	Not assessed	N/A

Condition requirement	Means of monitoring during period under review	Compliance achieved?
19. Limit on electroconductivity of soil/waste layer post application	Sampling	Yes
20. Limit on sodium absorption ratio of soil/waste layer post application	Sampling	Yes
21. Limits on levels of metals in soil	Sampling	Yes
22. Limits on levels of certain parameters in soil prior to expiry/surrender	Not applicable	N/A
23. Limit on levels of hydrocarbons in soil prior to expiry/surrender	Not applicable	N/A
24. Provision for review	Not exercised	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		**High**

The Company demonstrated an overall 'high' level of environmental performance and consent compliance for the Spence landfarm site during the monitoring period. It should be noted, however, that activity at the site over the past few years has been limited to a few small disposals.

During the monitoring period, the Council informed the Company that any storage pits intended for future use would require lining prior to the resumption of use, and equally that groundwater monitoring would be required should the Company decide to continue activity at the site.

The Company agreed to these requirements and were professional in all interactions with the Council.

5. Discussion

5.1 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 each year matters may arise which require additional activity by the Council e.g. 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 monitoring period, there were no incidents recorded by the Council that were associated with the Origin Energy operated landfarms.

5.2 Discussion of site performance

Disposals at the Geary Landfarm were completed in 2006 and disposals at the Schrider landfarm were completed in 2011. Spence Road Landfarm is now the only operating site. Four areas were landfarmed during the monitoring period. Inspections did not identify any issues of concern and the sites were well managed. Notifications were made to the Council regarding the transfer of wastes to site and landfarming activities. The Company continued to collect soil samples from disposal areas and provide the results to Council.

5.3 Environmental effects of exercise of consents

Disposal area soil sampling conducted by both the Company and the Council indicates compliance with the consent conditions. There are no surface water bodies in the immediate vicinity of disposal areas at the sites. Due to the location of the sites and the significant distance to any neighbours no air monitoring was undertaken as effects are known to be minimal.

5.4 Evaluation of performance

Tabular summaries of the consent holder's compliance record for the period under review are set out in the relevant section for each site.

During the period, the Company demonstrated a high level of environmental performance and compliance with the resource consents.

5.5 Recommendations from the 2010-2011 Annual Report

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

1. THAT the monitoring programme for consented activities at the Geary Landfarm in 2011-2012, remain unchanged from that for 2010-2011.

2. THAT the monitoring programme for consented activities at the Schrider Landfarm in 2011-2012, remain unchanged from that for 2010-2011.

3. THAT the monitoring programme for consented activities at the Spence Road Landfarm in the 2011-2012, remain unchanged from that for 2010-2011.

4. THAT the option for a review of resource consent 5935-1 in June 2012, as set out in condition 24 of the consent, not be exercised, on the grounds that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of the consents.

These recommendations were implemented.

5.6 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 monitoring programme for the Geary site remains unchanged from that for 2011-2013.

It is proposed that the monitoring programme for the Schrider site is modified to include the resumption of standard soil sampling of spreading areas.

It is proposed that, should activity resume at the Spence site, the monitoring programme be modified to include a groundwater component.

Recommendations to this effect are included in this report.

6. Recommendations

1. THAT the monitoring programme for consented activities at the Geary Landfarm in 2013-2014, remain unchanged from that for 2011-2013.

2. THAT the monitoring programme for consented activities at the Schrider Landfarm in 2013-2014, is modified from that for 2011-2012, with the resumption of standard soil sampling.

3. THAT the monitoring programme for consented activities at the Spence Road Landfarm in the 2013-2014, remain unchanged from that for 2011-2012, unless activity resumes at the site, at which time groundwater sampling should be implemented.

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^3s^{-1})
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	moncyclic aromatic hydrocarbons, molecules consist of a single six-sided hydrocarbon ring
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 watse
PAHs	polycyclic aromatic hydrocarbons, molecules consist of more than two 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
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 Origin Energy Resources NZ Ltd & AR Geary

TRK985325

TARANAKI REGIONAL COUNCIL

PRIVATE BAG 713
47 CLOTEN ROAD
STRATFORD
NEW ZEALAND
PHONE 0-6-765 7127
FAX 0-6-765 5097

DISCHARGE PERMIT

Pursuant to the RESOURCE MANAGEMENT ACT 1991 a resource consent is hereby granted by the Taranaki Regional Council

Name of Consent Holder:	GEARY ROBERT A & SYLVIA M GEARY ROAD, MANUTAHI, RD2, PATEA
Consent Granted Date:	28 May 1998

CONDITIONS OF CONSENT

Consent Granted:	TO DISCHARGE UP TO 40 CUBIC METRES/DAY OF DRILL CUTTINGS AND FLUIDS FROM OIL WELL DRILLING OPERATIONS AND GREEN REFUSE FROM A WASTE TRANSFER STATION ONTO AND INTO LAND IN THE VICINITY OF THE WAIKAIKAI STREAM AT OR ABOUT GR: Q21:288-681
Expiry Date:	1 June 2016
Review Date[s]:	June 2004 and June 2010
Site Location:	GEARY ROAD, MANUTAHI, PATEA
Legal Description:	LOT 2 DP5346 PT SEC 485 LOT 1, 9, 10, 13 DP14551 PATEA DIST BLK I CARLYLE SD
Catchment:	WAIKAIKAI 346.000

For General, Standard and Special Conditions pertaining to this consent please see reverse side of this document.

TRK985325

GENERAL CONDITIONS

(a) The consent holder shall provide on request by the General Manager, Taranaki Regional Council, plans, specifications and maintenance programmes of works associated with the exercise of the consent, showing that the conditions of the consent are able to be met.

(b) The standards, techniques and frequency of monitoring of the consent shall be to the specific approval of the General Manager, Taranaki Regional Council.

(c) The consent holder shall pay all charges required by the General Manager, Taranaki Regional Council, to enable recovery of the actual and reasonable costs incurred in administration, monitoring and supervision of the consent.

Special conditions

1. THAT the consent holder shall ensure that disposal of the cuttings and green refuse takes place in accordance with the information submitted in support of application 341.

2. THAT no waste materials other than green refuse and drill cuttings shall be included in the discharge.

3. THAT the consent holder shall keep records of volumes of cuttings and green refuse, and the method of disposal utilised, and shall make the records available to the Taranaki Regional Council upon request.

4. THAT the exercise of this consent, including the design, management and implementation of the system, shall not lead or be liable to lead to contaminants entering a surface waterbody.

5. THAT no adverse ecological or chemical effects shall occur to groundwater in the vicinity of the discharge, as a result of the exercise of this consent.

6. THAT the Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review during the month of June 2004 and/or June 2010, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects of the discharge on the environment arising from the exercise of this consent, which were not foreseen at the time the application was considered and which it was not appropriate to deal with at that time.

Signed at Stratford on 28 May 1998

For and on behalf of
TARANAKI REGIONAL COUNCIL

DIRECTOR - RESOURCE MANAGEMENT

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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:	Origin Energy Resources NZ [Rimu] Limited Private Bag 2022 NEW PLYMOUTH 4342
Decision Date (Change):	7 March 2012
Commencement Date (Change):	7 March 2012 (Granted: 7 December 2001)

Conditions of Consent

Consent Granted:	To discharge waste drilling cuttings, muds and fluids from wells drilled with water based muds, waste drilling cuttings from wells drilled with synthetic based muds and oily wastes, from hydrocarbon exploration and production operations onto and into land at or about (NZTM) 1722014E-5601830N
Expiry Date:	1 June 2016
Review Date(s):	June 2012
Site Location:	Kauri-C wellsite, Spence Road, Kakaramea (Property owner: G & W Vanner)
Legal Description:	Sec 486 Pt Sec 461 Sbdn 4 of Sec 637 Blk II Carlyle SD (Discharge site)
Catchment:	Kaikura

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) stockpiling means a discharge of drilling wastes from vehicles, tanks, or other containers onto land, but without subsequently spreading, or incorporating the discharged material into the soil within 24 hours; 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 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.

Management plan, notification, monitoring and reporting

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

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

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.

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.

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 in the soil/waste mix is less than:

   a) 50,000 mg/kg dry weight , anywhere in the 250 mm layer below the topsoil layer, for water based drilling wastes and drilling cuttings from wells drilled with synthetic based muds; or
   b) 15,000 mg/kg dry weight, anywhere in the 250 mm layer below the topsoil layer, for oily wastes, or drilling cuttings from wells drilled with oil based muds.

Operational requirements

9. No discharge shall take place within 25 metres of surface water or property boundaries, or within 6 horizontal metres of the existing gas pipelines.

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

11. The exercise of this consent shall not result in the destabilisation of neighbouring land.

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, including the design, management and implementation of the discharge, shall not lead or be liable to lead to contaminants entering a surface water body.

15. The exercise of the resource consent shall not result in any adverse impacts to groundwater as a result of leaching, and 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.

16. The discharge shall not give rise to any of the following effects in the adjacent surface water body of the Kaikura Stream:

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

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

Receiving environment limits - soil

18. The conductivity of the soil/waste layer after application 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 within the upper 20 cm by more than 100 mSm^{-1}.

19. The sodium absorption ratio [SAR] of the soil/waste layer after application 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.

20. 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 Ministry for the Environment and New Zealand Water & Wastes Assoication's Guidelines for the safe application of biosolids to land in New Zealand [2003].

21. At the time of expiry, cancellation, or surrender of this consent soil levels shall not exceed the following limits: conductivity, 290 mSm^{-1}; total soluble salts, 2500 mg/kg; sodium, 460 mg/kg; and chloride, 700 mg/kg.

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].

Review

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 2010 and/or June 2012, 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 7 March 2012

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Consent 6135-1

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Discharge Permit

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

Name of Consent Holder:	Origin Energy Resources NZ [Rimu] Limited Private Bag 2022 NEW PLYMOUTH 4342
Change To Conditions Date:	10 February 2010 [Granted: 6 March 2003]

Conditions of Consent

Consent Granted:	To discharge drilling cuttings and fluids from drilling operations with water based muds, drilling cuttings from wells drilled with synthetic based muds, drilling cuttings from wells drilled with oil based muds, and oily wastes, onto and into land via land farming at or about (NZTM) 1719054E-5605073N
Expiry Date:	1 June 2022
Review Date(s):	June 2010, June 2012, June 2016
Site Location:	Kauri-F wellsite, Corner of Lower Manutahi Road and Lower Taumaha Road [both unformed], Manutahi [Property owners: N Schrider & P Campbell]
Legal Description:	Road Reserve & Lot 3 DP 14551 & Lot 8 DP 14552 Blk I Carlyle SD
Catchment:	Waikaikai

For General, Standard and Special conditions pertaining to this consent please see reverse side of this document

General condition

a. The consent holder shall pay to the Taranaki Regional Council [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 the discharged material into the soil within 24 hours; 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.

Notification and sampling requirements prior to discharge

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; and
   d) the volume of waste to be stockpiled.

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. 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;
   f) for oily wastes the concentration of total petroleum hydrocarbons [C6-C9, C10-C14, and C15-C36], polycyclic aromatic hydrocarbons [PAH], and benzene, toluene, ethylbenzene and xylenes [BTEX]; and
   g) the specific location and area over which the waste will be landfarmed.

5. Prior to discharge/disposal of drilling cuttings from wells drilled with oil based muds from any well, the consent holder shall provide the Chief Executive, Taranaki Regional Council:

   a) information on location of discharge area;
   b) records of all additives used during the drilling process;
   c) a representative chemical analysis of the material to be discharged from each well [from a composite sample, including: concentrations of nitrogen, chloride, pH, K, Ca, Mg, Na, total petroleum hydrocarbon [TPH] composition in the ranges C_6-C_9, C_{10}-C_{14} and C_{15}-C_{36}, polynuclear aromatic hydrocarbon [PAH] composition, density, and BTEX]; and
   d) results of leachate testing.

Discharge Limits

6. 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;
   c) 20 mm thick for drilling cuttings from wells drilled with oil based muds [once mixed 1:1 with an absorbent material such as sawdust] regardless of the hydrocarbon concentration; and
   d) in a rate and manner such that no ponded liquids remain after one hour, for all wastes;

   prior to incorporation into the soil.

7. As soon as practicable following the application of drilling wastes to land in accordance with condition 6 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 in the soil/waste mix is less than:

   a) 50,000 mg/kg dry weight , anywhere in the 250 mm layer below the topsoil layer, for water based drilling wastes and drilling cuttings from wells drilled with synthetic based muds; or
   b) 15,000 mg/kg dry weight, anywhere in the 250 mm layer below the topsoil layer, for oily wastes, or drilling cuttings from wells drilled with oil based muds.

Operational requirements

8. 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.

9. The consent holder shall ensure that areas used for the stockpiling and disposal of water based drilling wastes are kept separate and distinct from areas utilised for the stockpiling and disposal of cuttings from wells drilled with synthetic based muds. Further, stockpile and disposal areas for individual wells shall also be kept separate and distinct. For the purpose of this consent condition 'disposal' means spreading, tilling or layering.

10. The consent holder shall ensure that areas for the disposal of oily wastes and drilling cuttings from wells drilled with oil based muds are kept separate and distinct, with either a buffer or bunding, from areas utilised for the stockpiling and disposal of wastes from wells drilled with water based mud and/or cuttings from wells drilled with synthetic based muds.

11. No discharge shall take place within 25 metres of surface water or property boundaries [with the exception of the northwest property boundary where discharge may take place right up to that boundary], or within 6 horizontal metres of the existing gas pipelines.

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

13. The stockpiling of material authorised by this consent shall be limited to a maximum volume of 2000 cubic metres 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.

14. There shall be no stockpiling of oily wastes, or drilling cuttings from wells drilled with oil based muds.

15. The discharge of drilling cuttings from wells drilled with oil based muds, is limited, in the first instance, to wastes generated at the Manutahi-A, Manutahi-B, Manutahi-C, Manutahi-D, Manutahi-G, and Kauri-C wellsites. The discharge of wastes from other wells drilled with oil based muds shall not be allowed until such time that the Chief Executive, Taranaki Regional Council, has received all information required under special conditions 5 and 30, and considered the need for a review under special condition 31.

16. The area used for disposal of drilling cuttings from wells drilled with oil based muds is limited to 10,000 square metres per well.

17. The maximum rate of nitrogen application [excluding stockpiling] shall not exceed 200 kg/ha.

18. The exercise of this consent shall not result in the destabilisation of neighbouring land.

Receiving environment limits - soil

19. The conductivity of the soil/waste layer after landfarming 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}.

20. The sodium absorption ratio [SAR] of the soil/waste 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.

21. 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 Ministry for the Environment and New Zealand Water & Wastes Assoication's Guidelines for the Disposal for the safe application of biosolids to land in New Zealand [2003].

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 levels shall not exceed the following limits: conductivity, 290 mSm^{-1}; total soluble salts, 2500 mg/kg; sodium, 460 mg/kg; and chloride, mg/kg.

Receiving environment limits - water

24. 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}.

25. 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 by direct surface overland flow.

26. 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.

27. 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.

Receiving environment limits - air

28. The discharges authorised by this consent shall not give rise to suspended or deposited dust at or beyond the boundary of the site that, in the opinion of at least one enforcement officer of the Taranaki Regional Council, is offensive or objectionable. For the purpose of this condition, discharges in excess of the following limits are deemed to be offensive or objectionable:

    a) dust deposition rate 0.13 $g/m^2/day$; and/or
    b) suspended dust level 0.15 mg/m^3.

29. The discharges authorised by this consent shall not give rise to an odour at or beyond the boundary of the site that, in the opinion of at least one enforcement officer of the Taranaki Regional Council, is offensive or objectionable.

Monitoring and reporting

30. 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]. For oily wastes, records shall include source, date collected, waste description and volume;
b) stockpiling area[s];
c) landfarming area[s], including a map showing individual disposal areas with GPS co-ordinates;
d) composition of material [including concentrations of nitrogen, chloride and total hydrocarbons];
e) PAH composition of oily wastes, and drilling cuttings from each well drilled with oil based muds;
f) volumes of material stockpiled;
g) volumes and weights of material landfarmed;
h) dates of commencement and completion of stockpiling and landfarming;
i) dates of sowing landfarmed areas;
j) treatments applied;
k) 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, upon request.

31. The consent holder shall collect and analyse a composite representative sample of the surface soil-waste layer [to a depth of 250 mm] on three occasions after the application drilling cuttings from wells drilled with oil based muds to land. The analysis shall include the analyses listed in condition 6. The three occasions shall be:

a) within one month of the discharge;
b) after three months, but before four months of the discharge; and
c) after six months but before eight months of the discharge.

The results of these analyses shall be provided to the Council within nine months of the exercise of this consent in respect of the disposal of oil based muds, cuttings and wastes from any one well.

Review

32. 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 consent, including the exclusion of drilling cuttings from wells drilled with oil based muds, by giving notice of review within three months of the receipt of any information required under condition 30.

33. 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 2010 and/or June 2012 and/or June 2016, 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 10 February 2010

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Consent 6297-1

TARANAKI REGIONAL COUNCIL

CHIEF EXECUTIVE
PRIVATE BAG 713
47 CLOTEN ROAD
STRATFORD
NEW ZEALAND
PHONE 06-765 7127
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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:	AR Geary Geary Road R D 2 PATEA
Consent Granted Date:	18 March 2004

Conditions of Consent

Consent Granted:	To discharge drilling cuttings from the Kauri-E4 well drilled with oil based muds onto and into land at or about GR: Q21:288-681
Expiry Date:	1 June 2005
Site Location:	Geary Road, Manutahi, Patea
Legal Description:	Road Reserve Lot 2 DP 5346 Pt Sec 485 Lots 1, 9, 10 & 13 DP 14551 Patea Dist Blk I Carlyle SD
Catchment:	Waikaikai

For General, Standard and Special conditions pertaining to this consent please see reverse side of this document

General conditions

a) On receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.

b) Unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.

c) The consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:

i) the administration, monitoring and supervision of this consent; and
ii) charges authorised by regulations.

Special conditions

1. The exercise of this consent shall be undertaken generally in accordance with the documentation submitted in support of application 2864, the documentation for consent 5325 [applications 1816, 2049, and 2405], and to ensure that the conditions of this consent are met at all times.

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.

3. The consent holder shall notify the Chief Executive, Taranaki Regional Council, in writing at least 48 hours prior to commencement of each operation involving transfer of wastes from a drilling waste holding receptacle, to the disposal property for discharge onto or into land via stockpiling, spreading, tilling, and/or layering.

4. The consent holder shall notify the Chief Executive, Taranaki Regional Council, in writing at least 12 hours prior to discharging stockpiled material onto or into land [for the purpose of this condition 'discharging' means spreading, tilling or layering].

5. Prior to disposal of wastes with hydrocarbon content equal or greater than 5%, the consent holder shall provide the Chief Executive, Taranaki Regional Council, with a chemical analysis of the wastes, including the results of leachate testing.

6. The consent holder shall ensure that areas for the stockpiling and disposing onto and into land of water based drilling wastes are kept separate and distinct from areas utilised for the stockpiling and disposing onto and into land of cuttings from wells drilled with synthetic based muds, which are kept separate and distinct from areas utilised for the stockpiling and disposing onto and into land of cuttings from wells drilled with oil based muds, which in turn are kept separate from areas for the stockpiling and disposing onto and into land of oily wastes. Further, disposal areas for individual wells shall also be kept separate and distinct. For the purpose of this consent condition 'disposing' means spreading, tilling or layering.

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

   - the wastes from Kauri E wellsite [including records of all additives used at the wellsite during the drilling process];
   - stockpiling area[s];
   - disposal area[s];
   - composition of material [including concentrations of nitrogen, chloride, polynuclear aromatic hydrocarbons [PAH], and hydrocarbons];
   - volumes of material stockpiled;
   - volumes of material disposed;
   - date of commencement and completion of stockpiling events;
   - dates and times of commencement and completion of discharge events [including stockpiling and/or disposal]; and
   - treatments applied;

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

8. The exercise of this consent is limited to wastes generated at the Kauri E4 well, within the Taranaki region.

9. No discharge [including but not limited to stockpiling on land and/or application onto or into land] shall take place within 25 metres of surface water or property boundaries.

10. The exercise of this consent shall not result in the destabilisation of neighbouring land.

11. The rate of discharge onto or into land via spreading, tilling or layering shall be limited to an application depth of 150 mm for waste solids with hydrocarbon content less than 5%, or, if hydrocarbon content of waste solids is equal or greater than 5% the application depth shall be limited to 50 mm of waste solids.

12. The hydrocarbon content in the waste prior to disposal onto or into land via spreading, tilling or layering, at the site shall be less than 5%, or, if hydrocarbon level in the waste is equal or greater than 5% the waste to be incorporated into the soil so that the hydrocarbon content in the soil/waste mix shall be less than 5% anywhere in the surface 250 mm of soil after mixing.

13. The electroconductivity of the soil/waste layer after disposal [for the purpose of this condition 'disposal' means spreading, tilling or layering but excludes stockpiling] shall be less than 400 mSm^{-1}, or alternatively, if the background soil electroconductivity exceeds 400 mSm^{-1}, the disposal of waste shall not increase the soil electroconductivity within the upper 20 cm by more than 100 mSm^{-1}.

14. The sodium absorption ratio [SAR] of the soil/waste layer after disposal [for the purpose of this condition 'disposal' means spreading, tilling or layering but excludes stockpiling] shall be less than 18.0, or alternatively if the background soil SAR exceeds 18.0, the disposal of waste shall not increase the SAR by more than 1.0.

15. The maximum rate of chloride application after disposal [for the purpose of this condition 'disposal' means spreading, tilling or layering, but excludes stockpiling] into the soil shall not exceed 800 kg Cl/ha/year.

16. The maximum rate of nitrogen application after disposal [for the purpose of this condition 'disposal' means spreading, tilling or layering, but excludes stockpiling] to the soil shall not exceed 200 kg N/ha/year.

17. Prior to the expiry, cancellation, or surrender of this consent the levels of contaminants 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].

18. At any time the levels of metals in the soil shall comply with the guidelines for heavy metals in soil set out in the Department of Health's Guidelines for the Disposal of Sewerage Sludge to Land [1992].

19. As far as is practicable the consent holder shall adopt the best practicable option, and in any case prior to the expiry, cancellation, or surrender of this consent, to ensure that the exercise of this consent shall not result in a level of total dissolved salts within any surface or groundwater of more than 2500 gm^{-3}.

20. Prior to the expiry, cancellation, or surrender of this consent soil levels will not exceed the following limits: conductivity, 290 mSm^{-1}; total dissolved salts, 2500 gm^{-3}; sodium, 460 gm^{-3}; and chloride, 700 gm^{-3}.

21. As soon as practicable following completion of disposal of material as authorised by this consent, the consent holder shall till and resow the areas into pasture [or into crop] following completion of each application. If revegetation can not be established within two months of the disposal, the consent holder shall undertake appropriate land stabilisation measures to minimise wind and/or stormwater erosion.

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

23. 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.

24. The stockpiling of material authorised by this consent shall be limited to a maximum volume of 5000 cubic metres at any one time on the property. In any case all stockpiled material must be disposed onto and into land within one month of being brought onto the site [for the purpose of this condition 'disposed' means spreading, tilling or layering].

25. The discharges authorised by this consent shall not give rise to suspended or deposited dust at or beyond the boundary of the site that, in the opinion of at least one enforcement officer of the Taranaki Regional Council, is offensive or objectionable. For the purpose of this condition, discharges in excess of the following limits are deemed to be offensive or objectionable:

    a) dust deposition rate 0.13 $g/m^2/day$; and/or
    b) suspended dust level 0.15 mg/m^3.

26. The discharges authorised by this consent shall not give rise to an odour at or beyond the boundary of the site that, in the opinion of at least one enforcement officer of the Taranaki Regional Council, is offensive or objectionable.

27. The consent holder shall undertake an analysis of the total petroleum hydrocarbon [TPH] composition, in the ranges C_{10}-C_{14} and C_{15}-C_{36}, on three occasions after the drilling cuttings are incorporated into the soil: within 7 days; after 2 months, but before 3 months; and after 5 months, but before 6 months. These results shall be supplied to the Chief Executive, Taranaki Regional Council, immediately they are available.

28. 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.

Signed at Stratford on 18 March 2004

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Appendix II

Geary Landfarm results

Site Source Waste Type	G9 Kauri E2 WBM	G22 Kauri E6 OBM	G23 Kauri E6 WBM	G24 Kauri E7 SBM	G26 Kauri E8 WBM	G36 - OW	G40 Kauri E11 WBM	Consent Limit
Specific Gravity g/ml	1.65	1.80	1.42	1.43	1.68			
Conductivity mSm-1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	290
Dry Matter g/100g as received	89.2	91.00	89.5	93.3	89.50	95.6	90.0	
Recoverable Ba mg/kg dry wt	284	610	388	370	159	123	140	
Recoverable Cl mg/kg dry wt	9	20	23	10	5	9	22	700
Recoverable Na mg/kg dry wt	420	440	410	320	440	390	280	460
Recoverable P mg/kg dry wt	757	616	842	901	770	825	945	
Recoverable S mg/kg dry wt	16	11	24	5	28	6	39	
C7-C9 mg/kg dry wt	<7	<8	<7	<7	<7	<7	<8	120
C10-C14 mg.kg dry wt	<10	23	<10	<10	<10	<10	<20	58
C15-C36 mg/kg dry wt	<30	1200	<30	<30	140	<30	<30	4000
Total HC's mg/kg dry wt	<50	1200	<60	<50	140	<60	<60	
Nitrogen g/100g dry wt	0.07	<0.05	0.07	0.06	0.09	0.07	0.08	
Arsenic mg/kg dry wt	<2	<2	<2	<2	<2	<2	<2	20
Cadium mg/kg dry wt	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1
Chromium mg/kg dry wt	14	13	13	9	13	14	17	600
Copper mg/kg dry wt	12	10	12	12	21	12	23	100
Lead mg/kg dry wt	1.2	1.0	3	9.2	2.70	13.9	4	300
Mercury mg/kg dry wt	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1
Nickel mg/kg dry wt	7	6	6	5	7	6	9	60
Zinc mg/kg dry wt	68	61	58	37	59	50	66	300
Benzene mg/kg dry wt	<0.05	<0.03	<0.04	<0.02	<0.02	<0.04	<0.04	1.1
Toluene mg/kg dry wt	<0.05	<0.03	<0.04	<0.02	<0.02	<0.04	<0.04	68
Ethylbenzene mg/kg dry wt	<0.05	<0.03	<0.04	<0.02	<0.02	<0.04	<0.04	53
m & p-xylene mg/kg dry wt	<010	<0.06	<0.08	<0.02	<0.02	<0.07	<0.08	48
o-Xylene mg/kg dry wt	<0.05	<0.03	<0.04	<0.02	<0.02	<0.04	<0.04	48
PH	7.5	6.2	7.4	7.1	6.4	7.7	6.3	
Olsen P mg/l	17	31	10	8	18	12	22	
Potassium me/100g	0.19	0.17	0.14	0.15	0.14	0.10	0.10	
Calcium me/100g	4.10	42.00	3.40	2.60	1.80	3.50	1.90	
Magnesium me/100g	0.25	8.00	0.59	0.37	0.49	0.21	0.42	
Sodium me/100g	0.11	24.00	0.17	0.10	0.10	<0.05	0.21	
CEC me/100g	8	3	4	3	4	4	5	
Base Saturation %	100	73	100	100	69	100	58	
Volume Weight	1.76		1.77	1.65	1.73	1.85	1.79	
Soluble Salts g/100g dry wt	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	2500
Sodium Absorption Ratio SAR	0.5	0.90	1.7	0.70	0.90	0.50	0.70	18
Acenaphthene	<0.03	<0.02	<0.03	<0.02	<0.03	<0.02	<0.03	
Acenaphthylene	<0.03	<0.02	<0.03	<0.02	<0.03	<0.02	<0.03	
Anthracene	<0.03	<0.02	<0.03	<0.02	<0.03	<0.02	<0.03	
benzo(a)anthracene	<0.03	<0.02	<0.03	<0.02	<0.03	<0.02	<0.03	
Benzo(a)pyrene (BAP)	<0.03	<0.02	<0.03	<0.02	<0.03	<0.02	<0.03	0.027
Benzo(b)fluoranthene	<0.03	0.06	<0.03	<0.02	<0.03	0.04	<0.03	
Benzo(g,h,i)perylene	<0.03	0.03	<0.03	<0.02	<0.03	<0.02	<0.03	
Benzo(k)fluoranthene	<0.03	<0.02	<0.03	<0.02	<0.03	<0.02	<0.03	
Chrysene	<0.03	<0.02	<0.03	<0.02	<0.03	<0.02	<0.03	
Dibenzo(a.h)anthracene	<0.03	<0.02	<0.03	<0.02	<0.03	<0.02	<0.03	
Fluoranthene	<0.03	<0.02	<0.03	<0.02	<0.03	<0.02	<0.03	
Fluorene	<0.03	<0.02	<0.03	<0.02	<0.03	0.04	<0.03	

Site Source Waste Type	G9 Kauri E2 WBM	G22 Kauri E6 OBM	G23 Kauri E6 WBM	G24 Kauri E7 SBM	G26 Kauri E8 WBM	G36 - OW	G40 Kauri E11 WBM	Consent Limit
Indeno(1,2,3-c,d)pyrene	<0.03	<0.02	<0.03	<0.02	<0.03	<0.02	<0.03	
Naphthalene	<0.12	<0.1	<0.13	<0.01	<0.13	<0.1	<0.13	7.2
Phenanthrene	<0.03	<0.02	<0.03	<0.02	<0.03	0.05	<0.03	
Pyrene	<0.03	0.06	<0.03	<0.03	<0.03	0.21	<0.03	160

Appendix III

TRC Guidelines for the Control of Drilling Wastes

Appendix 1 – Sodium, chloride, and salinity

Salinity is the presence of soluble salts in or on soils, or in waters. High salinity levels in soils may result in reduced plant productivity or in extreme cases, the elimination of crops and native vegetation.

Sodicity is the presence of a high proportion of sodium (Na^+) ions relative to other cations [predominantly calcium (Ca^{2+}) and magnesium (Mg^{2+})] in soil (in exchangeable and/or soluble form) or water. Sodicity degrades soil properties by making the soil more dispersible and erodible, restricting water entry and reducing hydraulic conductivity (the ability of the soil to conduct water). (from Australian Water Quality Guidelines for Fresh and Marine Waters, Australia and New Zealand Environment and Conservation Council, 1998) (ANZEEC)

Low salinity water can be used on most crops on most soils. This assumes a normal amount of permeability. Medium salinity water can be used if a moderate amount of leaching is expected to occur. Sprinkler irrigation may cause leaf scorch on salt-sensitive crops, especially with low water application rates. Water of higher salinity can be used where factors such as permeable soils, adequate drainage, reasonable rainfall, salt-tolerant species, or limited applications can be taken into account.

The figures given in the ANZEEC guidelines are set out below.

Acceptable salinity and conductivity

EC of Irrigation Water (mSm^{-1})	Water Salinity Rating	Plant Suitability
<65	very low	sensitive crops
65–130	low	moderately sensitive crops
130–290	medium	moderately tolerant crops
290–520	high	tolerant crops
520–810	very high	very tolerant crops
>810	extreme	generally too saline

(from Table 5.1, ANZEEC 1998)

Acceptable chloride concentrations g m^{-3}

Sensitive <175	Moderately sensitive 175–350	Moderately tolerant 350–700	Tolerant >700
Almond	Pepper	Barley	Cauliflower
Apricot	Potato	Maize	Cotton
Citrus	Tomato	Cucumber	Sugar beet
Plum		Lucerne	Sunflower
Grape		Safflower	
		Sesame	
		Sorghum	

(From Table 5.2, ANZEEC)

Acceptable sodium concentrations g m^{-3}

Sensitive <115	Moderately sensitive 115–230	Moderately tolerant 230–460	Tolerant >460
Almond	Pepper	Barley	Cauliflower
Apricot	Potato	Maize	Cotton
Citrus	Tomato	Cucumber	Sugar beet
Plum		Lucerne	Sunflower
Grape		Safflower	
		Sesame	
		Sorghum	

(From Table 5.4 ANZEEC)

Effect of sodium (expressed as sodium adsorption ratio [SAR]) on crop yield and quality under non-saline conditions

Tolerance to SAR and range at which affected	Crop	Growth response under field conditions
Extremely sensitive SAR = 2–8	Avocado Deciduous Fruits Nuts Citrus	Leaf tip burn, leaf scorch
Sensitive SAR = 8–18	Beans	Stunted growth
Medium SAR = 18–46	Clover Oats Tall fescue Rice Dallis grass	Stunted growth, possible sodium toxicity, possible calcium or magnesium deficiency
High SAR = 46–102	Wheat Cotton Lucerne Barley Beets Rhodes grass	Stunted growth, soil structural problems

(From Table 5.5 ANZEEC)

Guide G-50, 'Drilling Waste management', prepared by the Alberta Energy and Utilities Board (October 1996), set limits for land application of drilling wastes to soil at conductivity 400 mSm^{-1} and a SAR (see below) of 8. If either of these were to be exceeded, then the maximum increase over background levels could be only 100 mSm^{-1} or an additional SAR of 1, with no discharge at all if the receiving soil SAR already exceeds 16.

It is considered that in setting limits for Taranaki, greater weight should be given to the ANZEEC guidelines than to the Alberta guidelines. Notwithstanding this, it is considered that in the short term, it may be acceptable in some circumstances to exceed ANZEEC guidelines (where the G-50 guidelines are higher) as long as in the longer term these guidelines are satisfied.

Given Taranaki's rainfall, permeability of soils, and proximity to the coast, it is considered that in the absence of special considerations such as frequently repeated applications of saline wastewaters, an appropriate level of protection of soils used for pasture growth purposes is the setting of soil limits prior to relinquishing or surrendering a consent at **conductivity 290 mSm^{-1} ,**

sodium at 460 g m^{-3} , and chloride at 700 g m^{-3}. On an interim basis (e.g. after any disposal activity), the electroconductivity of the waste-soil mixed layer should not exceed 400 mS m^{-1}, or alternatively if the background electroconductivity already exceeds 400 mS m^{-1}, the background soil electroconductivity should not be increased by more than 100 mS m^{-1} .

On clay soils, medium sodium water may pose a problem unless gypsum is added. This problem is unlikely on sandy or organic soils. Pasture species such as clover and fescue are considered moderately tolerant to sodium, with other grasses being even more tolerant; some market crops are more sensitive. From ANZEEC, pastures are generally considered able to withstand a sodium adsorption ratio (SAR) of between 18 and 46, where

$$SAR = \frac{Na+}{\left\{\frac{(Ca^{2+} + Mg^{2+})}{2}\right\}^{0.5}}$$

An **SAR limit for soil of less than 18** is therefore considered appropriate in most circumstances, with up to 46 being acceptable depending on the particular situation.

In terms of livestock watering USEPA (1972) consider water of total dissolved salts less than 1000 g m^{-3} to be excellent, and up to 2000 g m^{-3} to be very satisfactory for all classes of livestock and poultry (some possible temporary mild diarrhoea in livestock not accustomed to the higher levels). ANZEEC consider there to be no effects upon cattle or sheep at 2500 g m^{-3} , and with reluctance to drink or some scouring, but no loss of production, 4000 g m^{-3} . ANZEEC suggest 2000 g m^{-3} as the no effect limit for poultry.

Barium

USEPA (1972) have no restriction upon barium for livestock watering or for irrigation. ANZEEC (1998) have no restriction upon barium for livestock watering or for irrigation, nor for any requirement for protection of water ecosystems.

Two criteria for barium have been found during a search of the literature. An interim Canadian soil quality guideline is tagged that there is insufficient data to develop criteria for the protection of human health or the environment. The guideline given is 750 g m^{-3}. The USEPA Region 9 uses a value of 1600 g m^{-3} in soil to protect groundwater as a drinking water source for humans, and 5300 g m^{-3} for residential soil.

References:
Water Quality Criteria, USEPA, 1972
Canadian Soil Quality Guidelines for the protection of environmental and human health, Canadian Council of Ministers of the Environment 1999
Region 9 Preliminary Remediation Goals, EPA Region 9, 1996

Appendix IV

Schrider Landfarm Results

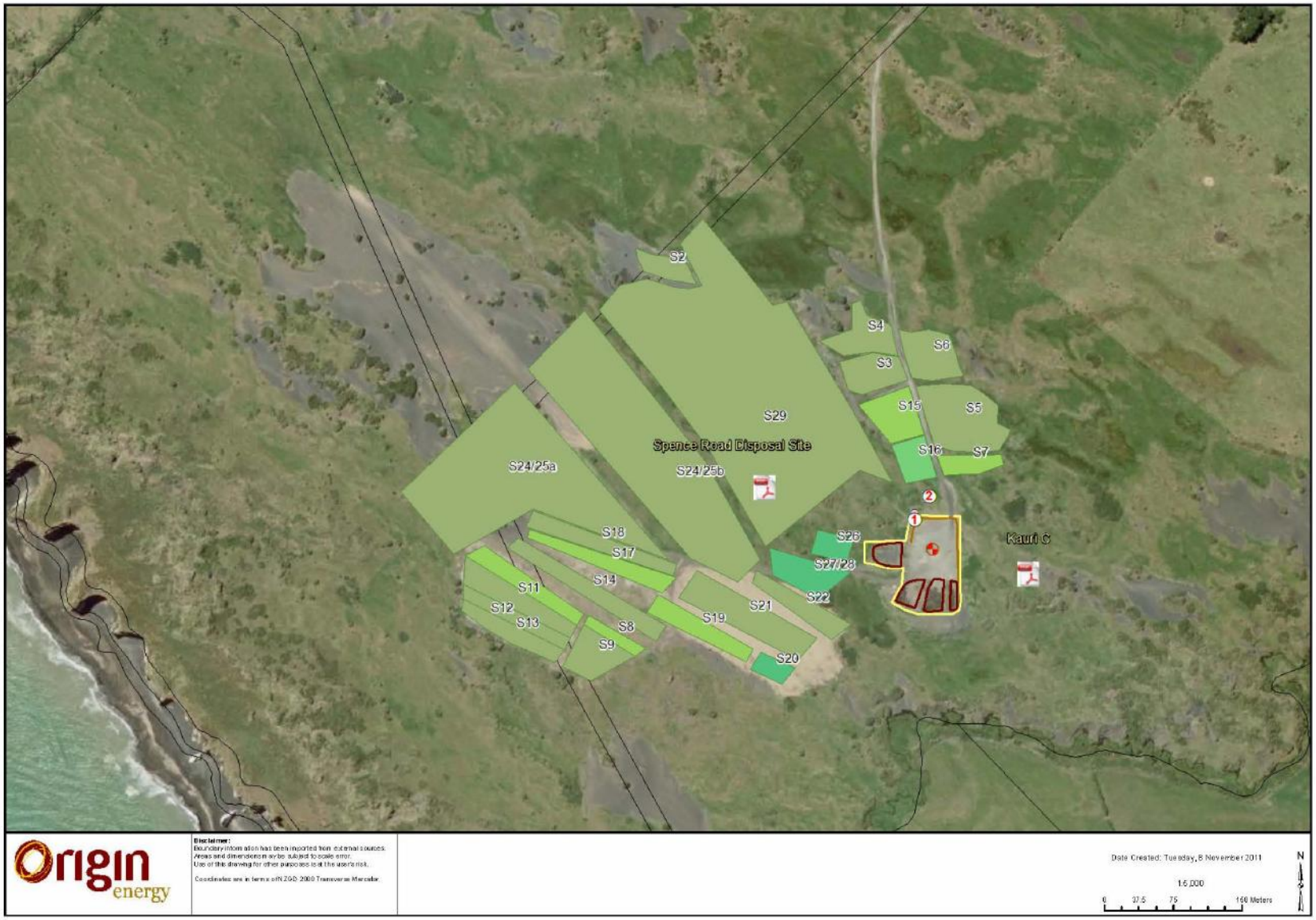
Site Source Waste Type	H33 Oily Waste OW	H38 Oily Waste OW	H37 Trapper A WBM	H57 Rimu Station OW	H63 Ahuroa B WBM	H66 Kauri E OW	H64 Kauri F WBM	H62 Oily Waste OW	Consent 6135-1 Limits
Conductivity (mSm-1)	<0.02	<0.20	<0.02	<0.2	1.3	<0.2	1.1	<0.20	400 (mS/m)
Dry Matter (g/100g as recvd)	91.0	95.0	95.3	89.0	90.0	96.0	92.0	95	
Recov Ba (mg/kg dry wt)	30	270	234	470	690	57	35	56	
Recov Ca (mg/kg dry wt)				11.0					
Recov Cl (mg/kg dry wt)	13	160	23	42	<3	6	1.1	9	700 (g/m3)
Recov K (mg/kg dry wt)							92.0		
Recov Mg (mg/kg dry wt)				1			35		
Recov Na (mg/kg dry wt)	370	360	370	320	400		310	360	460 (g/m3)
Recov P (mg/kg dry wt)		880							
Total S (g/100gm dry wt)			0.010	0.030					
Recov S (mg/kg dry wt)	13	16	10		1000				
C7-C9 (mg/kg dry wt)	<8	<8	<7	<8	<8	<8	<8	<8	120
C10-C14 (mg/kg dry wt)	<20	<20	<10	25	<20	<20	<20	<20	58
C15-C36 (mg/kg dry wt)	<40	<30	<30	490	100	<40	<40	<40	4000
Total HC's (mg/kg dry wt)	<60	<60	<50	510	100	<70	<60	<70	50,000/15,000
Nitrogen (g/100g dry wt)	<0.05	<0.05	0.1	0.076	<0.051		0.139	0.182	
Arsenic (mg/kg dry wt)	<2	<2	<2	<2	4.1	<2	2.9	<2	20
Boron (mg/kg dry wt)									
Cadium (mg/kg dry wt)	<0.1	<0.1	<0.1	<0.1	0.26	<0.10	<0.10	<0.10	1
Chromium (mg/kg dry wt)	16	20	15	19	16	14	25	14	600
Copper (mg/kg dry wt)	10	15	12	15	34	10	21	13	100
Lead (mg/kg dry wt)	0.9	4.0	1.3	1.4	13.0	1	16.0	1.4	300
Mercury (mg/kg dry wt)	<0.1	<0.1	<0.1	<0.1	<0.10		<0.10	<0.10	1
Nickel (mg/kg dry wt)	7	9	8	9	19	6.0	22	6	60
Vanadium (mg/kg dry wt)		270.0	222.0	<0.021					
Zinc (mg/kg dry wt)	67	90	69	92	57	59	64	57	300
Benzene (mg/kg dry wt)	<0.05	<0.1	<0.03	<0.05	<0.05	<0.05	<0.05	<0.05	1.1

Site Source Waste Type	H33 Oily Waste OW	H38 Oily Waste OW	H37 Trapper A WBM	H57 Rimu Station OW	H63 Ahuroa B WBM	H66 Kauri E OW	H64 Kauri F WBM	H62 Oily Waste OW	Consent 6135-1 Limits
Toluene (mg/kg dry wt)	<0.05	<0.1	<0.03	<0.05	<0.05	<0.05	<0.05	<0.05	68
Ethylbenzene (mg/kg dry wt)	<0.05	<0.1	<0.03	<0.05	<0.05	<0.05	<0.05	<0.05	53
m & p-xylene (mg/kg dry wt)	<0.1	<0.1	<0.07	<0.10	<0.10	<0.10	<0.10	<0.10	48
o-Xylene (mg/kg dry wt)	<0.05	<0.1	<0.03	<0.05	<0.05	<0.05	<0.05	<0.05	48
Soluble Salts (g/100g dry wt)	<0.05	<0.050	<0.05	<0.05	0.46	<0.05	0.39	<0.050	2500
Sodium Absorption Ratio SAR	1	1.80	0.6	3.1	0.6		0.7	1.2	18
Acenaphthene (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	
Acenaphthylene (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	
Anthracene (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	
benzo(a)anthracene (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	
Benzo(a)pyrene (BAP) (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	0.027
Benzo(b)fluoranthene (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	
Benzo(g,h,i)perylene (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	
Benzo(k)fluoranthene (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	
Chrysene (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	
Dibenzo(a.h)anthracene (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	
Fluoranthene (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	
Fluorene (mg/kg/dry wt)	<0.03	<0.022	<0.02	<0.024	<0.04	<0.03	<0.03	<0.03	
Indeno(1,2,3-c,d)pyrene	<0.03	<0.022	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	

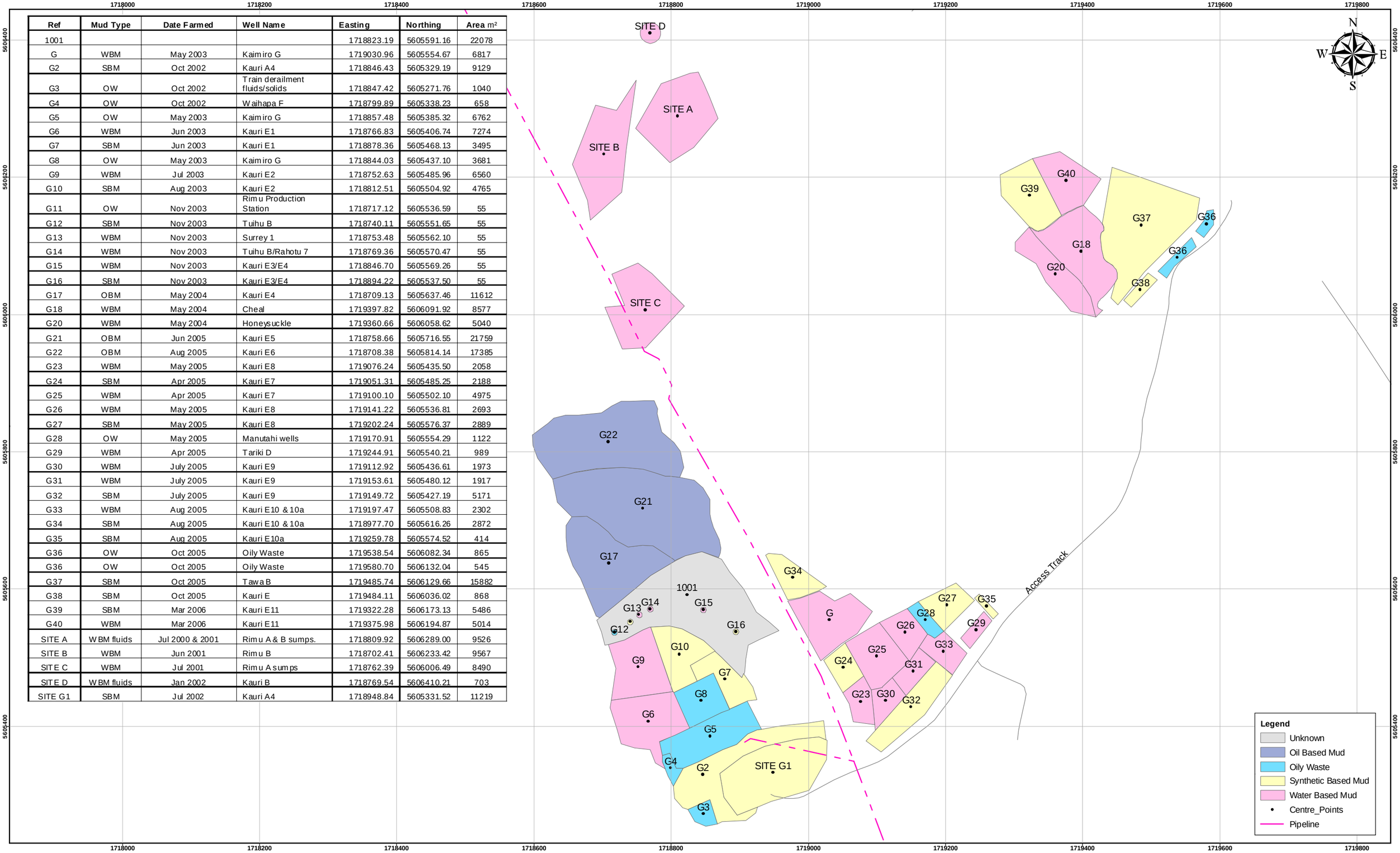
Site Source Waste Type	H33 Oily Waste OW	H38 Oily Waste OW	H37 Trapper A WBM	H57 Rimu Station OW	H63 Ahuroa B WBM	H66 Kauri E OW	H64 Kauri F WBM	H62 Oily Waste OW	Consent 6135-1 Limits
(mg/kg/dry wt)									
Naphthalene (mg/kg/dry wt)	<0.1	<0.11	<0.1	<0.12	<0.12	<0.12	<0.12	<0.12	7.2
Phenanthrene (mg/kg/dry wt)	<0.03	0.21	<0.02	<0.024	<0.09	<0.03	<0.03	<0.03	
Pyrene (mg/kg/dry wt)	<0.03	0.33	<0.02	<0.024	<0.03	<0.03	<0.03	<0.03	160

Appendix V

Maps of Landfarmed Sites


S2
S4
S6
S3
S15
S5
S29
Spence Road Disposal Site
S16
S7
S24/25a
S24/25b
S18
S17
S14
S11
S12
S13
S8
S9
S19
S21
S22
S20
S26
S27/28
Kauri C
1
2
Origin energy
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.
Coordinates are in terms of NZGD 2000 Transverse Mercator.
Date Created: Tuesday, 8 November 2011
1:6,000
0 37.5 75 150 Meters
N

Ref	Mud Type	Date Farmed	Well Name	Easting	Northing	Area m²
1001				1718823.19	5605591.16	22078
G	WBM	May 2003	Kaimiro G	1719030.96	5605554.67	6817
G2	SBM	Oct 2002	Kauri A4	1718846.43	5605329.19	9129
G3	OW	Oct 2002	Train derailment fluids/solids	1718847.42	5605271.76	1040
G4	OW	Oct 2002	Waihapa F	1718799.89	5605338.23	658
G5	OW	May 2003	Kaimiro G	1718857.48	5605385.32	6762
G6	WBM	Jun 2003	Kauri E1	1718766.83	5605406.74	7274
G7	SBM	Jun 2003	Kauri E1	1718878.36	5605468.13	3495
G8	OW	May 2003	Kaimiro G	1718844.03	5605437.10	3681
G9	WBM	Jul 2003	Kauri E2	1718752.63	5605485.96	6560
G10	SBM	Aug 2003	Kauri E2	1718812.51	5605504.92	4765
G11	OW	Nov 2003	Rimu Production Station	1718717.12	5605536.59	55
G12	SBM	Nov 2003	Tuihu B	1718740.11	5605551.65	55
G13	WBM	Nov 2003	Surrey 1	1718753.48	5605562.10	55
G14	WBM	Nov 2003	Tuihu B/Rahotu 7	1718769.36	5605570.47	55
G15	WBM	Nov 2003	Kauri E3/E4	1718846.70	5605569.26	55
G16	SBM	Nov 2003	Kauri E3/E4	1718894.22	5605537.50	55
G17	OBM	May 2004	Kauri E4	1718709.13	5605637.46	11612
G18	WBM	May 2004	Cheal	1719397.82	5606091.92	8577
G20	WBM	May 2004	Honeysuckle	1719360.66	5606058.62	5040
G21	OBM	Jun 2005	Kauri E5	1718758.66	5605716.55	21759
G22	OBM	Aug 2005	Kauri E6	1718708.38	5605814.14	17385
G23	WBM	May 2005	Kauri E8	1719076.24	5605435.50	2058
G24	SBM	Apr 2005	Kauri E7	1719051.31	5605485.25	2188
G25	WBM	Apr 2005	Kauri E7	1719100.10	5605502.10	4975
G26	WBM	May 2005	Kauri E8	1719141.22	5605536.81	2693
G27	SBM	May 2005	Kauri E8	1719202.24	5605576.37	2889
G28	OW	May 2005	Manutahi wells	1719170.91	5605554.29	1122
G29	WBM	Apr 2005	Tariki D	1719244.91	5605540.21	989
G30	WBM	July 2005	Kauri E9	1719112.92	5605436.61	1973
G31	WBM	July 2005	Kauri E9	1719153.61	5605480.12	1917
G32	SBM	July 2005	Kauri E9	1719149.72	5605427.19	5171
G33	WBM	Aug 2005	Kauri E10 & 10a	1719197.47	5605508.83	2302
G34	SBM	Aug 2005	Kauri E10 & 10a	1718977.70	5605616.26	2872
G35	SBM	Aug 2005	Kauri E10a	1719259.78	5605574.52	414
G36	OW	Oct 2005	Oily Waste	1719538.54	5606082.34	865
G36	OW	Oct 2005	Oily Waste	1719580.70	5606132.04	545
G37	SBM	Oct 2005	Tawa B	1719485.74	5606129.66	15882
G38	SBM	Oct 2005	Kauri E	1719484.11	5606036.02	868
G39	SBM	Mar 2006	Kauri E11	1719322.28	5606173.13	5486
G40	WBM	Mar 2006	Kauri E11	1719375.98	5606194.87	5014
SITE A	WBM fluids	Jul 2000 & 2001	Rimu A & B sumps.	1718809.92	5606289.00	9526
SITE B	WBM	Jun 2001	Rimu B	1718702.41	5606233.42	9567
SITE C	WBM	Jul 2001	Rimu A sumps	1718762.39	5606006.49	8490
SITE D	WBM fluids	Jan 2002	Kauri B	1718769.54	5606410.21	703
SITE G1	SBM	Jul 2002	Kauri A4	1718948.84	5605331.52	11219



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

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Print from PDF: scale not accurate.
Pipelines are indicative only.

Nb	DATE	BY	CH	AP	OP	DESCRIPTION

REVISIONS

DRAWN	THOMPSON	14/11/08
CHECKED	JOINES	DATE
PROJECT Nb.	02234	
LOCATION	MANUTAHI	
ORIGINAL SIZE	A3	
SCALE	1:5,000	

0 40 80 160 240 320
Meters

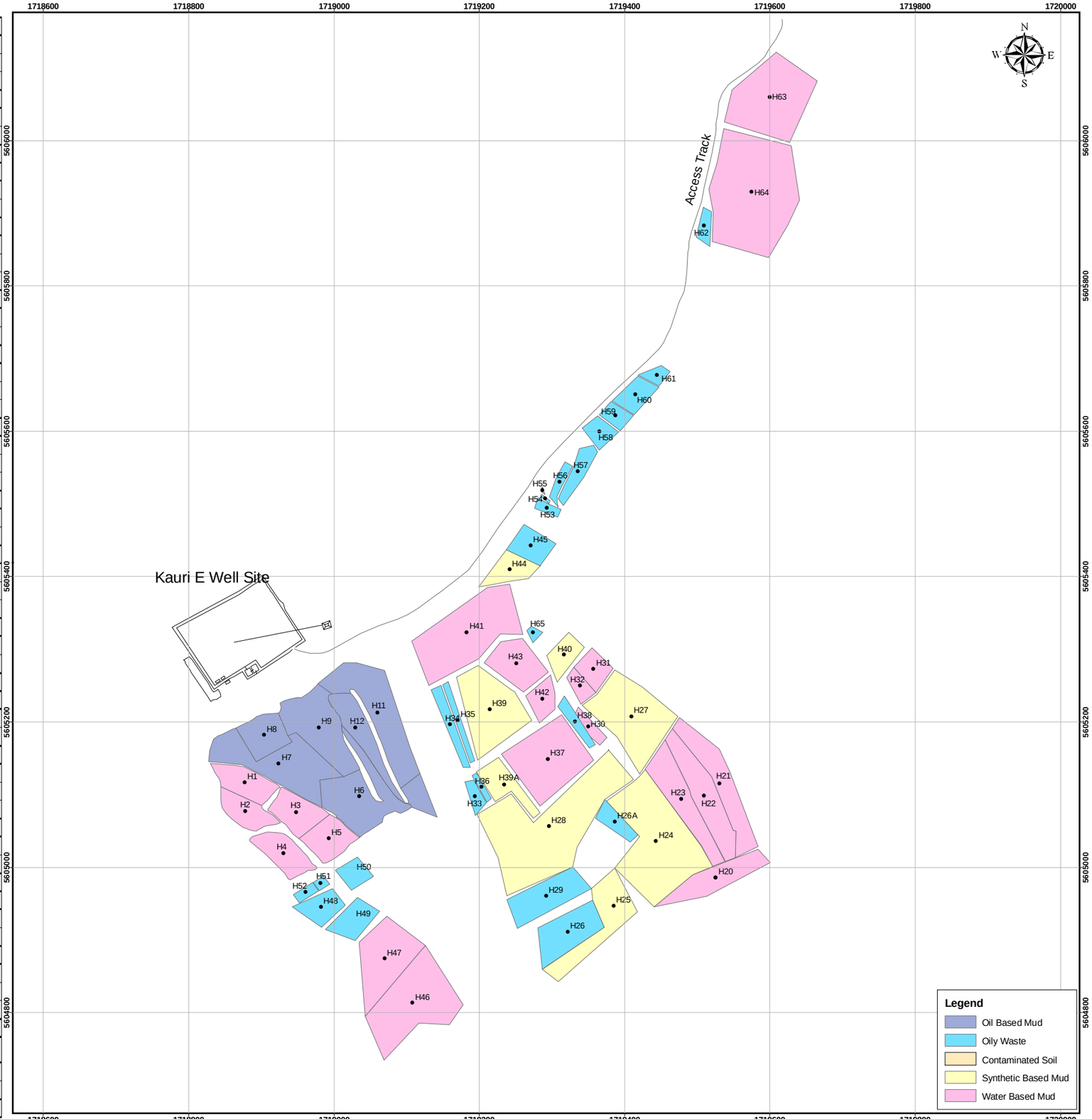
GEARY ROAD DISPOSAL SITE

Origin energy

DRAWING Nb: 02234-02-GIS

REVISION: 0

Ref.	Mud Type	Date Farmed	Well Name	Easting	Northing	Area m²	Volume m³
H1	WBM	Jun 2004	Manutahi B	1718877	5605117	2890	
H2	WBM	Jun 2004	Manutahi A	1718878	5605077	2488	
H3	WBM	Jul 2004	Manutahi D	1718949	5605075	2996	
H4	WBM	Jun 2004	Kauri E5	1718931	5605019	2984	
H5	WBM	Jul 2004	Manutahi C	1718993	5605039	2917	
H6	OBM	Jul 2004	Manutahi D	1719035	5605098	6943	
H7	OBM	Jun 2004	Manutahi A	1718924	5605143	7965	
H8	OBM	Aug 2004	Kauri C	1718904	5605182	3031	
H9	OBM	Jun 2004	Manutahi B	1718979	5605192	6570	
H11	OBM	Jul 2004	Manutahi G	1719060	5605212	7922	
H12	OBM	Jul 2004	Manutahi C	1719030	5605192	4838	
H20	WBM	Jan 2006	Pohutukawa A	1719526	5604985	4087	
H21	WBM	Mar 2006	Goss A	1719531	5605115	5357	
H22	WBM	Mar 2006	Kauri E12	1719510	5605098	5518	
H23	WBM	Feb 2006	Trapper A	1719479	5605093	5059	
H24	SBM	Feb 2006	Trapper A	1719444	5605035	13480	
H25	SBM	Mar 2006	Kauri E12	1719385	5604947	5323	
H26	OW	Feb 2006	Oily Waste	1719322	5604911	4289	
H26A	OW	Mar 2006	Oily Waste	1719387	5605063	1338	
H27	SBM	Apr 2006	Kauri E12	1719410	5605207	8636	
H28	SBM	Mar 2006	Goss A	1719296	5605056	17012	
H29	OW	Jun 2006	Oily Waste	1719293	5604960	4402	
H30	WBM	Aug 2006	Waihapa C MBC sump	1719350	5605194	925	
H31	WBM	Sept 2006	Waihapa C	1719358	5605273	1645	
H32	WBM	Sept 2006	Waihapa H	1719339	5605249	936	
H33	OW	Oct 2006	Oily Waste	1719194	5605098	662	
H34	OW	Oct 2006	Waihapa C Oily waste	1719160	5605197	1416	
H35	OW	Feb 2007	Rimu PS Glycol OW	1719171	5605202	892	
H36	OW	Dec 2006	Oily Waste	1719203	5605110	308	
H37	WBM	Feb 2007	Trapper A sump	1719295	5605149	8138	
H38	OW	Feb 2007	Oily Waste	1719332	5605201	960	
H39	SBM	Feb 2007	Kauri E12 tank waste	1719215	5605217	7310	
H39A	SBM	Feb 2007	Kauri E12 tank waste	1719235	5605114	2491	
H40	SBM	Feb 2007	Trapper A	1719317	5605292	1709	
H41	WBM	Feb 2007	Goss A sump	1719183	5605323	10487	
H42	WBM	May 2007	Waihapa C Sump	1719287	5605231	1529	
H43	WBM	May 2007	Waihapa H Sump	1719251	5605280	3666	
H44	SBM	Aug 2007	Goss A SBM	1719242	5605410	2061	
H45	OW	Aug 2007	RPS Oily Waste	1719271	5605443	2037	
H46	WBM	Aug 2007	Piakau A	1719109	5604813	9840	
H47	WBM	Aug 2007	Ahuroa B	1719070	5604874	6339	
H48	OW	Sept 2007	WPS Oily Waste	1718982	5604945	1919	
H49	OW	Oct 2007	Oily Waste	1719027	5604928	2187	
H50	OW	May 2008	RPS Oily Waste	1719028	5604992	1255	
H51	OW	July 2008	RPS Glycol Waste	1718982	5604978	237	
H52	OW	July 2008	Oily Waste	1718961	5604965	452	
H53	OW	Sept 2008	Tariki A contaminated metal	1719294	5605495	437	
H54	OW	Sept 2008	Kauri F contaminated metal	1719291	5605507	45	
H55	OW	Sept 2008	Manutahi D contaminated metal	1719287	5605518	24	
H56	OW	Sept 2008	Waihapa Production Station Cleanings	1719311	5605530	648	
H57	OW	Sept 2008	Rimu Production Station	1719336	5605544	1565	
H58	OW	June 2009	Rimu A Contaminated Soil	1719365	5605599	1179	40
H59	OW	June 2009	Rimu A Oily Waste	1719388	5605621	933	20
H60	OW	June 2009	Rimu A Oily Waste	1719415	5605650	1675	100
H61	OW	June 2009	Waihapa Production Station	1719445	5605677	608	30
H62	OW	June 2010	Oily waste from cleaning (various sources)	1719274	5605322	250	3.5
H63	WBM	June 2010	Ahuroa B3	1719600	5606060	9496	768
H64	WBM	June 2010	Kauri F	1719575	5605929	16571	1406
H65	OW	Aug 2009	Oily waste from cleaning old waste pits	1719274	5605322	250	



btw company
. surveyors
. planners
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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.

No.	DATE	BY	CH	DESCRIPTION
5	28/06/10	PT	PS	Adjust H64 & H62.
4	25/06/10	PT	PS	Add H62 & H65 and amend areas.
3	23/06/10	PT	PS	Add disposal areas H63 & H64
2	10/07/09	PT	GA	Add disposal areas H62
1	10/07/09	PT	GA	Add disposal areas H58, H59, H60, H61

REVISIONS

DRAWN	THOMPSON	04/11/08
CHECKED	JOINES	04/11/08
PROJECT No.	05342	
LOCATION	MANUTAHI	
ORIGINAL SIZE	A3	
SCALE	1:6,000	

0 50 100 200 300 400
Meters

SCHRIDER DISPOSAL SITE

Origin energy

DRAWING No. 05342-06-GIS

REVISION 5

Appendix VI

Spence Road Landfarm results

Site Source Waste Type	S27/28 Rimu A Pipeline -	S24/25 Kauri F WBM	S29 Ahuroa B/ Manu D WBM	S31 Manu D WBM	Consent Limit
Conductivity (mSm-1)	<0.20	<0.20	<0.02	<0.02	290 mS/m
Dry Matter (g/100g as recvd)	95	61.0	96.0		
Recov Ba (mg/kg dry wt)	450	93	49	17	
Recov Ca (mg/kg dry wt)		25.0	188.0		
Recov Cl (mg/kg dry wt)	22	2	22	11	700 g/m^3
Recov Mg (mg/kg dry wt)		8	15		
Recov Na (mg/kg dry wt)	350	28	320	250	460 g/m^3
C7-C9 (mg/kg dry wt)	<8	<8	<8	<8	120
C10-C14 (mg.kg dry wt)	<20	<20	<20	<20	58
C15-C36 (mg/kg dry wt)	<40	<40	<40	<40	4000
Total HC's (mg/kg dry wt)	<70	<70	<70	<70	
Nitrogen (g/100g dry wt)		0.139	<0.06		
Arsenic (mg/kg dry wt)	<2	<2	<2	<2	20
Cadium (mg/kg dry wt)	<0.10	<0.10	<.10	<.10	1
Chromium (mg/kg dry wt)	12	11	13	13	600
Copper (mg/kg dry wt)	14	11	11	11	100
Lead (mg/kg dry wt)	2.1	1.8	1.1	1.1	300
Mercury (mg/kg dry wt)	<0.10	<0.10	<.10	<.10	1
Nickel (mg/kg dry wt)	6.0	6.0	6	7	60
Zinc (mg/kg dry wt)	57	47.0	58	59	300
Benzene (kg dry wt)	<0.05	<0.05	<0.05	<0.05	1.1
Toluene (mg/kg dry wt)	<0.05	<0.05	<0.05	<0.05	68
Ethylbenzene (mg/kg dry wt)	<0.05	<0.05	<0.05	<0.05	53
m & p-xylene (mg/kg dry wt)	<0.10	<0.10	<0.10	<0.10	48
o-Xylene (mg/kg dry wt)	<0.05	<0.05	<0.05	<0.05	48
Soluble Salts (g/100g dry wt)	<0.05	<0.05	<0.05	<0.05	2500 g/m^3
Sodium Absorption Ratio SAR	1.1	0.9	1.5	1.1	18
Acenaphthene	<0.03	<0.03	<0.03	<0.03	
Acenaphthylene	<0.03	<0.03	<0.03	<0.03	

Site Source Waste Type	S27/28 Rimu A Pipeline -	S24/25 Kauri F WBM	S29 Ahuroa B/ Manu D WBM	S31 Manu D WBM	Consent Limit
Anthracene	<0.03	<0.03	<0.03	<0.03	
benzo(a)anthracene	<0.03	<0.03	<0.03	<0.03	
Benzo(a)pyrene (BAP)	<0.03	<0.03	<0.03	<0.03	0.027
Benzo(b)fluoranthene	<0.03	<0.03	<0.03	<0.03	
Benzo(g,h,i)perylene	<0.03	<0.03	<0.03	<0.03	
Benzo(k)fluoranthene	<0.03	<0.03	<0.03	<0.03	
Chrysene	<0.03	<0.03	<0.03	<0.03	
Dibenzo(a.h)anthracene	<0.03	<0.03	<0.03	<0.03	
Fluoranthene	<0.03	<0.03	<0.03	<0.03	
Fluorene	<0.03	<0.03	<0.03	<0.03	
Indeno(1,2,3-c,d)pyrene	<0.03	<0.03	<0.03	<0.03	
Naphthalene	<0.12	<0.13	<0.12	<0.12	
Phenanthrene	<0.03	<0.03	<0.03	<0.03	7.2
Pyrene	<0.03	<0.03	<0.03	<0.03	160

Appendix VII

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]		Sample 1
				Non-irrigated	Non irrigated	Irrigated	
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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Wellington Regional Council 2012. Soil quality and stability in the Wellington Region. State and Trends. Great Wellington Regional Council.

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	-

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.

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

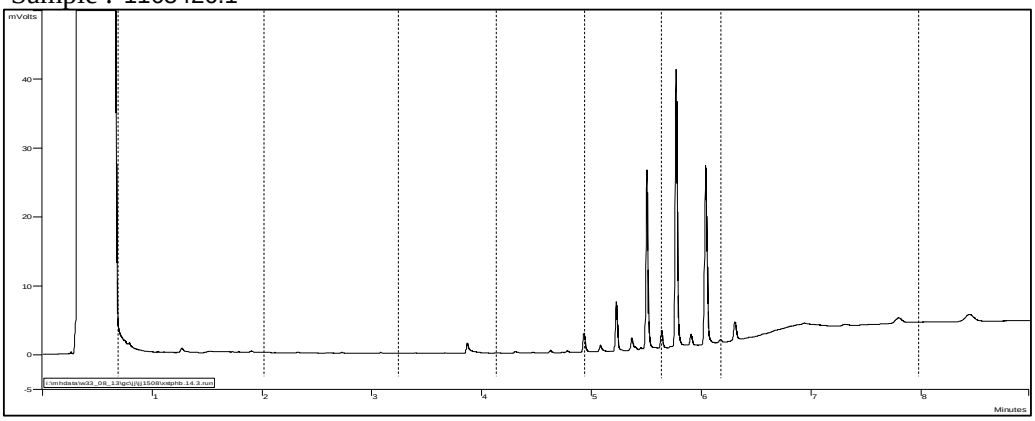
Sample Type: Plant Material			
Test	**Method Description**	**Default Detection Limit**	**Samples**
TPH in Biota extraction by Sonication (Instrument Vial)	Sonication extraction, Silica cleanup, GC-FID analysis.	-	1-4
TPH in Biota extraction by Sonication (Storage Vial)	Sonication extraction, Silica cleanup, GC-FID analysis.	-	1-4

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

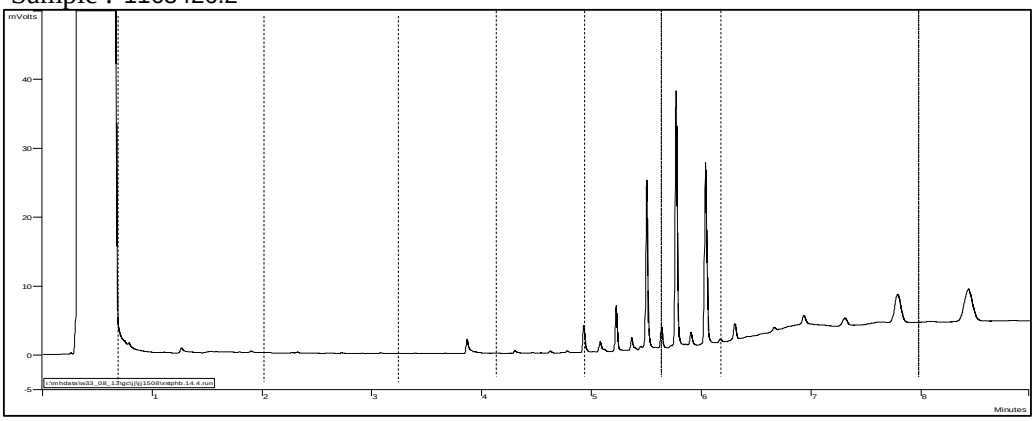
Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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

Sample : 1165426.1



Sample : 1165426.2



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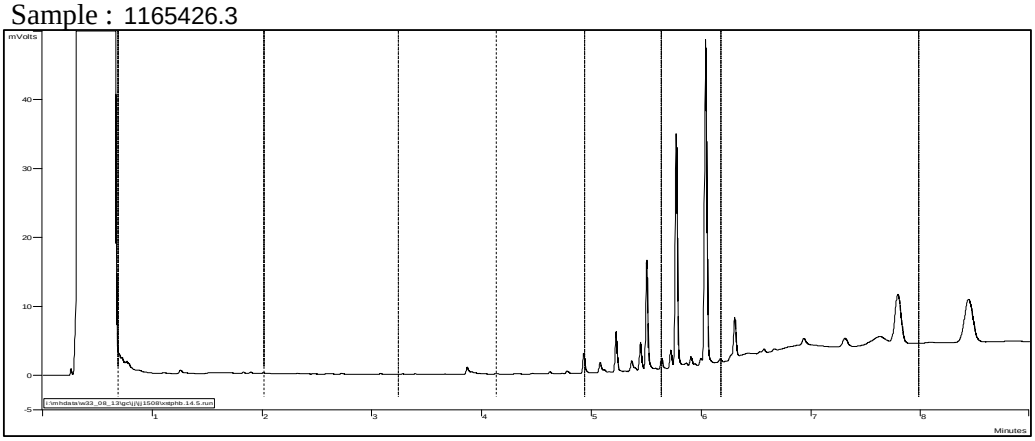
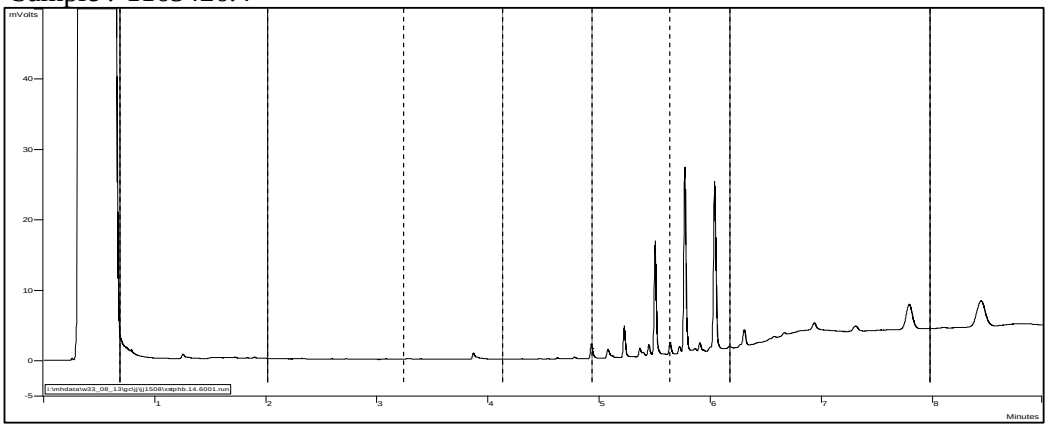


C7 C10 C15 C20 C25 C30 C34 C44

Sample : 1165426.4



C7 C10 C15 C20 C25 C30 C34 C44