Tonkin & Taylor

T&T Ref : 24968
20 May 2008

Horizons Regional Council
11-15 Victoria Avenue
Private Bag 11025
Palmerston North

Attention: Greg Bevin

Dear Greg

Disposal of Wastewater associated with ink machines
Hokio Beach Rd, Levin

Introduction

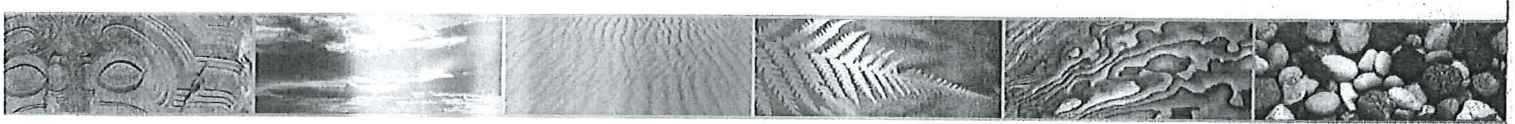
Horizons Regional Council (Horizons RC) has requested that Tonkin & Taylor undertake an assessment of the potential and actual effects associated with the disposal of wastewater associated with the ink machines on a property in Hokio Beach Rd, Levin. This assessment has been undertaken in accordance with our proposal (email dated 13 September 2007).

Horizons RC has provided the following information in regard to the assessment:

- Horizons RC document: Tatana Contractors photographic booklet, including a topographic map of the Hokio Beach Rd Area and Aerial photograph showing location of disposal (undated, photographs dated 2 July 2007).
- RJ Hill Laboratories analysis results dated 24 July 2007. Included as Appendix 1.
- Horizons RC email entitled Horizons Regional Council - Assistance with Council Investigation, dated 6 September 2007;
- Horowhenua District Council: Levin Landfill monitoring 2006-2007; and
- RJ Hill Laboratories analysis results reported 6 December 2007. Included as Appendix 2.

Background

Information provided by Horizons RC indicates that a complaint was received that wastewater was being dumped into an excavated pit, on a property located on Hokio Beach Road, Levin. Horizons RC staff visited the site and confirmed that a black wastewater was present in the pit. Two water samples were collected (Pit #1 and Pit #2), and analysis for metals, volatile organic compounds (VOC) and banded total petroleum hydrocarbons (TPH) undertaken at RJ Hill Laboratories. Analysis results are presented in Appendix 1.



Tonkin & Taylor Ltd - Environmental and Engineering Consultants, 105 Carlton Gore Road, Newmarket, Auckland, New Zealand
PO Box 5271, Wellesley St, Auckland 1141, Ph: 64-9-355 6000, Fax: 64-9-307 0265, Email: auck@tonkin.co.nz, Website: www.tonkin.co.nz

The subsequent investigation has ascertained the wastewater was sourced from a Carter Holt Harvey operation, located in Levin. CHH operate several print machines as part of their onsite activities. Periodically these print machines are serviced/cleaned with the resulting wastewater being discharged into a holding tank that forms part their onsite wastewater treatment plant.

Further background searches by Horizons RC indicate that wastewater was also collected from a different tank at the CHH facility, and dumped at the pit. The analysis results reported on 6th December 2007 relate to samples obtained from this tank. Horizons RC estimate that between August 2003 and June 2007, at least 300,000 litres of wastewater obtained from this tank were dumped in the pit.

A further sample was collected by Horizons RC from the CHH Starch Tank and tested for pH, boron and formaldehyde. These parameters are considered by Horizons RC to be representative of the wastewater disposed in the Hokio Beach Rd pit between August 2003 and June 2007. These results are included as Appendix 2.

Physical setting

The disposal site is located at the rear of 725 Hokio beach Road, Levin. The legal description of the property is Lot 1 DP59966 and has an approximate area of 7.1228ha. The site as of 18th April 2008 as shown on Terraview is owned by Tatana Contracting Ltd. The location of the dump site is within an area of exotic pine forest that has recently been harvested. The disposal site is located approximately 360m south of Hokio Beach Road.

The nearest buildings appear to be residential/ farm buildings located 160m to the north of the dump site.

Geology and Hydrogeology

The published literature[1] suggests the site is located within an area of Quaternary to present aged sand dunes. The dunes range in height from 20m to 30m and comprise fine to medium sand. The site is underlain at depth by the Ohakea Gravels which comprise poorly to moderately sorted gravel with minor sand and silt.

The soils of the area are Foxton - Omanuka and Waitarere - Hokio Associations[2]. These units are commonly sandy loams with peaty swampy deposits in depressions commonly

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[1]Begg, J.G., Johnston, M.R. (compilers) 2000. Geology of the Wellington area. Institute of Geological and Nuclear Sciences 1:250,000 geological map 10. 1 sheet + 64 p. Lower Hutt, New Zealand.

[2] Cowie, J.D., Fitzgerald, P., Ownes, W. 1967: Soils of the Manawatu - Rangitikei sand Country, Soil Bureau Bulletin 29, New Zealand Department of Scientific and Industrial Research.

found between dunes. Pastoral land to the north of the site is known to contain peat deposits of unknown thickness[3].

Two aquifers are likely present beneath the site; a shallow sand aquifer, and a deep gravel aquifer with the Ohakea Gravels. The shallow aquifer is likely to be unconfined and the deeper aquifer could be confined or unconfined.

The shallow aquifer is likely to be of low to moderate permeability and highly affected by strong surface water interaction. Groundwater flows within this shallow aquifer are likely to follow and be perturbed by surface features. Groundwater flows have been shown to be towards the north west[3]. The groundwater level within this shallow aquifer is likely to be near the ground level between dunes.

The deeper aquifer within the Ohakea Gravels is at approximately -6m to -15m RL. This aquifer is likely part of the regional Horowhenua Aquifer[4]. Regional groundwater flow in the Horowhenua Aquifer is generally towards the west.

The closest stream/ water body to the dump site is Hokio Stream located approximately 500m north running adjacent to Hokio Beach Road. The Hokio Stream discharges to the ocean approximately 2.3km to the west.

Wastewater characteristics

The Horizons RC photographs show that the waste deposited into the dump site contains timbers, vegetation, soils and construction debris. The dump pit also contained black discoloured water with a visible hydrocarbon sheen on the surface.

The photographic record shows that a significant volume of contaminated wastewater was disposed in the pit. For the duration that the contaminated wastewater was present in the pit, the area was exposed to rainfall infiltration, with a high potential for contaminant transport to the groundwater (and subsequently, to any downgradient groundwater bores and the Hokio Stream).

Laboratory Analysis results

Analysis results for compounds exceeding the detection limit are presented in Table 1. Full laboratory transcripts are provided as Appendix 1. The results have been evaluated against potable guidelines published in the Drinking Water Standards (DWS, New Zealand) and ecological guidelines published by The Australian and New Zealand Environment and Conservation Council (ANZECC).

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[3] MWH August 2007: Horowhenua District Council, Levin landfill Monitoring 2006-2007. Ref Z1116504.

[4] Bekesi, G. 2001: Manawatu- Wanganui. In Groundwaters of New Zealand, M.R Rosen and P.A. White (eds). New Zealand Hydrological Society Inc., Wellington. P387-396

Table 1: Laboratory Analysis results

Sample Name	Pit #1	Pit #2	DWSNZ (2005)	ANZECC (2000) 95% Protection Freshwater	ANZECC (2000) 80% Protection Freshwater
Cyanide	-	-	-	0.007	0.018
Arsenic	0.05	0.05	0.01	0.013	0.140
Cadmium	0.002	0.002	0.004	0.0002	0.0008
Chromium	0.08	0.08	0.05	0.001	0.040
Copper	1.71	1.43	2	0.0014	0.0025
Nickel	0.01	<0.01	0.02	0.011	0.017
Lead	0.061	0.053	0.01	0.0034	0.0094
Zinc	3.66	3.29	1.5	0.008	0.031
Boron	-	11[1]	1.4	0.37	1.3
Formaldehyde	-	0.59[1]	1.0	-	-
Naphthalene	<0.005	<0.005	-	0.016	0.085
Benzo(a)pyrene	-	-	0.00070	0.00007	ID
Benzene	<0.005	<0.005	0.01	0.95	2.0
Toluene	<0.005	<0.005	0.8	0.33	0.33
Ethylbenzene	<0.005	<0.005	0.3	0.16	0.16
Xylene-o	<0.005	<0.005	0.6	0.35	0.64
C_7-C_9	<0.1	5.8	-	-	-
C_{10}-C_{14}	0.7	7.3	-	-	-
C_{15}-C_{36}	4.0	1020	-	-	-
TPH (total)	5	1030	-	-	-

Notes for table:

Results in mg/L

- \- no guideline value derived
- ND not detected
- POE Point of Exposure
- 1 Concentration of Boron from starch tank that is representative of Boron concentrations in the wastewater
- 2 Predicted surface water concentration derived by applying a dilution factor of 0.00036 (L-gw/L-sw)
- 3 Analytes not included in RBCA modelling because they were recorded below the laboratory limit of detection

The maximum zinc concentration of 3.66 mg/L exceeds the relevant DWSNZ (2005). Boron concentration exceeds both the DWS 2005 MAV of 1.4 mg/L, and the relevant ANZECC values for protection of aquatic ecosystems.

A formaldehyde concentration of 0.59 mg/L is not considered to be a concern in terms of human health risk, given the DWS 2005 MAV of 1.0 mg/L.

The hydrocarbon chromatogram is indicative of lube oil, so it is assumed that the TPH is more likely to be in the aliphatic fraction than the aromatic fraction. The concentrations

present are significantly higher than the solubilities for the relevant aliphatic fraction, suggesting the presence of liquid phase hydrocarbons.

Given the type and amount of data regarding TPH and the lack of environmental quality guidelines available, a meaningful quantitative risk assessment could not be produced. However, to undertake a semi-quantitative assessment reference has been made the MfE 1998 '*Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand*'. This document provides a TPH concentration for the 'discharge water quality' of 15 mg/l based on dispersion modelling carried out by Woodward Clyde Ltd. The point of compliance in this case is the point at which the discharger loses control of the effluent. Although this guideline is not directly applicable to this site, it does provide an industry recognised concentration for TPH that is protective of the environment.

As discussed, the chromatograph fingerprint suggests the TPH is representative of lube oil, so it is assumed that the TPH is more likely to be in the aliphatic fraction than the aromatic fraction. The total solubility of the aliphatic fraction of hydrocarbons is around 12 mg/l. Therefore, assuming that the soluble portion of the TPH concentrations measured on the site is 12 mg/l, which is below the MfE guideline of 15 mg/l, and all free product has been removed, there is unlikely to be a significant risk to the environment.

It is recommended that any confirmatory downgradient groundwater quality sampling include polycyclic aromatic hydrocarbons (PAH) to characterise the concentrations of carcinogenic PAHs, and better determine the potential for health effects. This additional testing is discussed in detail below.

Preliminary Tier 2 Risk Assessment

Due to the nature of the near-surface hydrogeology, there is considered to be a high potential for contaminant migration from the pit into the adjacent and downgradient groundwater, particularly the more soluble organic compounds, metals and boron. Accordingly a preliminary risk assessment was undertaken to characterise the potential for adverse human health and environmental effects on groundwater quality in the borehole 350 m north of the site and surface water in the Hokio Stream.

The Tier 2 risk assessment was conducted using the RBCA (Risk Based Corrective Action) software model developed by Groundwater Services Inc. The RBCA process is described in ASTM PS 104-98 Standard Provisional Guide for Risk-Based Corrective Action.

Table 2 Model Input – Saturated Zone

Parameter	Value Selected for Model Input	Source
Contaminant concentration in Groundwater (mg/L)	Refer Table 1 and Appendix 3	Site specific parameter testing
Fraction organic carbon (f_{oc})	0.0001	RBCA model default

Parameter	Value Selected for Model Input	Source
Horizontal Hydraulic Conductivity (m/day)	9	Site specific parameter testing
Effective Porosity	0.25	Professional judgement
Saturated Thickness (m)	3.05	
GROUNDWATER HYDRAULIC GRADIENT;	0.007	Region specific groundwater contours
First-order decay half-life (days)	NO BIODEGRADATION USED IN MODEL	
Dispersion (m)	α_x = 540 α_y = 0.33 α_z = 0.05	ASTM PS 104-98, Groundwater Services, Inc., 1996

Additional input values, including model domain dimensions, adsorption, longitudinal and transverse dispersivity values are presented in the individual RBCA input sheets in Appendix 3.

Table 3: Predicted contaminant concentrations in groundwater at borehole 350 m north of pit

Sample Name	Pit #1	Pit #2	RBCA Predicted Groundwater Concentration at POE	DWSNZ (2005)	ANZECC (2000) Livestock Watering Guidelines	MfE Timber Treatment Irrigation Guidelines
Cyanide	-	-		-	-	-
Arsenic	0.05	0.05	0.0006	0.01	0.5	0.1
Cadmium	0.002	0.002	0.00002	0.004	0.01	-
Chromium	0.08	0.08	0.001	0.05	1	0.1
Copper	1.71	1.43	0.02	2	0.4	0.2
Nickel	0.01	<0.01	0.00012	0.02	1	-
Lead	0.061	0.053	0.0007	0.01	0.1	-
Zinc	3.66	3.29	0.043	1.5	20	-
Boron	-	11[1]	0.13	1.4	5	0.5
Naphthalene	<0.005	<0.005	-[3]	-	-	-
Benzo(a)pyrene	-	-	-[3]	0.00070	-	-
Benzene	<0.005	<0.005	-[3]	0.01	-	-
Toluene	<0.005	<0.005	-[3]	0.8	-	-
Ethylbenzene	<0.005	<0.005	-[3]	0.3	-	-
Xylene-o	<0.005	<0.005	-[3]	0.6	-	-
C_7-C_9	<0.1	5.8	-	-	-	-
C_{10}-C_{14}	0.7	7.3	-	-	-	-
C_{15}-C_{36}	4.0	1020	-	-	-	-
TPH (total)	5	1030	-	-	-	-

Notes for table:

Results in mg/L

- \- no guideline value derived
- ND not detected
- POE Point of Exposure
- 1 Concentration of Boron from starch tank that is representative of Boron concentrations in the wastewater
- 2 Predicted surface water concentration derived by applying a dilution factor of 0.00036 (L-gw/L-sw)
- 3 Analytes not included in RBCA modelling because they were recorded below the laboratory limit of detection

Table 4: Predicted contaminant concentrations in groundwater and Hokio Stream at the point of exposure

Sample Name	Pit #1	Pit #2	RBCA Predicted Groundwater Concentration at POE	RBCA Predicted Surface Water Concentration in Hokio Stream[2]	DWSNZ (2005)	ANZECC (2000) 95% Protection Freshwater	ANZECC (2000) 80% Protection Freshwater
Cyanide	-	-		-	-	0.007	0.018
Arsenic	0.05	0.05	0.00039	0.00000014	0.01	0.013	0.140
Cadmium	0.002	0.002	0.000016	0.000000005	0.004	0.0002	0.0008
Chromium	0.08	0.08	0.00062	0.00000023	0.05	0.001	0.040
Copper	1.71	1.43	0.013	0.0000048	2	0.0014	0.0025
Nickel	0.01	<0.01	0.000078	0.000000028	0.02	0.011	0.017
Lead	0.061	0.053	0.00047	0.00000017	0.01	0.0034	0.0094
Zinc	3.66	3.29	0.028	0.00001	1.5	0.008	0.031
Boron	-	11[1]	0.085	0.000031	1.4	0.37	1.3
Naphthalene	<0.005	<0.005	-[3]	-[3]	-	0.016	0.085
Benzo(a)pyrene	-	-	-[3]	-[3]	0.00070	0.00007	ID
Benzene	<0.005	<0.005	-[3]	-[3]	0.01	0.95	2.0
Toluene	<0.005	<0.005	-[3]	-[3]	0.8	0.33	0.33
Ethylbenzene	<0.005	<0.005	-[3]	-[3]	0.3	0.16	0.16
Xylene-o	<0.005	<0.005	-[3]	-[3]	0.6	0.35	0.64
C_7-C_9	<0.1	5.8	-	-	-	-	-
C_{10}-C_{14}	0.7	7.3	-	-	-	-	-
C_{15}-C_{36}	4.0	1020	-	-	-	-	-
TPH (total)	5	1030	-	-	-	-	-

Notes for table:

Results in mg/L

- \- no guideline value derived
- ND not detected
- POE Point of Exposure
- [1] Concentration of Boron from starch tank that is representative of Boron concentrations in the wastewater
- [2] Predicted surface water concentration derived by applying a dilution factor of 0.00036 (L-gw/L-sw)
- [3] Analytes not included in RBCA modelling because they were recorded below the laboratory limit of detection

Potential human health and environmental effects

Analytical testing for contaminants of concern in the disposed wastewater confirms the potential exists for adverse human health and environmental effects that are greater than minor.

Results of the preliminary Tier 2 Risk Assessment indicate there is unlikely to be an adverse impact on the Hokio Stream from the maximum concentrations of metals detected in the source zone. Additionally, the potential for adverse effects on human health from potable water supply extracted from the Hokio Stream is considered to be very low.

However the potential exists for adverse effects on human health from ingestion of contaminated groundwater. The magnitude of effects is a function of the location of the groundwater abstraction, and the current use (e.g. potable or irrigation use). The preliminary Tier 2 risk assessment indicates there is unlikely to be an adverse impact on human health or livestock from exposure to the groundwater at the borehole 350 m north of the pit from the maximum concentrations of metals detected in the source zone.

Although, the discharges to the pit were undertaken over a period of at least 4 years, resulting in approximately 300,000 litres of wastewater entering the ground, the preliminary Tier 2 risk assessment indicates there is not immediate or long term risk in terms of the potential environmental and human health receptors considered in the assessment. However the potential for adverse effects in the future on soil quality and groundwater quality cannot be excluded, particularly if groundwater was to be abstracted closer to the pit in the future. The preliminary Tier 2 Risk Assessment is based on various assumptions regarding residual soil and downgradient groundwater quality, some of which have not been fully characterised.

The Horowhenua District Council Levin Landfill is located to the east of the site. The pit site may be slightly down gradient of the landfill. The test results from the 2006 – 2007 Levin Landfill Monitoring report indicate concentrations of aluminium, cadmium, iron and lead above the DWSNZ and concentrations of aluminium, cadmium, chromium, lead, nickel and zinc above the ANZECC (2000) 95% protection guidelines (refer Appendix 4). These exceedances indicate that the landfill is having a clear impact in the ambient water quality in the area. However, the metals concentrations recorded in the wastewater are generally higher than those measured in the landfill monitoring bores. In many cases they are 1 or 2 orders of magnitude higher. This indicates that the wastewater is likely to be having a greater impact on the ambient water quality in the area than the landfill.

The programme set out below is designed to better characterise residual contamination, and confirm the level of risk posed by the contamination, including any groundwater takes north and west of the disposal site, and to the Hokio Stream.

Sampling of the adjacent and underlying soils was not undertaken after wastewater removal and therefore the nature of any effects on soil quality has not been determined. A programme of soil testing is recommended to characterise the nature and extent of contamination within the waste and adjacent and underlying soils.

A recommended suite of laboratory analyses for soils include:

- Metals suite (total and TCLP)
- Total petroleum hydrocarbons (TPH)
- Volatile organic compounds (VOC)
- Polycyclic aromatic hydrocarbons (PAH)
- Semi-volatile organic compounds (SVOC)
- Formaldehyde

It is recommended that a monitoring well be located immediately downgradient of the former disposal pit to characterise the actual nature and extent residual contamination resulting from the disposal of the contaminated wastewater. The well should be appropriately placed (laterally and with depth) to intercept any contaminants migrating from the pit.

A recommended suite of laboratory analyses for groundwater include:

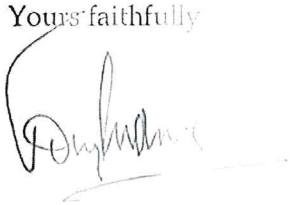
- pH
- Metals suite (total and soluble)
- Total petroleum hydrocarbons (TPH)
- Volatile organic compounds (VOC)
- Polycyclic aromatic hydrocarbons (PAH)
- Semi-volatile organic compounds (SVOC)
- Formaldehyde

It is further recommended that, in the event that soil contamination is determined to be above acceptable levels, a remediation action plan (RAP) should be prepared and remedial work undertaken in accordance with the RAP. A full quantitative risk assessment may also be required to demonstrate that the potential for human health and environmental effects from the wastewater disposal are acceptable.

Applicability

This report has been prepared for the benefit of Horizons Regional Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Yours faithfully



Tony Cussins
Senior Environmental Scientist

20-Jun-08
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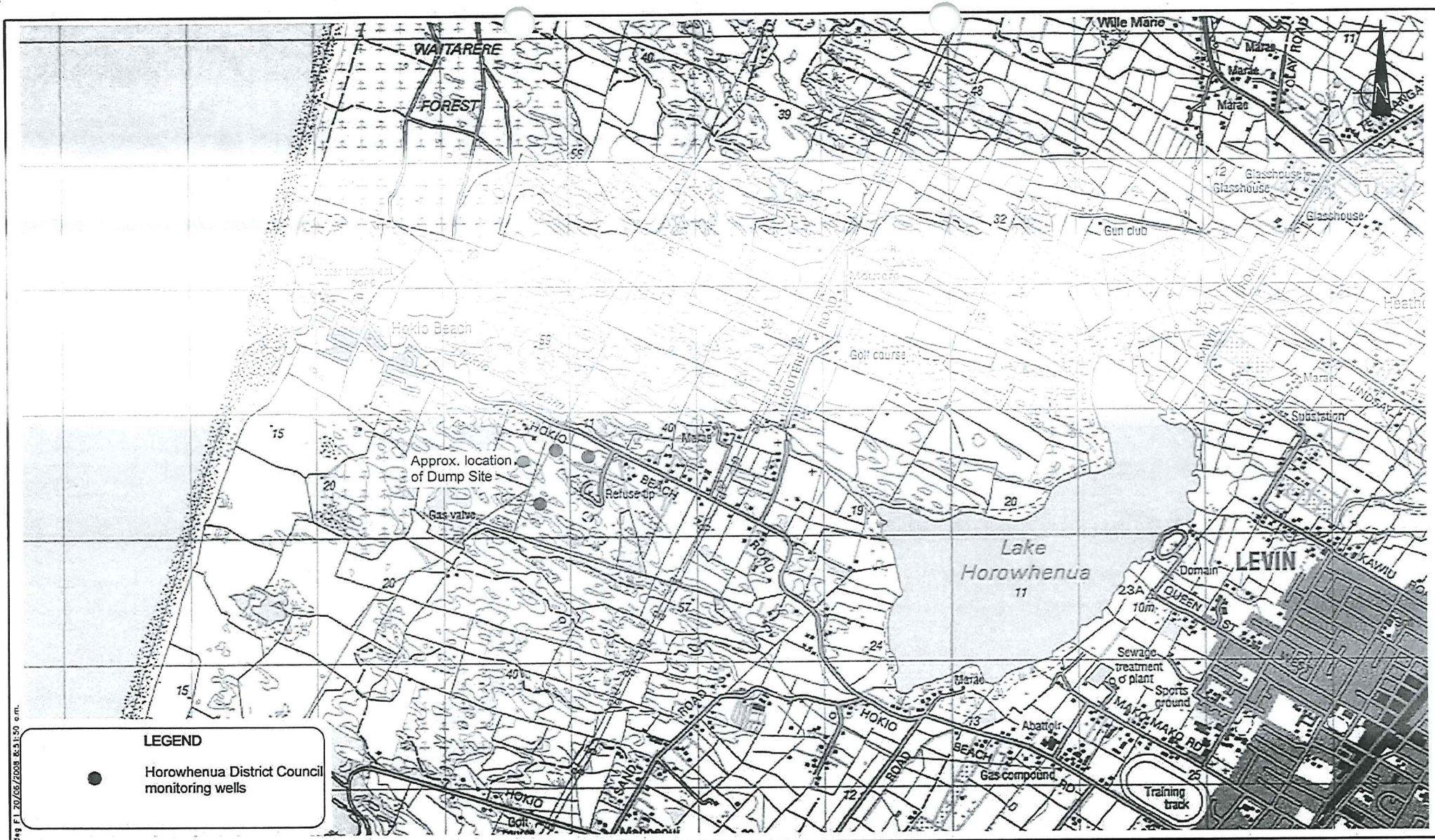
Figures



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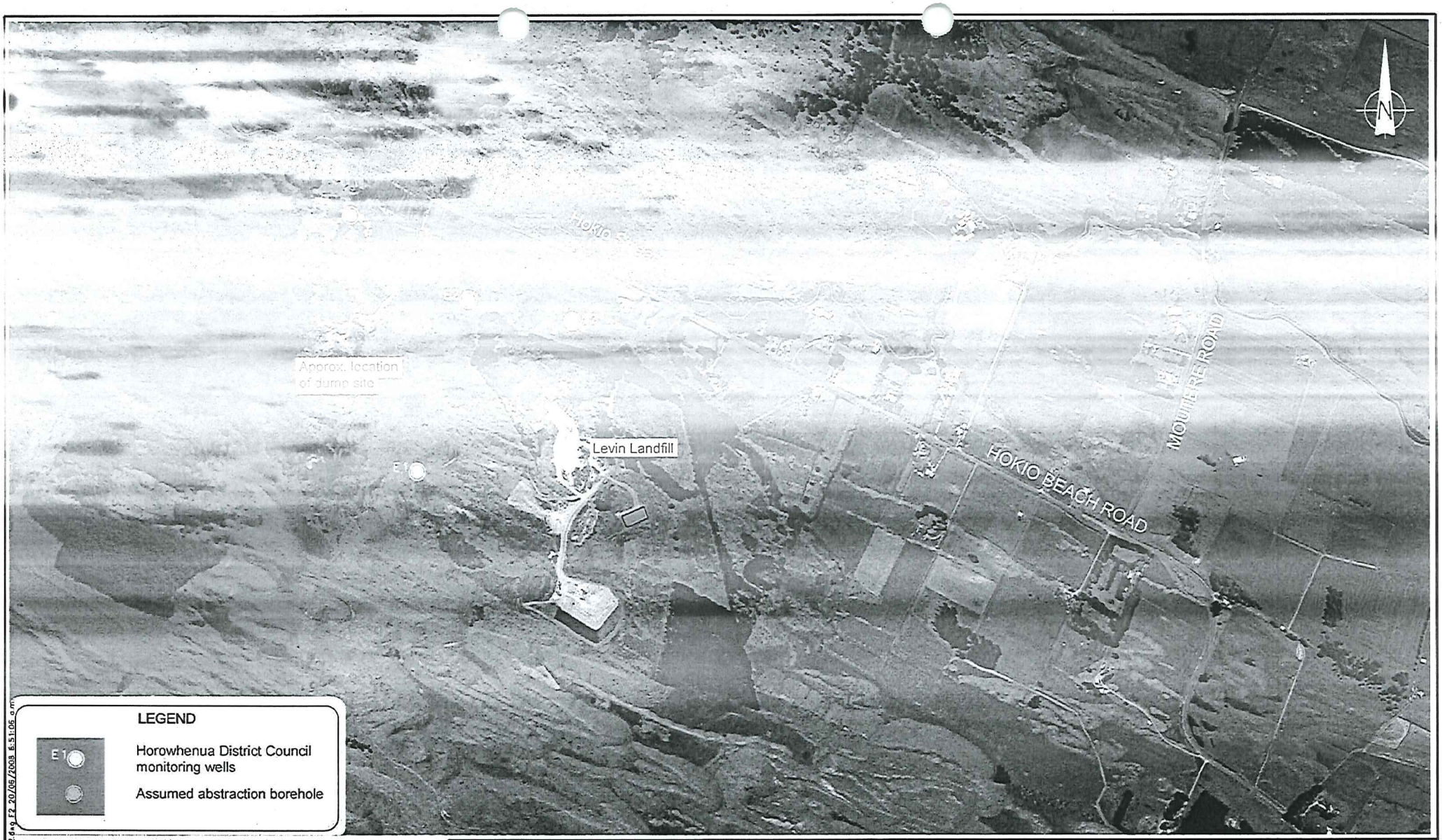
Tonkin & Taylor
Environmental & Engineering Consultants
Auckland
Hamilton Christchurch
Nelson Wellington Whangarei

HORIZONS REGIONAL COUNCIL
WASTEWATER DISPOSAL
HOKIO BEACH
Location Plan

FIG. No. Figure 1

REV. 0



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Tonkin & Taylor
Environmental & Engineering Consultants
Auckland
Hamilton Christchurch
Nelson Wellington Whangarei

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APPROVED		6/08
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PROJECT No. 24968		

HORIZONS REGIONAL COUNCIL
WASTEWATER DISPOSAL
HOKIO BEACH
Site Plan

FIG. No. Figure 2

REV. 0

Appendix I Laboratory analysis results- reported 24 July 2007

Hill Laboratories
A WORLD LEADER IN ANALYTICAL SERVICES

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Client: Horizons MW Regional Council
Address: Private Bag 11025,
PALMERSTON NORTH
Contact: Greg Bevin

Laboratory No: 457928
Date Registered: 4/07/2007
Date Completed: 24/07/2007
Page Number: 1 of 5

Client's Reference: Prosecution Sample

The results for the analyses you requested are as follows:

Sample Type: Water,

Sample Name		Tatana Contracting Ltd Pit #1 02/07/07 1410	Tatana Contracting Ltd Pit # 2 02/07/07 1425
Lab No		457928/1	457928/2
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	($g.O_2.m-3$)	57	1640
Total Arsenic	(g.m-3)	0.05	0.05
Total Cadmium	(g.m-3)	0.002	0.002
Total Chromium	(g.m-3)	0.08	0.08
Total Copper	(g.m-3)	1.71	1.43
Total Nickel	(g.m-3)	0.01	< 0.01
Total Lead	(g.m-3)	0.061	0.053
Total Zinc	(g.m-3)	3.66	3.29
Oil & Grease	(g.m-3)	< 20	570 #

See Note 1.

Volatile organic compounds (VOC)

Sample Name	Tatana Contracting Ltd Pit #1 02/07/07 1410	Tatana Contracting Ltd Pit # 2 02/07/07 1425
Lab No	457928/1	457928/2
Units	(g.m-3)	(g.m-3)
Dichlorodifluoromethane	< 0.005	< 0.005
Chloromethane	< 0.005	< 0.005
Vinyl chloride	< 0.005	< 0.005
Bromomethane	< 0.005	< 0.005
Chloroethane	< 0.005	< 0.005
Trichlorofluoromethane	< 0.005	< 0.005
1,1-Dichloroethene	< 0.005	< 0.005
Carbon disulphide	< 0.05	< 0.05
1,1,2-Trichlorotrifluoroethane (Freon 113)	< 0.05	< 0.05

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

Sample Name	Tatana Contracting Ltd Pit #1 02/07/07 1410	Tatana Contracting Ltd Pit # 2 02/07/07 1425
Lab No	457928/1	457928/2
Units	(g.m-3)	(g.m-3)
Dichloromethane (Methylene chloride)	< 0.1	< 0.1
trans-1,2-Dichloroethene	< 0.005	< 0.005
1,1-Dichloroethane	< 0.005	< 0.005
2-Butanone (MEK)	0.07	< 0.05
cis-1,2-Dichloroethene	< 0.005	< 0.005
2,2-Dichloropropane	< 0.005	< 0.005
Chloroform (Trichloromethane)	< 0.005	< 0.005
1,1,1-Trichloroethane	< 0.005	< 0.005
1,2-Dichloroethane	< 0.005	< 0.005
Carbon tetrachloride	< 0.005	< 0.005
1,1-Dichloropropene	< 0.005	< 0.005
Benzene	< 0.005	< 0.005
Trichloroethene	< 0.005	< 0.005
1,2-Dichloropropane	< 0.005	< 0.005
Dibromomethane	< 0.005	< 0.005
Bromodichloromethane	< 0.005	< 0.005
cis-1,3-Dichloropropene	< 0.005	< 0.005
4-Methylpentan-2-one (MIBK)	< 0.05	< 0.05
Toluene	< 0.005	< 0.005
trans-1,3-Dichloropropene	< 0.005	< 0.005
1,1,2-Trichloroethane	< 0.005	< 0.005
1,3-Dichloropropane	< 0.005	< 0.005
Dibromochloromethane	< 0.005	< 0.005
Tetrachloroethene	< 0.005	< 0.005
1,2-Dibromoethane	< 0.004	< 0.004
Chlorobenzene	< 0.005	< 0.005
1,1,1,2-Tetrachloroethane	< 0.005	< 0.005
Ethylbenzene	< 0.005	< 0.005
m & p-Xylene	< 0.005	< 0.005
o-Xylene	< 0.005	< 0.005
Styrene	< 0.005	< 0.005
Bromoform (tribromomethane)	< 0.005	< 0.005
Isopropylbenzene	< 0.005	< 0.005
1,1,2,2-Tetrachloroethane	< 0.005	< 0.005
1,2,3-Trichloropropane	< 0.005	< 0.005
Bromobenzene	< 0.005	< 0.005
2-Chlorotoluene	< 0.005	< 0.005
n-Propylbenzene	< 0.005	< 0.005
4-Chlorotoluene	< 0.005	< 0.005
1,3,5-Trimethylbenzene	< 0.005	< 0.005
tert-Butylbenzene	< 0.005	< 0.005
1,2,4-Trimethylbenzene	< 0.005	< 0.005
1,3-Dichlorobenzene	< 0.005	< 0.005
sec-Butylbenzene	< 0.005	< 0.005

Sample Name	Tatana Contracting Ltd Pit #1 02/07/07 1410	Tatana Contracting Ltd Pit # 2 02/07/07 1425
Lab No	457928/1	457928/2
Units	(g.m-3)	(g.m-3)
1,4-Dichlorobenzene	< 0.005	< 0.005
4-Isopropyltoluene	0.008	0.006
1,2-Dichlorobenzene	< 0.005	< 0.005
n-Butylbenzene	< 0.005	< 0.005
1,2-Dibromo-3-chloropropane	< 0.005	< 0.005
1,2,4-Trichlorobenzene	< 0.005	< 0.005
Naphthalene	< 0.005	< 0.005
1,2,3-Trichlorobenzene	< 0.005	< 0.005
Hexachlorobutadiene	< 0.005	< 0.005
MTBE (methyl-t-butylether)	< 0.05	< 0.05
Surrogates	-	-
Toluene-d8 (% Recovery)	99	87
4-Bromofluorobenzene (% Recovery)	92	87

Total Hydrocarbons by GC-FID [OIEWG carbon bands]

Sample Name	Tatana Contracting Ltd Pit #1 02/07/07 1410	Tatana Contracting Ltd Pit # 2 02/07/07 1425
Lab No	457928/1	457928/2
Units	(g.m-3)	(g.m-3)
C7-C9	< 0.1	5.8
C10-C14	0.7	7.3
C15-C36	4.0	1020
TOTAL	5	1030

Sample Containers

The following table shows the sample containers that were associated with this job.

Container Description	Container Size (mL)	Number of Containers
Unpreserved (1L)	1000	1
Unpreserved (BOD) (500 mL)	500	2
Glass oil & grease (500 mL)	500	2
Glass for TPH (250 or 500 mL)	250	2
PET, microbial testing, leave 1cm air gap (400 mL)	400	2
Brown glass for VOC (40 mL)	40	2
Nitric Preserved Pottle	100	2

Details of sample bottle preparation procedures are available upon request.

Summary of Methods Used and Detection Limits

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.

Substance Type: Water

Parameter	Method Used	Detection Limit
Total (nitric) acid digest for low level metals	Nitric acid digestion. APHA 3030 E 21st ed. 2005.	N/A
Carbonaceous Biochemical Oxygen Demand (CBOD5)	Incubation 5 days, DO meter, nitrification inhibitor added, dilutions, seeded. APHA 5210 B 21st ed. 2005.	1 g.O_2.m-3
Total Arsenic	Nitric acid digestion. ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	0.02 g.m-3
Total Cadmium	Nitric acid digestion. ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	0.001 g.m-3
Total Chromium	Nitric acid digestion. ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	0.01 g.m-3
Total Copper	Nitric acid digestion. ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	0.01 g.m-3
Total Nickel	Nitric acid digestion. ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	0.01 g.m-3
Total Lead	Nitric acid digestion. ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	0.002 g.m-3
Total Zinc	Nitric acid digestion. ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	0.02 g.m-3
Oil & Grease	Sample filtration through filter aid, Soxhlet extraction, gravimetric determination of extracted Oil & Grease. APHA 5520 D 21st ed. 2005.	5 g.m-3
Total Hydrocarbons by GC-FID [OIEWG carbon bands]	Solvent (hexane) extraction, GC-FID US EPA 8015B/NZ OIEWG	N/A
Volatile organic compounds (VOC)	Purge and Trap GC-MS US EPA Method 524.2	N/A

Analyst's Comments:

These samples were collected by yourselves 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 submitter.

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Arrived via courier. Chilly bin arrived at Hill Labs with tape still intact and PP stickers unbroken. Inside large chilly bin were 2 poly bins tape still intact, 6 ice packs and bubble wrap.

The samples initially foamed on the GC-MS (Purge & Trap) for the VOC analysis. A smaller volume was analysed, hence the higher detection limits reported.

Note 1: It has been noted that the results for "Oil and Grease" do not compare well with the Total Hydrocarbons (C15 – C36). Due to significant levels of 'Oil and Grease' present, this analysis was performed on a smaller (less representative) sample volume than that routinely used for this test. The sample was also noted to be very heterogeneous in nature.

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

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental Division

Appendix 2 – Laboratory analysis results – Reported 6 December 2007

Hill Laboratories
A WORLD LEADER IN ANALYTICAL SERVICES

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Hamilton 3240, New Zealand

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

ANALYSIS REPORT

Client:	Horizons MW Regional Council	Lab No:	621127 SPv1
Contact:	Bevin, Greg	Date Registered:	29-Nov-2007
	c/o Horizons MW Regional Council	Date Reported:	06-Dec-2007
	Private Bag 11025	Quote No:	
	PALMERSTON NORTH	Order No:	
		Client Reference:	POSSIBLE PROSECUTION
		Submitted By:	Bevin, Greg

Sample Type: Trade Waste

Sample Name:		CHH Starch Tank (Levin) 27-Nov-2007 10:20 am				
Lab Number:		621127.1				
Individual Tests						
pH	pH Units	10.5	-	-	-	-
Total Boron	g/m³	11	-	-	-	-
Formaldehyde in Water by DNPH & HPLC						
Formaldehyde*	g/m³	0.59	-	-	-	-

Analyst's Comments

Tape applied and intact

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: Trade Waste

Test	Method Description	Default Detection Limit	Samples
Formaldehyde in Water by DNPH & HPLC*	DNPH derivatisation, extraction, HPLC	-	1
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 21st ed. 2005.	-	1
pH	pH meter. APHA 4500-H+ B 21st ed. 2005.	0.1 pH Units	1
Total Boron	Nitric acid digestion, ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	0.11 g/m³	1

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

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

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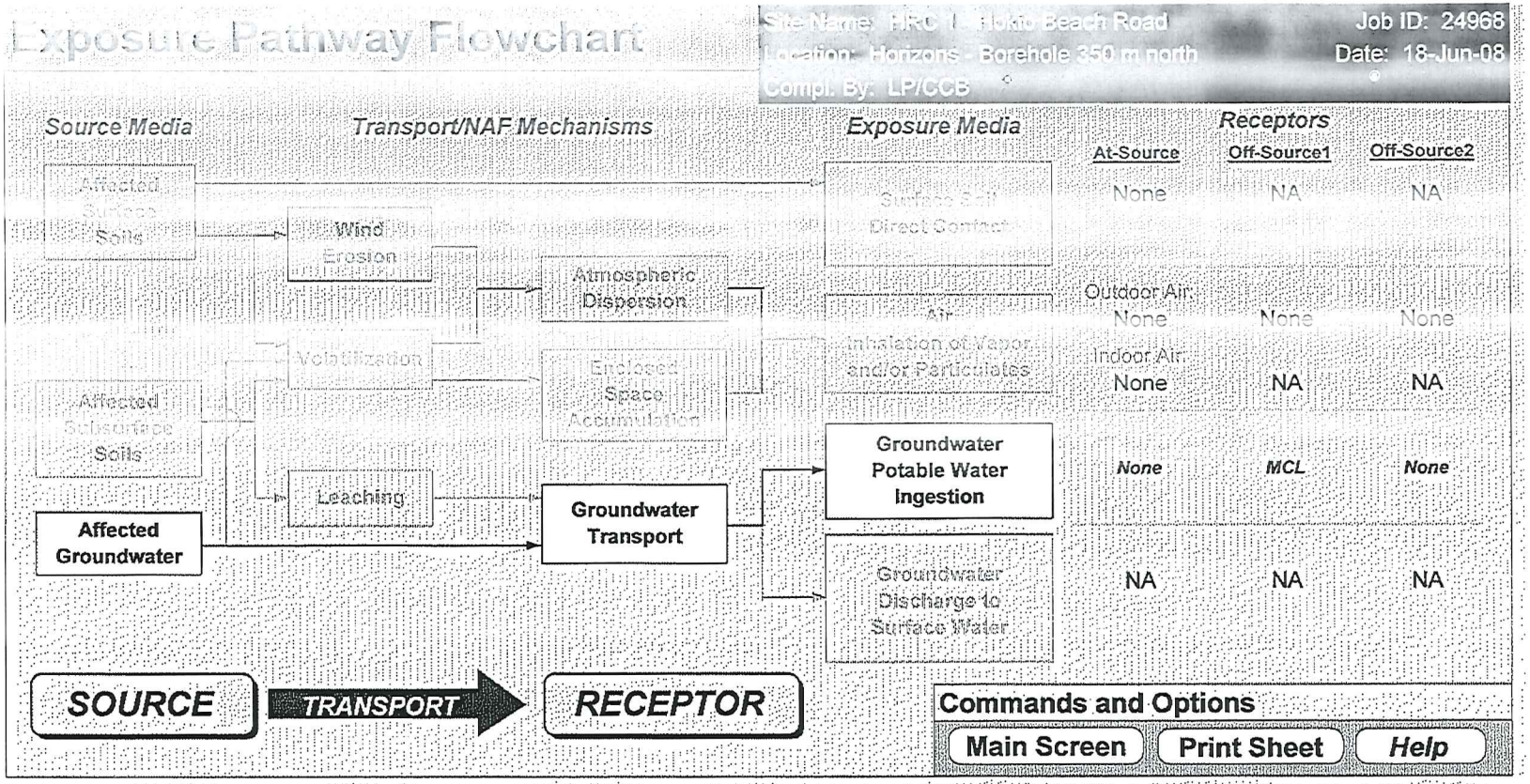
Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

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

Appendix 3 – Preliminary Tier 2 Risk assessment

- Borehole 350 m north of pit site
- Hokio Stream 540 m north of the pit site


Exposure Pathway Flowchart
Site Name: HRC I - Hokit Beach Road
Location: Horizons - Borehole 350 m north
Compl. By: LP/CCB
Job ID: 24968
Date: 18-Jun-08
Source Media
Transport/NAF Mechanisms
Exposure Media
Receptors
At-Source
Off-Source1
Off-Source2
Affected Surface Soils
Wind Erosion
Surface Soil Direct Contact
None
NA
NA
Atmospheric Dispersion
Air
Outdoor Air:
None
None
None
Volatilization
Inhalation of Vapor and/or Particulates
Indoor Air:
None
NA
NA
Enclosed Space Accumulation
Affected Subsurface Soils
Groundwater Potable Water Ingestion
None
MCL
None
Leaching
Affected Groundwater
Groundwater Transport
Groundwater Discharge to Surface Water
NA
NA
NA
SOURCE
TRANSPORT
RECEPTOR
Commands and Options
Main Screen
Print Sheet
Help

TIER 2 TRRP AFFECTED PROPERTY ASSESSMENT — Input Parameter Summary

Site Name: HRC 1 - Hokio Beach Road — Completed By: LP/CCB — Job ID: 24968

Site Location: Horizons - Borehole 350 m north — Date Completed: 18-Jun-08 —

Exposure Parameters		Residential				Commercial/Industrial	
		Adult	(1-6yrs)	(6-16 yrs)	Age Adjusted	Chronic	Construc.
AT_c	Averaging time, carcinogens (yr)	70					
AT_n	Averaging time, non-carcinogens (yr)	30				25	1
τ	Averaging time, vapor flux (yr)	30				30	1
BW	Body weight (kg)	70	15	45		70	
ED	Exposure duration (yr)	30	6	12		25	1
EF	Exposure frequency (days/yr)	350				250	180
EF_D	Dermal exposure frequency	350				250	
IR_w	Ingestion rate, water (L/day)	1.59	0.64		0.80	1.4	
IR_s	Ingestion rate, soil (mg/day)	127	191		120	100	100
SA	Skin surface area (dermal) (cm^2)	4800	2200	3500	352	2500	2500
M	Soil to skin adherence factor	0.1	0.2	0.1		0.2	
ET_{swim}	Swimming exposure time (hr/event)	3					
EV_{swim}	Swimming event frequency (events/yr)	12	12	12			
IR_{swim}	Water ingestion while swimming (L/hr)	0.05	0.5		2.6		
SA_{swim}	Skin surface area for swimming (cm^2)	23000		8100	96890		
IR_{ag}	Ingestion rate, above-ground vegs. (kg/day)	0.0057	0.0024		0.0029		
IR_{bg}	Ingestion rate, below-ground vegs. (kg/day)	0.0025	0.0010		0.0012		
VC	Below-ground vegetable correction factor (-)	0.01					

Complete Exposure Pathways and Receptors	At-Source	Off-Source 1	Off-Source 2	(Units)
Class 1 or 2 Groundwater:				
Groundwater Ingestion	None	MCL	None	
Distance to GW receptor	NA	350	NA	(m)
Soil Leaching to Groundwater	None	None	None	
Distance to GW receptor	NA	NA	NA	(m)
Apply secondary MCLs?	NA	No	NA	
Base Soil PCL on Site GW Conc.?	NA	No	NA	
Groundwater Discharge to Surface Water:				
Recreation/Swimming			NA	
TRRP Human Health Protection			NA	
TRRP Aquatic Life Protection			NA	
Soil:				
Total Soil Combined	None			
Outdoor Air:				
Particulates from Surface Soils	None	None	None	
Volatilization from Soils	None	None	None	
Volatilization from Groundwater	None	None	None	
Distance to air receptor	NA	NA	NA	(m)
Indoor Air:				
Volatilization from Subsurface Soils	None	NA	NA	
Volatilization from Groundwater	None	NA	NA	

Target Hazard/Risk Values	Individual	Cumulative
TR	Target Risk (class A&B carcinogens)	1.0E-5	1.0E-4
THQ	Target Hazard Quotient (non-carcinogens)	1.0E+0	1.0E+1

Natural Attenuation Factor (NAF) Modeling Options	
Outdoor air volatilization model	NA
Indoor air volatilization model	NA
Soil leaching model	NA
Use first attenuation model (SAM) for leachate?	NA
Biodegradation considered with SAM	NA
Dilution air transport model	NA
Dilution groundwater transport model	Domenico model
Biodegradation considered with Domenico model	None

Source Zone Parameters		General Case	Construction	(Units)
A	Source zone area	NA	NA	(m^2)
W	Length of source-zone parallel to wind	NA	NA	(m)
W_{gw}	Length of source-zone parallel to GW flow	NA		(m)
L_s	Depth to top of affected soils	NA		(m)
L_{sb}	Depth to base of affected soils	NA		(m)
L_s	Thickness of affected soils	NA		(m)
L_s	Thickness of affected surface soils	NA		(m)

TIER 2 TRRP AFFECTED PROPERTY ASSESSMENT — Input Parameter Summary

Site Name: IRC 1 - Hokio Beach Road | Completed By: LP/CCB | Job ID: 24968

Site Location: Horizons - Borehole 350 m north | Date Completed: 18-Jun-08 |

Surface Soil Column Parameters	Value				(Units)
		total soil column	surface soils		
h_{cap} Capillary zone thickness	NA				(m)
h_v Vadose zone thickness	NA				(m)
ρ_b Soil bulk density	NA				(g/cm^3)
f_{oc} Fraction organic carbon		NA	NA		(-)
θ_T Soil total porosity	NA				(-)
K_{vs} Vertical hydraulic conductivity	NA				(m/d)
k_v Vapor permeability	NA				(m^2)
L_{gw} Depth to groundwater	NA				(m)
pH Pore water/soil pH	NA	capillary fringe	vadose zone	foundation	(-)
θ_w Volumetric water content		NA	NA	NA	(-)
θ_a Volumetric air content		NA	NA	NA	(-)

Outdoor Air Parameters	General Case	Construction	(Units)
U_{air} Ambient air velocity in mixing zone	NA		(m/s)
δ_{air} Air mixing zone height	NA		(m)
C/Q Inverse mean concentration at center of source	NA		[g/m^2/s]/[kg/m^3]
J_A Areal particulate emission flux	NA		(g/cm^2/s)
χ Fraction vegetative cover	NA		(-)
U_{10} Mean annual air velocity at 7m height	NA		(m/s)
U_t Equivalent 7-m air velocity threshold value	NA		(m/s)
$F(x)$ Windspeed function dependent on U_m/U_t	NA		(-)
PEF Particulate emission factor	NA	NA	(kg/m^3)

Indoor Air (Building) Parameters	Residential	Commercial	(Units)
B_{vol} Building volume/area ratio	NA	NA	(m)
A_B Foundation area	NA	NA	(m^2)
X_{crack} Foundation perimeter	NA	NA	(m)
ER Building air exchange rate	NA	NA	(1/s)
L_{crack} Foundation thickness	NA	NA	(m)
Z_{crack} Depth to bottom of foundation slab	NA	NA	(m)
η Foundation crack fraction	NA	NA	(-)
ΔP Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_{soil} Convective air flow through foundation cracks	NA	NA	(m^3/s)

Groundwater Parameters	Value	(Units)
δ_{gw} Groundwater mixing zone depth	NA	(m)
I Net groundwater infiltration rate	NA	(cm/yr)
U_{gw} Groundwater Darcy velocity	6.3E-2	(m/d)
V_{gw} Groundwater seepage velocity	2.5E-1	(m/d)
K_s Saturated hydraulic conductivity	9.0E+0	(m/d)
i Groundwater gradient	7.0E-3	(-)
W_{sz} Width of groundwater source zone	1.0E+1	(m)
d_{sz} Depth of groundwater source zone	1.0E+0	(m)
θ_e Effective porosity in water-bearing unit	2.5E-1	(-)
$f_{oc,aq}$ Fraction organic carbon in water-bearing unit	1.0E-4	(-)
pH$_{gw}$ Groundwater pH	9.0E+0	(-)
LDF Leachate dilution factor	NA	(-)

Lateral Transport Modeling Parameters	Off-Source 1	Off-Source 2	Off-Source 1	Off-Source 2	(Units)
Groundwater Transport	Groundwater Ingestion		Soil Leaching to GW		
α_x Longitudinal dispersivity	3.5E+1	NA	NA	NA	(m)
α_y Transverse dispersivity	1.2E+1	NA	NA	NA	(m)
α_z Vertical dispersivity	1.8E+0	NA	NA	NA	(m)
Outdoor Air Transport	Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
β_y Transverse dispersion coefficient	NA	NA	NA	NA	(m)
β_z Vertical dispersion coefficient	NA	NA	NA	NA	(m)
AF Air dilution factor	NA	NA	NA	NA	(-)

Surface Water Parameters	Off-Source 2	(Units)
Q_{sw} Surface water flowrate	NA	(m^3/s)
W_{gw} Width of GW plume at SW discharge	NA	(m)
d_{gw} Thickness of GW plume at SW discharge	NA	(m)
DF Groundwater-to-surface water dilution factor	NA	(L-gw/L-sw)

NOTE: NA = Not applicable.

Domenico Groundwater Modeling Summary

Site Name: TRC 1 - Hokie Beach R Site Location: Horizons - Borehole 350 m non Completed By: LP/CCB Date Completed: 18-Jun-08

DOMENICO GROUNDWATER MODELING SUMMARY

OFF-SOURCE GROUNDWATER EXPOSURE PATHWAYS ☐ (CHECKED IF PATHWAY IS ACTIVE)

SOILS : LEACHING TO GROUNDWATER INGESTION

Exposure Concentration

CHEMICALS OF CONCERN	1) Source Medium	2) Steady-state Exposure Concentration Groundwater: POE Conc. (mg/L)		3) POE Concentration Limit Groundwater: POE Conc. (mg/L)		4) Time to Reach POE Conc. Limit Conc. limit reached? ("■" if yes) ; Time (yr)	
	Soil Conc. (mg/kg)	Off-Source 1 (65 m) None	Off-Source 2 (65 m) None	Off-Source 1 (65 m) None	Off-Source 2 (65 m) None	Off-Source 1 (65 m) None	Off-Source 2 (65 m) None
Arsenic						NA	NA
Cadmium						NA	NA
Chromium (III) (total chromium)						NA	NA
Copper						NA	NA
Nickel and compounds						NA	NA
Lead (inorganic)						NA	NA
Zinc						NA	NA
Boron						NA	NA

NOTE: POE = Point of exposure

Tier 2 Domenico Groundwater Modeling Summary

Site Name: NRC 1 - Nokia Beach R Site Location: Horizons - Borehole 350 m non Completed By: LP/CCB Date Completed: 18-Jun-08 2 OF 2

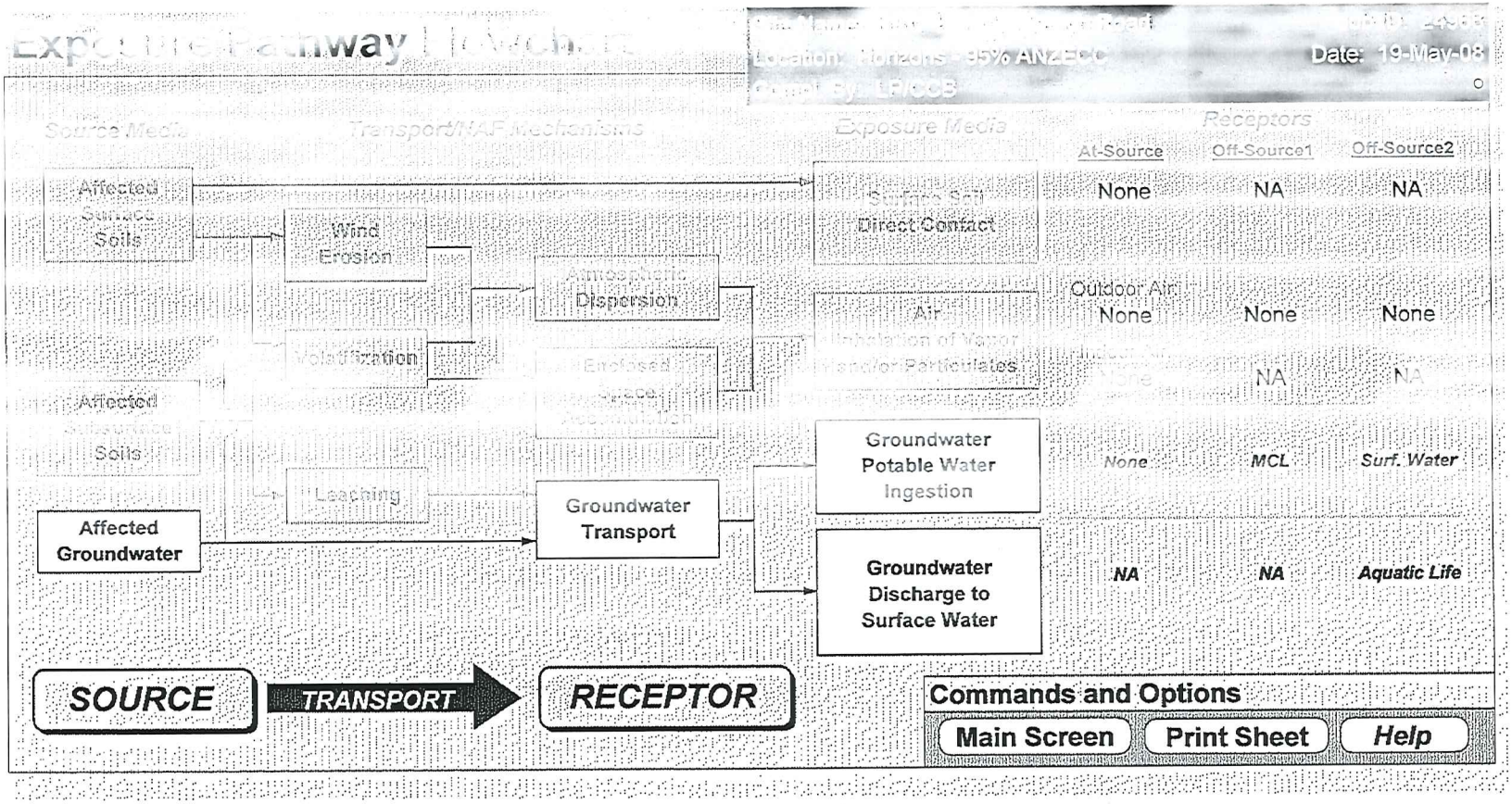
DOMENICO GROUNDWATER MODELING SUMMARY

OFF-Source GROUNDWATER EXPOSURE PATHWAYS ■ (CHECKED IF PATHWAY IS ACTIVE)

GROUNDWATER: INGESTION Exposure Concentration

CHEMICALS OF CONCERN	1) Source Medium	2) Steady-state Exposure Concentration Groundwater: POE Conc. (mg/L)		3) POE Concentration Limit Groundwater: POE Conc. (mg/L)		4) Time to Reach POE Conc. Limit Conc reaches limit? ("■" If yes) ; Time (yr)	
	Groundwater Conc. (mg/L)	Off-Source 1 (350 m) MCL	Off-Source 2 (350 m) None	Off-Source 1 (350 m) MCL	Off-Source 2 (350 m) None	Off-Source 1 (350 m) MCL	Off-Source 2 (350 m) None
Arsenic	5.0E-2	6.0E-4		1.0E-2		□ NA	NA
Cadmium	2.0E-3	2.4E-5		5.0E-3		□ NA	NA
Chromium (III) (total chromium)	8.0E-2	9.6E-4		NC		□ NA	NA
Copper	1.7E+0	2.0E-2		1.3E+0		□ NA	NA
Nickel and compounds	1.0E-2	1.2E-4		NC		□ NA	NA
Lead (inorganic)	6.1E-2	7.3E-4		1.5E-2		□ NA	NA
Zinc	3.7E+0	4.4E-2		NC		□ NA	NA
Boron	1.1E+1	1.3E-1		NC		□ NA	NA

NOTE: POE = Point of exposure


Exposure Pathway Flowcharts
Date: 19-May-08
Source Media
Transport/NAF Mechanisms
Exposure Media
Receptors
At-Source
Off-Source1
Off-Source2
Affected Surface Soils
Wind Erosion
Atmospheric Dispersion
Surface Soil Direct Contact
None
NA
NA
Volatilization
Enclosed Space
Air Inhalation of Vapor and/or Particulates
Outdoor Air None
None
None
Affected Soils
Leaching
Groundwater Transport
Groundwater Potable Water Ingestion
None
MCL
Surf. Water
Affected Groundwater
Groundwater Discharge to Surface Water
NA
NA
Aquatic Life
SOURCE
TRANSPORT
RECEPTOR
Commands and Options
Main Screen
Print Sheet
Help

Site Name: HRC 1 - Hokie Beach Road | Completed By: LP/CCB | Job ID: 24968
Site Location: Hurricane - 95% ANZECC | Date Completed: 19-May-08 | 1 OF 2

Exposure Parameters		Adult	Residential (1-6 yrs)	Residential (6-18 yrs)	Residential Age-Adjusted	Commercial/Industrial Chronic	Commercial/Industrial Construc.
AT_c	Averaging time, carcinogens (yr)	70					
AT_n	Averaging time, non-carcinogens (yr)	30				25	1
τ	Averaging time, vapor flux (yr)	30				30	1
BW	Body weight (kg)	70	15	45		70	
ED	Exposure duration (yr)	30	6	12		25	1
EF	Exposure frequency (days/yr)	350				250	180
EF_D	Dermal exposure frequency	350				250	
IR_w	Ingestion rate, water (L/day)	1.58	0.84		0.66	1.4	
IR_s	Ingestion rate, soil (mg/day)	127	181		120	100	100
SA	Skin surface area (dermal) (cm^2)	4473	2373	3400	382	3473	2373
M	Soil to skin adherence factor	0.1	0.2	0.1		0.2	
ET_{swim}	Swimming exposure time (hr/event)	3					
EV_{swim}	Swimming event frequency (event/yr)	12	12	12			
IR_{swim}	Water ingestion while swimming (L/hr)	0.05	0.5		2.6		
SA_{swim}	Skin surface area for swimming (cm^2)	23000		5100	90090		
IR_{abg}	Ingestion rate, above-ground vegs. (kg/day)	0.0057	0.0024		0.0029		
IR_{bg}	Ingestion rate, below-ground vegs. (kg/day)	0.0025	0.0010		0.0012		
VG_{bg}	Below-ground vegetable correction factor (-)	0.01					

Complete Exposure Pathways and Receptors		At-Source	Off-Source 1	Off-Source 2	(Units)
Class 1 or 2 Groundwater:					
Groundwater Ingestion		None	MCL	Surf. Water	
	Distance to GW receptor	NA	540	NA	(m)
Soil Leaching to Groundwater		None	None	None	
	Distance to GW receptor	NA	NA	NA	(m)
Apply secondary MCLs?		NA	No	No	
Base Soil PCL on Site GW Conc.?		NA	No	No	
Groundwater Discharge to Surface Water:					
Recreation/Swimming				No	
TRRP Human Health Protection				No	
TRRP Aquatic Life Protection				Yes	
Soil:					
Total Soil Combined		None			
Outdoor Air:					
Particulates from Surface Soils		None	None	None	
Volatilization from Soils		None	None	None	
Volatilization from Groundwater		None	None	None	
	Distance to air receptor	NA	NA	NA	(m)
Indoor Air:					
Volatilization from Subsurface Soils		None	NA	NA	
Volatilization from Groundwater		None	NA	NA	

Target Health Risk Values		Individual	Cumulative
TR_{ab}	Target Risk (class A&B carcinogens)	1.0E-5	1.0E-4
THQ	Target Hazard Quotient (non-carcinogens)	1.0E+0	1.0E+1

Natural Attenuation Factor (NAF) Modeling Options	
Outdoor air volatilization model	NA
Indoor air volatilization model	NA
Soil leaching model	NA
Use soil attenuation model (SAM) for leachate?	NA
Biodegradation considered with SAM	NA
Lateral air transport model	NA
Lateral groundwater transport model	Domenico model
Biodegradation considered with Domenico model	None

Source Zone Parameters		General Case	Construction	(Units)
A	Source zone area	NA	NA	(m^2)
W	Length of source-zone parallel to wind	NA	NA	(m)
W_{gw}	Length of source-zone parallel to GW flow	NA		(m)
L_s	Depth to top of affected soils	NA		(m)
L_{base}	Depth to base of affected soils	NA		(m)
L_{soils}	Thickness of affected soils	NA		(m)
L_{sp}	Thickness of affected surface soils	NA		(m)

ENCANA PRODUCTED PROPERTY ASSESSMENT — Input Parameter Summary

Site Name: HRC 1 - Hokie Beach Road | Completed By: LP/CCB | Job ID: 24968
Site Location: Hurricane - 95% ANZECC | Date Completed: 19-May-08 | 2 OF 2

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	NA			(m)
h_v	Vadose zone thickness	NA			(m)
ρ_s	Soil bulk density	NA	Inlet soil column	surface soils	(g/cm^3)
f_{oc}	Fraction organic carbon		NA	NA	(-)
θ_T	Soil porosity	NA			(-)
K_{vs}	Vertical hydraulic conductivity	NA			(m/d)
k_v	Vapor permeability	NA			(m^2)
L_{gw}	Depth to groundwater	NA			(m)
pH	Pore water/soil pH	NA	capillary fringe	vadose zone	saturation (-)
θ_w	Volumetric water content		NA	NA	NA (-)
θ_a	Volumetric air content		NA	NA	NA (-)

Outdoor Air Parameters		General Case	Construction	(Units)
U_{air}	Ambient air velocity in mixing zone	NA		(m/s)
δ_{air}	Air mixing zone height	NA		(m)
Q/C	Inverse mean concentration at center of source	NA		[g/m^2/s]/[g/m^3]
P_e	Areal particulate emission flux	NA		(g/cm^2/s)
V	Fraction vegetative cover	NA		(-)
U_m	Mean annual air velocity at 7m height	NA		(m/s)
U_t	Equivalent 7-m air velocity threshold value	NA		(m/s)
F(x)	Windspeed function dependent on U_m/U_t	NA		(-)
PEF	Particulate emission factor	NA	NA	(kg/m^3)

Indoor Air (Building) Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	NA	(m)
A_b	Foundation area	NA	NA	(m^2)
X_{crk}	Foundation perimeter	NA	NA	(m)
ER	Building air exchange rate	NA	NA	(1/s)
L_{crk}	Foundation thickness	NA	NA	(m)
Z_{crk}	Depth to bottom of foundation slab	NA	NA	(m)
η	Foundation crack fraction	NA	NA	(-)
dP	Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_s	Convective air flow through foundation cracks	NA	NA	(m^3/s)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	NA	(m)
I_f	Net groundwater infiltration rate	NA	(cm/yr)
U_{gw}	Groundwater Darcy velocity	8.3E-2	(m/d)
V_{gw}	Groundwater seepage velocity	2.5E-1	(m/d)
K_s	Saturated hydraulic conductivity	9.0E+0	(m/d)
I	Groundwater gradient	7.0E-3	(-)
S_w	Width of groundwater source zone	1.0E+1	(m)
S_d	Depth of groundwater source zone	1.0E+0	(m)
θ_{ef}	Effective porosity in water-bearing unit	2.5E-1	(-)
f_{oc-aq}	Fraction organic carbon in water-bearing unit	1.0E-4	(-)
pH_{aq}	Groundwater pH	9.0E+0	(-)
LDF	Leachate dilution factor	NA	(-)

Lateral Transport Modeling Parameters		Off-Source 1	Off-Source 2	Off-Source 1	Off-Source 2	(Units)
Groundwater Transport		Groundwater Ingestion		Soil Leaching to GW		
α_x	Longitudinal dispersivity	5.4E+1	5.4E+1	NA	NA	(m)
α_y	Transverse dispersivity	1.8E+1	1.8E+1	NA	NA	(m)
α_z	Vertical dispersivity	2.7E+0	2.7E+0	NA	NA	(m)
Outdoor Air Transport		Soil to Outdoor Air Inhal.		GW to Outdoor Air Inhal.		
σ_y	Transverse dispersion coefficient	NA	NA	NA	NA	(m)
σ_z	Vertical dispersion coefficient	NA	NA	NA	NA	(m)
ADF	Air dilution factor	NA	NA	NA	NA	(-)

Surface Water Parameters		Off-Source 2	(Units)
Q_{sw}	Surface water flowrate	0.02	(m^3/s)
W_{pl}	Width of GW plume at SW discharge	10	(m)
δ_{pl}	Thickness of GW plume at SW discharge	1	(m)
DF_{gw}	Groundwater-to-surface water dilution factor	3.6E-4	(L-gw/L-sw)

NOTE: NA = Not applicable.

SOURCE AREA COC CONCENTRATIONS

CHEMICALS OF CONCERN	Representative COC Concentration			
	Groundwater		Soils (0 - 0.9 m)	
	(mg/L)	note	(mg/kg)	note
Arsenic	5.0E-2			
Cadmium	2.0E-3			
Chromium (III) (total chromium)	8.0E-2			
Copper	1.7E+0			
Nickel and compounds	1.0E-2			
Lead (inorganic)	6.1E-2			
Zinc	3.7E+0			
Boron	1.1E+1			

Site Name: HRC 1 - Hokio Beach Road
Site Location: Horizons - 95% ANZECC
Completed By: LP/CCB

Date Completed: 19-May-08
Job ID: 24968

User-Specified COC Data

SURFACE WATER QUALITY CRITERIA

CHEMICALS OF CONCERN	Concentration (mg/L)	Basis
Arsenic	0.013	Aquatic life protection
Cadmium	0.0002	Aquatic life protection
Chromium (III) (total chromium)	0.001	Aquatic life protection
Copper	0.0014	Aquatic life protection
Nickel and compounds	0.011	Aquatic life protection
Lead (inorganic)	0.0034	Aquatic life protection
Zinc	0.008	Aquatic life protection
Boron	0.37	Aquatic life protection

Site Name: HRC 1 - Hokio Beach Road
Site Location: Horizons - 95% ANZECC
Completed By: LP/CCB

Date Completed: 19-May-08
Job ID: 24968

ASSESSMENT — Domenico Groundwater Modeling Summary

Site Name: MPC 1 - Mokio Beach R Site Location: Horizons - 65% ANZECC Completed By:&P/CCB Date Completed: 19-May-08

DOMENICO GROUNDWATER MODELING SUMMARY

OFF-SOURCE GROUNDWATER EXPOSURE PATHWAYS ☐ (CHECKED IF PATHWAY IS ACTIVE)

SOILS : LEACHING TO GROUNDWATER INGESTION

Exposure Concentration

CHEMICALS OF CONCERN	1) Source Medium	2) Steady-state Exposure Concentration Groundwater POE Conc. (mg/L)		3) POE Concentration Limit Groundwater POE Conc. (mg/L)		4) Time to Reach POE Conc. Limit Conc. limit reached? ("=" if yes) ; Time (yr)	
	Soil Conc. (mg/kg)	Off-Source 1 (65 m) None	Off-Source 2 (65 m) None	Off-Source 1 (65 m) None	Off-Source 2 (65 m) None	Off-Source 1 (65 m) None	Off-Source 2 (65 m) None
Arsenic						NA	NA
Cadmium						NA	NA
Chromium (III) (total chromium)						NA	NA
Copper						NA	NA
Nickel and compounds						NA	NA
Lead (inorganic)						NA	NA
Zinc						NA	NA
Boron						NA	NA

NOTE: POE = Point of exposure

Tier 2 Domenico Groundwater Modeling Summary

Site Name: HRC 1 - Hobie Beach F Site Location: Horizons - 95% ANZECC Completed By: LP/CCB Date Completed: 19-May-08 2 OF 2

DOMENICO GROUNDWATER MODELING SUMMARY

OFF-Source GROUNDWATER EXPOSURE PATHWAYS (CHECKED IF PATHWAY IS ACTIVE)

GROUNDWATER: INGESTION

Exposure Concentration

CHEMICALS OF CONCERN	1) Source Medium	2) Steady-state Exposure Concentration Groundwater: POE Conc. (mg/L)		3) POE Concentration Limit Groundwater: POE Conc. (mg/L)		4) Time to Reach POE Conc. Limit Conc reaches limit? ("■" if yes) ; Time (yr)	
	Groundwater Conc. (mg/L)	Off-Source 1 (540 m) MCL	Off-Source 2 (540 m) Surf. Water	Off-Source 1 (540 m) MCL	Off-Source 2 (540 m) Surf. Water	Off-Source 1 (540 m) MCL	Off-Source 2 (540 m) Surf. Water
Arsenic	5.0E-2	3.9E-4	3.9E-4	1.0E-2	3.6E+1	☐ NA	☐ NA
Cadmium	2.0E-3	1.6E-5	1.6E-5	5.0E-3	5.5E-1	☐ NA	☐ NA
Chromium (III) (total chromium)	8.0E-2	6.2E-4	6.2E-4	NC	2.7E+0	☐ NA	☐ NA
Copper	1.7E+0	1.3E-2	1.3E-2	1.3E+0	3.8E+0	☐ NA	☐ NA
Nickel and compounds	1.0E-2	7.8E-5	7.8E-5	NC	3.0E+1	☐ NA	☐ NA
Lead (inorganic)	6.1E-2	4.7E-4	4.7E-4	1.5E-2	9.3E+0	☐ NA	☐ NA
Zinc	3.7E+0	2.8E-2	2.8E-2	NC	2.2E+1	☐ NA	☐ NA
Boron	1.1E+1	8.5E-2	8.5E-2	NC	1.0E+3	☐ NA	☐ NA

NOTE: POE = Point of exposure