Tonkin+Taylor

Job No: 1003207.7000
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Christchurch City Council
Civic Offices
53 Hereford Street
PO Box 73011
Christchurch 8154

Attention: Peter MacGibbon, Project Manager, Capital Delivery Major Facilities

Dear Peter

Groundwater quality assessment, proposed Hornby Community Centre, Christchurch

1 Introduction

Tonkin & Taylor Ltd (T+T) was engaged by Christchurch City Council (CCC) to undertake a qualitative assessment of the potential effects that the development of the Hornby Community Centre could have on groundwater quality beneath and down gradient of the site.

This work has been completed in accordance with the CCC statement of work agreement with T+T dated 22 March 2019.

2 Background and objectives

CCC proposes to develop the Hornby Community Centre in the north-eastern corner of Kyle Park (hereafter referred to as 'the Site' and shown in Figure 2.1). Concept design for the centre is currently underway. At this stage it is anticipated that the centre would include:

- A service centre and library building (either one or two-storey), including community meeting rooms and offices;
- A leisure facility including swimming pools (fun and lane pools); and
- Car parking, landscaping and footpaths connecting the centre to the remainder of Kyle Park and to transport links and facilities at the Hornby Hub, located south of Kyle Park.

In addition, due to the present ground levels on the Site relative to surrounding land, the centre will be largely built on top of current ground level(s), with limited excavation into existing ground.

Kyle Park was formerly a gravel pit and was backfilled with a mixture of uncontrolled fill materials (e.g. domestic, industrial and commercial wastes) in the 1970s before being developed as a community park in the 1980s. It is anticipated that the site will be constructed on piled foundations which will penetrate through the waste and be installed in underlying gravels.

Tonkin & Taylor Ltd | Level 3, PwC Centre, 60 Cashel Street, West End, Christchurch, 8013, New Zealand | PO Box 13-055, Christchurch 8141
P +64-3-363 2440 F +64-9-307 0265 E chc@tonkintaylor.co.nz

To support the assessment of resource consent requirements (currently being completed by others), CCC engaged T+T to undertake an assessment of current groundwater quality at the site and a qualitative assessment of the potential for the development to adversely impact groundwater quality. This report presents the finding of those assessments.

Figure 2.1: Kyle Park (red line) including the Site (blue line). Image source: Canterbury maps.

3 Scope

The groundwater quality assessment completed by T+T comprised:

1. Groundwater sampling on two occasions (12 July 2019 and 19 November 2019) from four previously installed dual purpose gas/groundwater monitoring wells;
2. Laboratory analysis of the collected groundwater samples for a range of potential organic and inorganic contaminants;
3. Manual measurement of groundwater levels in the monitoring wells on ten occasions between April and December 2019;
4. Automated groundwater level measurement in one monitoring well between April and December 2019 using an automated level logger;
5. The assessment of reported groundwater contaminant concentrations against assessment criteria derived from the New Zealand Drinking Water Standards (NZDWS); and
6. A qualitative assessment of the potential for site redevelopment to adversely impact groundwater beneath the site, taking into consideration the likely nature of ground disturbance.

4 Ground monitoring, sampling and analysis

T+T completed groundwater level monitoring and collected groundwater samples from four monitoring wells installed at the site (MW201-MW204). The monitoring wells were installed through the waste and into the underlying gravels. The locations of the four monitoring wells are shown in Figure 4.1.

Figure 4.1: Groundwater monitoring well locations. Image source: Canterbury Maps.

The purpose of the groundwater monitoring and sampling completed by T+T was to:

- Monitor how the depth to water beneath the landfill changes over time and how groundwater interacts with the waste. This was undertaken by manually measuring the depth to groundwater within each well on ten occasions between April and December 2019, and also collecting water level measurements from an automated water level monitor installed within one of the four wells (MW202) over the same period; and
- Understand what the current contaminant conditions of groundwater beneath the site are, and whether the waste is currently having and adverse impact on groundwater quality. To do this, T+T collected groundwater samples on two occasions (July and November 2019) and analysed the samples for a range of potential contaminants based on the known or potential contaminants within the waste. The samples were collected during periods when groundwater was at different depths, nominally representing 'summer low' and 'winter high' to assess whether contaminant concentrations could vary seasonally and according to groundwater depth.

The monitoring well installation and groundwater sampling methodology is described in Appendix A.

The water level depth data shows that:

- Based on the data from MW202, groundwater levels may fluctuate seasonally by a metre;
- The highest groundwater levels were below the waste/natural gravel interface, though in the case of MW203 and MW204 groundwater did rise to within a few centimetres of the

interface. The data therefore indicate that for the majority of the time, the waste is located above groundwater, though from time to time, groundwater may rise to within the base of the waste; and

- The relative groundwater levels in the monitoring wells (relative to each other for a given monitoring event) indicate that groundwater flows in a generally easterly direction, which is consistent with the inferred regional groundwater flow direction based on ECan groundwater monitoring.

Table 4.1 summarises the groundwater analytical results for each well and each sampling event. Laboratory analysis certificates are included in Appendix B.

Reported concentrations have been compared against the 50% of the Maximum Acceptable Value (MAV) for contaminants of significance as listed in the NZDWS.

Comparison against the NZDWS provides an indication of current groundwater quality relative to that acceptable for drinking water. Comparison against 50% of the MAV allows for an assessment of current groundwater contaminant conditions against the rules for the passive discharge of contaminants in groundwater from a site, in accordance with rule 5.187 of the Canterbury Land and Water Regional Plan (LWRP).

The analytical results show that:

- Organic contaminants including polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCP)s, total petroleum hydrocarbons (TPH) and volatile organic compounds (VOCs) were not detected above 50% of the respective MAV, with the majority of organic contaminants not detected above the laboratory limits of reporting;
- Dissolved concentrations of all metals analysed were below 50% of the respective MAV, with some metals (including arsenic and mercury) not detected above the laboratory limits of reporting;
- There is relatively little difference in contaminant concentrations between the monitoring wells. There does not appear to be any increase in contaminant concentrations as groundwater flows beneath the site from west to east;
- Overall, the groundwater results indicate that there is limited impact on groundwater quality beneath the site from the waste material; and
- Contaminants do not appear to be leaching into groundwater from the waste to the extent that a resource consent for the ‘passive’ discharge of contaminants from the site in groundwater is required under the LWRP.

Table 4.1: Summary of groundwater analytical results.

Monitoring well ID	Units	MW201		MW202		MW203		MW204		Assessment criteria
Sample date		12/07/2019	19/11/2019	12/07/2019	19/11/2019	12/07/2019	19/11/2019	12/07/2019	19/11/2019	50% MAV [3]
Inorganic determinands										
pH	pH	**6.6**	**6.9**	**6.6**	**6.9**	**6.6**	7.0	**6.6**	**6.6**	7.0-8.5 [4]
Total arsenic	g/m3	0.0026	**0.029**	<0.0005	**0.02**	<0.0005	0.0039	0.0011	**0.018**	0.005
Soluble arsenic	g/m3	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Total cadmium	g/m3	0.000072	0.00152	0.00002	0.00014	<0.00001	0.000023	0.000016	0.00011	0.002
Soluble cadmium	g/m3	<0.00001	<0.00001	0.000029	0.000016	<0.00001	<0.00001	0.000017	0.000024	
Total chromium	g/m3	0.003	**0.0548**	0.0013	**0.0988**	<0.0002	0.0045	0.0024	**0.0354**	0.025
Soluble chromium	g/m3	<0.0002	0.0003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	
Total copper	g/m3	0.0048	0.0816	0.004	0.0541	0.00097	0.0037	0.0023	0.0246	1
Soluble copper	g/m3	0.00026	<0.0002	0.0028	0.0017	0.00082	0.00027	0.0011	0.00045	
Total lead	g/m3	**0.0146**	**0.612**	0.0011	**0.0868**	0.00013	**0.0106**	0.0033	**0.0472**	0.005
Soluble lead	g/m3	<0.00005	0.00014	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	
Total mercury	g/m3	<0.0001	0.00077	<0.0001	0.00042	<0.0001	<0.0001	<0.0001	0.00033	0.0035
Soluble mercury	g/m3	<0.0001	<0.00008	<0.0001	<0.00008	<0.0001	<0.00008	<0.0001	<0.00008	
Total nickel	g/m3	0.0026	0.0352	0.00077	0.0284	0.0002	0.0021	0.0013	0.019	0.04
Soluble nickel	g/m3	0.00052	0.0023	0.00044	0.00027	0.00022	0.00027	0.00028	0.00029	
Total zinc	g/m3	0.027	0.502	0.0057	0.132	0.0082	0.024	0.01	0.098	0.75 [4]
Soluble zinc	g/m3	0.0096	0.0076	0.0035	<0.001	0.0084	0.0031	0.0038	<0.001	
Polycyclic aromatic hydrocarbons (PAHs) [1]										
1-Methylnaphthalene	g/m3	<0.00006	<0.00006	0.00012	<0.00006	<0.00006	<0.00006	<0.00006	<0.00006	NGV
2-Methylnaphthalene	g/m3	<0.00006	<0.00006	0.00023	<0.00006	<0.00006	<0.00006	0.00007	<0.00006	NGV
Acenaphthene	g/m3	<0.00002	0.00009	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.00002	NGV
Anthracene	g/m3	<0.00002	<0.00002	0.00011	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.5 [5]
Benz[a]anthracene	g/m3	<0.00003	<0.00003	0.00012	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	NGV
Benzo[a]pyrene	g/m3	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.00035
Benzo[b]&[j] fluoranthene	g/m3	<0.00002	<0.00002	0.00005	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	NGV
Benzo[k]fluoranthene	g/m3	<0.00002	<0.00002	0.00012	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	NGV
Chrysene	g/m3	<0.00002	<0.00002	0.0001	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	NGV
Dibenz[a,h]anthracene	g/m3	<0.00002	<0.00002	0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	NGV
Fluoranthene	g/m3	<0.00002	<0.00002	0.00049	<0.00002	0.00004	<0.00002	<0.00002	0.0001	0.05 [5]
Fluorene	g/m3	<0.00002	0.00007	0.00015	<0.00002	<0.00002	<0.00002	<0.00002	0.00004	0.05 [5]
Naphthalene	g/m3	<0.00006	<0.00006	0.00014	<0.00006	<0.00006	<0.00006	<0.00006	0.00008	0.005 [5]
Phenanthrene	g/m3	<0.00003	<0.00003	0.00049	<0.00003	<0.00003	<0.00003	<0.00003	0.00018	0.05 [5]
Pyrene	g/m3	<0.00002	<0.00002	0.00042	<0.00002	0.00004	<0.00002	<0.00002	0.00008	0.05 [5]
Benzo[a]pyrene TEQ (LOR) [2]	g/m3	0.00005	0.00005	0.00008	0.00005	0.00005	0.00005	0.00005	0.00005	0.00035
Organochlorine pesticides (OCPs) [1]	g/m3	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	0.000006	Various
Organonitrogen and organophosphate pesticides (ONOPs) [1]		<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	Various
Total petroleum hydrocarbons (TPHs) [1]		<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	Various
Volatile organic compounds (VOCs) [1]		<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	Various

Notes:

Highlighted values exceed assessment criteria.

NGV indicates no guideline value.

<LOR indicates all compound concentrations within the specified group are below laboratory limits of reporting.

1- Full suite analysed, selected determinands displayed only.

2- Benzo[a]pyrene potency equivalence is laboratory calculated based on the LOR, in accordance with the NES Soil Methodology for Deriving Standards in Soil to Protect Human Health, MfE 2011.

3- MfE 2005 (Revised 2018) New Zealand Drinking Water Standards (NZDWS). Tables 2.2 and 2.3: Maximum acceptable values (MAVs) for inorganic and organic determinands of health significance. As a conservative approach, 50% of the MAV has been adopted.

4- MfE 2005 (Revised 2018) NZDWS. Table 2.5: Guideline values for aesthetic determinands. These values have been used as a proxy where no MAV exists for that determinand.

5- MfE 1997, Guidelines for Assessing and Managing Contaminated Gasworks Sites in New Zealand. Table 4.7 Acceptance criteria for water (mg/L). As a conservative approach, 50% of the potable water criteria has been adopted.

5 Qualitative assessment of development impact on groundwater quality

5.1 Purpose and approach

The following assessment is based on a consideration of:

- The geology and hydrogeology of the site including the thickness and nature of waste beneath the site and measured groundwater levels;
- Contaminant conditions within the waste and groundwater, groundwater quality up gradient and down gradient of the site (i.e. groundwater flowing onto the site and off of the site, respectively), and down gradient activities that could have an adverse impact on groundwater quality;
- What ground-disturbance is likely to occur during the proposed development including the installation of piles, foundation excavation and placement of imported fill;
- How the above-ground development will affect current ground conditions at the site, including for example the introduction of impermeable surfaces, which could alter the amount of rainfall infiltration through the landfill; and
- Groundwater use down-hydraulic gradient of the site, and how this could be affected by groundwater contamination from the site.

5.2 Supporting information

These elements are summarised below in Table 5.1.

Table 5.1: Summary of supporting information

Consideration	Discussion
Geology and hydrogeology	• The geological sequence from the ground surface downwards comprises a relatively low permeability sandy silt layer (up to 1 m thick) underlain by landfill waste of varying composition to approximately 10 m below ground level. Coarse sandy gravels of the Upper Springston formation/Riccarton Gravel aquifers directly underlie the waste. The Upper Springston and Riccarton Gravel aquifers are unconfined in the vicinity of the site, meaning they are not protected by an overlying barrier that would reduce contaminants reaching groundwater; • Based on cores recovered during drilling the landfill material is relatively dry, with no evidence of perched groundwater units; • Groundwater is present at or below the interface between waste and gravel. The depth to groundwater may vary seasonally by a metre or more, but generally is expected to be below the waste; • Relative groundwater levels indicate that groundwater flow beneath the site is generally from west to east, consistent with the regional regime; and • Borelogs for bores drilled in the vicinity of the site indicate that the Springston Formation/Riccarton Gravel is 40 m – 45 m thick, and is separated from the confined Linwood Gravel aquifer by the Bromley Formation aquitard which provides protection to the Linwood Gravel from contamination from above.
Contaminant conditions	• Soil analysis indicates waste materials contain elevated concentrations of metals, PAHs, asbestos and petroleum hydrocarbons; • Leachate can be generated from landfill waste when the waste comes into contact with water – through the infiltration of rainwater or stormwater from above, or with groundwater. Some contaminants are more soluble in water than others and this will affect the degree to which they are leached from the waste. For example,

Consideration	Discussion
	petroleum hydrocarbons are generally moderately to highly soluble, whilst metals and pesticides have low or moderate solubility; • The potential for a landfill to generate leachate generally reduces as the landfill ages due to the natural breakdown of the waste over time. The waste in the landfill is at least 40 years old and so organic contaminants in the waste would be expected to be reducing. However, as the landfill is generating landfill gas this process is still occurring, albeit at very low rate; • Groundwater analysis indicates that organic compounds were either not detected (TPH, OCPs, ONOPs, VOCs) or were detected at low concentrations, below 50% of the NZDWS MAV. Dissolved metals concentrations were also below 50% of the NZDWS MAV. The waste material does not appear to be having a significant adverse effect on groundwater quality beneath the site; • There is very limited groundwater quality data for the Riccarton Gravel up gradient of the site with which to assess contaminant conditions in groundwater entering the site. ECan records contain data from June 2017 from an irrigation bore located approximately 75m north west of the site in Hornby Primary School. The data indicates comparable concentrations of metals to those on site and no detected VOCs; and • The ECan database does not contain groundwater quality data for the Riccarton Gravel immediately down gradient of the site with the closest data being from a bore located on the Ravensdown Fertiliser Co Ltd site some 1000 m south east of the Site. This data indicates elevated concentrations of nitrate and nitrite are present. Other contaminants including VOCs and metals were not detected. However, the ECan Listed Land Use Register (LLUR) of potentially contaminated sites indicates that most properties within 500m of the site to the east contain one or more HAIL[1] activities. In addition, one property (Momentive Speciality Chemicals), located 400 m east of the site has the classification of "significant adverse environmental effects" due to elevated nitrate concentrations in groundwater associated with the site's urea-formaldehyde resin manufacturing process.
Ground disturbance activities	• Current concept design options will require the excavation to a maximum of 1m below the existing site level within the building footprint. However, in order to allow gravity drainage to the council stormwater and sewer systems within Waterloo or Smarts Roads, it is likely that the building platform will be raised and that minimal excavation will occur within the building footprint, other than to remove the existing grass/topsoil layer; • With the exception of service trenches at the site boundary, and the removal of the existing grass/topsoil layer, no excavation is likely to occur outside of the building footprint; • The principal ground disturbance activity will occur with the installation of foundation piles. Concept level pile design indicates that piles are likely to be driven steel 'H' piles, driven to approximately 18 m below the current site ground level (i.e. approximately 8 m below the base of the waste). In cross section the overall height of the pile is approximately 330 mm by 310 mm wide, and with flanges approximately 5 mm thick. Predrilling of the pile holes is unlikely to be required and hence the cross sectional area of disturbed ground as the pile cuts through the waste into the underlying gravel is small; • Pile spacing is likely to be between 4 m and 6 m. Piling will be limited to the building footprint, with the extent and number of piles dependent on whether a one or two-storey building solution is chosen; and • Pile installation is likely to take several weeks to complete.

[1] HAIL – Hazardous Activities and Industries List.

Consideration	Discussion
Changes to current site conditions	• The most significant change to current site conditions will be the installation of impermeable surfaces across the majority of the site, which will reduce rainfall infiltration through the surface of the site into the waste below. This means that less water will be able to infiltrate through the waste, resulting in lower potential for leachate generation; • Buildings will be constructed on a concrete foundation slab, which will extend slightly beyond the building footprint. Exterior areas will largely comprise sealed car park or footpath surfaces, though small areas of unsealed landscaping will also be present; and • Stormwater detention ponds are likely to be constructed in either the north eastern or south eastern corners of the site. As the stormwater detention pond will be lined, it will reduce the amount of infiltration through the waste in this area. No discharge of operational phase stormwater to ground is proposed, other than in landscaped areas.
Down gradient groundwater users	• ECan records indicate that there are two consented groundwater abstractions from the Riccarton Gravel aquifer located within 1000 m of the site. The wells are located at the Hornby Primary and Hornby High schools, approximately 75 m north of the site. Both abstractions are for irrigation use; and • The closest consented groundwater abstractions down hydraulic gradient (east) of the site are located at the Tegel Foods facility and Ravensdown Fertiliser Co Ltd facility, approximately 650 m north east and 950 south east of the site, respectively. Bore logs indicate that abstraction in both bores occurs from the confined Linwood Gravel aquifer at depths of between 90 and 100 mbgl

5.3 Assessment

Overall, it is our opinion that the development of the site is unlikely to have a significant long term adverse effect on groundwater quality, for the following reasons:

- There is currently no barrier layer between the landfill waste, the natural gravel beneath the waste and unconfined groundwater which sits approximately at the interface between the waste and gravel. This means that any leachate currently being generated by the landfill would be expected to enter groundwater beneath the site. As groundwater sampling indicates that the waste is not having a significant adverse effect on groundwater quality beneath the site, this means that leachate is not being generated and/or contaminant concentrations in the leachate are low;
- Driving piles through the waste into the underlying gravel will not puncture a low permeable layer that protects groundwater from contaminants in leachate generated from the overlying waste. Therefore piling is unlikely to increase the potential for leachate generated in the landfill to reach groundwater;
- Driving H piles through the waste is unlikely to provide a more rapid route for surface infiltration through waste to groundwater as the pile will be in close contact with the waste. The potential for infiltration is in any case likely to be reduced by the presence of the overlying building;
- The use of driven H piles is likely to result in lower waste disturbance than alternative piling techniques. Whilst it is possible that waste material could be forced down into groundwater as the pile is driven, given the cross sectional area of the pile, the amount of waste driven into the gravel/groundwater is likely to be minimal;
- If waste is driven into groundwater during piling, it is possible that soluble contaminants in the waste could enter groundwater. However, on the assumption that the amount of waste

driven into the gravel is small, the resulting effect on groundwater is likely to be small and temporary; and

- The development of the site will result in the majority of the site being covered with impermeable surfaces. This means that rainfall infiltration through the waste (and therefore potential to generate leachate) will be reduced from the current site condition.

In addition, we would also note that:

- There are no records of groundwater abstraction from the Riccarton Gravel aquifer immediately down gradient of the site. Where groundwater abstraction occurs within 1000 m down gradient of the site, it is from confined aquifers that are separated from the Riccarton Gravel;
- In the unlikely event that groundwater quality beneath the site is adversely affected by piling there is no evidence to indicate that currently consented groundwater users down gradient of the site would be affected; and
- Land use immediately down gradient of the site is predominantly industrial. There is existing impact on groundwater quality downgradient of the site associated with these industrial activities. Any increased contaminant discharge from the site associated with piling is considered unlikely to exacerbate the existing impacts on groundwater quality in the Riccarton Gravel aquifer.

6 Applicability

This report has been prepared for the exclusive use of our client Christchurch City 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, or by any person other than our client, without our prior written agreement.

Recommendations and opinions in this report are based on data from discrete sampling points and times. The nature and continuity of ground conditions and groundwater conditions are inferred and it must be appreciated that actual conditions could vary from the assumed model.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:

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Paul Walker
Technical Director, Contaminated Land

Authorised for Tonkin & Taylor Ltd by:

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Peter Cochrane
Project Director

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Appendix A: Monitoring well installation and groundwater sampling methodology

A1 Monitoring well installation

Groundwater samples were collected from four dual-purpose gas/groundwater monitoring wells (MW201-MW204) that were installed by Prodrill at the site in April 2019. The monitoring wells were installed within boreholes that had been drilled using sonic drilling techniques.

During drilling waste materials were encountered to a maximum depth of approximately 10.4 mbgl. The waste encountered comprised a variable matrix of silt, sand and gravel, with differing quantities of man-made materials and/or waste including paper, plastic wrapping, brick, concrete, ash and asbestos cement sheet. Underlying the waste material were natural sandy gravels, inferred by T+T to comprise the Riccarton Gravel aquifer.

Each monitoring well comprised 50 mm (internal diameter) HDPE pipe with 1 mm slotted sections. The annulus of each well (between the pipe and bore walls) was filled with Walton park gravel to approximately 0.5 m above the screened interval. Bentonite clay was placed above the gravel to within approximately 0.5m of the ground surface. Each well was completed with a lockable well cover, which was cemented in place.

Table A.1 below summarises the well construction, groundwater depth monitoring and estimated waste thickness.

Table A.1: Summary of monitoring well installation details

Monitoring well No.	Groundwater depth (mbgl#)	Well depth	Screen interval#	Waste thickness#
MW201	10.37-11.37	12.0	3-12	2.3-8.9
MW202	10.15-11.13	12.0	3-12	1.5-7.6
MW203	10.08-11.93	12.0	3-12	1.5-10.0
MW204	10.07-11.07	12.0	3-12	1.0-10.4

Notes:

mbgl – metres below ground level.

The location and height (to top of well casing) of each well was undertaken by a CCC appointed contractor.

A2 Groundwater level monitoring

Depth to groundwater was measured in each well from the top of the well casing using an air/oil/water interface probe on ten occasions between 29 April 2019 and 13 December 2019. The top of each monitoring well was surveyed by a CCC-appointed contractor relative to the Christchurch Drainage Datum (CDD). Relative groundwater levels have been calculated for each monitoring well, for each monitoring event and are listed in Table A.2 below.

Table A.2: Groundwater relative levels (April-November 2019)

Monitoring well No	Groundwater relative level (m relative to CDD)									
	Date of monitoring round									
	29.04.19	03.05.19	06.06.19	12.07.19	23.08.19	10.10.19	22.10.19	13.11.19	19.11.19	13.12.19
MW201	25.06	25.09	25.22	25.20	25.61	25.99	26.06	25.98	25.96	25.64
MW202	25.05	25.07	25.20	25.19	25.59	25.98	26.03	25.95	25.94	25.62
MW203	24.98	25.08	25.21	24.19	25.60	25.99	26.04	25.96	25.94	25.63
MW204	25.09	25.13	25.26	25.24	25.65	26.04	26.09	26.01	26.00	25.68

Continuous groundwater level monitoring was also undertaken within monitoring well MW202 using an automatic data logger between April and December 2019. Figure A.1 below illustrates the depth to groundwater level change over this period.

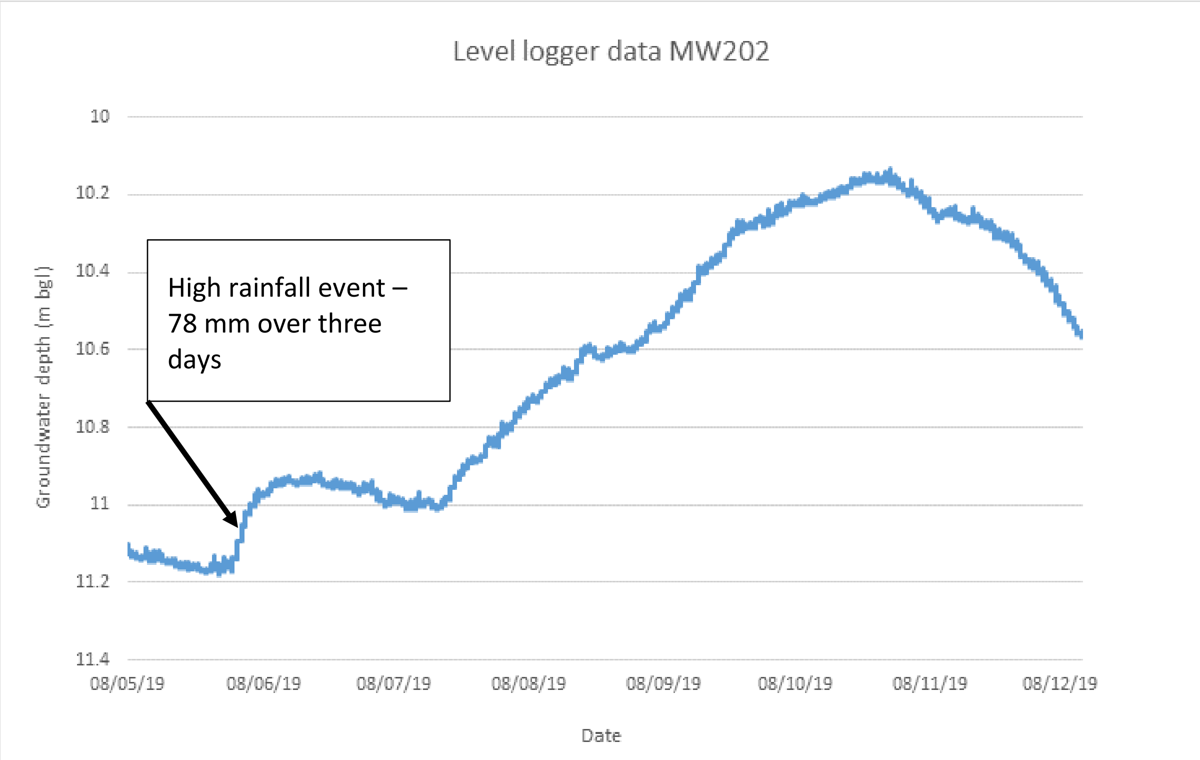

Figure A.1: Groundwater level fluctuation April-November 2015. Monitoring well MW202.

A3 Groundwater sampling and analysis

Groundwater samples were collected from the four monitoring wells on 12 July 2019 and 19 November 2019. Sampling was completed in general accordance with the methodology outlined in the MfE publication, "*A national protocol for state of the environment groundwater sampling in New Zealand*" (December 2006), summarised as follows:

- Purging and sampling was completed using a 'Poseidon' submersible pump (for the 12 July 2019 sampling round) and dedicated disposable bailers (for the 19 November sampling round due to the malfunction of the Poseidon pump);
- Purge water was screened for selected water quality parameters (pH, conductivity and temperature) using a calibrated field meter. Samples were collected after parameters had stabilised (i.e. three consecutive readings stabilised within 10%). The pump was decontaminated with Decon 90 and thoroughly rinsed with tap water before and after use at each well, or a fresh disposable bailer was used at each well;
- Disposable nitrile gloves were worn during sampling and changed prior to monitoring and sampling activities at each well;
- The depth to groundwater in each monitoring well was measured using an electronic dip meter; and
- All samples were collected into laboratory-supplied containers and immediately placed into a chilled cooler for transport to IANZ-accredited Analytica laboratories under chain of custody documentation.

Groundwater sampling field record sheets are included at the end of this appendix.

All groundwater samples were submitted to Analytica Laboratories in Hamilton for analysis for:

- Total and dissolved metals;
- pH;
- Polyaromatic hydrocarbons (PAHs);
- Organochlorine pesticides (OCPs);
- Organonitrogen and Organophosphorus pesticides (ONOPs);
- Total petroleum hydrocarbons (TPH); and
- Volatile organic compounds (VOCs).

bailer used

bailer used

bailer used

Appendix B: Groundwater analysis certificates

Analytica Laboratories Limited
Ruakura Research Centre
10 Bisley Road
Hamilton 3214, New Zealand
Ph +64 (07) 974 4740
sales@analytica.co.nz
www.analytica.co.nz

Certificate of Analysis

Tonkin and Taylor Ltd
Level 3, 60 Cashel Street, West End
Christchurch
Attention: Mark Morley
Phone: 027 7052843
Email: kstephenson@tonkintaylor.co.nz

Lab Reference: 19-40612
Submitted by: Katie Stephenson
Date Received: 20/11/2019
Date Completed: 28/11/2019
Order Number: 1003207
Reference: Kyle Park

Sampling Site: Kyle Park 1003207

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories. Samples were in acceptable condition unless otherwise noted on this report.

Soluble Heavy Metals in Water

		Client Sample ID	MW201	MW202	MW203	MW204
		Date Sampled	19/11/2019	19/11/2019	19/11/2019	19/11/2019
Analyte	Unit	*Reporting Limit*	19-40612-1	19-40612-2	19-40612-3	19-40612-4
Arsenic	g/m^3	*0.0005*	<0.00050	<0.00050	<0.00050	<0.00050
Cadmium	g/m^3	*0.00001*	<0.000010	0.000016	<0.000010	0.000024
Chromium	g/m^3	*0.0002*	0.00030	<0.00020	<0.00020	<0.00020
Copper	g/m^3	*0.0002*	<0.00020	0.0017	0.00027	0.00045
Lead	g/m^3	*0.00005*	0.00014	<0.000050	<0.000050	<0.000050
Mercury	g/m^3	*0.00008*	<0.000080	<0.000080	<0.000080	<0.000080
Nickel	g/m^3	*0.0002*	0.0023	0.00027	0.00027	0.00029
Zinc	g/m^3	*0.001*	0.0076	<0.0010	0.0031	<0.0010

Total Heavy Metals in Water

		Client Sample ID	MW201	MW202	MW203	MW204
		Date Sampled	19/11/2019	19/11/2019	19/11/2019	19/11/2019
Analyte	Unit	*Reporting Limit*	19-40612-1	19-40612-2	19-40612-3	19-40612-4
Arsenic	g/m^3	*0.0005*	0.029	0.020	0.0039	0.018
Cadmium	g/m^3	*0.00001*	0.00152	0.00014	0.000023	0.00011
Chromium	g/m^3	*0.0002*	0.0548	0.0988	0.0045	0.0354
Copper	g/m^3	*0.0002*	0.0816	0.0541	0.0037	0.0246
Lead	g/m^3	*0.00005*	0.612	0.0868	0.0106	0.0472
Mercury	g/m^3	*0.0001*	0.00077	0.00042	<0.00010	0.00033
Nickel	g/m^3	*0.0002*	0.0352	0.0284	0.0021	0.019
Zinc	g/m^3	*0.001*	0.502	0.132	0.024	0.098

IANZ ACCREDITED LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation, with the exception of tests marked *, which are not accredited.

Polycyclic Aromatic Hydrocarbons - Water

		Client Sample ID	MW201	MW202	MW203	MW204
		Date Sampled	19/11/2019	19/11/2019	19/11/2019	19/11/2019
Analyte	Unit	*Reporting Limit*	19-40612-1	19-40612-2	19-40612-3	19-40612-4
1-Methylnaphthalene	g/m^3	*0.00006*	<0.00006	<0.00006	<0.00006	<0.00006
2-Methylnaphthalene	g/m^3	*0.00006*	<0.00006	<0.00006	<0.00006	<0.00006
Acenaphthene	g/m^3	*0.00002*	0.00009	<0.00002	<0.00002	0.00002
Acenaphthylene	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
Anthracene	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
Benz[a]anthracene	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Benzo[a]pyrene	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
Benzo[b]&[j] fluoranthene	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
Benzo[g,h,i]perylene	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
Benzo[k]fluoranthene	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
Chrysene	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
Dibenz[a,h]anthracene	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
Fluoranthene	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	0.00010
Fluorene	g/m^3	*0.00002*	0.00007	<0.00002	<0.00002	0.00004
Indeno[1,2,3-cd]pyrene	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Naphthalene	g/m^3	*0.00006*	<0.00006	<0.00006	<0.00006	0.00008
Phenanthrene	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	0.00018
Pyrene	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	0.00008
Benzo[a]pyrene TEQ (LOR)	g/m^3	*0.00005*	0.00005	0.00005	0.00005	0.00005
Benzo[a]pyrene TEQ (Zero)	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
Anthracene-d10 (Surrogate)	%	*1*	97.8	96.4	95.1	96.7

Water Aggregate Properties and Nutrients

		Client Sample ID	MW201	MW202	MW203	MW204
		Date Sampled	19/11/2019	19/11/2019	19/11/2019	19/11/2019
Analyte	Unit	*Reporting Limit*	19-40612-1	19-40612-2	19-40612-3	19-40612-4
pH	pH	*1*	6.9	6.9	7.0	6.6

Organochlorine Pesticides - Water

		Client Sample ID	MW201	MW202	MW203	MW204
		Date Sampled	19/11/2019	19/11/2019	19/11/2019	19/11/2019
Analyte	Unit	*Reporting Limit*	19-40612-1	19-40612-2	19-40612-3	19-40612-4
2,4'-DDD	g/m^3	*0.000005*	<0.000005	<0.000005	<0.000005	<0.000005
2,4-DDE	g/m^3	*0.000005*	<0.000005	<0.000005	<0.000005	<0.000005
2,4-DDT	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001
4,4-DDD	g/m^3	*0.000005*	<0.000005	<0.000005	<0.000005	0.000006
4,4'-DDE	g/m^3	*0.000005*	<0.000005	<0.000005	<0.000005	<0.000005
4,4'-DDT	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001
Total DDT	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
alpha-BHC	g/m^3	*0.000005*	<0.000005	<0.000005	<0.000005	<0.000005
Aldrin	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
beta-BHC	g/m^3	*0.000005*	<0.000005	<0.000005	<0.000005	<0.000005
cis-Chlordane	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001
cis-Nonachlor	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001

Organochlorine Pesticides - Water

		Client Sample ID	MW201	MW202	MW203	MW204
		Date Sampled	19/11/2019	19/11/2019	19/11/2019	19/11/2019
delta-BHC	g/m^3	*0.000005*	<0.000005	<0.000005	<0.000005	<0.000005
Dieldrin	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
Endosulfan I	g/m^3	*0.000005*	<0.000005	<0.000005	<0.000005	<0.000005
Endosulfan II	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001
Endosulfan sulfate	g/m^3	*0.000005*	<0.000005	<0.000005	<0.000005	<0.000005
Endrin	g/m^3	*0.00002*	<0.00002	<0.00002	<0.00002	<0.00002
Endrin aldehyde	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001
Endrin ketone	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001
gamma-BHC	g/m^3	*0.000005*	<0.000005	<0.000005	<0.000005	<0.000005
Heptachlor	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001
Heptachlor epoxide	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001
Hexachlorobenzene	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001
Methoxychlor	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001
trans-nonachlor	g/m^3	*0.00001*	<0.00001	<0.00001	<0.00001	<0.00001
trans-Chlordane	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Chlordane (sum)	g/m^3	*0.00004*	<0.00004	<0.00004	<0.00004	<0.00004
TCMX (Surrogate)	%	*1*	88.0	90.7	91.2	85.7

ONOPs in Water*

		Client Sample ID	MW201	MW202	MW203	MW204
		Date Sampled	19/11/2019	19/11/2019	19/11/2019	19/11/2019
Analyte	Unit	*Reporting Limit*	19-40612-1	19-40612-2	19-40612-3	19-40612-4
3-Hydroxycarbofuran	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Acephate	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
Acetochlor	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Alachlor	g/m^3	*0.0003*	<0.0003	<0.0003	<0.0003	<0.0003
Aldicarb	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Aldicarb sulfone	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Aldicarb sulfoxide	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Ametryn	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Atrazine	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Atrazine-desethyl	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Atrazine-desisopropyl	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Avermectin B1a	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Azaconazole	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Azinphos-methyl	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Azoxystrobin	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Benalaxyl	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Bendiocarb	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Bitertanol	g/m^3	*0.0003*	<0.0003	<0.0003	<0.0003	<0.0003
Bromacil	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Bupirimate	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Buprofezin	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Butachlor	g/m^3	*0.0003*	<0.0003	<0.0003	<0.0003	<0.0003
Carbaryl	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Carbendazim	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Carbofuran	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Chlorfluazuron	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Chlorpyrifos	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Chlorpyriphos-methyl	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
Chlortoluron	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Cyanazine	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003

ONOPs in Water*

Client Sample ID			MW201	MW202	MW203	MW204
Date Sampled			19/11/2019	19/11/2019	19/11/2019	19/11/2019
Cyproconazole	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Cyprodinil	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Deltamethrin	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Diazinon	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Dichlofluanid	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Dichlorvos	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
Difenoconazole	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
Dimethoate	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Diuron	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Emamectin B1a	g/m^3	*0.0003*	<0.0003	<0.0003	<0.0003	<0.0003
Fenarimol	g/m^3	*0.0003*	<0.0003	<0.0003	<0.0003	<0.0003
Fenpropimorph	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Fenpyroximate	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Fluazifop-butyl	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Fluometuron	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Flusilazole	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Furalaxyl	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Haloxyfop-methyl	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Hexaconazole	g/m^3	*0.0003*	<0.0003	<0.0003	<0.0003	<0.0003
Hexazinone	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Imazalil	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Imidacloprid	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Indoxacarb	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
IPBC	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Iprodione	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Kresoxim-methyl	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Linuron	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Lufenuron	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Malathion	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Metalaxyl	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Methamidophos	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Methiocarb	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Methomyl	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Metolachlor	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Metribuzin	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Mevinphos	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Molinate	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
Monocrotophos	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Myclobutanil	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Naled	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Norfluazuron	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Omethoate	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Oxyflurofen	g/m^3	*0.0003*	<0.0003	<0.0003	<0.0003	<0.0003
Paclobutrazol	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Parathion-ethyl	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Pendimethalin	g/m^3	*0.0003*	<0.0003	<0.0003	<0.0003	<0.0003
Permethrin	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Pirimicarb	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Pirimiphos-methyl	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Prochloraz	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Prometryn	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Propachlor	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Propanil	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Propazine	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003

ONOPs in Water*

Client Sample ID			MW201	MW202	MW203	MW204
Date Sampled			19/11/2019	19/11/2019	19/11/2019	19/11/2019
Propiconazole	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Pyrimethanil	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Pyriproxyfen	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Quizalofop-ethyl	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Simazine	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Simetryn	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Sulfentrazone	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
TCMTB	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Tebuconazole	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Terbufos	g/m^3	*0.0003*	<0.0003	<0.0003	<0.0003	<0.0003
Terbumeton	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Terbuthylazine	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Terbuthylazine-desethyl	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Terbutryn	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Tetrachlorvinphos	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Tetraconazole	g/m^3	*0.0002*	<0.0002	<0.0002	<0.0002	<0.0002
Thiabendazole	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Thiacloprid	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Thiobencarb	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Tolylfluanid	g/m^3	*0.00005*	<0.00005	<0.00005	<0.00005	<0.00005
Triazophos	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Triflumuron	g/m^3	*0.00003*	<0.00003	<0.00003	<0.00003	<0.00003
Triphenylphosphate (Surrogate)	%	*1*	123.0	136.0	134.0	105.0

Total Petroleum Hydrocarbons - Water

Client Sample ID			MW201	MW202	MW203	MW204
Date Sampled			19/11/2019	19/11/2019	19/11/2019	19/11/2019
Analyte	Unit	*Reporting Limit*	19-40612-1	19-40612-2	19-40612-3	19-40612-4
C7-C9	g/m^3	*0.2*	<0.2	<0.2	<0.2	<0.2
C10-C14	g/m^3	*0.2*	<0.2	<0.2	<0.2	<0.2
C15-C36	g/m^3	*0.3*	<0.3	<0.3	<0.3	<0.3
C7-C36 (Total)	g/m^3	*0.5*	<0.5	<0.5	<0.5	<0.5

Volatile Organic Compounds - Water

Client Sample ID			MW201	MW202	MW203	MW204
Date Sampled			19/11/2019	19/11/2019	19/11/2019	19/11/2019
Analyte	Unit	*Reporting Limit*	19-40612-1	19-40612-2	19-40612-3	19-40612-4
1,2-Dichloropropane	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
2,2-Dichloropropane	g/m^3	*0.002*	<0.002	<0.002	<0.002	<0.002
Cis-1,3-Dichloropropene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Trans-1,3-Dichloropropene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,2-Dibromoethane	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
Carbon disulfide	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Vinyl acetate	g/m^3	*0.008*	<0.008	<0.008	<0.008	<0.008
4-Methyl-2-pentanone (MIBK)	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
2-Hexanone	g/m^3	*0.008*	<0.008	<0.008	<0.008	<0.008

Volatile Organic Compounds - Water

Client Sample ID			MW201	MW202	MW203	MW204
Date Sampled			19/11/2019	19/11/2019	19/11/2019	19/11/2019
2-Methoxy-2-methylpropane (MTBE)	g/m^3	*0.005*	<0.005	<0.005	<0.005	<0.005
Benzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Toluene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Ethylbenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
m,p-Xylene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
o-Xylene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Styrene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Isopropylbenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
n-Propylbenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,3,5-Trimethylbenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
sec-Butylbenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,2,4-Trimethylbenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
tert-Butylbenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
p-Isopropyltoluene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
n-Butylbenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Naphthalene	g/m^3	*0.002*	<0.002	<0.002	<0.002	<0.002
Chlorobenzene	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
Bromobenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
2-Chlorotoluene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
4-Chlorotoluene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,2-Dichlorobenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,3-Dichlorobenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,4-Dichlorobenzene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,4-Dioxane	g/m^3	*0.02*	<0.02	<0.02	<0.02	<0.02
1,2,3-Trichlorobenzene	g/m^3	*0.002*	<0.002	<0.002	<0.002	<0.002
1,2,4-Trichlorobenzene	g/m^3	*0.002*	<0.002	<0.002	<0.002	<0.002
Carbon tetrachloride	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Methylene chloride	g/m^3	*0.002*	<0.002	<0.002	<0.002	<0.002
1,1-Dichloroethane	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
1,2-Dichloroethane	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Acetone	g/m^3	*0.04*	<0.04	<0.04	<0.04	<0.04
Trans-1,2-Dichloroethene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Cis-1,2-Dichloroethene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,1,1-Trichloroethane	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
Trichloroethene	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
Dibromomethane	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Iodomethane	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
1,1-Dichloroethene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
2-Chloroethyl vinyl ether	g/m^3	*0.008*	<0.008	<0.008	<0.008	<0.008
1,1,2-Trichloroethane	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,1-Dichloropropene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,3-Dichloropropane	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005
Tetrachloroethene	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,1,1,2-Tetrachloroethane	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,1,2,2-Tetrachloroethane	g/m^3	*0.005*	<0.005	<0.005	<0.005	<0.005
1,2,3-Trichloropropane	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,2-Dibromo-3-chloropropane	g/m^3	*0.008*	<0.008	<0.008	<0.008	<0.008
Hexachlorobutadiene	g/m^3	*0.002*	<0.002	<0.002	<0.002	<0.002
Chloroform	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Bromodichloromethane	g/m^3	*0.0005*	<0.0005	<0.0005	<0.0005	<0.0005

Volatile Organic Compounds - Water

		Client Sample ID	MW201	MW202	MW203	MW204
		Date Sampled	19/11/2019	19/11/2019	19/11/2019	19/11/2019
Dibromochloromethane	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Bromoform	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Dichlorodifluoro methane	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Chloromethane	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Vinyl chloride	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
Bromomethane	g/m^3	*0.008*	<0.008	<0.008	<0.008	<0.008
Chloroethane	g/m^3	*0.008*	<0.008	<0.008	<0.008	<0.008
Trichlorofluoromethane	g/m^3	*0.001*	<0.001	<0.001	<0.001	<0.001
1,2-Dichloroethane-d4 (Surrogate)	%	*1*	96.5	100.1	98.9	91.8
p-Bromofluorobenzene (Surrogate)	%	*1*	110.6	106.5	111.8	113.2
Toluene-d8 (Surrogate)	%	*1*	104.6	98.8	104.7	102.9

Sulfide in Water*

		Client Sample ID	MW201	MW202	MW203	MW204
		Date Sampled	19/11/2019	19/11/2019	19/11/2019	19/11/2019
Analyte	Unit	*Reporting Limit*	19-40612-1	19-40612-2	19-40612-3	19-40612-4
Sulfide	g/m^3	*0.1*	0.1	<0.1	<0.1	<0.1

Method Summary

Soluble Trace Elements
Samples were analysed as received by the laboratory using ICP-MS following a 0.45µm membrane filtration (except when field filtered). In house procedure based on US EPA 200.8.

Recoverable Trace Elements
Samples were analysed as received by the laboratory using ICP-MS following an acid digestion. In house procedure based on US EPA method 200.8.

PAH in Water
Liquid-liquid extraction with hexane, florisil cleanup with analysis by GC-MS.
Benzo[a]pyrene TEQ (LOR): The most conservative TEQ estimate, where a result is reported as less than the limit of reporting (LOR) the LOR value is used to calculate the TEQ for that PAH.
Benzo[a]pyrene TEQ (Zero): The least conservative TEQ estimate, PAHs reported as less than the limit of reporting (LOR) are not included in the TEQ calculation.
Benzo[a]pyrene toxic equivalence (TEQ) is calculated according to *'Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health'*. Ministry for the Environment. 2011. In accordance with in-house procedure.

pH
Samples measured as received using a conventional pH electrode. (APHA 4500 H^+ B. Online edition).

OCP in Water
Samples are extracted with hexane, pre-concetrated then analysed by GC-MSMS.(In house procedure).
(Chlordane (sum) is calculated from the main actives in technical Chlordane: Chlordane, Nonachlor and Heptachlor)

Total DDT
Sum of DDT, DDD and DDE (4,4' and 2,4 isomers)

ONOPs in Water
Water is extracted with acetonitrile and analysed by LC-MS/MS.

TPH in Water
Solvent extraction, silica cleanup, followed by GC-FID analysis (C7-C36). MFE Petroleum Industry Guidelines. (In accordance with in-house procedure based on US EPA 8015).

VOC in Water
GCMS analysis with headspace sample introduction (In accordance with US EPA Method 5021).

Sulfide in Water
Subcontracted to Watercare Laboratory Services. Sulfide by colour comparison (Methylene Blue Method) using APHA (online edition) 4500-S2 D.

Thara Samarasinghe, B.Sc.
Laboratory Technician

Sharelle Frank, B.Sc. (Tech)
Technologist

Nathan Howse, B.Sc.
Organics Team Leader

Derek Yang, B.Sc.(Tech)
Senior Technologist

Emily Hanna, B.Sc.
Trace Elements Team Leader