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Dear Dominique

XRF SURVEY OF RAINBOW CONNECTIONS

1.0 Introduction

Waikato Regional Council (WRC) has engaged Pattle Delamore Partners Limited (PDP) to undertake an x-ray fluorescence (XRF) survey of Rainbow Connections to identify the concentration of trace elements in surface soils at this site. WRC, on request from the Ministry of Education, has commissioned this work because elevated concentrations of arsenic (and in some other cases antimony, lead and thallium) were found in surface soils on the roadside verges near the Thames Early Childhood Education Centre and Moanataiari School.

The aim of this investigation was to use a screening method (XRF) to identify areas of low, medium and high trace element concentrations (particularly arsenic) to assist with the prioritisation of sites for further investigation.

2.0 Methodology

To determine the concentration of trace elements, an XRF instrument was used to test the surface soils. All XRF measurements were undertaken by a licensed XRF operator.

The XRF measurements were not undertaken in accordance with US EPA protocol 6200. Rationale for this is because the purpose of this investigation was only to identify areas of high trace element concentrations from areas of low trace element concentrations. Specifically, measurements were taken in-situ rather than being collected and sieved through a minus 2 mm sieve and dried before XRF measurements were undertaken. The consequence of the methodology undertaken is that the in-situ soils will likely have higher moisture content than laboratory analysed samples and may have included material greater than 2 mm (i.e. gravels). Furthermore, higher moisture content of the in-situ soils and the presence of gravels in the sample may result in the XRF measurements being slightly reduced. Thus the results provided should be regarded as only indicative of the concentration of target elements in the soils.

A total of seven XRF measurements were carried out by PDP the measurement locations and dates are provided below:

- Three XRF readings were taken from the back grassed area of the childcare centre (28 November 2011);



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- ∴ Two XRF readings were taken from beneath the plastic matting at the childcare centre (28 November 2011); and
- ∴ Two XFR readings were taken from the sandpit and small area of soil the children have access to (28 November 2011).

Figure H1 shows all XRF measurement locations with arsenic readings.

As discussed above, the XRF is only a field screening tool and due to the methodology used (compared with the standard methodology), there is a higher level of measurement uncertainty (greater than 30%). Results obtained should therefore not be compared to any New Zealand (or where applicable International) soil guidelines or standards for human health assessments to assess compliance or non-compliance with the soil guideline or standard. To assess both potential health risks; and compliance with any applicable soil guideline value or standard for human health protection, soil sampling will need to be undertaken and sent to an IANZ accredited laboratory for analysis.

The XRF measurement locations were recorded using a GPS (x-y positional RMS error less than 10 m). GPS locations were obtained so that any sampling site could be revisited should further sampling be required (for example, an area with elevated arsenic concentrations (known as a hotspot¹).

A small hole 0.1m in diameter was dug to a depth of approximately 0.1m to expose the soil below the root zone of the grass. The portable XRF instrument was placed on the exposed soil to ensure that the X-ray window was in full contact with the soil. XRF readings were taken for a minimum 90 seconds. The X-ray window was cleaned between sampling locations in accordance with the XRF manufacturer's Manual.

3.0 Results

For the trace elements which were reliably detected by the XRF (arsenic, copper, chromium, iron, lead, manganese and zinc) only arsenic and lead were found to exceed New Zealand (or where applicable International) soil guidelines or standards for human health assessments. The concentrations of arsenic and lead have therefore only been compiled and discussed in this report (see Table H1). An electronic copy of the full multi-element analysis has been provided to Waikato Regional Council (WRC file reference DM2093695) and is not included in this report.

The XRF data collected during this survey was from three areas of distinct use, based on soil type and likely exposure scenario. The three areas of distinct use were:

1. The back grassed area of the childcare centre (rai01 to rai03);
2. Beneath the plastic matting (rai05 and rai06); and
3. The sandpit and small area of soil the children have access to (rai04 and rai07).

3.1 Traffic Light Assessment

The aim of this work is to assess the site as either a low, medium or high priority area for further investigation. For child care centres, the term 'further investigation' may include the possibility of developing a site specific soil contaminant standard. To present these results, a 'traffic light' assessment tool has been developed to rank the sample locations. The traffic light system is based upon the likelihood that the average concentration, obtained from

¹ For the purpose of this report a hotspot is any value which; is either more than three times the SCS or when the average of the site exceeds the SCS; or any value which is more than 3.5 times the average concentration of that exposure area.

XRF measurements for a given assessment area, is likely to exceed Soil Contaminant Standard (SCS) values based on the 'Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health (MfE, 2011).

MfE, 2011 does not provide a specific standard for schools or childcare centres. Thus, for the purposes of carrying out a first "screening" comparison it has been assumed that one of the standard guideline scenarios is valid for this investigation. For example, a residential value has been used for a childcare centre or primary school. A residential value is anticipated to provide a conservative analysis because it assumes more frequent exposure to soil than the exposure that is likely to occur at a school or childcare centre (seven days per week for most weeks in a year rather than the maximum five days per week at a school or childcare centre). This assumption also includes a greater allowance for exposure to home-grown produce than is likely to occur even if a school has a vegetable garden. Similarly, the recreational guideline value has been used for a secondary school playing field (MfE, 2011) on the basis that human contact with the soil of the playing field is more appropriate to recreational use than residential use.

3.1.1 Green: Low Priority for Further Investigation

A sample that represents a "green status" indicates that the results obtained by XRF suggest that arsenic concentrations are likely to be low, and if soil samples were analysed by the conventional method, they would be likely to fall below the SCS for recreational areas (parks) (for secondary schools) or the standard for residential soils (primary schools).

3.1.2 Orange: Medium Priority for Further Investigation

An "orange status" is assigned to a sample location when results by XRF suggest that arsenic concentrations are moderately elevated for that land use, and may equal or marginally exceed the SCS for recreational areas (for secondary schools) or the SCS for residential areas (primary schools). Due to the measurement uncertainty of the XRF method used in this investigation, 'moderately elevated' is defined by the average of readings that appear to exceed the nominated standard by up to 20 mg/kg – i.e. up to 40 mg/kg for a primary school and up to 100 mg/kg for a secondary school.

3.1.3 Red: High Priority for Further Investigation

A "red status" is given when indicative results by XRF suggest that either:

- ∴ Average arsenic concentrations across all samples from a school are likely to be a multiple of the SCS; and
- ∴ One or more 'hot spot' sites are located on the school where samples are likely to be a multiple of the SCS.

4.0 Discussion

The results obtained from this investigation have been compiled together into three areas of distinct use (see Section 3.0). The average arsenic and lead concentrations of these distinct areas of use have then been calculated. When concentrations of arsenic or lead were below the instrumental detection limit then the value of the published detection limit (9 mg/kg for arsenic and 13 mg/kg for lead) has been used to calculate the average concentration of that element in soils. The interpretation of the areas of distinct use is discussed below.

4.1 The Back Grassed Area

The average arsenic and lead concentrations measured over the three XRF samples was 21 mg/kg (ranging from 13 mg/kg to 37 mg/kg) and 75 mg/kg (ranging from 22 mg/kg to 175 mg/kg) respectively. Two samples showed low levels of arsenic, with just one sample of rai01 (37 mg/kg) being above the residential standard of 20 mg/kg. All samples were below the SCS for lead in residential soils of 210 mg/kg. A very conservative approach has been taken and an **Orange light** has been assigned.

4.2 Beneath the Plastic Matting

The average arsenic and lead concentrations measured over the two XRF samples was 24 mg/kg (ranging from 14 mg/kg to 34 mg/kg) and 162 mg/kg (ranging from below the limit of detection (13 mg/kg) to 311 mg/kg) respectively. One sample showed low levels of arsenic and the other sample rai05 (34 mg/kg) was above the residential standard of 20 mg/kg. The average concentration of lead was lower than the SCS for lead in residential soils of 210 mg/kg. A very conservative approach has been taken and an **Orange light** has been assigned.

4.3 The Sandpit and Small Area of Soil the Children have Access to

The concentrations of arsenic in the two samples collected from the sandpit and the small area of soil the children have access to were below or at the XRF instrument's detection limit (approximately 9 mg/kg). The concentration of one of the samples of lead (rai07) was also lower than the XRF instrument's detection limit (approximately 13 mg/kg) and the other sample (rai04) had a lead concentration of 57 mg/kg.

Given that the sand for the sandpit has been imported, has a very low capacity to adsorb arsenic, and has low to non detectable concentrations of arsenic and lead in both of the samples, the sandpit and exposed soil have been assessed as being a low priority for further investigations (**Green light**).

5.0 Conclusion

An XRF survey of Rainbow Connections was undertaken in November 2011. The survey found the following:

- ∴ The back grassed area is a medium priority for further investigations (orange light);
- ∴ Beneath the plastic matting is a medium priority for further investigations (orange light); and
- ∴ The sandpit and small area of soil the children have access to be a low priority for further investigations (green light).

6.0 References

MfE, 2011. *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health* Office of the Minister for the Environment.

Yours faithfully

PATTLE DELAMORE PARTNERS LIMITED



Georgina Chase
Environmental Geologist



Keith Delamore
Director

Table H1: X-Ray Fluorescence (XRF) Raw Data Rainbow Connection Childcare				
Location	Sample	Units	Arsenic (As)	Lead (Pb)
Around the back	rai01	ppm	37	175
	rai02	ppm	14	28
	rai03	ppm	13	22
Soil that children have access to and the sand pit	rai04	ppm	9	57
	rai07	ppm	9	13
Beneath plastic matting on the site	rai05	ppm	34	311
	rai06	ppm	14	13
Statistical Analysis of Raw XRF Data from Rainbow Connection Childcare				
Location	Statistic	Units	Arsenic (As)	Lead (Pb)
Around the back	COUNT		3	3
	AVERAGE	ppm	21	75
	MIN	ppm	13	22
	MAX	ppm	37	175
Soil that children have access to and the sand pit	COUNT		2	2
	AVERAGE	ppm	<LOD	35
	MIN	ppm	<LOD	<LOD
	MAX	ppm	<LOD	57
Beneath plastic matting on the site	COUNT		2	2
	AVERAGE	ppm	24	162
	MIN	ppm	14	<LOD
	MAX	ppm	34	311

Notes:

Measurement below the level of measurement of the XRF. The value is set as equal to the estimated detection limit.

<LOD = below limit of detection

Count = number of samples



SOURCE: AERIAL IMAGERY SUPPLIED BY THAMES-COROMANDEL DISTRICT COUNCIL.
CADASTRAL INFORMATION DERIVED FROM LINZ DATA.

FIGURE H1 : RAINBOW CONNECTION CHILDCARE
XRF SAMPLING LOCATIONS WITH ARSENIC RESULTS