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17 January 2012

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Dear Dominique

XRF SURVEY OF THAMES EARLY CHILDHOOD EDUCATION CENTRE

1.0 Introduction

Waikato Regional Council (WRC) has engaged Pattle Delamore Partners Limited (PDP) to undertake an x-ray fluorescence (XRF) survey of Thames Early Childhood Education Centre 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) have been found in surface soils on the roadside verges near the childcare centre; and
- The early childhood education centre is located on land reclaimed from the Firth of Thames using local mine waste.

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 assess whether further investigation of the soils is necessary.

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 the standard methodology (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, soil measurements were taken in-situ rather than soil samples 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 17 XRF measurements were carried out by PDP, the measurement locations and dates are provided below:

- Four XRF readings were taken from the back grassed area of the childcare centre (27 November 2011);
- Three XRF readings were taken from sand removed from the under two-year-olds sandpit (27 November 2011);
- Three XRF readings were taken from sand removed from the over two-year-olds sandpit (27 November 2011);
- Three XRF readings were taken from the area around the slide (29 November 2011); and
- Three XRF readings were taken from exposed soils in the grassed area out the front of the Centre.

Figure G1 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 been 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 hotspot[1]).

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 G1). 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 has been grouped into three areas of distinct use, based on soil type, likely exposure scenario, and if there was a hotspot detected. The five areas of distinct use were:

1. The back grassed area of the childcare centre (tec01, tec02, tec04 and tec20);
2. The under two-year-olds sandpit (tec05 to tec07);
3. The over two-year-olds sandpit (tec08 to tec10);
4. The area around the slide (tec03, tec21 and tec24), and
5. The exposed soils in the grassed area out the front of the Centre (tec11 to tec14).

[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.

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 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 the five different areas of distinct use (see Section 3.0). The average arsenic and lead concentrations for each area of distinct 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

Results of the XRF survey undertaken by PDP on 27 November 2011 indicate that the average arsenic and lead concentrations measured over the four XRF samples was 55 mg/kg (ranging from 45 mg/kg to 66 mg/kg) and 73 mg/kg (ranging from 41 mg/kg to 124 mg/kg) respectively. Based on the sample test results, the average concentration of arsenic in the surface soils is higher than the SCS for arsenic in residential soils of 20 mg/kg and the average lead concentration is lower than the SCS for lead in residential soils of 210 mg/kg.

Since high concentrations of arsenic were detected in the grassed back area, the area has been assessed as being a high priority for further investigations **(Red light).**

4.2 The Under Two-Year-Olds Sandpit

The concentrations of arsenic in the samples collected from the sandpit were lower than the XRF instrument's detection limit (approximately 9 mg/kg). The concentrations of lead in the samples collected from the sandpit were also lower than the XRF instrument's detection limit (approximately 13 mg/kg).

Given that the sand for the sandpit has been imported, has a very low capacity to adsorb arsenic, and has no detectable concentration of arsenic or lead in any of the three samples, the sandpit has been assessed as being a low priority for further investigations **(Green light).**

4.3 The Over Two-Year-Olds Sandpit

The concentrations of arsenic in the samples collected from the sandpit were lower than the XRF instrument's detection limit (approximately 9 mg/kg). The concentrations of lead in the samples collected from the sandpit were also lower than the XRF instrument's detection limit (approximately 13 mg/kg).

Given that the sand for the sandpit has been imported, has a very low capacity to adsorb arsenic, and has no detectable concentration of arsenic or lead in any of the three samples, the sandpit has been assessed as being a low priority for further investigations **(Green light).**

4.4 The Area around the Slide

Results of the XRF survey undertaken by PDP on 29 November 2011 indicate that the average arsenic and lead concentrations measured over the three XRF samples was 163 mg/kg (ranging from 118 mg/kg to 252 mg/kg) and 98 mg/kg (ranging from 79 mg/kg to 108 mg/kg) respectively. Based on the sample test results, the average concentration of arsenic in the surface soils is higher than the SCS for arsenic in residential soils of 20 mg/kg and the average concentration of lead is lower than the SCS for lead in residential soils of 210 mg/kg.

Since high concentrations of arsenic were detected in the area around the slide, the area has been assessed as being a high priority for further investigations **(Red light).**

4.5 The Grassed Area out the Front of the Centre

Results of the XRF survey undertaken by PDP on 27 November 2011 indicate that the average arsenic and lead concentrations measured over the four XRF samples was 18 mg/kg (ranging from less than 9 mg/kg to 29 mg/kg) and 26 mg/kg (ranging from 16 mg/kg to 45 mg/kg) respectively. Based on the sample test results, the average concentration of arsenic in the surface soils is lower than the SCS for arsenic in residential soils of 20 mg/kg. and the average concentration of lead is lower than the SCS for lead in residential soils of 210 mg/kg.

Three samples showed low levels of arsenic, while one sample (tec12) was slightly above the 20 mg/kg residential guideline (29 mg/kg). The soil contamination standards are conservative. Expert evidence is that early childhood

centres are likely to be safe at concentrations higher than 20 mg/kg. For these reasons, this area is not a high priority for further investigations **(Green light)**.

5.0 Conclusion

An XRF survey of Thames Early Childhood Education Centre was undertaken in November 2011. The survey found the following:

1. The back grassed area is a high priority for further investigations (red light);
2. The under two-year-olds sandpit is a low priority for further investigations (green light);
3. The over two-year-olds sandpit is a low priority for further investigations (green light);
4. The grasses area out the front of the centre is a low priority for further investigations (green light); and
5. The area around the slide is a high priority for further investigations (red 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

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Director

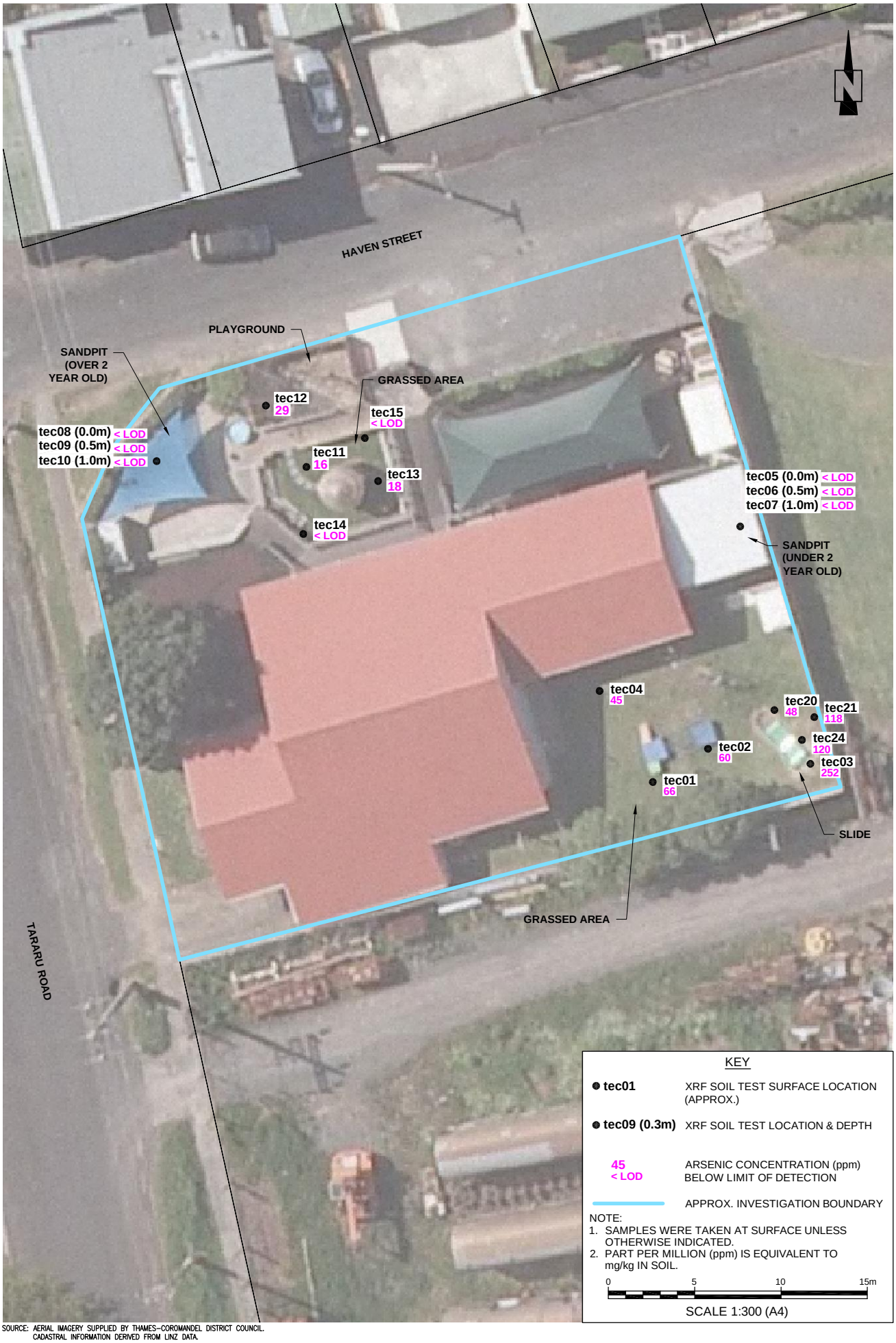
Table G1: X-Ray Fluoresence (XRF) Raw Data Thames Early Childcare Education Centre				
	Sample	**Units**	**Arsenic (As)**	**Lead (Pb)**
Back of childcare centre	tec01	ppm	66	124
	tec02	ppm	60	85
	tec04	ppm	45	41
	tec20	ppm	48	41
Area around slide	tec03	ppm	252	107
	tec21	ppm	118	108
	tec24	ppm	120	79
Sand from under two sand pit	tec05	ppm	9	13
	tec06	ppm	9	13
	tec07	ppm	9	13
Sand from over two sand pit	tec08	ppm	9	13
	tec09	ppm	9	13
	tec10	ppm	9	13
Exposed soils out front	tec11	ppm	16	24
	tec12	ppm	29	16
	tec13	ppm	18	45
	tec14	ppm	9	18
Statisitical Analysis of Raw XRF Data from Thames Early Childcare Education Centre				
	Statistic	**Units**	**Arsenic (As)**	**Lead (Pb)**
Back of childcare centre	COUNT		4	4
	AVERAGE	ppm	55	73
	MIN	ppm	45	41
	MAX	ppm	66	124
Area around slide	COUNT		3	3
	AVERAGE	ppm	163	98
	MIN	ppm	118	79
	MAX	ppm	252	108
Sand from under two sand pits	COUNT		3	3
	AVERAGE	ppm	<LOD	<LOD
	MIN	ppm	<LOD	<LOD
	MAX	ppm	<LOD	<LOD
Sand from over two sand pits	COUNT		3	3
	AVERAGE	ppm	<LOD	<LOD
	MIN	ppm	<LOD	<LOD
	MAX	ppm	<LOD	<LOD
Exposed soils out front	COUNT		4	4
	AVERAGE	ppm	18	26
	MIN	ppm	9	16
	MAX	ppm	29	45

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 G1 : THAMES EARLY CHILDHOOD EDUCATION CENTRE
XRF SAMPLING LOCATIONS WITH ARSENIC RESULTS