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Dear Dominique

## **XRF SURVEY OF MOANATAIARI SCHOOL AND THAMES MONTESSORI CENTRE**

### **1.0 Introduction**

Waikato Regional Council (WRC) has engaged Pattle Delamore Partners Limited (PDP) to undertake an x-ray fluorescence (XRF) survey of Moanataiari School and Montessori Early Childcare Centre to identify the concentration of trace elements in surface soils at these sites. 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 school; and
- The school is located on land reclaimed from the Firth of Thames using local mine waste.

Previous soil sampling of the main playing field, undertaken by Waikato Regional Council<sup>1</sup> (January 2007) and by Pattle Delamore Partners Limited (November 2011)<sup>2</sup> has provided laboratory test results below the National Environmental Standard, Soil Contaminant Standard (SCS) values for residential land use. Therefore, this investigation has been limited to areas not previously sampled including the grassed areas which children have access to on the northern portion of the site and around the Montessori Centre located in the north-western corner of the main playing field.

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.

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<sup>1</sup> WRC (2007) Unpublished Data. File Reference DM 2091171. Urban Parks and Schools Sampled and Tested for Trace Elements and PAHs.

<sup>2</sup> PDP (2011) Moanataiari Subdivision Site Investigation Report.



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 46 XRF measurements were carried out by PDP, the measurement locations and dates are provided below;

- ∴ 35 XRF readings were taken from the grassed areas around the northern part of the school (26 November 2011),
- ∴ Nine XRF readings were taken from the area used by the Thames Montessori Centre (30 November 2011), and
- ∴ Two XRF readings were also obtained from the bark area of the Montessori playground (15 November 2011), at the request of the Moanataiari School principal.

Figure A1 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 1.0 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<sup>3</sup>).

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 Tables A1, A2 and A3). 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. These three areas of distinct use were:

1. the northern grassed area around the school buildings (mps01 to mps035),

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<sup>3</sup> 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.

2. the sandpit at the Montessori site (mom03 to mom05), and
3. the grassed areas of the Montessori site (mom05 to mom09).

The main playing field south of the school buildings was previously sampled by Waikato Regional Council on 19 January 2007. The sampling involved the collection of 16 sub-samples from the upper 10 cm of the soils of the Moanataiari School recreational field to form a single composite sample which was analysed by Hill Laboratories. Also, the main playing field was surveyed using an XRF at 5 locations on 15 November 2011 as part of the initial subdivision investigation. The results of these two investigations have been summarised in Table A2.

### **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 primary schools, 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 arsenic 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 together with the results from the two other previous site investigations (WRC, 2007 and PDP, 2011) have been compiled together into the three 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 together with the previous results from the main playing field are discussed below.

### 4.1 Playing Field to the South of the School

Results of the XRF survey undertaken by PDP on 15 November 2011 and soil sampling undertaken by WRC in 2007 indicate that the average arsenic concentration in the soil of the main playing field is likely to be lower than SCS for arsenic in residential soils of 20 mg/kg.

Since, low concentrations of arsenic and lead were detected in both of these surveys (9.2 mg/kg and 11 mg/kg respectively) the playing field has been assessed as being a low priority for further investigations (**Green light**).

### 4.2 Northern Areas of the School Grounds

The average concentration of arsenic and lead measured over the 36 XRF samples was 22.6 mg/kg (ranged from 8 to 72 mg/kg) and 42 mg/kg (ranged from 9.5 to 254 mg/kg) respectively. No distinct hotspots of arsenic were detected during the investigation, but based on the sample test results the average concentration of arsenic in the surface soils is likely to be higher than the SCS for arsenic in residential soils of 20 mg/kg. At one sampling location (mps 28) the concentration of lead (258 mg/kg) was slightly higher than the SCS for lead in residential soils of 210 mg/kg.

As a result of these measurements, part of the site has been assessed as being a medium priority for further investigations (**Orange light**). Further investigations could include undertaking soil sampling, and then analysis at an IANZ accredited laboratory and/or the development of a site specific soil guideline (for primary schools) for arsenic. A site specific soil guideline may be more appropriate as it is more likely to assess the actual risk associated with arsenic in soils in a primary school setting.

### 4.3 Grassed Areas used by Montessori Early Childcare Centre

The average concentration of arsenic and lead measured over seven samples was 13 mg/kg (ranged from less than 9 mg/kg to 23 mg/kg) and 32 mg/kg (ranged from 16 to 62 mg/kg) respectively. No distinct hotspots of arsenic or lead were detected during the investigation. The average concentration of both of these trace elements in the surface soils is likely to be lower than the applicable SCS for residential soils (20 mg/kg for arsenic and 210 mg/kg for lead). As a result of these findings, the grassed areas around the Montessori Early Childcare Centre have been assessed as being a low priority for further investigations (**Green light**). An arsenic concentration of 23 mg/kg result was obtained at the sample location in the slightly sunken area on the south west corner of the site. It therefore may be advisable in future to collect a composite soil sample from this area at the same time as any soil sampling is undertaken of the northern areas of the site. Alternatively, a site specific soil guideline value could be developed for this location to provide a more accurate assessment of the risk associated with arsenic in an early childcare facility type setting.

### 4.4 Sandpit used by Montessori Early Childcare Centre

The concentrations of arsenic in the samples collected from the sandpit were lower than the XRF instrument's detection limit (approximately 9 mg/kg). Sample mom01 was an XRF measurement of the sand within the sandpit, while sample mom02 was an XRF measurement undertaken on the underlying soils below the sand in the sandpit.

The average concentration of lead in both of these samples was 11 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 in either of the two samples, the sandpit has been assessed as being a low priority for further investigations (**Green light**).

## 5.0 Conclusion

An XRF survey of the grassed areas of the Moanataiari school grounds was undertaken in November 2011. The survey found the following:

1. Main playing field the south of the school buildings is a low priority for further investigations (green light).
2. Northern grassed areas around the school buildings is a medium priority for further investigations (orange light).
3. Grassed areas used by the Montessori Early Childcare Centre is a low priority for further investigations (green light), but the area in the south west corner (mom08) may need further sampling.
4. Sandpit used by the Montessori Early Childcare Centre is 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**



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**Environmental Chemist**



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**Director**

| <b>Table A1: X-Ray Fluorescence (XRF) Raw Data (Moanataiari Primary School)</b> |              |                     |                  |
|---|--------------|---------------------|------------------|
| <b>Sample Name</b>  | <b>Units</b> | <b>Arsenic (As)</b> | <b>Lead (Pb)</b> |
| mps01   | ppm          | 25                  | 31               |
| mps02   | ppm          | 9                   | 16               |
| mps03   | ppm          | 22                  | 65               |
| mps04   | ppm          | 9                   | 34               |
| mps05   | ppm          | 33                  | 37               |
| mps06   | ppm          | 22                  | 36               |
| mps07   | ppm          | 38                  | 44               |
| mps08   | ppm          | 9                   | 113              |
| mps09   | ppm          | 72                  | 26               |
| mps10   | ppm          | 32                  | 31               |
| mps11   | ppm          | 24                  | 39               |
| mps12   | ppm          | 17                  | 42               |
| mps13   | ppm          | 23                  | 45               |
| mps14   | ppm          | 55                  | 68               |
| mps15   | ppm          | 16                  | 36               |
| mps16   | ppm          | 18                  | 36               |
| mps17   | ppm          | 9                   | 33               |
| mps18   | ppm          | 15                  | 39               |
| mps19   | ppm          | 17                  | 29               |
| mps20   | ppm          | 15                  | 25               |
| mps21   | ppm          | 16                  | 23               |
| mps22   | ppm          | 29                  | 66               |
| mps24   | ppm          | 44                  | 35               |
| mps25   | ppm          | 17                  | 39               |
| mps26   | ppm          | 14                  | 36               |
| mps27   | ppm          | 14                  | 42               |
| mps28   | ppm          | 53                  | 254              |
| mps29   | ppm          | 9                   | 34               |
| mps30   | ppm          | 8                   | 10               |
| mps31   | ppm          | 15                  | 30               |
| mps32   | ppm          | 13                  | 24               |
| mps33   | ppm          | 18                  | 29               |
| mps34   | ppm          | 9                   | 32               |
| mps35   | ppm          | 9                   | 12               |
| moa40   | ppm          | 55                  | 11               |
| moa41   | ppm          | 9                   | 15               |
| <b>Statistical Analysis of Moanataiari Primary School Samples</b>               |              |                     |                  |
| <b>Statistic</b>  | <b>Units</b> | <b>Arsenic (As)</b> | <b>Lead (Pb)</b> |
| Count   |              | 36                  | 36               |
| Average   | ppm          | 22.57               | 42.09            |
| Minimum   | ppm          | 8                   | 10               |
| Maximum   | ppm          | 72                  | 254              |

Notes:

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

Count = number of samples

| <b>Table A2: X-Ray Fluorescence (XRF) Raw Data (Montessori Early Childcare Centre)</b> |               |              |                     |                  |
|--|---------------|--------------|---------------------|------------------|
| <b>Location</b>  | <b>Sample</b> | <b>Units</b> | <b>Arsenic (As)</b> | <b>Lead (Pb)</b> |
| Sandpit Samples  | mom01         | ppm          | 9                   | 12               |
|  | mom02         | ppm          | 9                   | 11               |
| Statistical Analysis of Sandpit Samples  | Count         | ppm          | 2                   | 2                |
|  | Average       | ppm          | 9                   | 11               |
|  | Minimum       | ppm          | 9                   | 11               |
|  | Maximum       | ppm          | 9                   | 12               |
| School Samples   | mom03         | ppm          | 16                  | 16               |
|  | mom04         | ppm          | 15                  | 36               |
|  | mom05         | ppm          | 9                   | 37               |
|  | mom06         | ppm          | 18                  | 27               |
|  | mom07         | ppm          | 9                   | 22               |
|  | mom08         | ppm          | 23                  | 60               |
|  | mom09         | ppm          | 9                   | 24               |
| Statistical Analysis of School Samples   | Count         |              | 7                   | 7                |
|  | Average       | ppm          | 14.1                | 31.7             |
|  | Minimum       | ppm          | 9                   | 16               |
|  | Maximum       | ppm          | 23                  | 60               |

Notes:

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

| <b>Table A3: X-Ray Fluorescence (XRF) Raw Data and WRC Sample Playing Field Results</b> |               |                  |                     |                  |
|---|---------------|------------------|---------------------|------------------|
| <b>Location</b>   | <b>Sample</b> | <b>Units</b>     | <b>Arsenic (As)</b> | <b>Lead (Pb)</b> |
| School Playfield Samples  | xrf 23        | ppm              | 9                   | 23               |
|   | xrf 24        | ppm              | 12                  | 11               |
|   | xrf 25        | ppm              | 9                   | 16               |
|   | xrf 26        | ppm              | 7                   | 14               |
|   | xrf 27        | ppm              | 9                   | 12               |
|   | THA1          | g/m <sup>3</sup> | 11                  | 27.7             |
| Statistical Analysis of School Samples  | Count         |                  | 6                   | 6                |
|   | Average       | ppm              | 9.5                 | 17.3             |
|   | Minimum       | ppm              | 7.0                 | 11.0             |
|   | Maximum       | ppm              | 12.0                | 27.7             |

Notes:

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

Count = number of samples





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

**KEY**

- **mps01** XRF SOIL TEST SURFACE LOCATION (APPROX.) (26 Nov - 30 Nov 2011)
- **mom01** XRF SOIL TEST LOCATION & DEPTH (26 Nov - 30 Nov 2011)
- **tec09 (0.5m)** XRF SOIL TEST LOCATION (15 Nov 2011)
- **xrf 1** XRF SOIL TEST LOCATION (15 Nov 2011)
- 25** ARSENIC CONCENTRATION (ppm)
- <LOD** BELOW LIMIT OF DETECTION
- APPROX. INVESTIGATION BOUNDARY

**NOTE:**

1. SAMPLES WERE TAKEN AT SURFACE UNLESS OTHERWISE INDICATED.
2. PART PER MILLION (ppm) IS EQUIVALENT TO mg/kg IN SOIL.

0 10 20 30m  
SCALE 1:750 (A3)

FIGURE A1 : MOANATAIARI SCHOOL AND THAMES MONTESSORI XRF SAMPLING LOCATIONS WITH ARSENIC RESULTS