PATTLE DELAMORE PARTNERS LTD
Level 4, PDP House
235 Broadway, Newmarket, Auckland 1023
PO Box 9528, Auckland 1149, New Zealand

Tel +9 **523 6900** Fax +9 **523 6901**
Web Site **http://www.pdp.co.nz**
Auckland Wellington Christchurch

17 January 2012

Dominique Noiton
Waikato Regional Council
Private Bag 3038
Waikato Mail Centre
HAMILTON 3240

Dear Dominique

XRF SURVEY OF THAMES HIGH SCHOOL AND DANBY FIELD

1.0 Introduction

Waikato Regional Council (WRC) has engaged Pattle Delamore Partners Limited (PDP) to undertake an x-ray fluorescence (XRF) survey of Thames High School and Danby Field 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 Thames early childcare education centre and the Moanataiari school; and
- Sampling undertaken by Waikato Regional Council on 19 January 2007 found elevated concentrations of arsenic in the main playing field of Thames High School. The sampling of the main playing field south of the school buildings undertaken by Waikato Regional Council involved the collection of 16 sub-samples from the upper 10 cm of the soils which were composited together to form a single sample. Analysis of the single composite sample found that the concentration of arsenic and lead within the composite sample was 107 mg/kg and 105 mg/kg respectively.

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 identity 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 18 XRF measurements were carried out by PDP on the main school grounds and another 28 XRF measurements were undertaken on Danby field, the measurement locations and dates are provided below;

- 18 XRF readings were taken from the main playing field, school gardens and near the school pool (28 November 2011), and
- 28 XRF readings were taken from the Danby field which is used as sport playing field by Thames High School (1 December 2011).

Figure C1 and C2 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 Tables C1 and C2). 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 five areas of distinct use (with samples in brackets) were:

1. The gardens in the horticultural areas on the southern side of the main playing field (ths01 – ths06).
2. The grassed areas near the gardens (ths07 and ths08).
3. The main playing field within the school grounds (ths09-ths16 and ths18-ths21).

[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

4. The grassed area near to the pool (beside the mine shaft flooded in 1906) (ths17 and ths18), and
5. Danby field (dan01 to dan28).

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 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 has 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 is discussed below.

4.1 Gardens in the School Horticultural Area

Six XRF measurements undertaken by PDP on 28 November 2011 found arsenic concentrations in the garden's topsoil to be below the instrument's detection limit. The average concentration of lead in the garden soils was 47 ppm (ranged between 14 to 133 ppm). Therefore the concentration of arsenic and lead in the garden topsoils is likely to be lower than the SCS for arsenic and lead in residential soils of 20 mg/kg and 210 mg/kg respectively.

Since, low concentrations of arsenic and lead were detected in this survey and since the garden topsoil has been imported into the site, the gardens in the school horticultural area have been assessed as being a low priority for further investigations **(Green light).**

4.2 Grassed areas next to the Gardens

Two XRF measurements were taken from the grassed area next to the school's gardens in the horticultural area which found arsenic concentrations of 33 and 34 mg/kg and lead concentrations of 68 and 84 mg/kg. Based on the XRF results the average concentration of arsenic in the surface soils is likely to be lower than the SCS for arsenic in recreational soils of 80 mg/kg. Therefore this part of the site has been assessed as being a low priority for further investigations **(Green light).**

It should be noted that the soil in this location may not be suitable for growing vegetables due to the elevated concentrations of arsenic (compared to appropriate SCS considering produce consumption), detected in the two sampling locations measured as part of this survey. If any further expansion of the schools horticultural area is undertaken then either more sampling may be required and/or imported soil may need imported to construct a raised garden. Expert advice would be required before any further expansion of the horticultural area is undertaken.

4.3 Main Playing Fields

The average concentration of arsenic and lead measured over 11 samples from the main playing field was 79 mg/kg (ranged from 14 mg/kg to 138 mg/kg) and 138 mg/kg (ranged from 45 to 341 mg/kg) respectively. No distinct hotspots of arsenic or lead were detected during the investigation. The average concentration of arsenic in the surface soils is likely to be higher than the applicable SCS for recreational soils (80 mg/kg for arsenic and 880 mg/kg for lead). This conclusion is supported by the composite sampling undertaken by Waikato Regional Council which contained an arsenic concentration of 107 mg/kg and a lead concentration of 105 mg/kg. As a result of these findings, the grassed areas around the main playing field at Thames High School have been assessed as being a medium priority for further investigations **(Orange light).**

4.4 Grassed area Adjacent to Main Pool

Two XRF measurements were taken from the grassed area next to the schools' pool which found arsenic concentrations of 31 and 43 mg/kg and lead concentrations of 69 to 71 mg/kg.

The average concentration of arsenic and lead in both of these samples was 37 mg/kg and 70 mg/kg respectively. The main pool is located near a former mine shaft and therefore there is the possibility that mine waste may have been deposited in this area.

However, the limited sampling undertaken to date indicates that the average concentration of arsenic and lead in both of these samples was 37 mg/kg and 70 mg/kg respectively. The average concentration of both of these trace elements in the surface soils is likely to be lower than the applicable SCS for recreational soils (80 mg/kg for arsenic and 880

mg/kg for lead). Therefore, the grassed area adjacent to the main pool has been assessed as being a low priority for further investigations **(Green light).**

4.5 Danby Field

The average concentration of arsenic and lead measured over 28 samples was 10 mg/kg (ranged from less than 9 mg/kg to 18 mg/kg) and 29 mg/kg (ranged from 11 to 85 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 recreational soils (80 mg/kg for arsenic and 880 mg/kg for lead). As a result of these findings, the Danby Field have been assessed as being a low priority for further investigations **(Green light).** However, it should be noted that this site is built on reclaimed land and they may be other contaminates (such as organic compounds) present which are not detectable using the XRF.

5.0 Conclusion

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

1. Gardens in the School horticultural area are a low priority for further investigations (green light).
2. The grassed areas next to the gardens are a low priority for further investigations (green light).
3. The main playing field is a medium priority for further investigations (orange light).
4. Grassed areas around the swimming pool are a low priority for further investigations (green light).
5. Danby Field 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

Andrew Rumsby

Environmental Chemist

Keith Delamore

Director

Table C1: X-Ray Fluoresence (XRF) Raw Data Thames High School				
Location	**Sample**	**Units**	**Arsenic (As)**	**Lead (Pb)**
Gardens in the horticultural areas on the southern side of the main playing field	ths01	ppm	9	133
	ths02	ppm	9	34
	ths02	ppm	9	14
	ths04	ppm	9	37
	ths05	ppm	9	31
	ths06	ppm	9	32
Grassed area near the gardens	ths07	ppm	33	84
	ths08	ppm	34	68
Main playing field	ths09	ppm	120	341
	ths10	ppm	69	111
	ths11	ppm	62	171
	ths12	ppm	14	52
	ths13	ppm	97	45
	ths14	ppm	121	123
	ths15	ppm	138	103
	ths16	ppm	86	56
	ths19	ppm	32	133
	ths20	ppm	97	80
	ths21	ppm	38	304
Grassed area near the pool	ths17	ppm	31	71
	ths18	ppm	43	69
Statisitical Analysis of Raw XRF Data from Thames High School				
Location	**Statistic**	**Units**	**Arsenic (As)**	**Lead (Pb)**
Gardens in the horticultural areas on the southern side of the main playing field	COUNT		6	6
	AVERAGE	ppm	<LOD	47
	MIN	ppm	<LOD	14
	MAX	ppm	<LOD	133
Grassed area near the gardens	COUNT		2	2
	AVERAGE	ppm	34	76
	MIN	ppm	33	68
	MAX	ppm	34	84
Main playing field	COUNT		11	11
	AVERAGE	ppm	79	138
	MIN	ppm	14	45
	MAX	ppm	138	341
Grassed area near the pool	COUNT		2	2
	AVERAGE	ppm	37	70
	MIN	ppm	31	69
	MAX	ppm	43	71

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

Table C2: X-Ray Fluoresence (XRF) Raw Data Danby Field				
Location	**Sample**	**Units**	**Arsenic (As)**	**Lead (Pb)**
Grassed area	dan01	ppm	9	33
	dan02	ppm	9	21
	dan03	ppm	9	24
	dan04	ppm	9	29
	dan05	ppm	9	25
	dan06	ppm	12	24
	dan07	ppm	9	54
	dan08	ppm	9	17
	dan09	ppm	10	29
	dan10	ppm	9	62
	dan11	ppm	9	20
	dan12	ppm	9	30
	dan13	ppm	11	11
	dan14	ppm	9	37
	dan15	ppm	10	11
	dan16	ppm	9	22
	dan17	ppm	14	50
	dan18	ppm	18	85
	dan19	ppm	9	33
	dan20	ppm	9	11
	dan21	ppm	9	15
	dan22	ppm	9	20
	dan23	ppm	9	27
	dan24	ppm	9	25
	dan25	ppm	9	44
	dan26	ppm	9	23
	dan27	ppm	9	17
	dan28	ppm	9	23
Statisitical Analysis of Raw XRF Data from Danby Field				
Location	**Statistic**	**Units**	**Arsenic (As)**	**Lead (Pb)**
Grassed area	COUNT		28	28
	AVERAGE	ppm	10	29
	MIN	ppm	<LOD	11
	MAX	ppm	18	85

Notes:

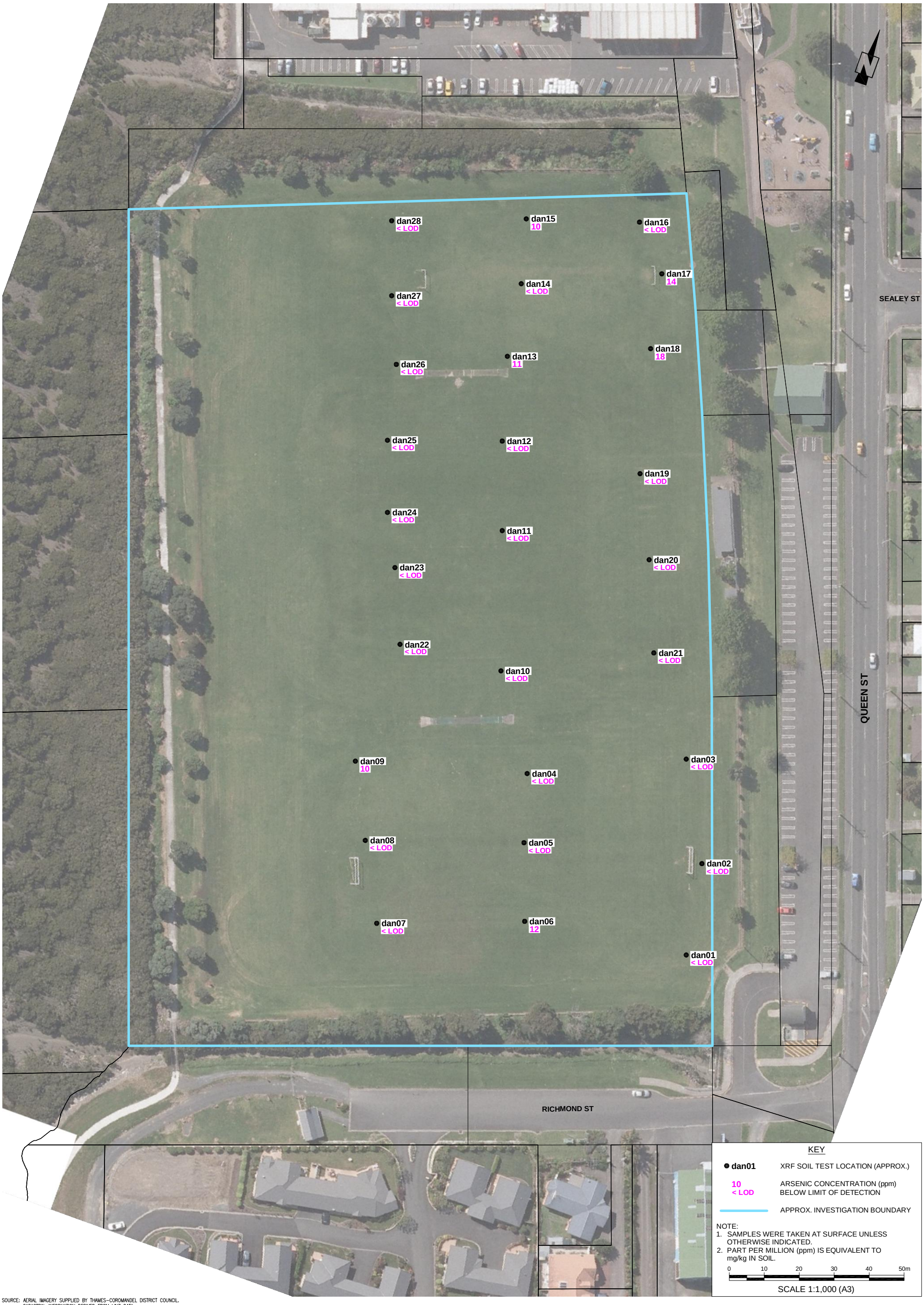
Measurement below the level of measurement of the XRF. The value is set as equal to the estimated detection limit.

<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 C1 : THAMES HIGH SCHOOL XRF SAMPLING LOCATIONS WITH ARSENIC RESULTS



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

FIGURE C2 : DANBY FIELD XRF SAMPLING LOCATIONS WITH ARSENIC RESULTS