GREENCAP
Going Further in Managing Risk

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Australia

PRELIMINARY ASSESSMENT

February 2018
J153826

(Interim Report)

NSW Department Of Education

Northwest Hotspot

Cringila Public School
35 Sheffield St, Cringila NSW 2502

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Statement of Limitations

This report has been prepared in accordance with the agreement between NSW Department of Education and Greencap.

Within the limitations of the agreed upon scope of services, this work has been undertaken and performed in a professional manner, in accordance with generally accepted practices, using a degree of skill and care ordinarily exercised by members of its profession and consulting practice. No other warranty, expressed or implied, is made.

This report is solely for the use of NSW Department of Education and any reliance on this report by third parties shall be at such party's sole risk and may not contain sufficient information for purposes of other parties or for other uses. This report shall only be presented in full and may not be used to support any other objective than those set out in the report, except where written approval with comments are provided by Greencap.

Sampling Risks

It is noted that professional judgment has been used to interpret the data obtained from site sampling and subsequent laboratory testing in order to characterise contamination that is present on site. NSW Department of Education accepts that even a comprehensive sampling and testing program, implemented with the appropriate equipment and experienced personnel under the direction of a trained professional who functions in accordance with a professional standard of care, may fail to detect certain conditions because they are hidden and therefore cannot be considered in development of a sub-surface exploration program.

The extent of soil sampling and analysis has been targeted towards areas where contamination is considered to be most likely, based on site history and visual assessment. The methods adopted are in accordance with recognised industry standards. This approach maximises the probability of identifying contaminants. However, it may not identify contamination that occurs in unexpected locations or from unexplained sources. Soil contamination can be expected to be non-homogenous across the stratified soils where present on site, and the concentrations of contaminants may vary significantly within areas where the contamination has occurred. For this reason the results should be regarded as indicative only.

Contaminant movement within the soil and within groundwater can follow paths of high permeability and it is possible that sampling will not have intersected these preferential pathways. In the case of groundwater, the flow can follow relatively narrow migration paths within minor aquifers, but in any event, the scope of services included with the Proposal is that which NSW Department of Education agreed to or selected in light of his own risk preferences and other considerations.

Sampling of soil or groundwater may result in contamination of certain sub-surface areas, as when a probe or boring device moves through a contaminated area, linking it to an aquifer or other water body not previously contaminated. Greencap Pty Ltd has applied it best efforts to minimise and eliminate such cross contamination during the conduct of any sub-surface investigation. Because sub-surface sampling is a necessary aspect of the work which Greencap Pty Ltd may perform on NSW Department of Education's behalf, NSW Department of Education waives any claims against Greencap Pty Ltd and agrees to defend, indemnify and hold Greencap Pty Ltd harmless from any claims or liability for injury or loss which may arise as a result of alleged cross contamination caused by sampling.

Reliance on Information Provided by Others

Whilst the techniques used in the assessment are in accordance with recognised industry standards, the investigations also rely on information provided to Greencap Pty Ltd by third parties. Naturally, Greencap Pty Ltd cannot guarantee completeness or accuracy of any descriptions or conclusions based on information supplied to it during site surveys, visits and interviews. The extent of risk NSW Department of Education wishes to accept is something which NSW Department of Education must determine and accordingly, NSW Department of Education waives any claim against Greencap Pty Ltd and agrees to defend, indemnify and hold Greencap Pty Ltd harmless from any claim or liability for injury or loss allegedly arising from errors, omissions or inaccuracies in documents or other information provided to Greencap Pty Ltd by NSW Department of Education.

Recommendations for Further Study

Greencap Pty Ltd preliminary findings which may result from this investigation/study may require verification through further analytical testing programs. The final decision to conduct additional investigative activities will be dependent upon NSW Department of Education's assessment of the business risks involved. NSW Department of Education agrees to hold Greencap Pty Ltd harmless from any claim, losses or damages arising out of NSW Department of Education's rejection of any additional work suggested by Greencap Pty Ltd as a result of the work performed hereunder/

This report was prepared in February 2018 and is based on conditions encountered and information reviewed at the time of preparation. Greencap Pty Ltd disclaims responsibility for any changes that may have occurred after this time.

Preliminary Assessment

NSW Department of Education

Northwest Hotspot - Cringila Public School

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1. Introduction and Background

Greencap Pty Ltd was engaged by NSW Department of Education on the 31st October 2017 to undertake a Preliminary Assessment of a hotspot identified within the northwest region of the playground at Cringila Public School, NSW 2502.

During September 2017 NSW EPA issued a clean-up Notice to NSW Department of Education following an event in which steam and gas was emanating from the ground surface within a fenced area in the northwest portion of the school playground.

An initial assessment of the site was undertaken by WSP between 25-29th September 2017, in which Air Monitoring was undertaken and the results presented in 'Air Quality Monitoring Report – Cringila Public School' dated 19th October 2017. The findings of the Air Monitoring Report by WSP indicate that inhalation risk to human health is likely to be very low.

2. Project Objectives

The purpose of the assessment was to gather information and data to undertake the following:

- Assess the immediate risks on the site
- Assess the actual or potential risks to human health or environment;
- Review site history and review previous works undertaken on the site;
- Begin to prepare a conceptual site model for the site;
- Provide temperature profile information so that further management options can be developed.

3. Project Scope

As part of the assessment Greencap undertook the following:

Phase 1: Initial Site inspections (31st October - November 2017)

- Visual Inspection of the site to assess risks;
- Review of history of the site and previous works undertaken;
- Air Monitoring;
- Surface temperature measurements using a hand-held Infrared Thermometer;
- Temperature measurements using near surface probes (150mm and 300mm);
- Research and development of temperature profiling plan;

Phase 2: Surface Temperature Profiling (28th November - December 2017)

- Construction and Installation of Surface (0.3m) Thermocouples
- Temperature recording of thermocouples
- Continuation of Air Monitoring
- Evaluation of Surface (0.3m) Thermocouples and development of Near Surface Temperature Plan

Phase 3: Near Surface Temperature Profiling (January 2018)

- Construction and Installation of Near Surface (0.5m) Thermocouples
- Construction and Installation of Near Subsurface (1.0m) Thermocouples
- Continuation of Air Monitoring
- Testing and Evaluation of Near Surface Thermocouples

Phase 4: Provide Preliminary Assessment (February 2018)

- Prepare Preliminary Assessment Report with findings to date
- Prepare Initial Conceptual Site Model – Northwest Hotspot

4. Phase 1: Initial Site inspections (31st October - November 2017)

4.1 Initial Visual Inspection of the Site to Assess Risks

An initial inspection of the site was undertaken on the 31st October after meeting with NSW Department of Education to assess the immediate risks on the site. At the time of the inspection the following risks were identified:

- Grass around the concrete pad was very brown indicative of deterioration to exposure to heat;
- Hot to touch soil surface in the vicinity of the concrete pad, small mound, and old internal fence-line;
- Hot to touch base of old internal fence-line metal posts;
- No visual smoke or vapours were evident at the time of the inspection;
- No significant subsidence was visually identified and ground was firm under foot;
- The site was adequately secure with a new temporary fence installed around the site.

Photo 1. Initial Site Assessment – 31st October 2017 – Area of Concrete Pad and internal fence

Photo 2. Initial Site Assessment – 31st October 2017 – Area of Concrete Pad

Photo 3. Initial Site Assessment – 31st October 2017 – Dry brown grass and vegetation along internal fence

Photo 4. Initial Site Assessment – 31st October 2017 – Dry brown grass and vegetation along internal fence

After discussion with NSW Department of Education the following actions were implemented to reduce the immediate risks on the site:

- Remove vegetation from immediate areas adjacent hotspot;
- Wet the site down to reduce immediate heat at surface and to determine where steam is generated in order to delineate hotspot;
- Install wet sand across the surface of the heat affected areas of the site to immediately reduce potential ignition of dried vegetation/grass;
- Undertake regular (daily) site inspections to monitor to potential fire risk;
- Install a water source point close to the immediate area;
- Investigate temperature monitoring equipment;
- Investigate air monitoring equipment.

	
Photo 5. Initial Site Assessment – 31st October 2017 – Area of Concrete Pad and internal fence covered with wet sand	**Photo 6.** Initial Site Assessment – 31st October 2017 – Area of Concrete Pad and internal fence covered with wet sand
	
Photo 7. Initial Site Assessment – 31st October 2017 – Area of Concrete Pad and internal fence covered with wet sand	**Photo 8.** Initial Site Assessment – 31st October 2017 – Area of internal fence covered with wet sand

4.2 Review of Site History

Following on from the initial site inspection Greencap undertook a desktop assessment of previous works. Site inspections were also carried out to locate features from previous remediation works and assess the feasibility to utilise existing thermocouples. A review of the site history indicated that the site is historically split into three areas which have had remediation works undertaken at various times since 2001.

Site Plan 1: Created from historical review of site works – 2001-2018

Legend	
	Southern Playground Area (Area 1) – Previous Remediation Works 2001-2004
	Western Playground Area (Area 2) – Previous Remediation Works 2004-2006
	Northwest Playground Area - Current Area of Concern

A review of the site history and the occurrence of underground hotspots and combustion is briefly summarised below:

- Prior to 2001 – Area was a quarry which was infilled with waste products from local industry. From previous investigations and remediation by New Environment and Avopiling much of the fill is coal wash with some blast furnace (slag-like) materials.
- 2001 – Hotspot identified in Southern Playground Area (Area 1);
- 2001-2003 – Investigation and successful remediation program of Southern Playground Area (Area 1). Three (3) Hotspots identified Eastern, Central, and Western Hotspots. Works Undertaken by New Environment – Bentonite slurry injection process.
- 2003-2004 – Investigation of Western Area of Playground (Area 2)
- 2004-2006 – Remediation of Western Area of Playground (Area 2). Works undertaken by Avopiling – Inert Gas Injection Process.
- September 2017 – Evidence of steam emanating from Northwest Area of Playground within fenced area of site. NSW Fire Services, NSW EPA and NSW Department of Education attended Site.

4.3 Surface Temperature Measurements using hand-held Infrared Thermometer

Following on from the initial site inspection from the 6th November 2017 Greencap undertook hand-held infrared thermometer readings across the site in order to determine the areas of the site that had surface temperatures above normal background levels. Readings were taken across a number of days with different ambient air temperatures and variable ground surface temperatures. Results generally displayed surface background temperatures between 25-35°C.

The area considered to have elevated surface temperatures from the hand-held infrared thermometer is that illustrated in Site Plan 1 'Northwest Playground Area (Current Area of Concern)' highlighted red. Surface temperatures in this area generally ranged from 35-70°C with the highest temperature usually recorded on the northern side of a small mound directly west of the concrete pad (Reference TA-118.75-112.5). After extended rain periods the surface temperatures would diminish appreciably back to temperatures only slightly higher than background then increase again thereafter the rain event. This information was then used to determine areas in which near surface probes (150mm and 300mm) would be used to provide more temperature data across the site.

Highest Surface Temperatures Recorded – Northern side of Small Mound direct west of concrete pad

Daily measurements between 22 °C and 70°C

Site Plan 2: Surface Temperatures Hotspot

4.4 Surface Temperature Measurements using hand-held push probe Thermometers (150mm & 300mm)

Following on from the infrared thermometer surface temperature monitoring Greencap purchased two (2) K-Type Thermocouple hand-held push probes 150mm and 300mm in length in order to provide more reliable surface temperature data. From the 16th November the hand-held thermocouple probes were inserted at various locations to depths of 150 mm and 300 mm and left for several minutes until a stable temperature could be recorded. The comparison of surface temperature versus temperature at 150mm and 300mm depth provided information to assess if the greater temperature was at depth, indicating a possible hotspot within the subsurface.

This temperature information was then used to determine areas in which semi-permanent thermocouples would be installed in the surface of the site (300mm depth). Readings were taken across a number of days with different ambient air temperatures and variable ground surface temperatures. The area considered to have elevated surface temperatures from the hand-held push probes was similar to that indicated by the infrared thermometer that is illustrated in Site Plan 1 'Northwest Playground Area (Current Area of Concern)' highlighted red.

The background temperature recordings at 150mm were generally between 26-32°C. Surface temperatures in the hotspot area generally ranged from 35-85°C with the highest temperature usually recorded on the northern side of a small mound directly west of the concrete pad (Reference TA-118.75-112.5). After extended rain periods the surface temperatures would diminish appreciably back to temperatures slightly higher than background then increase again thereafter the rain event. This information was then used to determine areas in which near surface semi-permanent thermocouples (300mm depth) would be used to provide more temperature data across the site.

Photo 9. Hand-held Temperature Probe - Surface (300mm depth) – 17th November 2017 – internal northern fence line

Photo 10. Hand-held Temperature Probe - Surface (150mm depth) – 24th November 2017 – internal northern fence line

Photo 11. Hand-held Temperature Probe - Surface (150mm depth) – 24th November 2017 – Small mound

Photo 12. Hand-held Temperature Probe - Surface (150mm depth) – 24th November 2017 – internal northern fence line

Photo 13. Hand-held Temperature Probe - Surface (300mm depth) – 17th November 2017 – internal northern fence line

Photo 14. Hand-held Temperature Probe - Surface (150mm depth) – 24th November 2017 – internal northern fence line

4.5 Air Monitoring

After review of the WSP Air Monitoring Report and information from previous remediation works, Greencap undertook air monitoring across the site from the 15th November 2017. Air monitoring was generally undertaken on a daily weekday basis. It was assessed that based on the WSP results and the occurrence of no visible emissions that the use of hand-held 'Spot-check' air quality monitoring at locations within the vicinity of the subsurface hotspot area is used to determine the extent of atmospheric pollutants (gases) associated with the hotspot. This allows point source measurements as well as background measurements to be taken across the site. Pollutants monitored using real-time Multi-Gas Detectors continue to provide a profile of air quality which include: carbon monoxide (CO), carbon dioxide (CO_2), volatile organic compounds (VOCs), sulphur dioxide (SO_2), hydrogen sulphide (H_2S), methane (CH_4) as LEL, oxygen (O_2), nitric oxide (NO) and nitrogen dioxide (NO_2). These potential pollutants were selected to be monitored as they are commonly associated with the combustion of coal-like substances.

These air quality parameters were recorded at specific nominated locations within the northwest hotspot area over an interval of up to 15 minutes at each location. Monitoring included sensitive receptors such as locations within the school boundary and adjacent neighbouring residences in order to effectively delineate the extent and distribution of these potential atmospheric pollutants.

In the assessment, RAE Systems Multi RAE Gas Detectors were used with specific sensor configurations to target the nominated pollutants/gases to be assessed against the Air Quality Monitoring Criteria detailed below in Table 1.

As demonstrated in Table 1 below, the assessment criteria referenced as part of this project is based on several sources as this monitoring assessment had to consider numerous factors including outside air exposure, indoor air quality exposure and personal worker exposure. These reference sources included Approved Methods for Modelling and Assessment of Air Pollutants in NSW (NSW EPA 2016), Workplace Exposure Standards for Airborne Contaminants (SWA, 2013), ASHRAE Standard 62.1 Ventilation for Acceptable Indoor Air Quality (2016), or equivalent publications as a point of reference.

For the purpose of this assessment, these criteria values highlighted in bold will be referenced in this report as they are deemed to be the most conservative levels based on the multifaceted monitoring works undertaken. It is however important to note that WES do not apply to children. Reference to WES is purely for guidance purposes only.

Table 1 Air Quality Monitoring Assessment Criteria

POLLUTANT	**AVERAGING PERIOD**	**CRITERIA**	**SOURCE**
Carbon monoxide (CO)	8-hours	9 ppm	NSW EPA 2016[a]
		9 ppm	ASHRAE Standard 62.1-2016
		30 ppm	SWA 2013[b]
Carbon dioxide (CO^2)	8-hours	5000 ppm	SWA 2013[b]
		Not greater than 700 ppm above local outdoor concentration levels	ASHRAE Standard 62.1-2016
Sulphur dioxide (SO^2)	24-hours	0.08 ppm (8 ppm)	NSW EPA 2016[a]
	8-hours	2 ppm (5 ppm STEL) [d]	SWA 2013[b]
Hydrogen sulphide (H^2S)	8-hour	10 ppm (15 ppm STEL) [d]	SWA 2013
		0.9 ppm (Peak)	NSW EPA 2016
Nitric oxide (NO)	8-hour	25 ppm	SWA 2013
Nitrogen dioxide (NO^2)	1-hour	0.12 ppm (12 ppm)	NSW EPA 2016[a]
	8-hours	3 ppm (5 ppm STEL) [d]	SWA 2013[b]
Oxygen (O^2)	-	19.5-23.5%	SWA 2011[c]
Volatile organic compounds (VOC)	-	Contaminant specific	-
Methane (as LEL)	-	<5%	SWA 2011[c]

Sources:

a - NSW EPA 2016, Approved methods for the Modelling and Assessment of Air Pollutants in New South Wales, NSW Environment Protection Authority.
b - SWA 2013, Workplace Exposure Standards for Airborne Contaminants, Safe Work Australia. These concentrations are based on Time Weighted Averages (TWA) for an 8-hour shift.
c - SWA 2011, Confined Spaces Code of Practice, Safe Work Australia. These concentrations are based on conditions that do not pose an immediate risk to human health.
d - Short term exposure limit (STEL) means the average airborne concentration of a substance calculated over a 15-minute period. The STEL should not be exceeded at any time during a normal eight hour working day.

Air Monitoring Results to Date:

All the Air Monitoring undertaken to date (15th November to 2nd February) have results at acceptable levels (refer to Greencap Air Monitoring Reports – AMR-01 to AMR-10).

Spot measurements were taken within the North-Western Hotspot area and at surrounding locations to determine whether potential air pollutants from the subsurface hotspot were present. These monitoring locations included the following:

- A-01 General Background;
- A-02 NW Hotspot – Concrete Cap Surface;
- A-03 NW Hotspot – Small Mound;
- A-04 NW Hotspot – NE fence line;
- A-05 Exclusion Area Fence Line East of Hotspot (Approx. 10m);
- A-06 Exclusion Area Fence Line Southeast of Hotspot (Approx. 15m);
- A-07 Exclusion Area Fence Line South of Hotspot (Approx. 30m);
- A-08 Exclusion Area Fence Line Northwest of Hotspot, adjacent 17 Lackawanna Street (Approx. 50m).

Summary of Air Monitoring: Wednesday 15th November 2017 - 2nd February 2018- All locations									
Carbon monoxide (CO) (ppm)	Carbon dioxide (CO^2) (ppm)	Sulphur dioxide (SO^2) (ppm)	Hydrogen sulphide (H^2S) (ppm)	Nitric oxide (NO) (ppm)	Nitrogen dioxide (NO^2) (ppm)	Oxygen (O^2) (%)	Volatile organic compounds (VOC) (ppm)	Methane (as LEL) (%)	**Within Acceptable Limits?**
0	300 to 400	0	0	0	0	20.8 to 20.9	0	0	✓

Based on the air quality monitoring data obtained the inhalation risk to human health as a result of the subsurface hotspot remains low. The reasons for this conclusions are as follows:

- Real time monitoring results did not indicate the presence of gas in elevated concentrations; even at the source (i.e. the subsurface hotspot vent source). Concentrations of gases commonly associated with combustion (e.g. carbon monoxide (CO), carbon dioxide (CO_2), volatile organic compounds, sulphur dioxide (SO_2), hydrogen sulphide (H_2S), methane (CH_4 – LEL), oxygen (O_2), nitric oxide (NO) and nitrogen dioxide (NO_2), were not detected at concentrations that pose a risk to human health in the Northwest Hotspot area, including locations surrounding the hotspot.

5. Phase 2: Surface Temperature Profiling (28th November - December 2017)

5.1 Construction and Installation of Semi-permanent Surface (0.3m) Thermocouple Probes

Following on the preliminary surface temperature investigation utilising the infrared thermometer as well as the surface temperature investigation utilising the hand-held push probes 150mm and 300mm in length, Greencap identified the need for semi-permanent and instantaneous temperature measurement in order to provide more reliable surface temperature data. Greencap utilised K-type welded tip fibreglass thermocouples affixed to 1.2m lengths of dowel, which were driven into the ground to a targeted depth of 300mm at various locations pre-identified as potential 'hot areas' from the surface temperature monitoring. From the 28th November 2017, the permanent thermocouple probes were inserted at various locations to the depth of 300mm, and the temperature recorded with a digital thermometer.

Photo 15. Construction of permanent Temperature Probe - (300mm depth) – 28th November 2017

Photo 16. Installation of permanent Temperature Probe - (300mm depth) – 28th November 2017 – internal northern fence line

Photo 17. Installation of permanent Temperature Probe - (300mm depth) – 28th November 2017 – internal northern fence line

Photo 18. Installation of permanent Temperature Probe - (300mm depth) – 12th December 2017 – internal northern fence line

5.2 Temperature Recording of Semi-permanent Surface (0.3m) Thermocouple Probes

From the 28th November 2017, Greencap undertook daily temperature recordings from the semi-permanent thermocouple probes and logged data into a temperature data log. This information was utilised to build a preliminary temperature profile of the site. The areas indicating elevated near-surface temperatures from the semi-permanent thermocouple probes was similar to that indicated by the infrared thermometer that is illustrated in Site Plan 1 'Northwest Playground Area (Current Area of Concern)' highlighted red.

5.3 Evaluation of Surface (0.3m) Thermocouples and development of Near Surface Temperature Plan

Surface (0.3m depth) temperatures in the hotspot area generally ranged from 34-195°C with the highest temperature usually recorded on the northern side of the small mound directly west of the concrete pad (Reference TA-118.75-112.5). The comparison of temperature at 300mm depth versus temperature at 150mm and surface temperature provided information to assess if greater temperature was correlated to greater depth. Greencap utilised this data to help develop a more in-depth targeted near-surface temperature profile plan to further delineate the extent of the subsurface hotspot.

6. Phase 3: Near Surface Temperature Profiling (10th January - Present)

6.1 Construction and Installation of Near Surface (0.5m) Thermocouples

Subsequent to the preliminary surface temperature investigation utilising the hand-held push probes 150mm and 300mm in length and the permanent thermocouple probes installed at 0.3m depth, Greencap identified the need for additional near-surface temperature data across the NW hotspot in order to further delineate the full extent of the hotspot at greater depth.

From the 2nd - 10th January 2018, permanent thermocouple probes were manufactured and installed at various locations to the target depth of 500mm. Greencap utilised K-type welded tip fibreglass Thermocouples affixed to 1.2 lengths of dowel, which were installed into the ground to a depth of 500mm on a cross-sectional 4 metre grid format across the NW hotspot. A total of 35 permanent thermocouples were installed at 500mm depth. The permanent thermocouples were allowed to stabilise in temperature before daily temperature recordings were undertaken from the 11th January with a digital thermometer.

6.2 Construction and Installation of Near Surface (1m) Thermocouples

In areas were elevated temperatures were consistently being recorded, Greencap manufactured and installed additional permanent thermocouple probes to depths of 1m, which were coupled with thermocouples installed to a depth of 0.5m.

Greencap utilised K-type welded tip fibreglass Thermocouples affixed to 1.8 lengths of dowel, which were installed into the ground to a depth of 1m and plotted onto the temperature profile for the site. A total of 11 permanent thermocouples were installed at 1m depth. From the 11th January 2018, temperature recordings were taken daily from the permanent thermocouple probes installed at various locations to the target depth of 1m.

Photo 19. Manufacture of permanent Temperature Probe - (500mm depth) – 2nd-10th January 2018

Photo 20. Installation of permanent Temperature Probe - (500mm & 1m depth) – 11th January 2018 – internal northwestern area

Photo 21. Installation of permanent Temperature Probe - (500mm & 1m depth) – 11th January 2018 – internal northeastern area

Photo 22. Four (4) metre grid pattern of permanent Temperature Probe - (500mm depth) – 28th January 2018

6.3 Evaluation of Near Surface (0.5m and 1m) Thermocouples

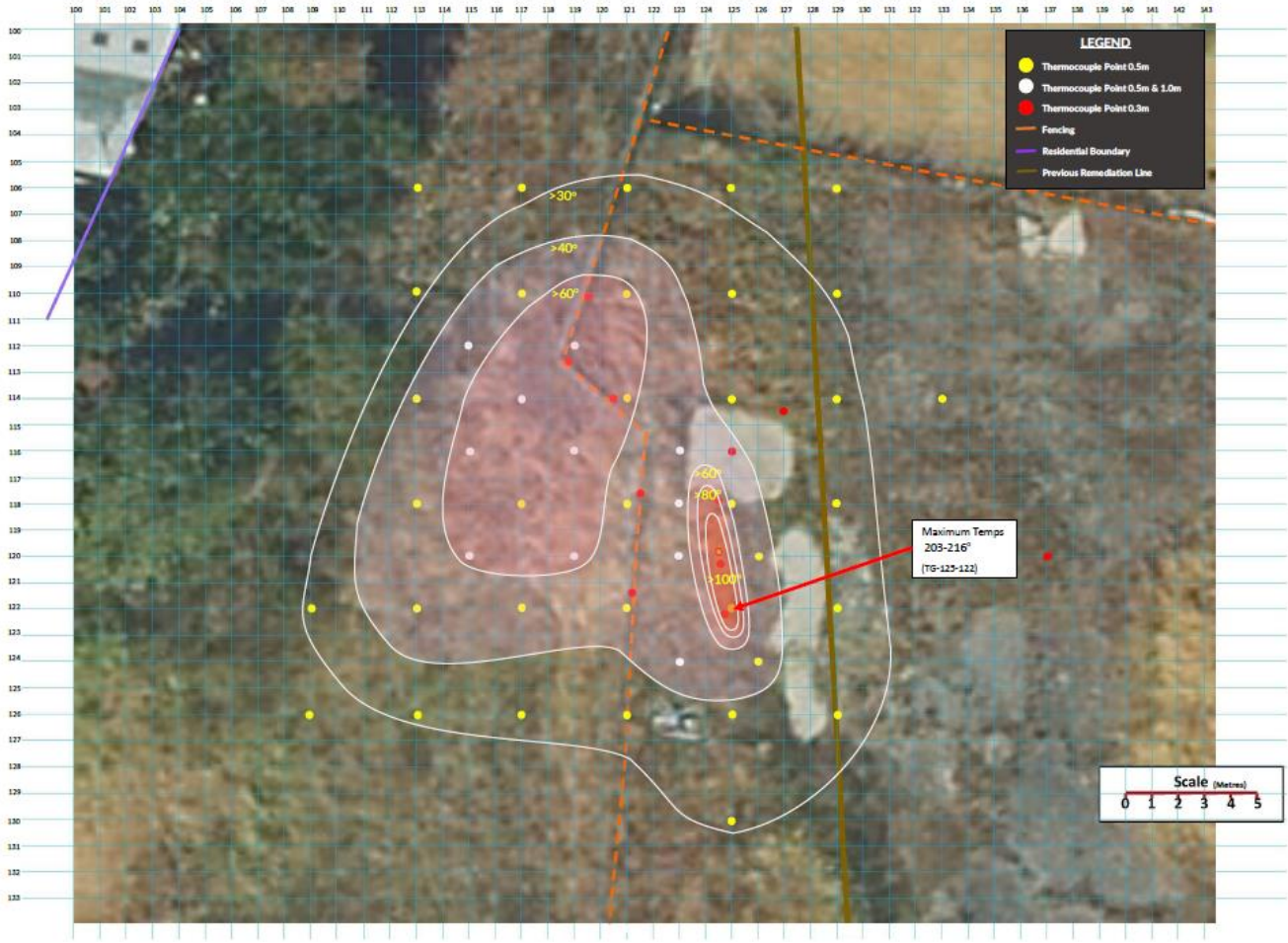
From the 11th January 2018 to the present, Greencap are undertaking daily temperature recordings from the permanent thermocouple probes installed at 500mm and 1m depths and logging the data into a temperature data log developed for the site. In addition to the preliminary surface temperature profile of the site, this information will be utilised to help delineate the extent of the subsurface hotspot and aid the development of a Conceptual Site Model (CSM) for the site.

Near-Surface (0.5m) temperatures in the hotspot area generally ranged from 24-208°C with the highest temperature usually recorded on the northern side of the small mound directly west of the concrete pad (Reference TA-118.75-112.5).

Near-Surface (1m) temperature data correlated with the temperatures recorded at 0.5m, with the highest temperature usually recorded on the northern side of the small mound directly west of the concrete pad (Reference TA-118.75-112.5). Near-Surface (1m) temperatures in the hotspot area generally ranged from 35-140°C.

The location of the near-surface thermocouple probes is illustrated below and in Appendix A (Larger Scale).

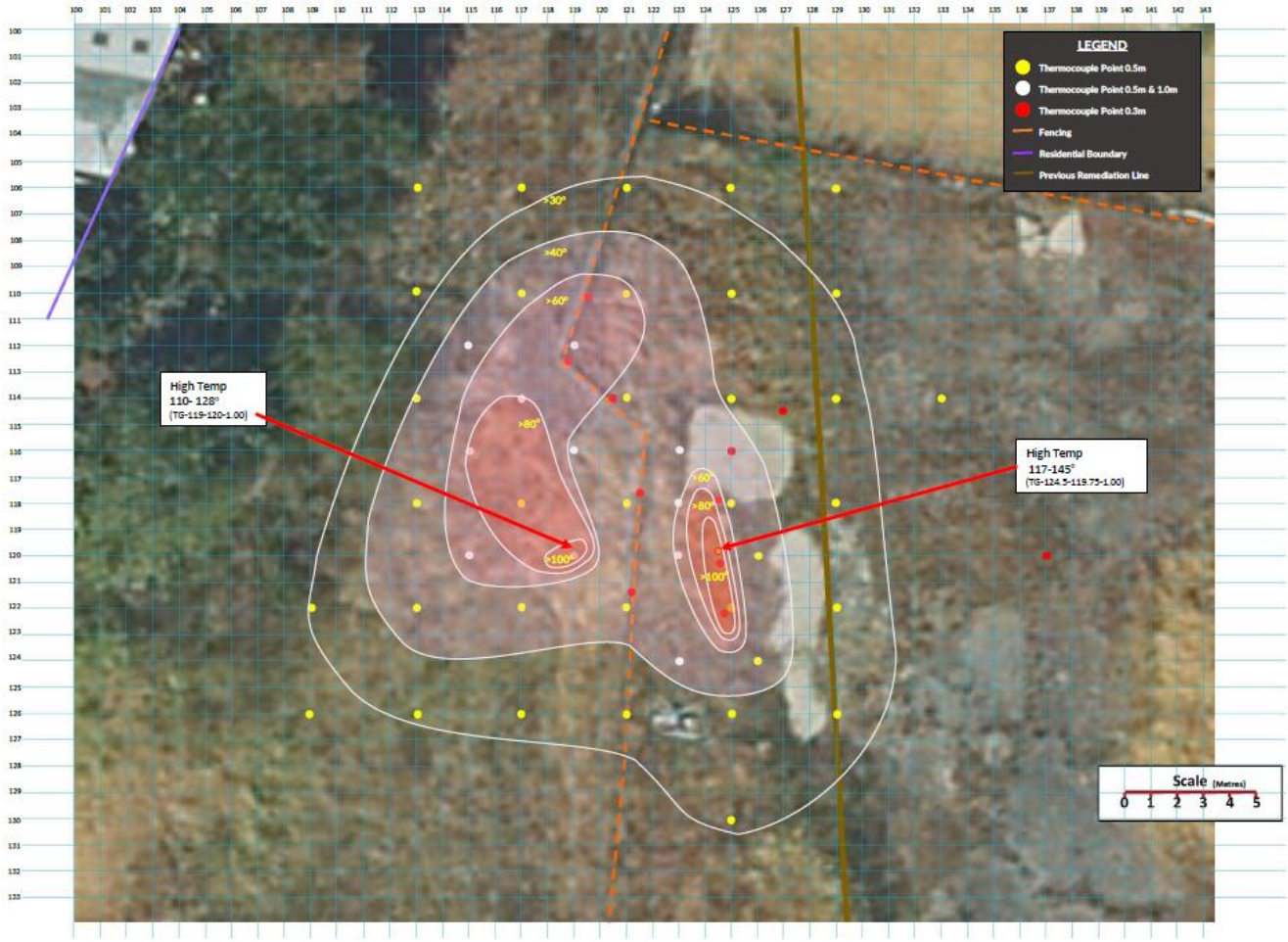
Greencap have prepared general isotherm mapping for the 0.5m and the 1.0m temperature recordings which provide an illustration of the temperature profile at 0.5m and 1.0m depths. Isotherm site plan for 0.5m depth is shown below and in Appendix B (Larger Scale).



The isotherm mapping of 0.5m depth shows a maximum temperature of over 200°C beneath the small mound west of the concrete cap. The heat map shows the general zone of influence for temperatures above 40°C, coloured light pink. There are two (2) areas where temperatures are above 60°C which may suggests that the hotspot may extend deeper than 0.5 and that the increased temperature is a result of venting to the surface. This temperature at the near-surface (0.5m) may be variable across the hotspot due to inconsistencies in the consolidation and compaction of the subsurface. During installation of the thermocouple probes it was noticed that the hillslope to the north of the internal fence line was quite unconsolidated in which metal star pickets could be driven in to a metre quite easily, whereas on the flatter areas of the hill slope the subsurface was quite compacted and difficulty driving in star pickets, resulted in hand digging many installation points.

From the isotherm mapping the hotspot appears to be localised. The overall area of influence with temperatures greater than 30°C is 22m (north-south) x 25m (east-west). The overall area of the hotspot with temperatures above 40°C at 0.5m depth appears to be 16m (north-south) x 18m (east-west).

The Isotherm site plan for 1.0m depth is shown below and in Appendix C (Larger Scale).



The isotherm mapping for 1.0m depth shows the same general area of influence as the 0.5m isotherm map. The area north of the internal fence line has significantly higher temperature at depth, with some areas above 80°C and a maximum of up to 128°C. The maximum temperatures in the small mound west of the pad at follow a similar pattern as those at 0.5m. It appears that the hotter areas on either side of the internal fence line are likely to be connected at further depth.

From the isotherm mapping it appears that the northwest hotspot is localised to an area of influence of 22m (north-south) x 25m (east-west).

7. Initial Conceptual Site Model – Northwest Hotspot

A conceptual site model (CSM) is a representation of site-related information regarding contamination sources or pollution incident, receptors and exposure pathways between those sources and receptors. A CSM provides the framework for identifying how a site became contaminated or a pollution incident occurred and how potential receptors may be exposed to contamination either in the present or future.

7.1 Setting

The site is located within an area that has a history of hotspots occurring due to spontaneous combustion of coal waste that was emplaced within the area as backfill. The area is believed to have been an old quarry that was infilled. From previous investigations and remediation within other areas of the site it is estimated that the fill in the northwest playground area is approximately 12-15m deep.

Groundwater is expected to be encountered at or below bedrock 15-20m depth with an expected net regional groundwater flow to the west towards a subsurface stormwater drain located within the adjacent oval which drains towards the south.

The primary land use in the surrounding area is noted to be a school to the east, low density residential to the north, and recreational parkland to the west and south.

7.2 Potential Pollution Sources

The historical importation of coal waste material fill during backfilling of the site has the potential for spontaneous combustion due to the unconsolidated nature of the fill which is unlikely to have been adequately compacted during original importation. Spontaneous combustion of coal waste can potentially cause emissions.

7.3 Primary Contaminants of Potential Concern

Combustion of subsurface soils including coal waste materials can result in the production of emissions that may contain contaminants of potential concern considered to be:

- Carbon monoxide (CO)
- Carbon dioxide (CO_2)
- Sulphur dioxide (SO_2)
- Hydrogen sulphide (H_2S)
- Nitric oxide (NO)
- Nitrogen dioxide (NO_2)
- Oxygen (O_2)
- Volatile organic compounds (VOC)
- Methane

7.4 Release Conditions, Contaminant Pathways/Transport Mechanisms

Contaminant release mechanisms will vary depending on the specific processes at the site, but based on the results of the assessment would potentially occur when subsurface soils containing coal waste materials are combusting.

Given the immediate area to the south (Western Playground – Area 2) has undergone previous remediation in which a soil mixing zone wall was installed it is unlikely the northwest hotspot would cause combustion beyond the previously installed wall.

There is potential that the hotspot could continue to combust subsurface materials within and adjacent to its current location, however any migration of combustion would likely to be quite slow due to the nature of subsurface combustion process. This can continue to be monitored by the near-surface temperature readings.

There is unlikely to be any impact on groundwater from the combustion process.

The emplacement of sand across the surface of the hotspot has reduced the immediate fire risk on the surface of the site as well as reduced potential for gas emission.

7.5 Potential Receptors

Based on the continued use of the site as a school, the adjacent properties containing low density residential houses and recreational use parklands, potential receptors identified onsite include the following:

- School Staff, Children and visitors;
- Occupants and visitors of the adjacent residential dwellings;
- Workers involved in the investigation and any proposed remediation works that have the potential to disturb the soil (i.e. excavation/landscaping works);
- Future users of the site;
- Workers accessing the site (for instance during future fence construction); and
- Flora and fauna.

7.6 Potential Exposure Pathways

Adverse health effects may be associated with contaminant exposure via ingestion, inhalation and/or direct contact pathways. An exposure pathway consists of the following elements:

- A source and mechanism for release;
- A storage and/or transport medium (e.g. contaminants are stored in soil, volatilise and are transported into the atmosphere);
- An exposure point, where the receptor comes in contact with the contamination; and
- An exposure route (e.g. inhalation and dermal contact and/or ingestion).
- The physio-chemical characteristics of the contaminant and the behaviour of the population of interest will determine the method of exposure and subsequent systemic absorption.

The following potential exposure pathways have been identified for the site:

- Inhalation of emissions created from active combustion of subsurface soils,
- Inhalation of emissions during subsurface investigations or excavation works where soils are disturbed;
- Dermal contact with hot subsurface soils during investigations;
- Plants can be exposed to heat causing plant stress;
- Buildings and structures can be affected by combustion emissions leading to corrosion or similar alteration of building materials.

7.7 Risk Assessment

The site in its current state does not appear to pose any adverse health effects associated with the potential exposure pathways or receptors. This assessment is based on:

- The air monitoring undertaken by WSP and Greencap is within acceptable levels;
- There is currently no visible emissions on the surface of the site;
- Access to the site is restricted due to a locked fence around the perimeter of the site;
- Combustion gases that may be produced within the subsurface appear to be too dilute to be measured at the surface;
- The sand emplaced across the surface of the immediate hotspot area has reduced the immediate fire risk on the surface and also reduced surface temperatures;
- The nature of the subsurface combustion process is unlikely to migrate at speed or impact neighbouring properties as the fill material appears to be restricted to the school playground.

Ongoing monitoring of the site will continue to manage the risks associated with the hotspot and potential combustion emissions.

8. Recommendations

Now that the near-surface temperature profile has been developed and provided valuable information in regard to the subsurface combustion process, it is recommended that the site continues to be monitored by the following means until remediation options are developed for the long term treatment and re-instatement of the site:

- Site Inspection – To visually assess for any immediate changes to the site that may increase risk of potential surface fire or subsidence;
- Air Monitoring – Spot-checks as per the current process detailed in this report – minimum three days a week;
- Temperature Monitoring – continuation of Near Surface monitoring – minimum of three days a week.

The next stages of the Investigation will require discussion around the options for further subsurface investigation and or remediation of the site based on the additional near-surface temperature monitoring information. From previous experience with subsurface hotspots and combustion, the successful treatment and remediation of such sites is largely due to the adoption of a careful methodical approach which includes gathering data prior to treatment, assessing potential treatment techniques and ongoing monitoring to measure the effectiveness of any treatment.

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Appendix A: Near Surface Thermocouple Probe Locations

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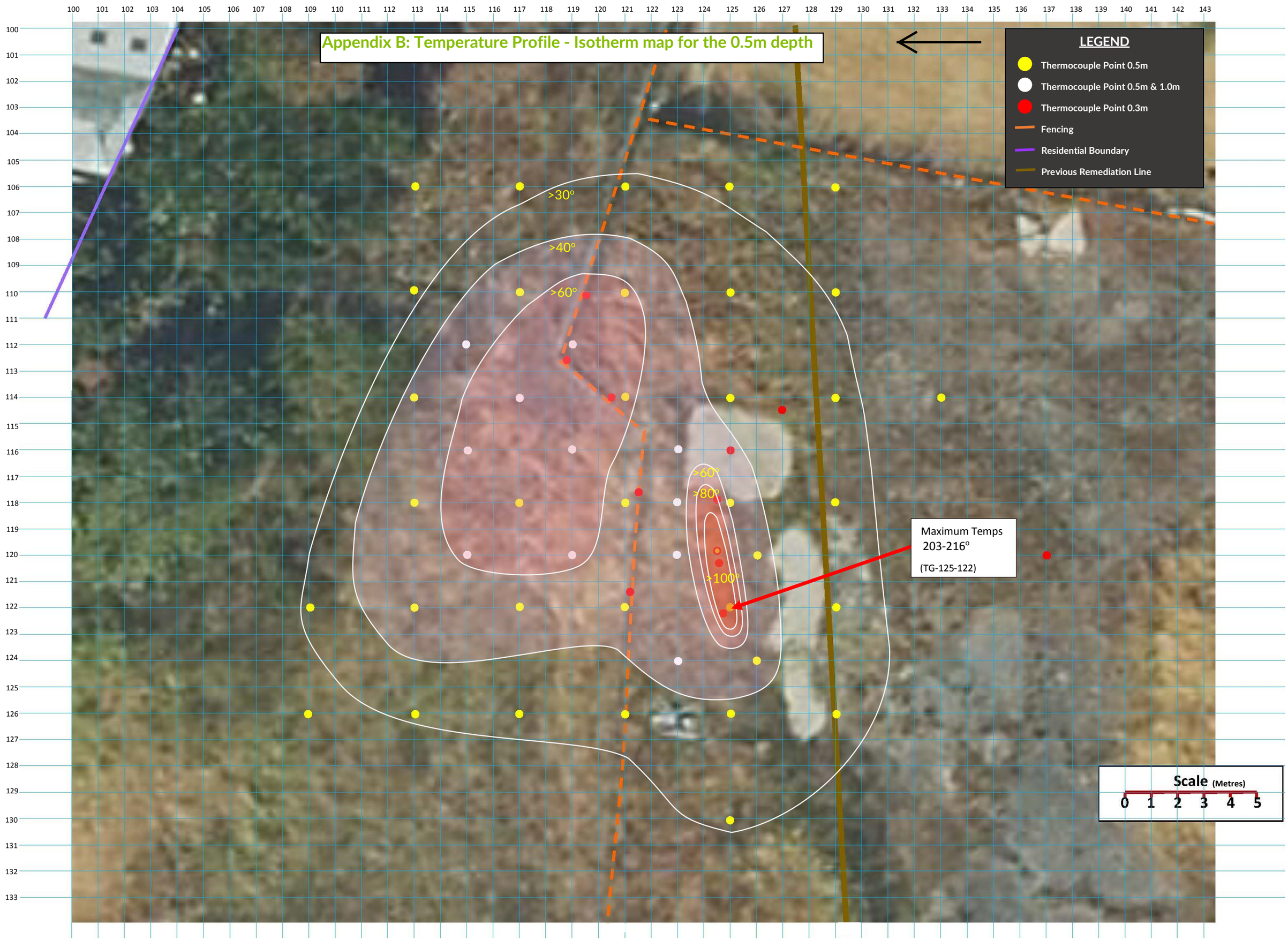
Appendix B: Temperature Profile - Isotherm map for the 0.5m depth

Appendix B: Temperature Profile - Isotherm map for the 0.5m depth



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Appendix C: Temperature Profile - Isotherm map for the 1.0m depth

Appendix C: Temperature Profile - Isotherm map for the 1.0m depth

LEGEND

- Thermocouple Point 0.5m
- Thermocouple Point 0.5m & 1.0m
- Thermocouple Point 0.3m
- Fencing
- Residential Boundary
- Previous Remediation Line

>30°
>40°
>60°
>80°
>100°

High Temp
110- 128°
(TG-119-120-1.00)

High Temp
117-145°
(TG-124.5-119.75-1.00)

Scale (Metres)
0 1 2 3 4 5