Plume Delineation Report, Capped Waste Stockpile

Prepared for:
Hydro Aluminium Kurri Kurri Pty Ltd

Prepared by:
ENVIRON Australia Pty Ltd

Date:
16 September 2016

Project Number:
AS130335

ENVIRON

Prepared by:				**Authorised by:**			
Name:	Kirsty Greenfield			Name:	Fiona Robinson		
Title:	Environmental Scientist			Title:	Manager – Hunter		
Phone:	02 4962 5444			Phone:	02 4962 5444		
Email:	kgreenfield@environcorp.com			Email:			
Signature:		Date:	27/8/13	Signature:		Date:	27/8/13

This document is issued in confidence to Hydro Aluminium Kurri Kurri Pty Limited for the purposes of investigating the groundwater plume associated with the Capped Waste Stockpile at the Kurri Kurri Aluminium Smelter. It should not be used for any other purpose.

VERSION CONTROL RECORD

Document File Name	**Date Issued**	**Version**	**Author**	**Reviewer**
AS130335_Plume_Delineation_Report	11 October 2013	Draft 1	K Greenfield	F Robinson
AS130335_Plume_Delineation_Report_Revised July 2016	16 September 2016	Final	K Greenfield	F Robinson

Contents

List of Appendices

List of Abbreviations

ACM	Asbestos Containing Material
AHD	Australian Height Datum
CLM Act	NSW Contaminated Land Management Act 1997
COC	Chain of Custody
DP	Deposited Plan
DQI	Data Quality Indicator
DQO	Data Quality Objective
EPA	Environment Protection Authority (NSW)
ESA	Environmental Site Assessment report
GME	Groundwater Monitoring Event
ha	Hectare
km	Kilometres
m	Metres
mg/L	Milligrams per Litre
mbgl	Metres below ground level
µg/L	Micrograms per Litre
n	Number of Samples
pH	a measure of acidity, hydrogen ion activity
ppm	Parts Per Million
QA/QC	Quality Assurance/Quality Control
SAQP	Sampling Analysis and Quality Plan
SWL	Standing Water Level
-	On tables is "not calculated", "no criteria" or "not applicable"

EXECUTIVE SUMMARY

ENVIRON Australia Pty Limited (Environ) was commissioned in June 2013 to assess a portion of the Hydro Aluminium Kurri Kurri Smelter located off Hart Road, Loxford, New South Wales, Australia. The portion of the site subject to this assessment comprises the former smelter waste storage area known as the 'Capped Waste Stockpile' and an associated area of leachate impacted groundwater.

ENVIRON has previously completed several investigations of the Capped Waste Stockpile and associated leachate plume. The most recent Environmental Site Assessment identified several data gaps, including the potential for the plume to extend to the east, south east and north east of the known sand lens within connected sand lenses. The delineation of the leachate plume is the subject of this report.

ENVIRON developed a staged approach to plume delineation and monitoring with the aim of providing sufficient information to assess the fate and transport of the plume, including:

- Stage 1 involved delineation of the plume via near surface investigations using field evaluation of colour and pH as indicators of groundwater;
- Stage 2 involved the installation of new monitoring wells at the edges of the plume, as identified in Stage 1;
- Stage 3 involved identification of suitable monitoring wells, development of a groundwater monitoring program and completion of 5 groundwater monitoring events over a 12 month period; and
- Stage 4 involves reporting on the above activities, including groundwater flow mapping and fate and transport modelling.

This report addresses the completion of Stage 1: plume delineation and Stage 2: monitoring well installation.

Stage 1 fieldwork included the drilling of 70 hand auger holes located within and around the east, south east and north eastern edges of the plume and sampling of intersected groundwater for pH and colour to identify leachate impacts. Following the completion of Stage 1 fieldworks, the leachate plume was delineated using the complied pH and colour data as well as lithology information.

Stage 2 fieldwork included the drilling and installation of 19 new groundwater wells to create a monitoring well network based on five sections through the leachate plume.

The results of the soil logging indicate there are several different strata at the site that are interbedded in a complex manner. The strata identified include estuarine mud deposits, fluvial channel sands and sandy levee deposits. The depositional environment of the strata at the site is interpreted to be within the upper reaches of an estuary, with the clay deposited as organic rich muds. The muds are interbedded with fluvial sands and sandy levee deposits, flowing into the estuary from up stream during periods of sea level fall.

The investigations have confirmed that groundwater flow occurs through two aquifers comprising a shallow sand channel aquifer that is underlain at depth by a separate and confined aquifer. The location of the sand channel and the mechanism for flow from the base of the Capped Waste Stockpile to the channel is now well understood. The downgradient flow path (north of the Northern Impact Area) of the channel is less understood however sufficient information is available to allow for fate and transport modelling of plume behaviour.

The mechanism for leachate generation from the Capped Waste Stockpile wastes is not currently understood. For the purpose of investigating mitigation measures, it is important to understand if leachate results from a rising water table (causing flushing of the lower waste products) or if leachate occurs from infiltration from the surface of the Capped Waste Stockpile (causing leachate generation from the full waste profile).

Mechanisms to intercept groundwater discharging beneath the north east corner of the landfill can be implemented to remove or reduce leachate migration. These measures can be implemented at any stage with intercepted leachate managed through the existing evaporation and irrigation process.

ENVIRON make the following recommendations:

- The mechanism for recharge of the leachate plume is not well understood. Monitoring of well up gradient of the Capped Waste Stockpile during rainfall is recommended to identify if recharge is occurring up gradient or within the Capped Waste Stockpile;
- Fate and transport modelling is recommended to understand discharge concentrations and timeframes to the receptor;
- An interception trench could be constructed to intercept groundwater at the toe of the Capped Waste Stockpile for disposal.

Quarterly groundwater monitoring commenced in July 2013 and is reported under a separate cover.

1 Introduction

1.1 Background

ENVIRON Australia Pty Limited (Environ) was commissioned in June 2013 to undertake assessment of a portion of the Hydro Aluminium Kurri Kurri Smelter located off Hart Road, Loxford, New South Wales, Australia. The portion of the site subject to this assessment comprises the former smelter waste storage area known as the 'Capped Waste Stockpile' and an associated area of leachate impacted groundwater. The site is shown in Figure 1.

ENVIRON completed a Phase 2 Environmental Site Assessment at the smelter and surrounding buffer zone in May 2012. The results of the Phase 2 ESA recommended notification to the EPA under Section 60 of the Contaminated Land Management Act 1997 of the Capped Waste Stockpile and associated leachate impact area. This notification was made to the EPA on the 11th July 2012. Pursuant to this notification the EPA has requested in a letter dated the 18th October 2012 that further information be provided. The information required by the EPA was addressed in an Environmental Site Assessment of the Capped Waste Stockpile and associated area of leachate impacted groundwater completed by ENVIRON in December 2012.

The Environmental Site Assessment (ENVIRON December 2012) of the Capped Waste Stockpile and associated area of leachate impacted groundwater made the following recommendations:

- A site-specific toxicological risk assessment should be completed to identify guidelines for fluoride in soil and water at the site for human health and the environment;
- The potential for the plume to extend to the east, south east and north east of the known sand lens within connected sand lenses should be investigated. Delineation of the plume could use a combination of existing data and further field investigations;
- Groundwater sampling of all available wells should be completed to provide baseline data for on-going works;
- The assessment of leachate impacts to groundwater should be investigated by assessing the permeability of the clay cap and by assessing groundwater variation in close proximity to the Capped Waste Stockpile.

This Plume Delineation Report addresses dot points two, three and four above. The first dot point was addressed in ENVIRON (March 2013) *Tier 2 Ecological Risk Assessment, Kurri Kurri Aluminium Smelter* and ENVIRON (April 2013) *Preliminary Screening Level, Health Risk Assessment for Fluoride and Aluminium, Part of the Kurri Kurri Aluminium Smelter, Hart Road, Loxford*.

1.2 Objectives and Scope of Work

Based on these recommendations above, ENVIRON developed a staged approach to plume delineation and monitoring with the aim of providing sufficient information to assess the fate and transport of the plume, as follows:

- Stage 1 involves delineation of the plume via near surface investigations of groundwater pH;

- Stage 2 involves the installation of new monitoring wells at the edges of the plume, as identified in Stage 1;
- Stage 3 involves identification of suitable monitoring wells, development of a groundwater monitoring program and completion of 5 groundwater monitoring events over a 12 month period; and
- Stage 4 involves reporting on the above activities, including groundwater flow mapping and fate and transport modelling.

The Plume Delineation Assessment includes Stages 1, 2 and part 3. The scope of work for each stage is described below.

STAGE 1 – Plume Delineation

ENVIRON intend to use pH as an indicator of the plume as leachate impacted groundwater is known to have a pH >9 and uncontaminated groundwater has a pH <7.

Field investigations involved the use of a hand auger to auger to as deep as possible below groundwater (depths achieved were between 0.5m and 2m), depth to groundwater measured and the soil profile logged. A stainless steel probe will be driven into the ground beside the hand auger hole to depths equal to the top of the water table and a groundwater sample will be collected from a Teflon tube with a pH reading taken and the colour of the water noted. This information provided a depth profile of the near surface groundwater across the areas of investigation. The northern, eastern and southern edges of the plume were delineated in this manner, with the completion of 70 locations.

STAGE 2 – Well Installation

New groundwater monitoring wells were installed within, on the edge and downgradient of the plume at locations ENVIRON consider assist with a monitoring program and fate and transport modelling of the plume. Sixteen new monitoring wells were installed on the north, east and possibly southern edges of current known extent of the plume.

STAGE 3 – Groundwater Monitoring Program

Task 1. Development of Program

ENVIRON consider the groundwater monitoring program should be completed quarterly to ideally provide at least 5 consecutive rounds of monitoring results prior to the start of any remediation works that may be required at the Capped Waste Stockpile. ENVIRON will evaluate the operational wells around the plume and select around 20 wells that will provide three cross sections and a long section through the plume. The three cross sections will be located at the source of the plume, in the middle of the plume and at the leading edge of the plume. The analytical program will be confirmed during the development of the monitoring program, but will likely include the following:

- Soluble fluoride, cyanide and aluminium;
- pH, EC.

1.3 Limitations

The scope of the Plume Delineation Assessment was based on ENVIRON's proposal dated 23 April 2013.

Specific assumptions and limitations identified by ENVIRON as being relevant are set out in the report. The methodology and sources of information used by ENVIRON are outlined in our scope of work. ENVIRON has made no independent verification of this information

beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions made by others.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose.

2 Site Identification

2.1 Site Location

The Hydro Aluminium Kurri Kurri Smelter is located approximately 30km west of the city of Newcastle and 150km north of Sydney, in New South Wales, Australia. The smelter includes a 60 ha plant area and a 2,500 ha buffer zone.

The Capped Waste Stockpile is a landfill of Spent Pot Liner (SPENT POT LINING) located near the eastern boundary of the smelter. Leachate from the Capped Waste Stockpile is known to have impacted on groundwater resulting in leachate impacted groundwater that is understood to have originated from the north-east corner of the Capped Waste Stockpile and extends approximately 250m north-east.

The site consists of the Capped Waste Stockpile and an area that is located down hydraulic gradient (downgradient) and comprises leachate impacted groundwater, surface water and impacted vegetation. The area was notified to the EPA under Section 60 of the Contaminated Land Management Act 1997 in a letter dated 11th July 2012 (ENVIRON 2012a).

The site is described as Part Lot 318 in DP755231, Part Lot 1 in DP457069, Part Lot 2 in DP233125 and is shown in Figure 1. A survey plan of the notified area, as provided to the EPA, is included in Appendix A.

2.2 Site Conceptual Model

2.2.1 Source of Contamination and Contaminants of Concern

The site consists of a portion of the Hydro Aluminium Kurri Kurri Smelter where spent pot lining and other smelter wastes including cryolite, alumina, floor sweepings, shot blast dust, cement and potlining mix were placed in a stockpile known as the Capped Waste Stockpile between 1969 and 1992 and a portion of adjacent buffer zone land that has been impacted by leachate from the Capped Waste Stockpile. The Capped Waste Stockpile is located within the smelter portion of the site and is approximately 170m in length by 130m in width and is up to 11m high and currently comprises a grassed clay cap.

The uncapped storage of waste and subsequent infiltration of rain water through the waste stockpile led to the generation of leachate over a period of approximately 25 years. Prior to capping, the leachate was collected behind bund walls surrounding the spent pot lining stockpile. During capping, leachate was suspected to have been buried beneath the north eastern corner of the Capped Waste Stockpile.

The Capped Waste Stockpile was capped in 1995 to prevent infiltration. Testing of the cap in 1999 indicated the hydraulic barrier had a permeability ranging between $1.2x10^{-9}$m/s and $2.6x10^{-11}$m/s, which meets the specification at the time of construction. The cap has been breached on several occasions in extreme weather events and was subsequently repaired. The base of the stockpile is not lined and waste is likely to be in contact with shallow groundwater at 14.5m AHD. Water table fluctuations in response to recharge would increase the groundwater contact with waste materials in the landfill.

The suspected burial of leachate during capping and the ongoing contact between waste material and shallow groundwater beneath the Capped Waste Stockpile may continue to further contribute to leachate generation.

Major contaminants in the leachate are sodium (4,800mg/L to 15,300mg/L), fluoride (1,100mg/L to 3,420mg/L), sulphate (4,000mg/L to 6,740mg/L) and cyanide (70mg/L to 200mg/L). Leachate impacted groundwater is observed to be brown in colour.

2.2.2 Topography

The site is located on low lying, relatively flat swampy land that straddles the central eastern portion of the smelter and the eastern portion of the buffer zone. Low lying areas within the smelter portion were filled to create a flat, elevated platform at approximately 14m AHD for construction of the smelter. The Capped Waste Stockpile was constructed in the central eastern portion of the smelter and comprises a stockpile of smelter wastes that was filled between 1969 and 1992. The Capped Waste Stockpile currently comprises a clay-capped and grassed hill approximately 130m by 160m with steep sides and a maximum elevation of 25m AHD.

Within the buffer zone, limited surface filling with refractory brick was completed to create access tracks along the smelter perimeter fenceline.

2.2.3 Regional Geology

According to the Geological Series Sheet 9312 (Department of Mineral Resources, 1993), the regional geology at the site comprises alluvial sediments of Quaternary age associated with the erosional and depositional environments of the Hunter River. The sediments include point bar, levee, overbank and alluvial terrace deposits, which are highly variable both horizontally and vertically and show extensive inter-fingering and inter-lensing.

The alluvial sediments are underlain by siltstone, marl and minor sandstone from the Permian aged Rutherford Formation (Dalwood Group) in the Sydney Basin. The Dalwood Group is stratigraphically located near the base of the Sydney Basin below both the Greta Coal Measures and Newcastle Coal Measures and was deposited in a marine environment.

2.2.4 Regional Hydrogeology

Regional groundwater is expected to follow topography and flow northeast towards surface water bodies that feed into the Hunter River. Groundwater aquifers are present within both bedrock and unconsolidated sediments. Topography and the presence of surface water bodies are expected to have significant impact on groundwater behaviour.

Groundwater studies show that groundwater flow is typically toward to the north east, although the complexity of the system likely results in discontinuities occurring within the flow pathways. Swamp Creek and Wentworth Swamp influence the regional groundwater flow regime. Swamp Creek is the closest identified receptor for groundwater flow from the site.

According to the Office of Industry and Investment, NSW, there are 17 licensed groundwater abstractions (bores) located within the buffer zone. There are no other licensed groundwater bores within 2km of the site.

Fourteen of the bores in the buffer zone are located within the Rutherford Formation close to or north-east of the evaporation ponds. The remaining three on-site bores are located within Quaternary Alluvium on the western bank of Swamp Creek. Data associated with these bores is limited, with no information regarding the depth of the bores, water bearing zone, or standing water depth. One bore indicates it was installed in 1999. It is understood that these bores were installed for monitoring purposes, not stock watering or domestic use.

The Hunter River is located approximately 15km north east of the site near Maitland. The Hunter River Alluvium Groundwater Management Unit (GMU) is an important groundwater resource to the region. Groundwater extraction for irrigation, urban supply, drought supply, stock, domestic and commercial/ industrial use occurs, with volumes in excess of 10,000ML per annum extracted from the Hunter River Alluvium GMU. Aquifer storage and recovery is also an important use of this GMU. It is noted that the Hunter River GMU is not the primary drinking water supply in the region, although protection of drinking water is a Water Quality Objective for the Hunter River (NSW Water Quality and River Flow Objectives).

2.2.5 Site Geology

The site is located within the Hexham and Hunter land systems, which are characterized by fresh water swamps and underlain by dark sandy and sandy-clay soils that can be high in organic matter. Soils vary greatly in texture and consistency from sands to clayey soils of medium to high plasticity. Profiles are generally indicative of high water tables and water logged ground conditions (Croft & Associates, 1980).

The Quaternary alluvium beneath the site comprises a finely interbedded sequence of unconsolidated sediments, including fine grained alluvial sands, silts and clays, including silty sand, sandy clay, sandy silt and clayey sand at least 17m thick (Woodward-Clyde, November 1997).

The variable and complex nature of the sedimentary layers is a result of the deposition of the sediments in an alluvial environment with a meandering river system migrating across a flood plain.

2.2.6 Site Hydrology

Surface water from within the smelter portion of the site is directed to Eastern Surge Dam via an open channel. The East Surge Dam, which is located to the north of the Capped Waste Stockpile on the eastern boundary of the smelter, is pumped to the North dams where surface water is discharged to an irrigation area in the buffer zone under licence. Surface water dams were constructed by excavation into the residual clay underlying extremely weathered bedrock.

Surface water from within the buffer zone portion of the site is distributed via infiltration into sandy soils, with some overland flow occurring. Excess surface water flows via overland flow through natural depressions to Swamp Creek, which is the closest surface water receptor. Swamp Creek flows north and discharges into Wentworth Swamp 2.5km north of the site. Wentworth Swamp in turn discharges to the Hunter River approximately 15km northeast of the site near Maitland.

The creek and swamp system are within the Fishery Creek Catchment, where declining stream water quality and a reduction in diversity of native plants and animals has occurred due to population growth and development pressures within the catchment over the last ten years (Hunter Catchment Management Trust). Down-stream of the site, water quality has been impacted by historical mining of the Greta Coal Seam (Hunter Catchment Management Trust).

2.2.7 Site Hydrogeology

Groundwater aquifers in the immediate location of the site have been found to comprise a very shallow near surface aquifer and a deeper aquifer.

The near surface aquifer is semi-continuous within a complex system of relict braided alluvial channels flowing to the north-east. One such channel is present beneath the Capped Waste Stockpile, which trends north-east and extends to depths of between 0.6m to 3.2m bgs.

The presence of local topographical changes and lenses of lower permeability strata within the geological sequence results in the discharge of shallow groundwater from this near surface aquifer to surface water in areas along the channel path. These seep zones form localised areas of overland surface water flow.

The presence of a semi-continuous clay aquitard has been identified in most locations were drilling has continued to depth and a deeper aquifer has been identified below the clay aquitard within sand lenses. These sand lenses have been identified beneath the clay aquitard extending to at least 15m bgs. It is likely that these sand lenses also form part of a relict braided alluvial system and that the clay aquitard is remnant of a period of floodplain or swamp environment. The clay aquitard acts to mitigate the vertical movement of groundwater from the shallow channel systems to the deep aquifer.

2.2.8 Vegetation Impact

Vegetation dieback is observed in two locations within the notified area, identified in **Appendix A**, where groundwater discharges to the surface and surface flow of leachate impacted water occurs. Dead and affected vegetation in these areas, known in this report as the southern vegetation impact area and northern vegetation impact area, was removed by Hydro in 2008 and the impacted areas are currently grassed.

2.2.9 Capped Waste Stockpile Integrity

An investigation of the capping layer in-situ permeability was undertaken by RCA in 2013 (RCA2013). This investigation found permeability at three of the four locations to be between $1e^{-8}$m/s and $5e^{-9}$m/s. At the fourth location (BH1) the in-situ permeability was found to be $2e^{-7}$m/s. RCA commented that a sand layer was present at all locations overlying the clay (topsoil vegetation layer) and that at BH1 this layer was included in the test and therefore voiding the test result.

3 Stage 1 Fieldwork

3.1 Objective

Stage 1 investigative works were undertaken to address the extent of the plume to the east, south east and north east of the known sand lens. The potential for the plume to migrate through connected sand lenses in these directions was identified as a data gap during previous investigations (ENVIRON December 2012). The objective of the Stage 1 investigation works was to delineate the extent of the leachate impacted groundwater plume.

3.2 Scope of Works

The scope of works included the following:

- Drilling of 70 hand auger holes located within and around the east, south east and north eastern edges of the plume;
- Sampling of groundwater from each hand auger hole that intersected groundwater for pH and colour;
- Using changes in pH and colour to indicate leachate impacts, refine the well network to allow real time delineation of the plume extent in the shallow stratum.

The field investigations were completed in accordance with the Sampling, Analysis and Quality Plan, as outlined in Appendix B.

The locations of the 70 hand auger holes are shown in Figure 3. The borehole logs are included in Appendix C.

4 Stage 1 Results

Data from Stage 1, including depth to groundwater, pH and geology, has been tabulated in Table 4.1 based around the area of the plume requiring delineation. The information in Table 4.1 indicates that the edges of the leachate plume to the east, south east and north east of the known plume extent have been delineated, either by an absence of groundwater or by the interception of groundwater with low pH (<8). The leachate plume delineation is presented in Figure 3.

The strata to the east of the Capped Waste Stockpile comprised interbedded sands and clayey sand/ sandy clay. Groundwater was not encountered within the clayey sand/ sandy clay strata. Groundwater was encountered within the sands at depths of 1m at M36 and 1.7m at M38. Aside from these two locations, groundwater was not encountered within the shallow sands east of the Capped Waste Stockpile until the ground level graded down towards the Southern Impact Area.

In the area beneath the two Impact Areas, shallow groundwater was identified at depths of approximately 0.2 to 0.3m bgl. The sand strata was thin (<0.4m) and underlain by high plasticity black clay which provides a barrier to downward flow forcing horizontalflow close to the surface. A decline in topography and the underlying confinement by the clay results in shallow groundwater discharging to the surface. Groundwater in these areas was found to be impacted by leachate.

The strata to the south east of the Capped Waste Stockpile was generally sandy clay/ clayey sand and groundwater was not encountered in this area within the shallow stratum.

Table 4.1: Groundwater Interception

Area of Site	Groundwater Intercepted?	Well IDs	Depth to Water (m bgl)	pH	Colour	Geology
South-east of the Capped Waste Stockpile	No	M42 to M45	-	-	-	Sandy CLAY to CLAY, brown to orange, high plasticity
East and north-east of the Capped Waste Stockpile (near existing wells E4 and A4)	Only immediately south of E4	M38	1.7m	6.8	Clear/ cloudy	SAND, grey, fine grained
	No	M32 to M37, M39 to M41	-	-	-	Sandy CLAY/ clayey SAND, grey/ orange mottled, high plasticity
East of the Southern Impact Area	No	M29* to M31, M47 to M51	-	-	-	SAND underlain by high plasticity black CLAY.
West of the Southern Impact Area	Yes	M26, M28, M58, M59, M60, M63	0.6-1.2m	8.5 to 9.8	Brown	SAND, yellow to grey, fine grained
	No	M25, M27*, M61, M62*	-	-	-	SAND, yellow to grey, fine grained(generally 0.2m of wet sand at 0.8m to 0.9m bgl but did not make water)
Between the Northern and Southern Impact Areas	Yes	M22 M19	0.4m 1.2m	7.56 7.76	Not recorded Cloudy	SAND, fine grained, grey underlain by high plasticity black CLAY SAND, black to orange to grey
	No	M23, M24,	-	-	-	Clayey SAND/ sandy CLAY, SAND, black to orange to

Table 4.1: Groundwater Interception

Area of Site	Groundwater Intercepted?	Well IDs	Depth to Water (m bgl)	pH	Colour	Geology
		M46, M64				grey
North of Well E11	No	M6, M11, M12*, M17	-	-	-	SAND, yellow to grey, fine grained (generally 0.2m of wet sand at 1.8m to 2.2m bgl but did not make water)
East of the Northern Impact Area	Yes	M67, M68, M71	0.4m to 0.8m	8.1 to 8.9	Brown	SAND, grey, fine grained, underlain by high plasticity black CLAY
West of the Northern Impact Area	Yes	M7, M13	0.1m	8.9 to 9.0	Brown	SAND, grey, fine grained
		M9	0.3m	6.2	Turbid	SAND, grey, fine grained, underlain by black CLAY
		M10	0.5m	9.2	Brown	SAND, dark grey, fine grained
		M4, M14	2.3m to 2.4m	6.2 to 7.5	Light brown	SAND, grey, fine grained
		M5, M16	1.3m to 1.5m	8.7 to 9.1	Light brown	SAND, brown, fine grained
	No	M2, M3, M8* M15*	-	-	-	SAND, grey, fine grained
North-east of Well N9	Yes	M54	1.7m	8.8	Brown	SAND, grey, fine grained
	No	M55*, M69, M70*	-	-	-	SAND, grey, fine grained underlain by black, high plasticity CLAY and clayey SAND/ sandy CLAY

*Sands in these wells were wet during drilling but did not make water.

5 Stage 2 Monitoring Well Network Installation

5.1 Delineation of the Plume

The completion of the Stage 1 fieldwork has allowed for the delineation of the leachate plume is areas that were previously considered to contain data gaps, i.e. the southern, eastern and northern edges of the plume. Figure 3 shows the delineation of the plume based on the Stage 1 fieldwork.

The results of the Stage 1 fieldwork and previously completed fieldwork reported in ENVIRON (2012) indicate the following:

- South: Shallow groundwater was not encountered within the clayey sand/ sandy clay strata to the south of the Capped Waste Stockpile. As this strata is not conducive to groundwater flow, movement of the leachate plume through this area is restricted;
- East: The leachate plume has previously been identified in well E4, with no wells directly east of this well. Well A4, located to the north east, is not within the plume. The strata in this area includes interbedded sands and clayey sand/ sandy clay. Groundwater was encountered at two locations (M36 and M38) in this area within sand. A sample of the groundwater could only be collected from M38, located approximately 6m south of E4, with this sample showing no signs of leachate impact. Well E4 is considered to be the eastern-most impacted well, with groundwater movement restricted through the clayey sand/ sandy clay strata to the south and east of this well;
- Southern and Northern Impact Area: The vegetation impact areas exist where leachate flows to the surface due to changes in topography. It is important to note that topographical changes occur both perpendicular and parallel to the groundwater flow path. Both impact areas are generally underlain by sands to depths of approximately 0.3m to 0.6m bgl. The sands are underlain by high plasticity clay that restricts groundwater migration vertically through the profile. As groundwater cannot migrate through the soil profile, the leachate impacted groundwater discharges to the surface with water table increases during periods of heavy rainfall. The movement of the leachate plume through this area is either via surface water flow or via shallow groundwater flow in the eastern portion of each vegetation impact area;
- North west: The strata encountered in the north west of the site generally comprised sand within the top 2m of the profile. Groundwater was identified within a narrow band (0.2m) within the sand at several locations to the north of well E11, including M6, M11, M12 and M17. A groundwater sample could only be extracted from one location, M11, which had a pH of 8.4 indicating likely leachate impact. The fact that groundwater only occurs within a narrow band in the sands within this area suggests that the continuity of groundwater flow is limited in this area. Well E11 is considered to be a leading edge well in this area;
- North east: The strata encountered in the north east comprised interbedded sands and clayey sand/ sandy clay. Leachate impacted groundwater has previously been identified at well N9 within sands at 1.6m bgl but not within the adjacent well N8, where groundwater was identified at a depth of 2.3m bgl within sand that was overlain by interbedded clayey sand/ sandy clay. It is likely that the clayey sand/ sandy clay layer prevents leachate migration or impact at well N8. During this investigation, leachate

impacted groundwater was identified 7m to the east of well N9 at M54 at a depth of 1m bgl. No water could be extracted from N55, located approximately 13m east of N9, nor in other locations to the east of N55 and north of the Northern Vegetation Impact Area. Well N9 is considered to be a leading edge well in this area.

5.2 Location of New Wells

Prior to locating new wells, the existing well network was reviewed for adequacy to determine wells that could be included in the ongoing monitoring network. The review included an evaluation of existing borelogs to determine screened intervals, field integrity testing, suitability of the location and of the aquifer screened in terms of the plume extent and the purpose of the monitoring well (eg. leading edge well). The following wells were identified as being suitable A7, A8, E5, E11, N8, N9, G2, G3, F11 and PUMP (see Figure 2).

The location of new wells was selected around the concept of monitoring groundwater wells at five sections along the length of the leachate plume, as follows:

- Section 1: parallel to the eastern side of the Capped Waste Stockpile and includes PUMP and E5. A new pair of shallow and deep wells would be installed between wells S3 and S4 to supplement this section;
- Section 2: extends from well E5 in the west to well E4 in the east. A new pair of shallow and deep wells would be installed south east of E4 near the location of M38;
- Section 3: extends from A7/A8 in the west through the Southern Vegetation Impact Area. Two new pairs of shallow and deep wells would be installed within the Southern Vegetation Impact Area;
- Section 4: extends from E11 in the west through the southern end of the Northern Vegetation Impact Area. One new pair of deep and shallow wells would be installed near the location of M22;
- Section 5: extends from G2 in the west through the northern end of the Northern Vegetation Impact Area and the leading edge of the plume. One new pair of shallow and deep wells would be installed east of well N9.

To supplement the existing wells on each section, new wells will be installed in pairs including one well targeting shallow groundwater and one well targeting deep groundwater.

6 Stage 2 Fieldwork

6.1 Objective

The objective of the Stage 2 investigation works was to install new groundwater wells to supplement the existing well network for future groundwater monitoring.

6.2 Scope of Works

The scope of works included the installation of sixteen new groundwater wells, as identified in Section 5.2.

The field investigations were completed in accordance with the Sampling, Analysis and Quality Plan, as outlined in Appendix B. During the field works, three unplanned wells were installed. A pair of shallow and deep wells was installed between the existing wells PUMP and E5 to assess the movement of leachate from the Capped Waste Stockpile and an additional shallow well was installed in the Southern Impact Area to monitor shallow leachate in this area.

The location and identification of the new wells is shown on Figure 4. Borehole logs are included in Appendix E.

The final monitoring network, including existing and newly installed wells is described in Table 6.1.

Table 6.1: Monitoring Well Network

Well ID	Easting	Northing	Surface RL	Depth to Well Base mbgl	Screened Interval mbgl	Aquifer Screened
W1S	358251.989	6371121.373	12.6	2.0	1.0 – 2.0	Shallow
W1D	358250.363	6371120.17	12.6	11.5	10.5 – 11.5	Deep
W2S	358206.834	6371097.034	13.4	2.0	1.0 – 2.0	Shallow
W2D	358206.788	6371098.685	13.4	8.4	7.4 – 8.4	Deep
W3S	358279.304	6371260.151	10.6	1.8	0.8 – 1.8	Shallow
W3SA	358289.839	6371250.183	10.1	0.5	0.0 – 0.5	Shallow
W3D	358279.421	6371262.113	10.6	9.4	8.0 – 9.5	Deep
W4S	358295.048	6371243.851	9.9	1.0	0.0 – 0.4	Shallow
W4D	358296.242	6371242.876	9.9	9.5	8.0 – 9.5	Deep
W5S	358345.058	6371302.487	9.3	1.0	0.35 – 0.65	Shallow
W5D	358346.806	6371303.142	9.3	9.5	8.0 – 9.5	Deep
W6S	358371.396	6371375.2	9.6	2.0	0.7 – 2.0	Shallow

Table 6.1: Monitoring Well Network

Well ID	Easting	Northing	Surface RL	Depth to Well Base mbgl	Screened Interval mbgl	Aquifer Screened
W6D	358373.36	6371376.787	9.6	9.5	8.0 – 9.5	Deep
W7S	358211.332	6371142.911	13.6	1.6	0.6 – 1.6	Shallow
W7M	358211.552	6371144.284	13.6	3.0	1.5 – 3.0	Shallow
PUMP	358209.804	6371131.618	13.5	2.7	0.5 – 2.85	Shallow
E4	358252.994	6371132.217	13.0	2.5	Screen unknown	Shallow
E5	358213.343	6371160.083	13.2	2.0	1.0 – 2.0	Shallow
E5D	358213.146	637112.495	13.1	5.0	3.5 – 5.0	Deep
E11	358272.508	6371316.331	12.6	4.8	1.5 – 4.5	Shallow
G2	358281.174	6371355.556	12.4	12.0	9.0 – 12.0	Deep
N2	358420.473	6371285.033	7.7	4.5	Screen unknown	Shallow
N8	358345.126	6371375.703	11.2	4.0	Screen unknown	Shallow
N9	358358.853	6371378.388	10.6	2.1	2.2 – 3.2	Shallow
A7	358260.893	6371257.637	11.2	5.0	3.0 – 5.0	Shallow

7 Discussion

7.1 Stage 1 and 2 Soil Logging Results

Soil logging of the 70 hand auger holes and 16 new groundwater wells was completed during the field investigation. The results of the soil logging indicate there are several different strata at the site that are interbedded in a complex manner. The strata identified are outlined in Table 7.1.

Table 7.1: Identified Strata

Strata Name	Description	Thickness	Locations Identified
Estuarine Muds	CLAY: black to grey, high plasticity, with no other inclusions. The black colour indicates the clay is organic rich. The high plasticity and lack of inclusions such as sand or gravel indicates the clay was deposited in a low energy environment, such as an estuary. This strata is of low hydraulic conductivity and would not be conducive to groundwater flow	Between 0.2m and 0.6m.*	The clay was generally identified on the eastern portion of the site, between sand layers from a depth of 0.5m below ground surface.
Fluvial Channel Sands	SAND: fine grained, yellow or grey, with no other inclusions. This fine grained sand was deposited in a high energy environment, such as a river. This strata is of high conductivity and would allow groundwater flow. Higher flow rates would occur with larger grain size and less dense strata.	Between 0.3m and >2.2m.*	Sand was the dominant strata identified throughout the site. Sand was generally intercepted at the surface and was interbedded with other strata in the top 2m.
	SAND: coarse grained rounded quartz sand	Between 2.9m and 3.5m in W6D Between 2.0m and 2.8m in W7M	Identified in two boreholes W6D in the north of the Northern Impact Area and W7M at the north eastern corner of the Capped Waste Stockpile.
Sandy Levee Deposits	Sandy CLAY/ Clayey SAND: fine grained, high plasticity, orange/ grey/ brown mottled This clay and sand mixture was deposited on the banks of a river within an estuary environment. This strata is of moderate hydraulic conductivity and would allow some passage of groundwater flow. Disconnected sand lenses may result in termination of flow paths and an overall low transmissivity of groundwater.	Between 0.3m and >1.1m.*	Clayey sand/ sand clay was generally identified throughout the site interbedded with sand or below the clay strata. This material was identified near the surface in the south of the site (to the south east of the Capped Waste Stockpile).

*The thickness of the strata was identified during hand auger drilling of shallow holes (generally <2m) and is not representative of thicknesses lower in the sequence.

The depositional environment of the strata at the site is interpreted to be within the upper reaches of an estuary, with the clay deposited as organic rich muds. The muds are interbedded with fluvial sands and sandy levee deposits, flowing into the estuary from up stream during periods of sea level fall.

This interpretation is consistent with the findings of Roy (1993) *Late Quaternary Geology of the Hunter Delta – A Study of Estuarine Valley-Fill Sequences*. This paper indicates 'the present-day floodplains of the lower Hunter, Patterson and William Rivers constitute a large, infilled estuary that extended inland from the coast a distance of about 30km; its upper reaches just west of Maitland'. Drilling in the areas of Wallis Creek and Fishery Creek (approximately 1-2km east of the site) indicate 'muds in the upper reaches of the former estuary contain fewer shells than further downstream, presumably because freshwater inflows made the estuary brackish. They are interbedded with lenses and layers of fluvial channel sand and are overlain by sandy levee deposits and floodplain silts'.

The coarse grained rounded quartz sands intercepted in boreholes W6D and W7M during the current investigations have not been intercepted in any of the other boreholes drilled by ENVIRON on site. Review of the logs provided for wells installed previously indicated the interception of similar gravelly/ pebbly sand in A2, A3 and MW01 (now E11). A summary of the location of this coarse grained sand stratum is included in Table 7.2.

Table 7.2: Coarse Grained Sand Stratum

Borehole ID	Description	Depth	Borehole Location
A2	Gravelly CLAY: coarse sand and some orange clay, wet	2.5-3.5	Near the north east corner of the Capped Waste Stockpile
A3	Sandy GRAVEL	2.5-3	Approximately 25m north east of the north east corner of the Capped Waste Stockpile
MW01 (now E11)	Pebbly sand and silty clay: medium light brown, with clay Pebbly sand: mottled light brown/ grey	5-7 12.5-14	Approximately 150m north of the Capped Waste Stockpile
W6D	Clayey GRAVEL: orange, wet, well rounded quartz gravel, grading to grey	2.9-3.5	At the leading edge of the leachate plume approximately 300m north east of the Capped Waste Stockpile
W7M	SAND: coarse grained, loose, grey, very minor clay	2-2.8	North east corner of the Capped Waste Stockpile

The stratum identified within these boreholes is representative of a high energy flood deposit within the river system. It is also a highly permeable stratum that given its location beneath the north east corner of the Capped Waste Stockpile, facilitates the movement of leachate into shallow groundwater.

7.2 Updated Site Conceptual Model

A site conceptual model was developed following the previous investigations at the Capped Waste Stockpile and associated groundwater plume and outlined in Section 2.2.2. The information derived from the current investigations has been used to refine the conceptual site model.

Consistent with the previous understanding of groundwater flows, the dominant pathway for the migration of leachate from the Capped Waste Stockpile is through sands flowing to the north east, including coarse grained sands, that occur within sediments comprising these strata.

From the recent investigations, the mechanism for discharge beneath the Capped Waste Stockpile is now understood to be through a narrow band of coarse grained quartz sand (identified in borehole W7M). This sand stratum was found to extend toward the north east of the Capped Waste Stockpile (boreholes W7M, W6D, A2, A3 and E11).

In locations to the north west of the Capped Waste Stockpile (boreholes W3S, M11, M12, M17, M25, M26, M27, M60, M61, M62) a narrow 0.2m thick band of wet sand was found, which was underlain dry fine dense sand. This indicates that the leachate impacted shallow groundwater does not readily migrate vertically through the tightly packed sand profile and that both dense sand and high plasticity clays act to limit the vertical migration of the plume.

In locations to the north east of the Capped Waste Stockpile (boreholes M8, M15, M55 and M70) grey, fine grained, poorly sorted sand was found, which was wet during drilling but did not make water while the borehole was left open. This indicates that groundwater does not readily migrate laterally through the tightly packed sand profile in this area. Based on the topography and historical observations from Hydro personnel, groundwater does not discharge to surface in the thick bushland down gradient (north east) of Northern Impact Area. It is possible that the leachate plume extends beyond the northern extent delineated during the fieldwork, however the aquifer is deeper in the profile, and groundwater flow rates are expected to be low based on the low permeability of the tightly packed sands.

Deep groundwater, intercepted at depths between 8m and 10m bgs, generally exists within sands underlying estuarine clays. Low pH values (<8) were detected in deep groundwater, confirming that the leachate impacted shallow groundwater has not moved vertically through the profile due to tightly packed sands and high plasticity clays, which have a very low permeability. Whilst it is difficult to confirm the continuity of the confining strata by drilling alone, the absence of leachate impacts identified during previous investigations within this deeper aquifer suggests that the aquifer is confined from the upper shallow groundwater system.

Delineation investigations show that the plume remains confined within one main sand filled channel which directs flow to the north east. This finding is consistent with observations of a heavily vegetated area evident in the 1961 aerial photograph. The heavy vegetation is a reflection of surface and subsurface drainage lines and likely represents the shallow groundwater table present in a sand filled channel. The 1961 aerial photograph depicts the vegetation extending further to the north east and connecting with Swamp Creek (refer to Figure 5). Given the correlation between the plume extent and the vegetation, it is reasonable to conclude that the groundwater flow path will continue along the historic vegetation alignment toward Swamp Creek.

Also of note, is the extent of the heavy vegetation to the south of the Capped Waste Stockpile. This indicates that the flow channel extends past the Capped Waste Stockpile and towards the playing fields and the South Surge Dam. The mechanism for recharge of the sand channel is not well understood but may be associated with recharge of these playing fields. Understanding the mechanism for aquifer recharge remains a data gap.

8 Conclusions

The Hydro Aluminium Smelter at Kurri Kurri contains a shallow plume of leachate-impacted groundwater associated the generation of leachate from the deposition of smelter wastes within a stockpile known as the Capped Waste Stockpile. ENVIRON completed a Phase 2 Environmental Site Assessment at the smelter and surrounding buffer zone in May 2012. The results of the Phase 2 ESA recommended additional works, including the delineation of the plume to the east, south east and north east of the known extent.

ENVIRON completed a two stage investigation to delineate the extent of the leachate plume. Stage 1 involved the drilling of 70 hand auger holes located within and around the east, south east and north eastern edges of the plume. The hand auger holes were logged and when groundwater was intersected during drilling, data including depth to water, pH, electrical conductivity and colour was collected. Correlations between pH and colour effects of the groundwater were used as a field indicator of leachate impacts.

The soil logging intersected interbedded sands, coarse grained sands, sandy clay/ clayey sand and high plasticity clays. The depositional environment of these sediments is understood to be a former estuary that extended 30km inland during the Quaternary (Roy, 1993).

Interpretation of the data collected during hand augering has allowed for delineation of the leach-impacted shallow groundwater, as shown in Figure 3.

Stage 2 involved the installation of groundwater monitoring wells to supplement the existing well network. Quarterly groundwater monitoring commenced in July 2013 and will be reported under a separate cover.

Based on these investigations, ENVIRON consider the plume has been delineated as follows:

- Western edge: delineated as drilling has intersected clay strata either without groundwater or with no impact to the clay aquitard (A5, A6, E6, S11, S14);
- Potential leading edge to the north (near E11): now delineated, as drilling to the north intersected tightly packed sands through which the movement of the leachate plume is limited. Shallow groundwater was not intersected within investigation boreholes M6, M11 and M12;
- Potential leading edge to the north east (near destroyed well N7): leachate identified in well N9 on the northern boundary of the Northern Impact Area. Highly permeable coarse grained quartz sands identified in this area.
- Eastern edge (near E4): now delineated, as drilling intersected low pH shallow groundwater south of E4 (at M38) and clay strata was intersected north and east of E4 (M32 to M37).

The investigations have confirmed that groundwater flow occurs through two aquifers comprising a shallow near surface aquifer and a deeper, separate aquifer. The near surface aquifer was found to comprise flow through shallow sands, with leachate able to migrate from beneath the Capped Waste Stockpile through a shallow sand channel located in the north east corner. The horizontal and vertical extent of groundwater flow within the channel is now well understood. The downgradient flow path (north of the Northern Impact Area) of the channel is less understood however sufficient information is available to allow for fate and transport modelling of plume behaviour.

8.1 Recommendations

Following from the investigation undertaken above further investigation is recommended to assess.

- The mechanism for recharge of the leachate plume. Monitoring of a well up gradient of the Capped Waste Stockpile is recommended during rainfall events to identify if recharge is occurring up gradient or within the Capped Waste Stockpile;
- Fate and transport modelling is recommended to understand discharge concentrations and timeframes to reach the receptor.

The presence of the coarse sand strata immediately downgradient of the north eastern toe of the Capped Waste Stockpile presents an opportunity for interception of leachate prior to migration downgradient. Interception could comprise construction of a trench and sump or network of groundwater pumping wells aimed to hydraulically control the movement of leachate. Treatment through the existing evaporation and irrigation treatment process could be undertaken.

9 Limitations

ENVIRON Australia prepared this report in accordance with the scope of work as outlined in our proposal Hydro Australia dated 23 April 2013 and in accordance with our understanding and interpretation of current regulatory standards.

A representative program of sampling and laboratory analyses was undertaken as part of this investigation, based on past and present known uses of the site. While every care has been taken, concentrations of contaminants measured may not be representative of conditions between the locations sampled and investigated. We cannot therefore preclude the presence of materials that may be hazardous.

Site conditions may change over time. This report is based on conditions encountered at the site at the time of the report and ENVIRON disclaims responsibility for any changes that may have occurred after this time.

The conclusions presented in this report represent ENVIRON's professional judgment based on information made available during the course of this assignment and are true and correct to the best of ENVIRON's knowledge as at the date of the assessment.

ENVIRON did not independently verify all of the written or oral information provided to ENVIRON during the course of this investigation. While ENVIRON has no reason to doubt the accuracy of the information provided to it, the report is complete and accurate only to the extent that the information provided to ENVIRON was itself complete and accurate.

This report does not purport to give legal advice. This advice can only be given by qualified legal advisors.

9.1 References

"Environmental Site Assessment, Capped Waste Stockpile, Kurri Kurri Aluminium Smelter", dated 13 December 2012 by ENVIRON

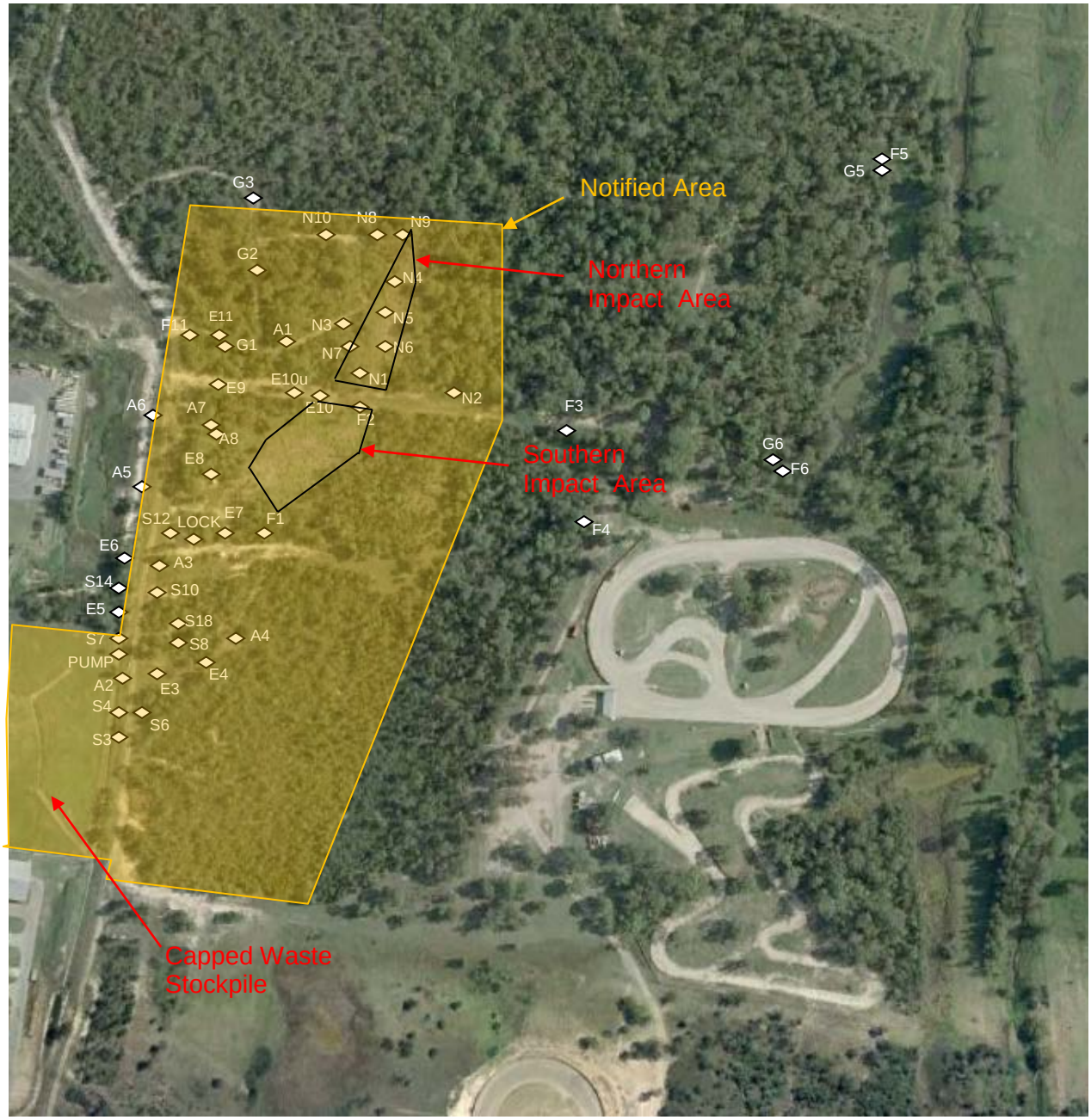
"Preliminary Health Screening Levels, Health Risk Assessment for Fluoride and Aluminium, Part of the Kurri Kurri Aluminium Smelter, Hart Road, Loxford", dated 2 April 2013 by ENVIRON

"Tier 2 Ecological Risk Assessment, Kurri Kurri Aluminium Smelter", dated March 2013 by ENVIRON

"Late Quaternary Geology of the Hunter Delta – A Study of Estuarine Valley-Fill Sequences", dated November 1993 by P.S. Roy

Figures

HYDRO ALUMINIUM KURRI KURRI	GROUNDWATER PLUME DELINEATION	Site Location Plan
ENVIRON	JOB NO: AS130335	DATE: 6 November
		FIGURE 1



HYDRO ALUMINIUM KURRI KURRI GROUNDWATER PLUME DELINEATION	**Historical Groundwater Well Locations**

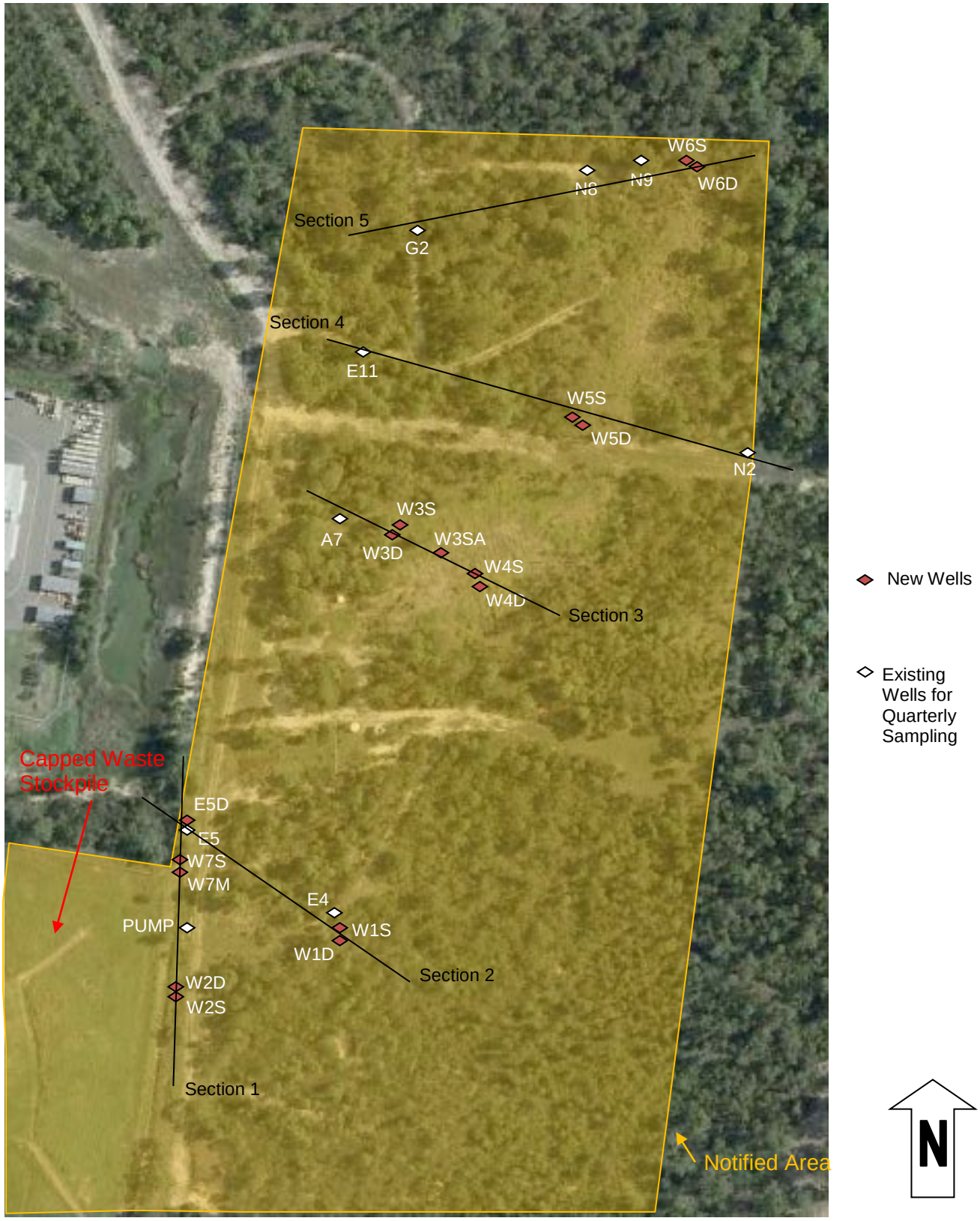
ENVIRON JOB NO:AS130335 DATE:6 November 2013 FIGURE 2

HYDRO ALUMINIUM KURRI KURRI

GROUNDWATER PLUME DELINEATION

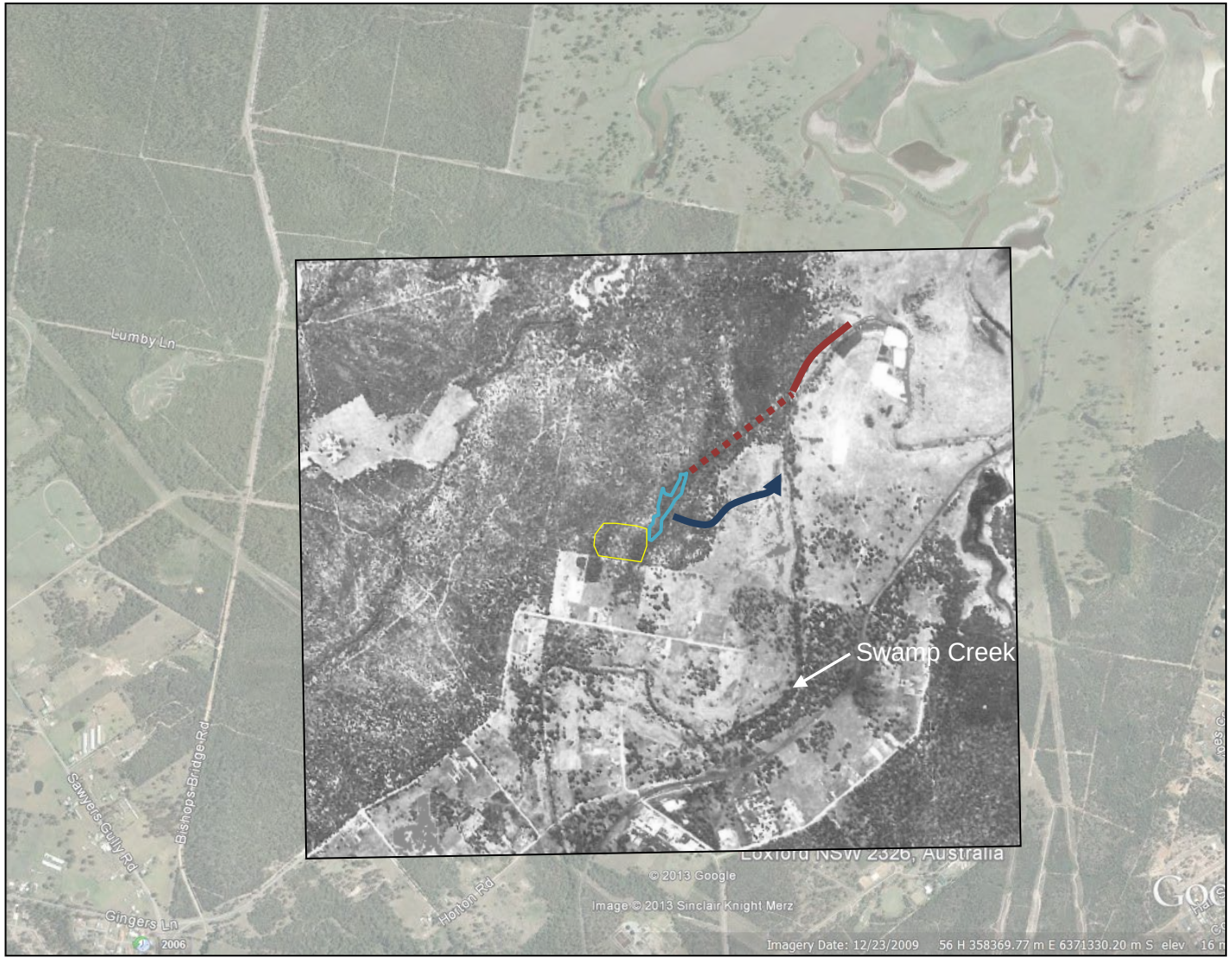
Stage 1 Hand Auger Hole Locations and Plume Delineation

ENVIRON JOB NO: AS130335 DATE: 10 October 2013 FIGURE 3



HYDRO ALUMINIUM KURRI KURRI GROUNDWATER PLUME DELINEATION	**New Groundwater Well Locations**

ENVIRON JOB NO:AS130335 DATE:26 August 2013 FIGURE 4



HYDRO ALUMINIUM KURRI KURRI GROUNDWATER PLUME DELINEATION	1961 Aerial Photograph showing Plume Location

ENVIRON

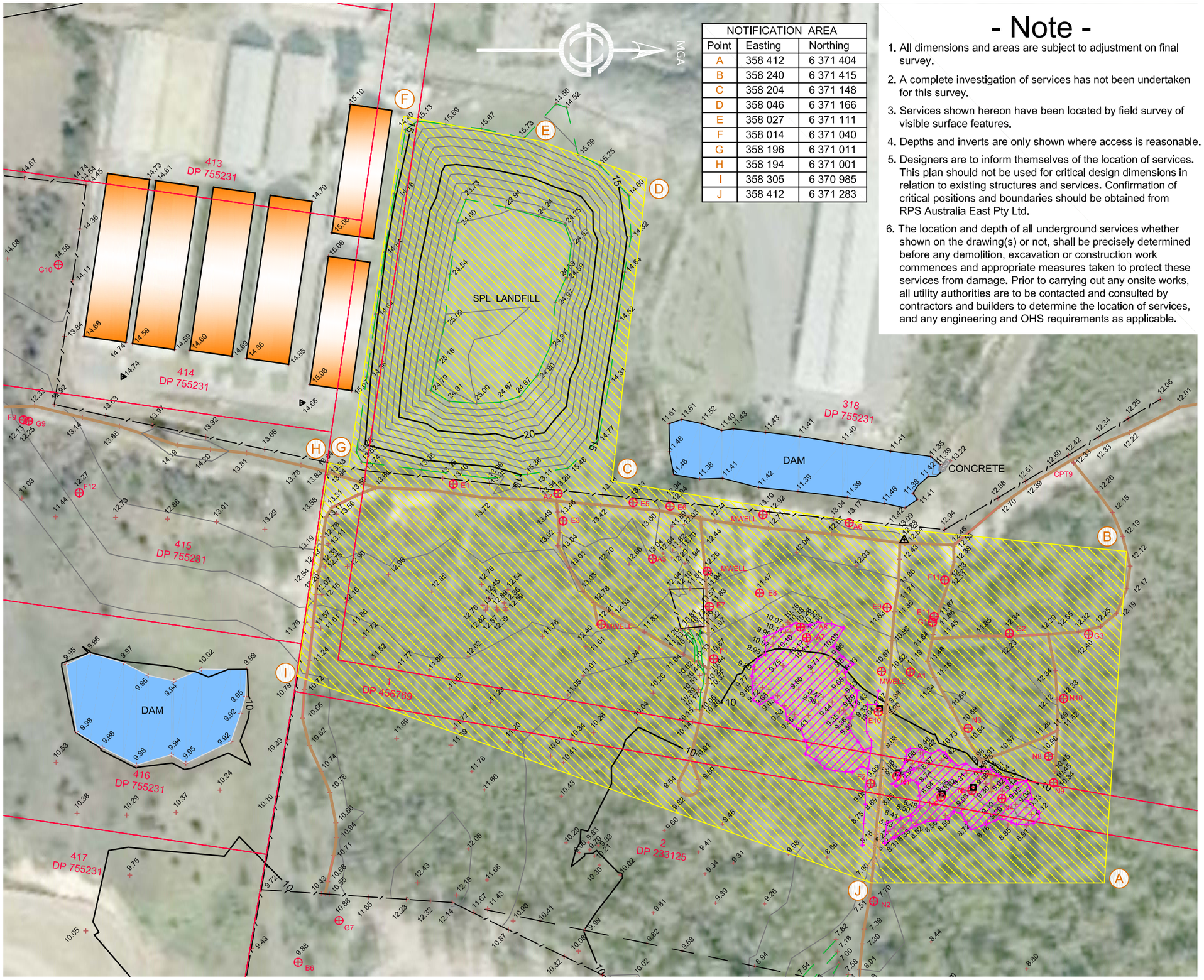
JOB NO: AS130335

DATE: 6 November 2013

FIGURE 5

Appendix A

Survey Plan of Notified Area



NOTIFICATION AREA		
Point	Easting	Northing
A	358 412	6 371 404
B	358 240	6 371 415
C	358 204	6 371 148
D	358 046	6 371 166
E	358 027	6 371 111
F	358 014	6 371 040
G	358 196	6 371 011
H	358 194	6 371 001
I	358 305	6 370 985
J	358 412	6 371 283

- Note -

1. All dimensions and areas are subject to adjustment on final survey.
2. A complete investigation of services has not been undertaken for this survey.
3. Services shown hereon have been located by field survey of visible surface features.
4. Depths and inverts are only shown where access is reasonable.
5. Designers are to inform themselves of the location of services. This plan should not be used for critical design dimensions in relation to existing structures and services. Confirmation of critical positions and boundaries should be obtained from RPS Australia East Pty Ltd.
6. The location and depth of all underground services whether shown on the drawing(s) or not, shall be precisely determined before any demolition, excavation or construction work commences and appropriate measures taken to protect these services from damage. Prior to carrying out any onsite works, all utility authorities are to be contacted and consulted by contractors and builders to determine the location of services, and any engineering and OHS requirements as applicable.

LEGEND

- BOUNDARIES
- TOP BANK
- TOE BANK
- ROAD CENTRELINE
- FENCE
- POWER POLE
- OVERHEAD POWER LINES
- TRACK CENTRELINE
- MONITORING WELL
- STATION FOUND
- STATION PLACED
- PERMANENT SURVEY MARK
- Area of Notification
- Extent of observable impacted vegetation July 2012

MONITORING WELLS		
WELL	EASTING	NORTHING
A1	358 303.019	6 371 303.387
A2	358 210.416	6 371 120.544
A3	358 244.318	6 371 169.540
A4	358 278.291	6 371 142.942
A5	358 221.372	6 371 226.882
A6	358 225.605	6 371 271.618
A7	358 285.273	6 371 249.548
A8	358 279.748	6 371 246.310
B6	358 453.697	6 370 985.618
E1	358 205.539	6 371 066.100
E3	358 224.678	6 371 123.145
E4	358 254.024	6 371 133.608
E5	358 215.146	6 371 159.473
E6	358 217.050	6 371 178.678
E7	358 269.118	6 371 199.073
E8	358 262.092	6 371 225.183
E9	358 269.595	6 371 291.284
E10	358 323.749	6 371 286.743
E10u	358 302.750	6 371 288.424
E11	358 274.231	6 371 315.740
F1	358 296.223	6 371 201.326
F2	358 360.933	6 371 282.774
F4	358 493.311	6 371 213.879
F5	358 650.190	6 371 435.269
F6	358 578.725	6 371 247.857
F8	358 311.845	6 370 747.959
F9	358 172.172	6 370 842.977
F11	358 255.345	6 371 321.262
F12	358 210.051	6 370 871.981
G1	358 277.219	6 371 314.874
G2	358 282.971	6 371 354.820
G3	358 283.520	6 371 395.910
G5	358 649.825	6 371 432.593
G6	358 574.579	6 371 249.831
G7	358 432.046	6 371 006.848
G8	358 307.764	6 370 748.526
G9	358 172.795	6 370 845.679
G10	358 091.658	6 370 861.141
LOCK	358 250.722	6 371 197.946
N1	358 357.153	6 371 296.335
N2	358 422.042	6 371 284.418
N3	358 332.277	6 371 333.410
N4	358 368.717	6 371 350.896
N5	358 364.677	6 371 335.332
N6	358 367.962	6 371 319.291
N8	358 346.831	6 371 375.182
N9	358 360.549	6 371 377.756
N10	358 316.907	6 371 382.912

0 25 50 100

SCALE 1 : 2000 (A3)

TITLE: NOTIFICATION AREA

LOCATION: " HYDRO ALUMINIUM " HART ROAD , LOXFORD

DATUM: AHD
PROJECTION:

DATE: 17TH JULY 2012
PURPOSE: DETAIL

AUTOCAD REF: 112931 - 1B 17.07.2012
VERSION (PLAN BY): Notification Area

CLIENT: ENVIRON AUSTRALIA PTY LTD
JOB REF: 112931

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
241 DENISON STREET BROADMEADOW PO BOX 428 HAMILTON NSW 2303
T: 02 4940 4200 F: 02 4961 6794 www.rpsgroup.com.au

RPS

Appendix B

Quality Assurance/ Quality Control

Stage 1 Sampling, Analysis and Quality Plan
Fieldwork Methodology

The fieldwork methodology for soil sampling is outlined in Table 1.

Table 1: Stage 1 Field Methodology

Activity	Details
Subsurface Clearance	A Dial Before You Dig underground services check was completed prior to fieldwork.
Soil Logging	Soil logging was undertaken by a suitably qualified and experienced Environmental Scientist from ENVIRON. The approximate sampling locations was recorded using GPS.
Hand Augering	A post hole digger was used to drill the first 600mm of soil from the surface. A hand auger was then used to extend each hole from 600mm to the groundwater table or refusal.
Groundwater Sampling	Where groundwater was encountered, a sampling probe with a retractable mesh tip was used to drive into the soil. The tip was retracted and a groundwater sample collected by pumping with peristaltic pump. Groundwater parameters, including pH, colour, temperature, electrical conductivity, dissolved oxygen and redox potential were recorded using a water quality meter. Groundwater sampling was undertaken by a suitably qualified and experienced Environmental Scientist from ENVIRON.
Decontamination	Non-disposable sampling equipment was decontaminated by washing in a Decon90 solution and rinsing with water between samples.
Disposal of Soil	Spoil was returned to the boreholes.

Stage 1 Data Quality Objectives

Data quality objectives for the Plume Delineation are outlined in Table 2.

Table 2: Stage 1 Data Quality Objectives

DQO	Outcome
State the Problem	Delineate the extent of leachate impacted groundwater plume, particularly to the east, north east and south east of the known plume.
Identify the Decision	Has the edge of the plume been identified in the field via groundwater sampling? What further investigations are required to meet the projects objectives?
Identify Inputs to the Decision	1) logging of the soil profile to identify the geomorphology at the site, including constraints to groundwater flow; 2) identification of the plume via groundwater sampling for pH and colour; 3) delineation of the plume using field data.
Define the Study Boundaries	The notified area identified in Figure 1. The investigation relates to soil, groundwater and surface water.
Develop a Decision Rule	The parameters of interest are the colour and pH of the intercepted groundwater. Brown colour and high pH (>9) indicates groundwater has been affected by leachate. Clear groundwater with a lower pH (<7) indicates groundwater that has not been affected by leachate.

Table 2: Stage 1 Data Quality Objectives	
DQO	**Outcome**
	The Decision Rules are: Where groundwater with a brown colour and a high pH was intercepted, it was considered to be within the leachate plume. Stepping out of sampling locations was required to identify the edges of the plume. Where sand was intercepted within sampling locations, there is potential for the plume to exist. The identification and mapping of clay strata is important to identify constraints to groundwater flow.
Specify Limits on Decision Errors	The leachate plume is known to exist within interconnected narrow sand lenses at the site. Closely spaced sampling locations were required to limit the potential for the pathway of the plume to be missed.
Optimise the Design for Obtaining Data	The design for obtaining data for this assessment included targeting areas identified as knowledge gaps following previous investigations. Additional sampling locations were completed in the field to maximise the data obtained.

Stage 1 Data Quality Indicators

Project data quality indicators have been established to set acceptance limits on field data collected as part of the Plume Delineation. The data quality indicators are outlined in Table 3.

Table 3: Stage 1 Data Quality Indicators		
DQI	**Field**	**Evaluation**
Completeness	All critical locations sampled All samples collected Experienced sampler Documentation correct	Sampling locations were identified prior to fieldwork. During fieldwork, additional locations were sampled to increase coverage of critical areas around the edges of the leachate plume
Comparability	Experienced sampler Climatic conditions appropriate for the type of analyte. Climatic conditions noted during sampling. Same types of samples collected	The sampler has over 10 years experience. Climatic conditions were noted on Daily Field sheets. The same types of samples (groundwater) were collected where groundwater was available.
Representativeness	Appropriate media sampled according to SAQP All media identified in SAQP sampled	Groundwater was sampled where it was intercepted.
Precision	Logging using the Unified Soil Classification System	See Appendix C for borehole logs.

Accuracy	Calibration of field equipment	The water quality meter was operated by suitably qualified and experienced Environmental Scientists from ENVIRON. The water quality meter was calibrated by the hire company prior to use in the field. A calibration certificate was provided.

Stage 2 Sampling, Analysis and Quality Plan
Fieldwork Methodology

The fieldwork methodology for the installation of new groundwater monitoring wells is outlined in Table 4.

Table 4: Stage 2 Field Methodology

Activity	Details
Subsurface Clearance	A Dial Before You Dig underground services check was completed prior to fieldwork.
Soil Logging	Soil logging was undertaken by a suitably qualified and experienced environmental scientist from ENVIRON.
Drilling	Due to the interbedded sands and clays and the intersection of shallow and deep groundwater within sands, drilling conditions were difficult. Drilling was completed using a combination of solid flight augers and drill tube. Drill tube was used as casing to assist with well installation for deep groundwater wells. Shallow wells were drilled to less than 2m below ground surface. Four shallow wells that were less than 0.5m deep were installed using a hand auger. Deep groundwater wells were drilled to depths ranging between 8m and 11.5m. Water table depths and saturated zones were able to be evaluated visually from soil cores obtained by direct push tubing techniques. This enabled accurate screen placement.
Well Installation	One metre slotted well screens were used for the shallow groundwater wells. One and a half metre pre-packed well screens were used for the deeper groundwater wells. The well was constructed using machine slotted 50mm or 35mm PVC screen from the base of the well to just past the intercepted groundwater depth and screw threaded 50mm or 35mm PVC casing was extend to the surface. The well annulus was backfilled with 2mm graded sand to approximately 0.5m past the top of the screen, followed by bentonite backfill for at least 0.5m, then spoil backfilled to the surface.
Well Gauging	Monitoring wells were gauged using a water interface probe.
Well Development	The new groundwater wells were developed by Hydro staff using a pump to pump each well dry.
Decontamination	Non-disposable sampling equipment was decontaminated by washing in a

Table 4: Stage 2 Field Methodology	
Activity	**Details**
	Decon90 solution and rinsing with water between samples.
Disposal of Soil	Spoil was returned to the boreholes.
Surveying	The locations and elevation of the new wells were surveyed by a registered surveyor.

Stage 2 Data Quality Objectives

Data quality objectives for the Stage 2 investigations and future groundwater monitoring are outlined in Table 5.

Table 5: Stage 2 Data Quality Objectives	
DQO	**Outcome**
State the Problem	To collect baseline and on-going monitoring data from a network of wells to understand the behaviour of the aquifer in the area of leachate impacted groundwater.
Identify the Decision	Are current monitoring wells of sufficient quality for use in on-going monitoring? Where should new monitoring wells be installed to supplement existing wells? What further investigations are required to meet the projects objectives?
Identify Inputs to the Decision	1) select appropriate existing wells for a groundwater monitoring program 2) select locations for new monitoring wells to supplement new wells 3) install new wells to supplement existing wells
Define the Study Boundaries	The notified area identified in Figure 1. The investigation relates to groundwater.
Develop a Decision Rule	Existing wells: to assess the reliability of existing wells, note information available for each well – bore logs, well installation information, depth of well screen, groundwater interval targeted (shallow or deep), availability of historical sampling data. Select existing wells with all information. New wells: the location of new wells will be selected to compliment reliable existing wells for on-going groundwater monitoring. Five sections through the leachate plume have been selected to provide monitoring data. At least two wells targeting deep groundwater and three wells targeting shallow groundwater are required per section. Sections are developed to extend to the lateral and longitudinal extent of the plume.
Specify Limits on Decision Errors	Decision errors include the incorrect selection of existing wells, the incorrect selection of new well locations, installation of wells to incorrect depths or the incorrect installation of new wells. Decision errors will be limited by visual evaluation of soil cores by using direct push tube techniques which avoids the use of water in drilling. This enables a visual evaluation of soil saturation to be undertaken and accurate well screen and seal placement.

Table 5: Stage 2 Data Quality Objectives	
DQO	**Outcome**
Optimise the Design for Obtaining Data	The design for obtaining data for this assessment included selecting existing wells for which logs and well installation information are available, selecting appropriate locations along the leachate plume to install new wells and the collection of groundwater data from the shallow and deep aquifers to optimise the information collected.

Stage 2 Data Quality Indicators

Project data quality indicators have been established to set acceptance limits on field data collected as part of the Stage 2 investigation works. The data quality indicators are outlined in Table 6.

Table 6: Stage 2 Data Quality Indicators		
DQI	**Field**	**Evaluation**
Completeness	All critical locations sampled All samples collected Experienced sampler Documentation correct	Sampling locations were identified prior to fieldwork. During fieldwork, additional locations were sampled to increase coverage of critical areas around the edges of the leachate plume
Comparability	Experienced sampler Climatic conditions appropriate for the type of analyte. Climatic conditions noted during sampling. Same types of samples collected	The sampler has over 10 years experience. Climatic conditions were noted on Daily Field sheets. The same types of samples (groundwater) were collected where groundwater was available.
Representativeness	Appropriate media sampled according to SAQP All media identified in SAQP sampled	Groundwater was sampled where it was intercepted.
Precision	Collection of blind and spent pot liningit duplicate samples	See Appendix E for borehole logs.
Accuracy	Collection of rinsate blanks	No field equipment was used that required calibration.

Appendix C

Stage 1 Borehole Logs

BOREHOLE NUMBER M2

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.1851, E151°29.2023

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; yellow, fine grained, dry.		
			1.0			Clayey SAND/sandy CLAY; grey/orange, mottled.		
			1.5			Too compact and dry, poor recovery Borehole M2 terminated at 1.5m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER N10/M3

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION**

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; yellow, fine grained		
			1.0			Clayey SAND; fine grained, orange/grey mottled, dry		
			1.5			Sandy CLAY; grey, low plasticity		
			2.0			Low recovery Borehole N10/M3 terminated at 1.8m		
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER N8/M4

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION**

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			SAND; light grey, fine grained, dry		
			1.5			Clayey SAND/sandy CLAY; grey/orange, fine grained sand		
			2.0			SAND; grey, fine grained, dry		
	▼		2.5			Getting damp more damp collapsing sand Borehole N8/M4 terminated at 2.5m		
			5.0					

BOREHOLE NUMBER N9/M5

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION**

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5 1.0 1.5			SAND; light brown, fine grained, compact		
						grading to grey sand collapsing sand Borehole N9/M5 terminated at 1.6m		
			2.0 2.5 3.0 3.5 4.0 4.5 5.0					

BOREHOLE NUMBER M6

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2033, E151°29.1928

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; fine yellow sand, slightly moist		
			1.0					
			1.5			Clayey SAND/ sandy CLAY; yellow, orange mottled, becoming SAND with some clayey, orange to yellow mottled		
			2.0					
			2.5					
			3.0			SAND; grey, slightly moist, cemented sand inclusions approx. 5mm		
			3.5			Borehole M6 terminated at 3.1m		
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M7

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2131, E151°29.2469

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						SAND; grey, saturated, minor silt/clay content		
			0.5			Borehole M7 terminated at 0.2m		
			1.0					
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M8

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2010, E151°29.2312

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5 1.0 1.5			SAND; grey/white/yellow, slightly moist, fine grained, becoming yellow Saturated at 1.4m		
			2.0 2.5 3.0 3.5 4.0 4.5 5.0			Borehole M8 terminated at 1.7m		

BOREHOLE NUMBER N4/M9

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 15/5/13 **COMPLETED** 15/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION**

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0			Silty SAND; light brown, fine grained		
	▼					Clayey SILT; black (mud), turbid water		
			0.5					
			1.0			Sandy CLAY; grey, high plasticity, fine grained clay, moist		
						Borehole N4/M9 terminated at 1.2m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M10

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2059, E 151°29.2463

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; dark grey, fine grained, moist wet, side of walls slumping dry sand		
			1.0					
			1.5			Sandy CLAY; orange/grey mottled		
			2.0			Collapsing sands at 0.5m Borehole M10 terminated at 1.6m		
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M11

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2135, E151°29.1975

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; orange, fine grained, dry		
			1.0					
			1.5			grading to grey		
			2.0			moist		
						Clayey SAND; grey, fine grained, wet		
			2.5			Collapsing sand Borehole M11 terminated at 2.4m		
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M12

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2053, E151°29.2030

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; yellow, fine grained		
			1.0					
			1.5					
			2.0			grading to grey sand		
	▼					damp wet		
			2.5			Borehole M12 terminated at 2.4m		
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M13

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2110

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						SAND; grey, saturated		
						Borehole M13 terminated at 0.1m		

0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

BOREHOLE NUMBER M14/N3

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri
PROJECT NAME Plume Delineation
PROJECT NUMBER AS130335
PROJECT LOCATION Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13
R.L. SURFACE
DATUM
DRILLING CONTRACTOR
SLOPE 90°
BEARING ---
EQUIPMENT Hand Auger
HOLE LOCATION S32°47.2085, E151°29.2287
HOLE SIZE
LOGGED BY KJG
CHECKED BY
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						SAND; grey, fine grained		
						SAND; yellow, fine grained		
			0.5					
			1.0					
						becoming grey sand		
			1.5			becoming moist		
			2.0			with some clay		
	▼		2.5			wet		
						Collapsing sand Borehole M14/N3 terminated at 2.5m		
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M15

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2034, E151°29.2281

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5 1.0 1.5			SAND; white/grey, slightly moist, becoming very moist at 1.4m		
			2.0 2.5 3.0 3.5 4.0 4.5 5.0			Borehole M15 terminated at 1.8m		

BOREHOLE NUMBER M16

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** Between N5 and N3

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; dark grey, fine grained moist augered to 600mm dry		
			1.0					
			1.5			Collapsing sands Borehole M16 terminated at 1.3m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M17

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2156, E151°29.2068

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; orange, fine grained		
			1.0			grading to grey		
			1.5					
			2.0			Collapsing sand Borehole M17 terminated at 1.9m		
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M18

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2147, E151°29.2344

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0			SAND; grey, fine grained		
			0.5			becoming moist		
	▼		1.0			water in hole		
			1.5			collapsing sands; dry under 1.4m (water only 20-30cm thick Borehole M18 terminated at 1.4m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M19

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2249, E151°29.2199

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			SAND; black/grey, fine grained		
			0.5			SAND; orange, fine grained		
			1.0			SAND; grey, fine grained, becoming moist		
	▼		1.5					
						Borehole M19 terminated at 1.6m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER N6/M20

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 15/5/13 **COMPLETED** 15/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION**

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			Silty SAND		
						Sandy CLAY, orange/grey, low plasticity		
			0.5					
			1.0					
			1.5					
			2.0					
			2.5					
			3.0					
						Borehole N6/M20 terminated at 3m		
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER N5/M21

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 15/5/13 **COMPLETED** 15/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION**

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.0			SAND; grey, fine grained		
			0.5			Sandy SILT; black		
						becoming clay, brown		
			1.0					
			1.5			Sandy CLAY; orange/grey mottled		
						Borehole N5/M21 terminated at 1.5m		
			2.0					
			2.5					
			3.0					

BOREHOLE NUMBER M22

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 16/5/13 **COMPLETED** 16/5/13 **R.L. SURFACE** --- **DATUM** ---

DRILLING CONTRACTOR --- **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** West of N1, S32°47.2246, E151°29.2387

HOLE SIZE --- **LOGGED BY** KJG **CHECKED BY** ---

NOTES ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5			SAND; grey, fine grained, moist water coming in side of hole, starting to collapse		
			1.0			CLAY; dark grey, high plasticity, moist grading to light grey, dry		
			1.5			Clayey SAND/sandy clay; grey/orange, fine grained, dry		
			2.0			grading to grey, some orange mottling		
			2.5			Borehole M22 terminated at 2.2m		
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER N1/M23

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 15/5/13 **COMPLETED** 15/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION**

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			TOPSOIL; sandy SILT, brown		
			0.5			Silty CLAY; brown/orange		
			1.0			SAND; orange, medium grained, dry with minor clay		
			1.5			more clay		
			2.0			SAND; grey, medium grained, dry		
			2.5			mottled orange with some clay grey sand, minor clay		
			3.0			CLAY; grey		
			3.5			Borehole N1/M23 terminated at 3m		
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER N2/M24

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 15/5/13 **COMPLETED** 15/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** 32°47.2348, E151°29.2869

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0			TOPSOIL		
						Clayey SAND/sandy CLAY; grey, fine grained, high plasticity, dry		
			0.5					
			1.0			some water then dry again		
	▼							
						SAND; grey, fine grained, wet		
			1.5					
						Borehole N2/M24 terminated at 1.7m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M25

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2379, E151°29.2190

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5			SAND; slightly moist, grey, fine grained, alluvial? becoming very moist to saturated at 0.7m		
			1.0			Borehole M25 terminated at 0.9m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M26

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2440, °29.2066

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5			SAND; grey, slightly moist		
			1.0			saturated, slight silt/clay content		
			1.5			becoming SAND, dark grey, slightly moist		
			2.0					
			2.5			Borehole M26 terminated at 2.2m		
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M27

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2505, E151°29.1985

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5			SAND; slightly moist, grey, fine grained saturated at 0.8m becoming tight sand, minor clay, slightly moist		
			1.0					
			1.5			Borehole M27 terminated at 1.4m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M28

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2549, E151°29.1999

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5			SAND; grey, slightly moist		
			1.0			Borehole M28 terminated at 0.8m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M29

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2593, E151°29.1976

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5			SAND; grey, black, fine grained, slightly moist SAND; light grey, slightly moist, fine grained. Seepage noted in wall of hole at 0.3m		
			1.0			Sandy CLAY; mottled orange/grey, slightly moist Borehole M29 terminated at 1.1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M30

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2583, E151°29.2061

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						SAND; slightly moist, light grey/brown, fine grained		
			0.5			Sandy CLAY, stiff, slightly moist, orange/grey mottled		
						Borehole M30 terminated at 0.7m		
			1.0					
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M31

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 17/5/13 **COMPLETED** 17/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2529, E151°29.2142

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; yellow, fine grained, slightly moist		
			1.0			Increasing clay content, becoming sandy CLAY; mottled orange/grey/brown		
						Clayey SAND; fine grained, orange/grey mottled, slightly moist		
						Borehole M31 terminated at 1.1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M32

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 21/5/13 **COMPLETED** 21/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2886, E151°29.1876

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						Clayey SAND; cream, fine grained, dry		
			0.5			Sandy CLAY; brown, high plasticity, dry grading to orange		
			1.0			Borehole M32 terminated at 1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M33

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2881, E151°29.2049

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			Clayey SAND; orange/brown, dry		
			1.0			Sandy CLAY/clayey SAND; grey/orange, mottled, high plasticity, loose grading to orange loose and dry		
			1.5			Borehole M33 terminated at 1.3m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M34

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 21/5/13 **COMPLETED** 21/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2999, N151°29.1805

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			Clayey SAND, brown/orange, fine grained, dry		
			1.0			Sandy CLAY; orange/grey mottled, high plasticity, dry		
						Borehole M34 terminated at 1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M35

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT **HOLE LOCATION** S32°47.2990, E151°29.1941

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			CLAY; grey, high plasticity, dry, hard, compact with some orange mottling		
			1.0			Borehole M35 terminated at 1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M36

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 21/5/13 **COMPLETED** 21/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT **HOLE LOCATION** S32°47.3097, E151°29.1792

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			TOPSOIL		
						SAND; grey, fine grained		
			0.5			grading to orange SAND, moist		
	▼		1.0			wet		
						Borehole M36 terminated at 1.1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M37

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT **HOLE LOCATION** South of A4, S32°47.3177, E151°29.1872

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; orange, fine grained		
			1.0			Sandy CLAY; orange/grey mottled, high plasticity		
			1.5			Borehole M37 terminated at 1.1m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M38

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 21/5/13 **COMPLETED** 21/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT **HOLE LOCATION** S32°47.3198, E151°29.1775

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			SAND; brown, fine grained		
			0.3			SAND; grey, fine grained, dry		
			0.5					
			1.0			Sandy CLAY/clayey SAND; fine grained, high plasticity, moist, grey, no mottling with some tree roots		
	▼		1.5					
			2.0			CLAY; orange/grey mottled, high plasticity with some sand		
						Borehole M38 terminated at 2m		
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M39

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT **HOLE LOCATION** S32°47.3237, E151°29.1797

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; grey, fine grained, dry		
			1.0			CLAY; orange/grey mottled, high plasticity, dry		
						Borehole M39 terminated at 1m		

BOREHOLE NUMBER M40

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 21/5/13 **COMPLETED** 21/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT **HOLE LOCATION** S32°47.3320, E151°29.1650

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0			SAND; grey, fine grained		
			0.5			SAND; orange, fine grained moist		
			1.0			Sandy CLAY; grey/orange, mainly grey, medium plasticity		
			1.5			becoming clayey SAND; orange/grey, dry		
						Borehole M40 terminated at 1.5m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M41

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 21/5/13 **COMPLETED** 21/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** 20m South of A4

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						SAND; brown, fine grained		
						SAND; grey, fine grained		
						SAND; orange, fine grained		
			0.5			CLAY; orange/brown, high plasticity, cry		
			1.0			grading to orange/grey with some sand		
						Borehole M41 terminated at 1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M42

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 15/5/13 **COMPLETED** 15/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION**

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			Sandy SILT; brown, some refractory brick		
			0.5			CLAY; brown/orange, high plasticity, with some sand, dry		
			1.0					
			1.5			Borehole M42 terminated at 1.5m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M43

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 15/5/13 **COMPLETED** 15/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION**

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0			Clayey SILT; brown		
						CLAY; brown/orange, high plasticity, dry		
			0.5					
			1.0					
			1.5					
						Borehole M43 terminated at 1.6m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M44

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 15/5/13 **COMPLETED** 15/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION**

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			Sandy SILT; cream		
						Sandy CLAY; brown/orange, high plasticity, dry		
			0.5					
			1.0					
			1.5			becoming sandier		
						Borehole M44 terminated at 1.7m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M45

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 15/5/13 **COMPLETED** 15/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION**

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			Sandy SILT; cream, dry		
			0.5			Silty CLAY; brown/orange, high plasticity, dry		
			1.0			Clayey SAND; light grey, medium grained		
			1.5			Sandy CLAY; grey, high plasticity, dry		
			1.6			Borehole M45 terminated at 1.6m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M46

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 15/5/13 **COMPLETED** 15/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** West of N2, 32°47.2344, 151°29.2589

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			TOPSOIL; clayey SAND, brown, fine grained		
			0.5			SAND; grey, fine grained, well compacted, moist		
			1.0			Sandy CLAY/clayey SAND; grey/yellow, fine grained, low plasticity, dry		
			1.1			Borehole M46 terminated at 1.1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M47

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2511, E151°29.2179

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			SAND; light grey, fine grained, dry		
			0.5			Sandy CLAY; grey/brown, high plasticity		
						CLAY; black, high plasticity		
			1.0			Sandy CLAY; orange/grey mottled, high plasticity, dry		
						Clayey SAND/sandy CLAY; orange, high plasticity, dry		
			1.5			grading to orange/grey, mottling		
			2.0			Borehole M47 terminated at 1.9m		
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M48

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2470, E151°29.2244

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						SAND; grey, fine grained		
						Sandy CLAY; brown/grey, high plasticity		
			0.5			CLAY; black, high plasticity		
			1.0			Sandy CLAY; orange/grey, high plasticity		
						Borehole M48 terminated at 1.2m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M49

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2448, E151°293.2345

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			SAND; grey, fine grained		
			0.2			Sandy CLAY; brown/grey, high plasticity		
			0.5			CLAY; black, high plasticity		
			0.8			Sandy CLAY; orange/grey mottled, high plasticity, dry		
			1.0			Borehole M49 terminated at 1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M50

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2541, E151°29.2158

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						SAND; grey, fine grained		
						Sandy CLAY; brown/grey		
			0.5			CLAY; black, high plasticity		
			1.0			Sandy CLAY; orange/grey mottled, high plasticity, dry		
						Borehole M50 terminated at 1.1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER MW51

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2649, E151°29.2054

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						Clayey SAND; brown, fine grained		
						CLAY; black, high plasticity		
			0.5					
			1.0			grading to lower plasticity, green/grey mottling		
						Sandy CLAY; orange/grey, mottled, high plasticity		
						Borehole MW51 terminated at 1.3m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M52

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.1976, E151°29.2395

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5 1.0			SAND; grey, fine grained		
			1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0			Borehole M52 terminated at 1.4m		

BOREHOLE NUMBER M53

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.1888, E151°29.2452

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5 1.0 1.5			SAND; grey, fine grained grading to yellow sand, moist		
			2.0 2.5 3.0 3.5 4.0 4.5 5.0			Borehole M53 terminated at 1.6m		

BOREHOLE NUMBER M54

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** 7m East of N9, S32°47.1878, S151°29.2502

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; grey, fine grained, dry		
			1.0			becoming wet with some clay (orange)		
			1.5			Clayey SAND/sandy CLAY; orange/grey mottled, becoming drier		
			2.0			Borehole M54 terminated at 1.8m		
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M55

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** East of N9, S32°47.1838, E151°29.2671

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0			SAND; grey, fine grained		
			0.5			grading to orange sand, moist, with some clay		
	▼		1.0			wet		
						Sandy CLAY/clayey SAND; orange/grey mottled, high plasticity		
						Borehole M55 terminated at 1.3m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M56

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** North of N4, S32°47.1924, E151°29.2549

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						SAND; grey, fine grained, dry		
			0.5			Sandy CLAY; black, high plasticity, moist, caving in		
						CLAY; black, high plasticity		
			1.0			Sandy CLAY/clayey SAND; grey/orange mottled, high plasticity, dry		
						Borehole M56 terminated at 1.2m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M57

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 20/5/13 **COMPLETED** 20/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** West of N4, S32°47.1935, E151°29.2514

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; grey, fine grained, moist		
			1.0			Clayey SAND/sandy CLAY; grey/orange mottled, dry		
			1.5			Borehole M57 terminated at 1.2m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M58

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** Entrance to D71, S32°47.2670, E151°29.1895

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5			SAND; grey, fine grained, wet collpsed back to 0.3m		
			1.0			Borehole M58 terminated at 0.6m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M59

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2547, E151°29.1911

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0			SAND; grey, fine grained		
			0.5					
			1.0			becoming wet		
						becoming dry		
	▼					Clayey SAND; black/grey, fine grained, moist		
			1.5			grading to SAND, grey with some clay		
						CLAY; grey, high plasticity		
						SAND; grey, fine grained, moist		
			2.0			Borehole M59 terminated at 1.7m		
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M60

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2467, E151°29.1896

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			SAND; grey, fine grained		
	▼		1.0			Borehole M60 terminated at 1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M61

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2397, E151°29.1917

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0			Silty SAND; brown, fine grained, dry		
						SAND; grey, fine grained		
			0.5					
			1.0			SAND, yellow, fine grained		
						wet		
						Borehole M61 terminated at 1.2m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M62

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR _____ **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2398, E151°29.1590

HOLE SIZE _____ **LOGGED BY** KJG **CHECKED BY** _____

NOTES _____

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			SAND; grey, fien grained, dry		
			0.5			SAND; brown, fine grained, moist		
	▼		1.0			wet Borehole M62 terminated at 1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M63

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2732, E151°29.1797

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0			SAND; grey, fine grained		
						SAND; orange, fine grained		
	after 1 hour ▼		0.5					
			1.0			SAND; grey, fine grained, moist		
	▼		1.5			wet Borehole M63 terminated at 1.5m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M64

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2710, E151°29.1734

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			SAND; grey, fine grained		
			0.5			SAND; orange, fine grained, dry		
			1.0			SAND; yellow, fine grained, dry		
			1.5			SAND; grey, fine grained, dry		
			2.0			Borehole M64 terminated at 1.9m		
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M65

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.2461, E151°29.1732

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			TOPSOIL; silty SAND; brown, fine grained, dry		
			0.5			SAND; cream/yellow, fine grained, dry		
			1.0			Clayey SAND; yellow with some brown cemented pieces, fine grained, dry		
						SAND; yellow, fine grained, dry with some compact sand, rootlets		
			1.5			loosened up		
						Borehole M65 terminated at 1.8m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M66

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** Upgradient of M63, near S12

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0			TOPSOIL; silty SAND; black		
						SAND; grey/cream, fine grained, dry		
			0.5					
						Clayey SAND; orange, fine grained with some tree roots, dry		
			1.0					
						grading to sandy CLAY		
			1.5					
	▼					SAND, grey, fine grained, wet		
						Borehole M66 terminated at 1.8m		
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M67

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** --- **DATUM** ---

DRILLING CONTRACTOR --- **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** 4m North of M56, S32°47.1902, E151°29.2598

HOLE SIZE --- **LOGGED BY** KJG **CHECKED BY** ---

NOTES ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.0			SAND; cream, fine grained		
			0.5			CLAY; grey, high plasticity		
						Sandy CLAY; grey, high plasticity		
			1.0			SAND; grey, grading to clayey sand		
						Clayey SAND/sandy CLAY; orange/grey mottled		
						Borehole M67 terminated at 1.3m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M68

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** 8m North of M67, S32°47.1873, E151°29.2644

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0			SAND; black, fine grained		
						SAND; grey, fine grained		
			0.5			wet		
	▼					CLAY; grey, high plasticity with some sand, rootlets		
			1.0			SAND; grey on end of hole Borehole M68 terminated at 1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M69

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** 12m North of M67 in gully

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5			SAND; grey, fine grained, dry		
						CLAY; black/grey, high plasticity, with some rootlets, moist		
						CLAY; dark grey/orange mottled, dry, high plasticity		
			1.0			Borehole M69 terminated at 0.9m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M70

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** 5m West of M69

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.0			TOPSOIL; silty SAND; dark brown, fine grained		
						SAND; grey, fine grained, moist		
	▼		0.5			wet		
			1.0			Clayey SAND/sandy CLAY; grey, some orange, fine grained, hihg plasticity, drying up, some mottling		
						Borehole M70 terminated at 1.1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

BOREHOLE NUMBER M71

ENVIRON

CLIENT Hydro Aluminium Australia Kurri Kurri **PROJECT NAME** Plume Delineation

PROJECT NUMBER AS130335 **PROJECT LOCATION** Kurri Kurri

DATE STARTED 22/5/13 **COMPLETED** 22/5/13 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR **SLOPE** 90° **BEARING** ---

EQUIPMENT Hand Auger **HOLE LOCATION** S32°47.1937, E151°29.2624

HOLE SIZE **LOGGED BY** KJG **CHECKED BY**

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
	▼		0.5			SAND; grey, fine grained, moist		
						CLAY; grey, high plasticity, moist		
			1.0			Clayey SAND/sandy CLAY; orange/grey mottled, dry		
						Borehole M71 terminated at 1m		
			1.5					
			2.0					
			2.5					
			3.0					
			3.5					
			4.0					
			4.5					
			5.0					

Appendix D

Stage 1 Sampling Results

Results of Groundwater Sampling							
Borehole ID	**Depth to Groundwater**	**Location**	**Colour**	**pH**	**EC mS/cm**	**Dissolved Oxygen**	**Redox mV**
M4	2.3m	North, near N8	NR	6.3	10.17	-	28.6
M5	1.5	North, near N9	NR	9.1	8.3	0.25mg/L	180.7
M7	Surface seep	In the central west of the Northern Vegetation Impact Area	brown	8.9	3.5	8.49	280.8
M9	0.3	In the north of the Northern Vegetation Impact Area, near N4	Clear (turbid)	6.2	4.5	6.36	123.7
M10	0.3	In the north west of the Northern Vegetation Impact Area	brown	9.2	10.11	NR	167.7
M11	2.3	North, near E11	NR	8.4	2.6	NR	-81.9
M13	Surface seep	In the central west of the Northern Vegetation Impact Area	brown	9.0	NR	5.17	242.1
M14	2.4	North, near N3	clear	7.5	9.6	NR	-25.3
M16	0.3	In the central west of the Northern Vegetation Impact Area, between N5 and N3	brown	8.7	9.7	NR	-8.3
M18	1.0	In the south west of the Northern Vegetation Impact Area	NR	8.5	10.3	7.71	-175.5
M19	1.5	North, north of E10	NR	7.8	2.5	4.73	231.4

Results of Groundwater Sampling							
Borehole ID	**Depth to Groundwater**	**Location**	**Colour**	**pH**	**EC mS/cm**	**Dissolved Oxygen**	**Redox mV**
M21	0.4	In the central west of the Northern Vegetation Impact Area, near N5	brown	8.8	NR	NR	NR
M22	0.4	North, west of N1	NR	7.6	3.6	NR	78.1
M26	0.8	In the central west of the Southern Vegetation Impact Area	NR	8.5	9.2	6.95	162
M28	0.4	In the south west of the Southern Vegetation Impact Area	NR	9.5	NR	10.65	246.7
M38	1.7	South, south of E4	clear	6.8	11.72	2.02	-17
M52	1.0	North, to the west of the Northern Vegetation Impact Area south of N8	cloudy	9.4	15.21	1.22	-188.3
M53	1.5	North, south of N9	cloudy	9.2	7.8	8.61	-40.8
M54	1.7	North, east of N9	NR	8.8	NR	10.22	107.3
M56	0.4	In the north west of the Northern Vegetation Impact Area	NR	8.0	4.3	1.09	-139.5
M58	0.3	At the south west corner of the Southern Vegetation Impact Area	brown	9.6	7.3	7.07	-121.2
M59	1.3	Near the south west corner of the Southern Vegetation Impact Area	brown	9.8	18.07	7.48	-16.1
M60	1.0	To the west of the Southern Impact Vegetation Area	cloudy	9.7	NR	10.2	23.3
M63	0.8	To the west of the Southern Impact Vegetation Area	NR	8.9	7.0	6.98	214
M67	0.4	In the north west of the Northern	cloudy	8.7	4.5	7.80	167.7

Results of Groundwater Sampling							
Borehole ID	**Depth to Groundwater**	**Location**	**Colour**	**pH**	**EC mS/cm**	**Dissolved Oxygen**	**Redox mV**
		Vegetation Impact Area					
M68	0.7	In the north of the Northern Vegetation Impact Area	NR	8.1	4.1	5.52	85.3
M71	0.6	In the west of the Northern Vegetation Impact Area	NR	8.9	8.7	7.63	40.8

NR – Not recorded

Appendix E

Stage 2 Borehole Logs