Pluton Resources

Report for Irvine Island Mine Pre-Feasibility Study

Groundwater Investigations

July 2011

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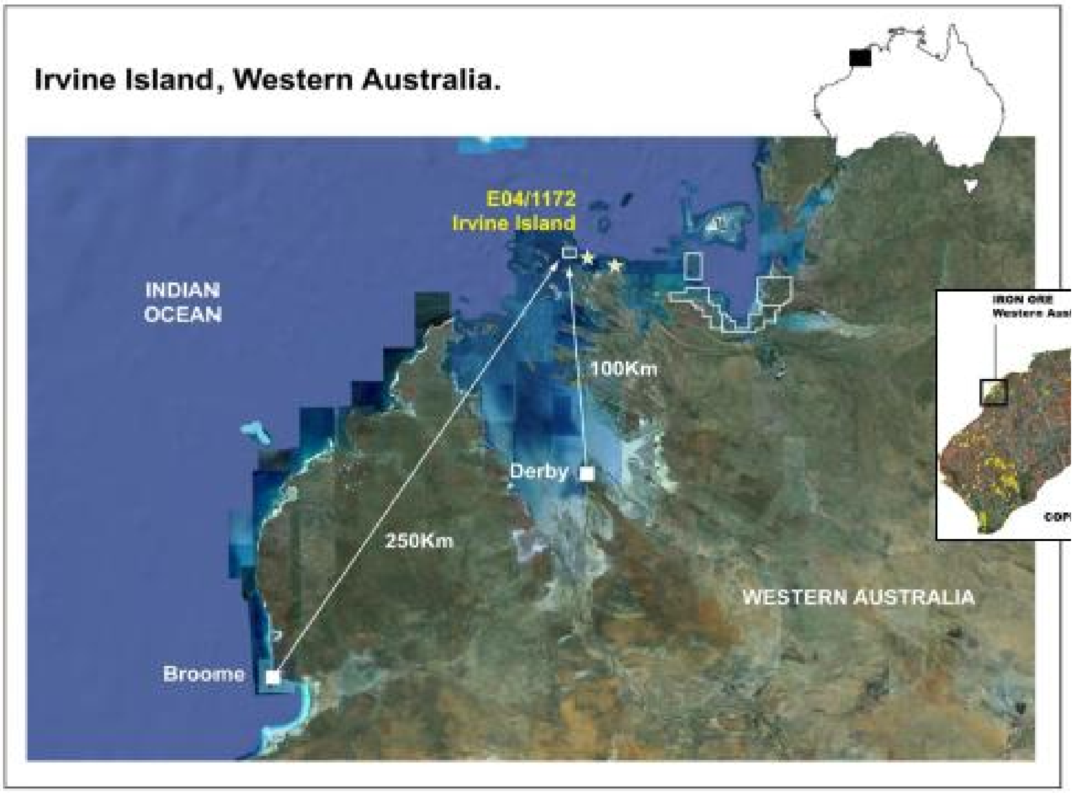
1. Introduction

Pluton Resources are currently undertaking exploration drilling on Irvine Island located to the northwest of Derby, Western Australia.

Extensive studies are being undertaken as part of a mine pre-feasibility study. These studies include the mine planning, geotechnical, hydrogeological, metallurgical and environmental studies and facilitate the data collection for these studies during the on-going exploration drilling phase.

The mining options being considered for the Hardstaff Peninsula include open cut, underground mining and a combination of the two with the possible extension of the underground operations under the shallow bay to the west of the Peninsula. Mining is also being considered in the Isthmus area.

Figure 1 Site Location



1.1 Project Objectives Scope

The Hydrogeological Assessment for Irvine Island has been undertaken to support the Irvine Island pre-feasibility study (PFS) and public environmental review (PER). Pluton Resources aims to complete the PFS and submit the PER in November 2011.

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The original scope of the hydrogeological investigations was developed in August 2010, and this has been re-evaluated on the basis of works undertaken to date and the Environmental Consultant Workshop and Scoping Meeting held in December, 2010 and discussions between GHD and Pluton on 17th December 2010. Other hydrological work related to environmental studies is reported in GHD 2011.

The purpose of this report is to describe the hydrogeological conditions in the project area. Specifically this report aims to provide details of:

- The groundwater monitoring bore network installed on the site;
- Groundwater level data obtained to date and trend analysis;
- Groundwater sampling and analysis of analytical results obtained to date;
- Aquifer testing and analysis of results, for estimation of hydraulic conductivity;
- Numerical groundwater modelling and preliminary assessment of pit groundwater inflows and the impact of mining on the surrounding groundwater and related ecosystems; and
- Assessment of Acid Sulphate soils in the mangroves and impacts from dewatering

2. Site Characteristics

2.1 Climate

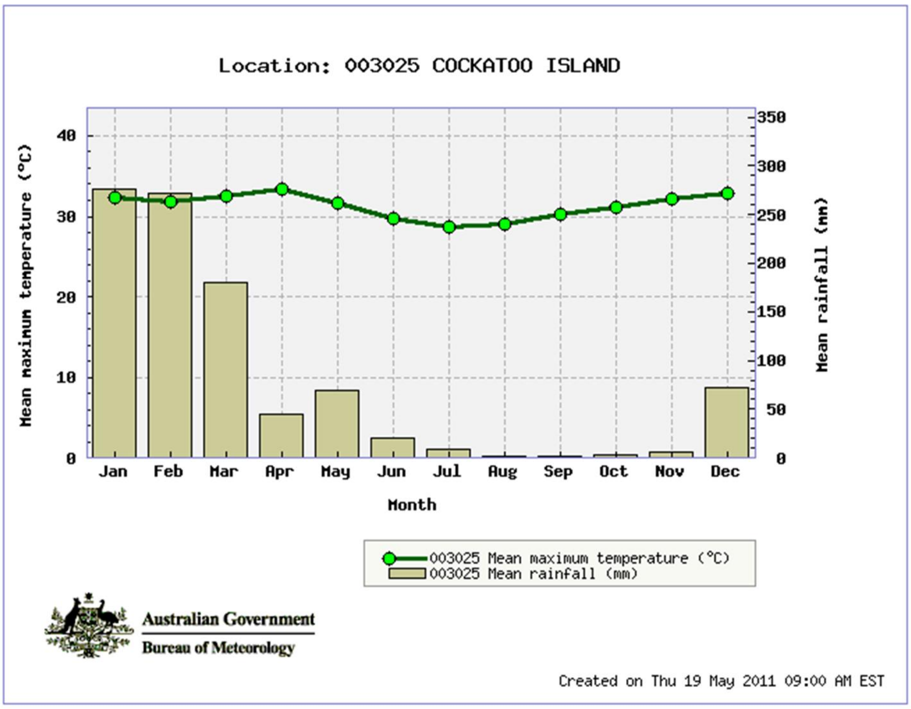
broadly 9 and 3 months long respectively. Climate information is available from the nearby Cockatoo Island (BOM, 2011, http://www.bom.gov.au/climate/averages/tables/cw_003025.shtml) for the period of 1948 to 1982 .Contemporary climate information is available from Cygnet Bay at One Arm Point (Bardi) on the Dampier Peninsula, approximately 70 km away from Irvine Island, for the period of 1985 to 2011 (BOM, 2011).

Temperatures are relatively constant with mean maximum temperatures at nearby Cockatoo Island ranging from 28.7°C in July to 33.4°C in April for Cockatoo Island and from 28.2 in July to 35.3 in November for Cygnet Bay (Figure 2).

High rainfall events are commonly associated with tropical low pressure systems and cyclones. Being associated to such low pressure systems, rainfall is highly variable (Figure 3) and (

Figure 5) Tropical cyclones in the region have been recorded in every month of the year throughout the historical record (BOM, 2011, http://www.bom.gov.au/cyclone/history/index.shtml), however, are more likely to occur during the summer and autumn months (December through May).

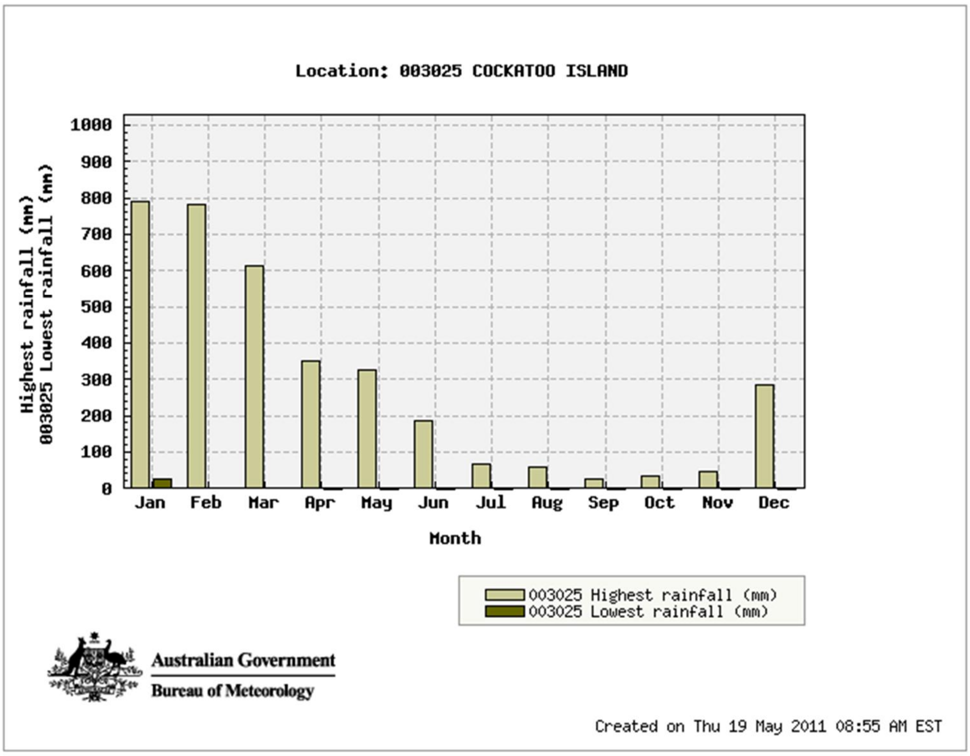
Figure 2 Cockatoo Island climate statistics, mean maximum temperature and mean rainfall (BOM, 2011)



Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean maximum temperature (°C) for years 1948 to 1982	32.4	31.9	32.6	33.4	31.7	29.7	28.7	29.1	30.2	31.1	32.2	32.9	31.3	24
Statistics	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**	**Years**
Mean rainfall (mm) for years 1948 to 1984	276.2	271.8	179.3	45.5	68.7	19.9	8.7	1.9	1.4	3.4	6.2	72.4	973.2	34

12.3 = Not quality controlled

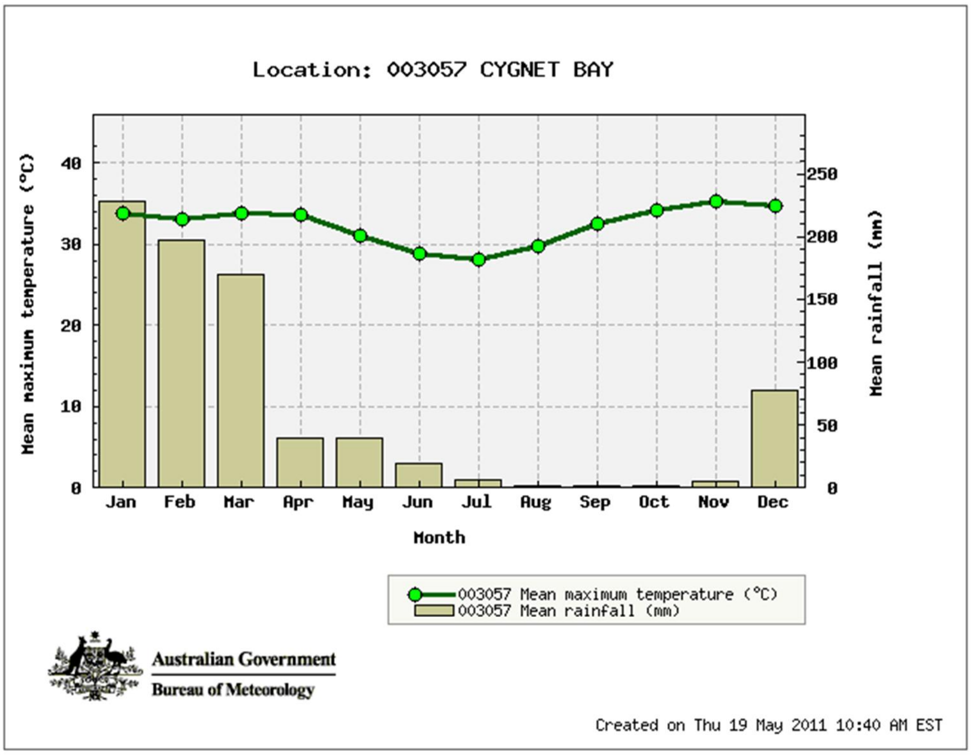
Figure 3 Cockatoo Island climate statistics, rainfall variability (BOM, 2011)



Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Highest rainfall (mm) for years 1948 to 1984	790.3	781.1	613.2	352.3	325.1	185.0	67.2	58.7	23.6	33.6	47.0	284.1	1603.1	34
Statistics	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**	**Years**
Lowest rainfall (mm) for years 1948 to 1984	27.5	2.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	304.6	34

12.3 = Not quality controlled

Figure 4 Cygnet Bay climate statistics, mean maximum temperature and mean rainfall (BOM, 2011)

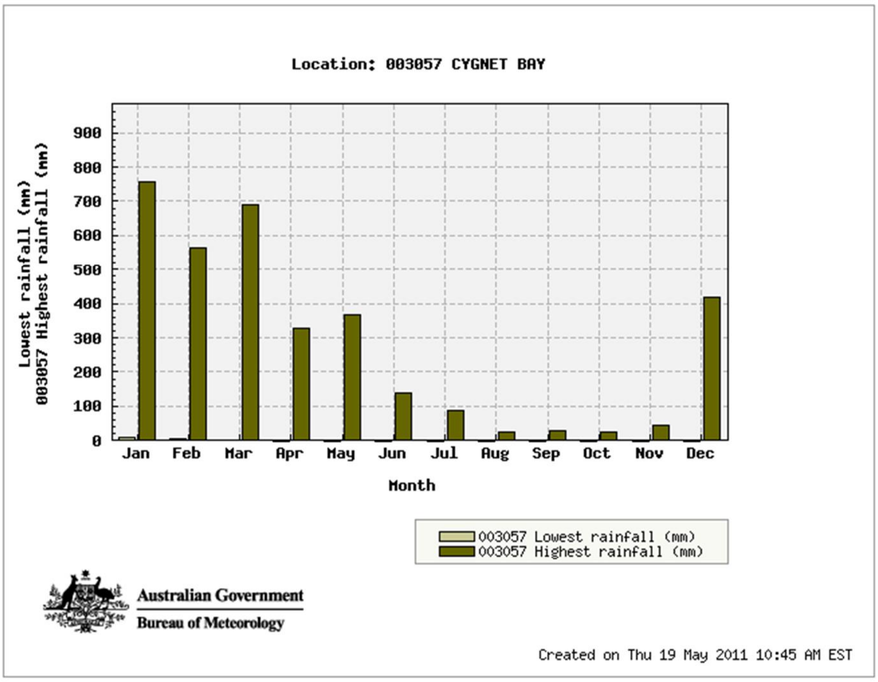


Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean maximum temperature (°C) for years 1985 to 2011	33.9	33.1	33.8	33.6	31.1	28.8	28.2	29.7	32.5	34.2	35.3	34.7	32.4	24
Statistics	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**	**Years**
Mean rainfall (mm) for years 1963 to 2011	228.3	197.4	169.5	39.9	39.9	19.3	6.6	1.1	1.4	1.6	5.0	77.1	794.1	47

12.3 = Not quality controlled

Figure 5 Cygnet Bay climate statistics, rainfall variability (BOM, 2011)

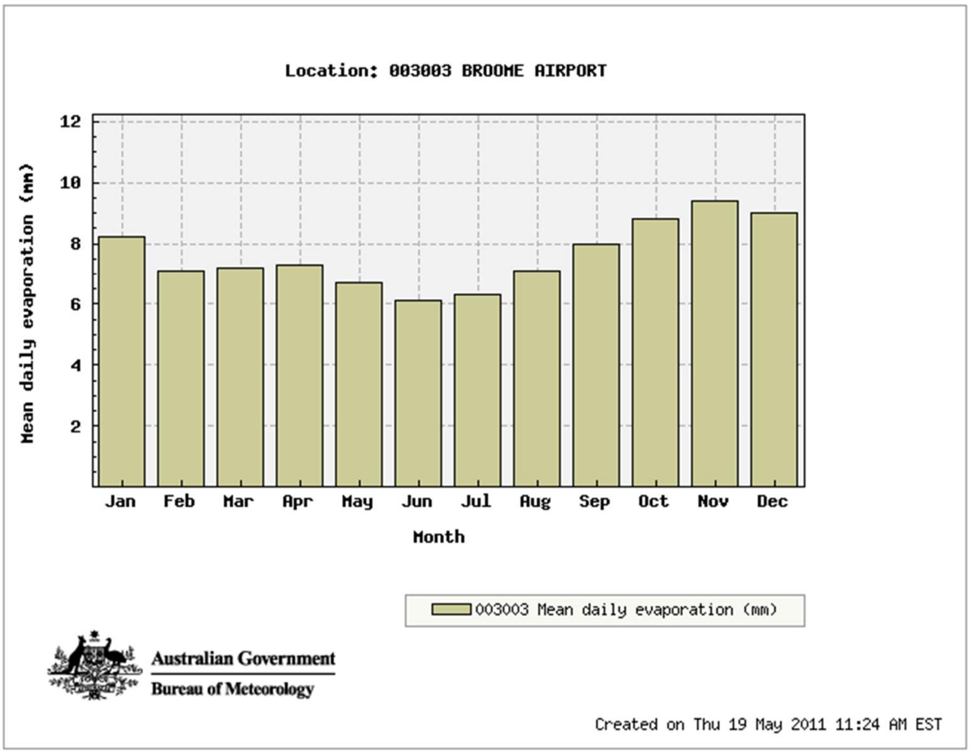
Mean daily evaporation data is available from Broome Airport for the period of 1968 to 2011 (BOM, 2011 http://www.bom.gov.au/climate/averages/tables/cw_003003_All.shtml). The mean daily evaporation average is 7.6 mm over these 43 years of data.



Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Lowest rainfall (mm) for years 1963 to 2011	10.5	4.5	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	170.2	47
Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Highest rainfall (mm) for years 1963 to 2011	757.2	563.1	688.5	327.0	365.6	138.8	86.8	24.0	27.0	25.0	42.9	416.4	1547.1	47

12.3 = Not quality controlled

Figure 6 Cygnet Bay climate statistics, mean daily evaporation (BOM, 2011)



Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean daily evaporation (mm) for years 1968 to 2011	8.2	7.1	7.2	7.3	6.7	6.1	6.3	7.1	8.0	8.8	9.4	9.0	7.6	43

12.3 = Not quality controlled

2.2 Topography

Irvine Island is one of the larger islands of the Buccaneer Archipelago off the Kimberley coast. These Islands typically comprise rocky undulating terrain closely associated to their individual geological structures.

The Hardstaff Peninsula on Irvine Island has high cliffs on its eastern side (Figure 7) and undulating terrain to the west and south. Either side of the Hardstaff Peninsula, are large shallow bays which empty to varying extents depending on tidal movements (Figure 7). Tidal fluctuations in the Buccaneer Archipelago are extreme, in the range of 11 m.

The Isthmus area separates the open shallow bay to the east of the Hardstaff Peninsula from a shallow mangrove covered bay on the north side of the island. The Isthmus is in the order of 150 m across and comprises sandy beach and rocky cliffy face on the southern side and an undulating rocky terrain to the north.

Figure 7 The eastern cliffs of the Hardstaff Peninsula from the Isthmus area

(http://www.plutonresources.com/projects)

2.3 Hydrology / Drainage

All drainage features appear to be ephemeral and no known permanent water pools are known to occur on the island. The most prominent drainage feature appears to be structurally controlled along a NW-SE striking lineament to the north of the Hardstaff Peninsula (Figure 8). Other drainage features drain small catchment in the undulating terrain and all flow ephemerally into the ocean.

More details on the site hydrology are described in the hydrology report for this project (GHD 2011).

LEGEND

Contours (m AHD)

Minor 5m Contours

Major 50m Contours

1:25,000 (at A4)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 51

N

GHD

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Pluton Resources
Irvine Island Pre Feasibility Groundwater Study

Job Number	31-2559600
Revision	A
Date	07 JUL 2011

Contour Plan of Irvine Island

Figure 8

Path: G:\31\2559600\GIS\Maps\mxds\312559600_ContourPlan.mxd

180 Lonsdale Street Melbourne VIC 3000 T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au W www.ghd.com.au

Data source: Client Created by: Cillingworth

3. Stratigraphy and Geological structure

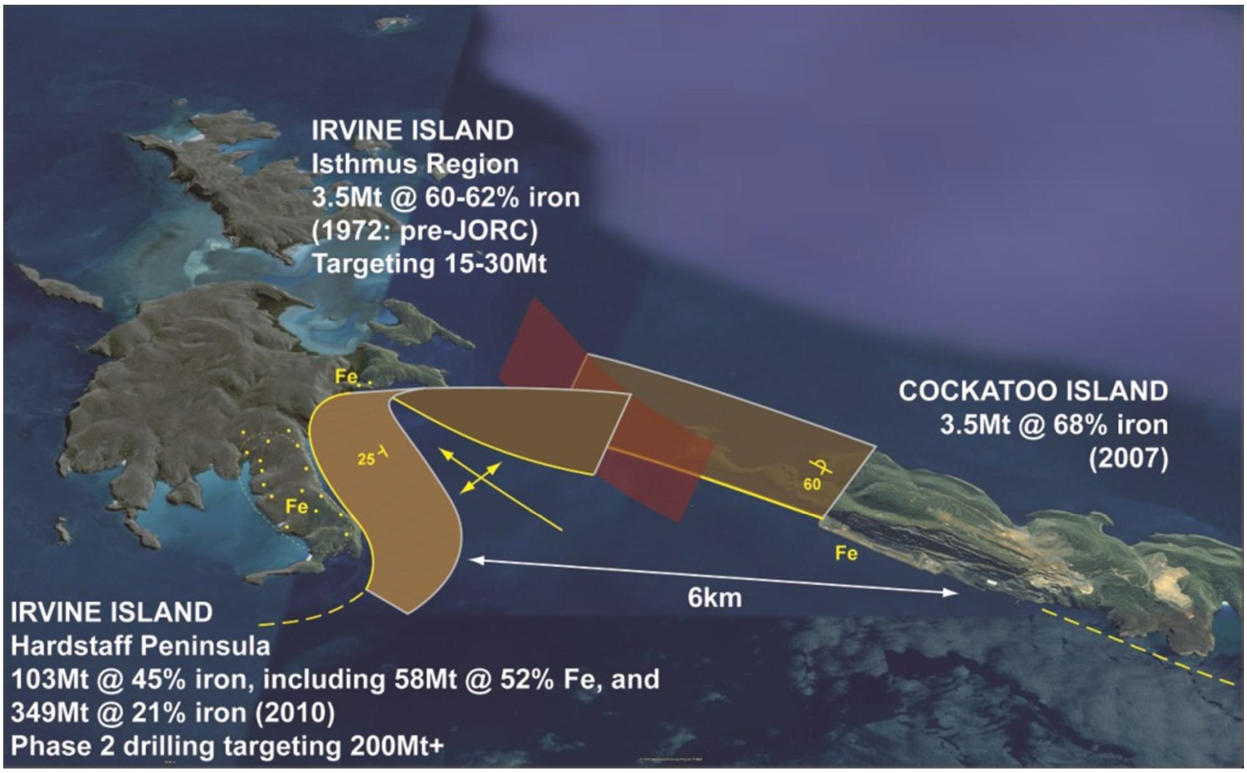
3.1 Regional Stratigraphy

The geology of Irvine island comprises an extension to the stratigraphy and structure occurring on Cockatoo and Koolan islands in the Yampi sound area, (Figure 9).

Within the Yampi Sound area stratigraphy of the region in relation to iron deposits, rock units of the Kimberley Group dominate. A summary of the geology of the area with a focus on the iron ore deposits is presented by Stocklmayer (1990).

Stocklmayer referred to the key units on island from as the Elgee siltstone which is disconformably overlain by the Yampi Member that comprises the ore horizon on Irvine Island. The overlying unit, mapped as the Pentecost Sandstone by Stocklmayer (1990), is subdivided in this project into the Sandfly Schist and the Wonganin Sandstone.

Figure 9 Irvine Island deposit geometry and resource



(http://www.plutonresources.com/wp-content/uploads/Irvine_orebode_Geometry-Dec_2010-01.jpg) (*From Pluton resources*)

The Elgee Siltstone underlies the Yampi Member, and is best exposed on Koolan and Irvine Islands. Throughout most of its thickness the Elgee Siltstone comprises alternating thinly bedded mudstone and laminated shale with sandier intervals at the base.

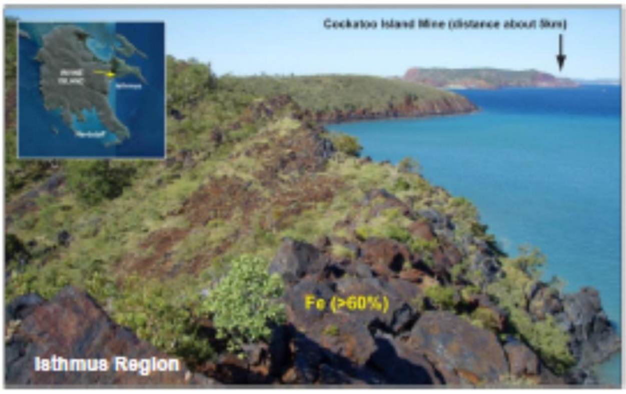
The Yampi Member, which disconformably overlies the Elgee siltstone is characterised by a high iron content and is the ore zone on Irvine Island. It comprises well bedded, hematite earil?g (accessory hematite) and hematite (hematite a major constItuent) sandstones. Stocklmayer reports the presence of phyllite and conglomerate intercalations are underlain by an impersistent basal conglomerate that is best developed on Koolan and Irvine Islands.

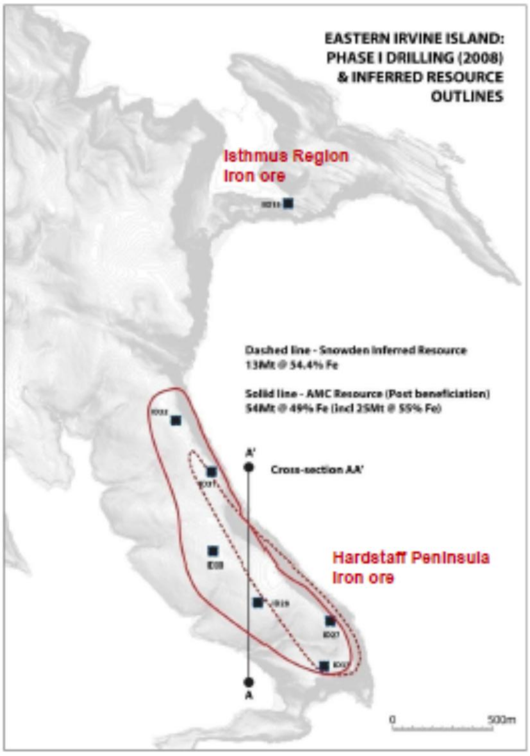
Numerous narrow phyllitic horizons immediately above the ferruginous basal ore zone (Yampi Member) are persistent, and provide excellent marker horizons. On Irvine Island these units are inferred to equate to the Sandfly Schist. The Wonganin Sandstone, described on Irvine Island in this project as the upper most unit on the island, is probably the equivalent to the Pentecost sandstone of Stocklmayer.

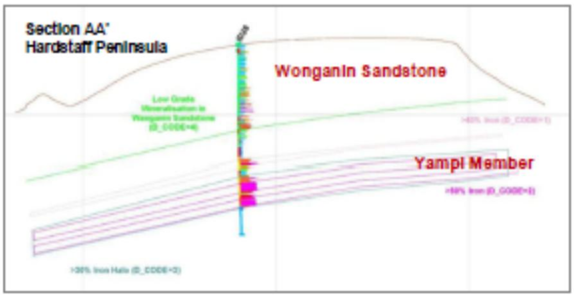
3.2 Geological Structure

The ·structural pattern is dominated by tight asymmetrical folds extending from Koolan Island to Irvine Island. On Koolan Island the southern limb of the folds are overturned (Stocklmayar, Figure 1). As this limb extends to Irvine Island the sequence is folded into a plunging anticline the nose of which is exposed in the Isthmus on Irvine Island (see Figure 9)

In contrast to the more structurally complex Isthmus area, the on the Hardstaff Peninsula the formations are understood to be uniformly dipping to the southwest at around 20º to 25º. Limited information on the geology and structure of the far western side of the island is available although GHD understands that some airborne geophysical surveys have been completed.







From Pluton Resources statement, Oct 2009,

3.3 Hydrogeological Units

For the purposes of this investigation, the geological units encountered in this investigation are treated as separate hydrogeological units and are thus treated as an inter-layered sequence of aquifers and aquitards. The hydraulic properties of the geological formations and the structure/geometry of these formations are the subject of this investigation.

3.3.1 Hardstaff Peninsula

The distribution of aquifer units in the Hardstaff Peninsula is controlled by the relatively "layer cake" southwesterly dipping geological sequence, comprising:

Wonganin Sandstone: - the uppermost unit that outcrops across the peninsula, aquifer potential unknown; rainfall recharge occurring to this unit has potential for a perched aquifer to form at the base of the unit;

Sandfly Schist and Siltstone: – understood to be uniform across the site and 25 metres thick; it has the potential to be a low permeability layer on which a seasonal perched aquifer could form and depending on the secondary permeability of the unit (which will be controlled by the degree of fracturing), could limit recharge to underlying units.

Yampi Member: ***the orebody*****;** has shown moderate permeability along joints and beds in sandstone on nearby islands.

Elgee Siltstone: – known to be a low permeability hydraulic barrier on nearby islands limiting mining impacts on adjacent area across strike. Outcrops along the base of the cliff along the eastern side of the peninsula and then dips down below sea level further northern eastern coast. (Structure contours to show the distribution)

3.3.2 Isthmus

The Isthmus area is understood to be comprised of the same hydrogeological units as the Hardstaff Peninsula but is structurally more complex with overturned folds and steeply dipping strata.

The mining options of the Isthmus area being considered are understood to include both mining of the ore above and below the water table including open cut mining to 65 metres below sea level.

The proximity of the Isthmus area to the mangrove and potential groundwater dependant ecosystems (GDEs) will require further investigations in this area to determine the elevation of the water table in this area and characterise the aquifer parameters and flow systems.

4. Scope of the Hydrogeological Investigation

The hydrogeological assessment used in the geotechnical investigations and environmental impact assessment has focussed on the likely mining areas in the Hardstaff Peninsula and Isthmus area. The hydrogeological site investigations have been and will continue to be directed towards understanding the hydrogeological regime on the island, including hydraulic properties of the formations intersected, vertical saltwater profile (halocline), groundwater flow patterns, recharge and discharge processes and groundwater quality.

In addition, the project has an environmental investigation component that includes establishing a monitoring network for subterranean fauna in the mine area and in a non-impact area to the northwest.

The scope of work includes a field testing and sampling program. The results have been analysed to estimate the aquifer parameters such as the hydraulic conductivity and storativity and characterise the groundwater quality across the site. A conceptual groundwater model has been developed characterising the groundwater flow systems and used as a basis for groundwater modelling to provide preliminary estimates of groundwater inflows to the proposed mine development. To date the modelling work has been restricted to the Hardstaff Peninsula.

Modelling of the structurally more complex Isthmus area is awaiting final surfaces of the various geological units, as well as updates on water levels from the recently installed bores.

4.1 Major Activities

The major hydrogeological related activities that have been undertaken can be summarised as:

- Establishment of a network of groundwater monitoring bores in the mine areas and beyond for monitoring groundwater level, groundwater quality and assessment of stygofauna- and troglofauna. The monitoring bore network comprises of bores that have been drilled for mineral resource investigation and converted to groundwater monitoring bores.
- Characterisation of the aquifers present and their hydraulic properties and groundwater quality.
- Preliminary estimate of groundwater inflows (i.e. rates, volumes) into the proposed mine over the development period using analytical methods. The results will be required for preliminary design of the water management systems and in producing a site water balance.
- Preliminary assessment of the groundwater quality of mine inflows to input in the mine water management treatment systems and environmental impacts. This will be based on the proposed mine plan and predicted drawdowns from the analytical groundwater modelling. It will include a preliminary assessment for the potential for saline groundwater intrusion into the aquifer over time.
- Preliminary assessment of potential impact of the proposed mine development on groundwater dependant ecosystems if they are identified in the region.
- Identification of areas where additional hydrogeological investigations may be recommended to further assess mine dewatering requirements.

4.2 Drilling Investigations

4.2.1 Drilling Program

Exploration drilling is continuing on the Peninsula and the Isthmus and the hydrogeological investigation is based around the siting of the drilled exploration bores. This is necessitated by the remoteness of the site, the need to coordinate the presence and minimise the potential impact of heavy equipment on the island.

The bores on the island have been drilled for mineral exploration, geotechnical and hydrogeological investigations. There are a number of angled holes. Bores have been drilled in the vicinity of the proposed operational areas, and to date the bores drilled are in the operating areas of the Hardstaff Peninsula and at a number of locations in the Isthmus. Borehole locations are shown in Figure 10 and listed in

Table 1. A more detailed plan of the boreholes in the Isthmus area is shown in Figure 11

A summary of the bores used for the purpose of this hydrogeological study are detailed in

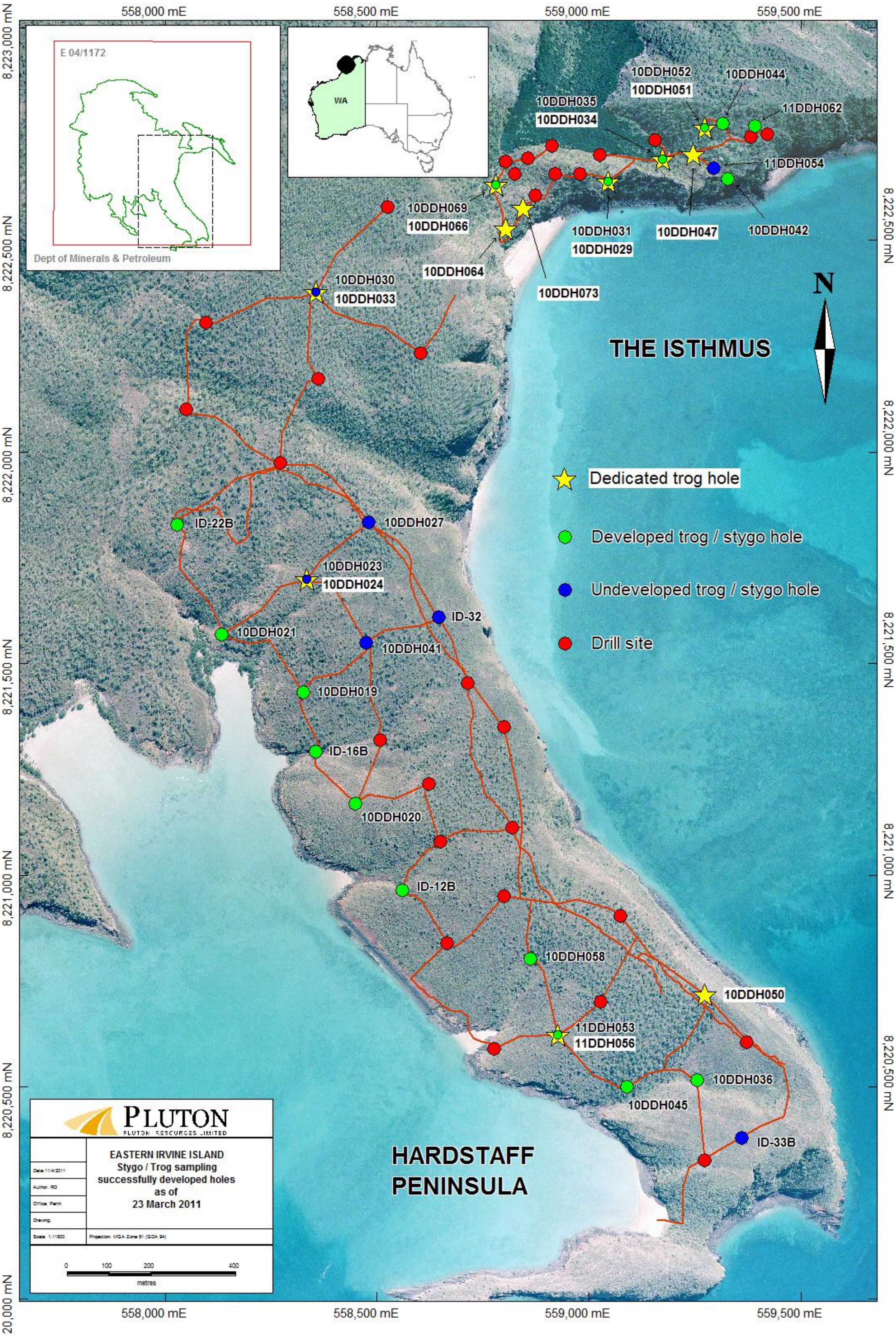
Table 1. The combined geological exploration and groundwater investigation takes advantage of the availability of drilling rigs.

Future Phase III ‘environmental” holes are planned in an area to the northwest of the Hardstaff Peninsula to establish a long-term environmental monitoring network in the 'reference' part of the island (see Figure 12)

Bores drilled on Irvine Island are typically rotary drilled cored holes, typically drilled as PQ at the top reducing to HQ beneath about 40 m (ie; a 122.6 mm diameter hole reducing to a 96 mm diameter hole). Depth varies depending on the depth of the exploration target (the Yampi Member). The maximum drilled bore is 414 m, although this is an angled resource hole. The maximum depth vertical hole is 333.8 m deep (Y2-21 (10DDH027) (Table 1). Note that angled exploration bores are not converted to groundwater monitoring bores, whereas the majority of the vertical holes have been converted to groundwater monitoring installations.

Table 1: Borehole summary for Irvine Island

Bore hole / site no	site no	location	easting	northing	depth	screen from	screen to	comments		camera survey data
10DDH018	Y2-18A	Hardstaff	558325	8221433	291.4			0.35m PVC collar	Angle geotech hole	
10DDH019	Y2-18B	Hardstaff	558325	8221433	266.4	37.7	67?	0.67m PVC collar		upper screen 1.65 - 29m (above WT 37.7 - 67 then obscured by dark water to EoH
10DDH020	Y2-14B	Hardstaff	558448	8221170	263.3	5.3	83.3	1.25m PVC collar	solid to EoH	
10DDH021	Y2-20B	Hardstaff	558132	8221569	265.5	1.5	73.5	.29m PVC collar	no end cap at 265.5	
10DDH022	Y2-20A	Hardstaff	558132	8221569	414.5				Angle resource hole	
10DDH023	Y2-10	Hardstaff	558334	8221700	274.6	4.6	112.6		no end cap at 274.6	
10DDH024	Y2-10	Hardstaff	558334	8221700	42.1				Short trog hole - uncased	
10DDH025	Y2-21	Hardstaff	558480	8221833	131.5				Failed hole, stuck rods to surface	
10DDH026	Y2I-12	Isthmus	559045	8222638	274.2				Angle resource hole	
10DDH027	Y2-21	Hardstaff	558480	8221833	206.1	104.1	152.1		Redrill of 10DDH025	
10DDH028	Y2I-12	Isthmus	559045	8222638	40.8				Short met hole - uncased	
10DDH029	Y2I-12	Isthmus	559045	8222638	68.4				Failed hole, stuck rods to surface	
10DDH030	Y2-26	Hardstaff	558354	8222378	333.8	132.9	192.9		solid to 282.9, NQ from 282.9	
10DDH031	Y2I-12	Isthmus	559045	8222638	211.3	?	215		Redrill of 10DDH029. GJ has details of PVC? L	Low visibility from approx 40m - several lengths at the base to 215m
10DDH032	Y2I-15	Isthmus	559173	8222690	159				Angle resource hole	
10DDH033	Y2-26	Hardstaff	558354	8222378	??				Short Troglofauna monitoring hole	
10DDH034	Y2I-15	Isthmus	559173	8222690	18.8	0.8	18.8		Short Troglofauna monitoring hole. Uncapped at Eoh	
10DDH035	Y2I-15	Isthmus	559173	8222690	144	6	36		solid to EoH	
10DDH036	Y2-3	Hardstaff	559256	8220517	143.5				Resource/Monitoring	
10DDH037	Y2I-15	Isthmus	559173	8222690	29.4				Short met hole - uncased	
10DDH038	Site B	Isthmus	559421	8222749						
10DDH039	Y2-3	Hardstaff	559256	8220517						
10DDH040	Site A	Isthmus	559327.19	8222644.1						
10DDH041	Y2-19	Hardstaff	558474	8221550	264.6	6.6	138.6		blank casing to EoH, end cap installed	
10DDH042	Site A	Isthmus	559327.19	8222644.1	93.6	45.6	81.6		solid casing to EoH, no end cap	
10DDH043	Site G	Isthmus	559314.6	8222775						
10DDH044	Site G	Isthmus	559314.6	8222775	197.25	0	197.25			
10DDH045	Y2-2	Hardstaff	559089	8220500		0	153			
10DDH046	F	Isthmus	559245.14	8222703.1						
10DDH047	F	Isthmus	559245.14	8222703.1						
10DDH048	Y2-4	Hardstaff	559273	8220719						
10DDH049	Site H	Isthmus	559272	8222765						
10DDH050	Y2-4	Hardstaff	559273	8220719						
10DDH051	Site H	Isthmus	559272	8222765						
10DDH052		Isthmus	559272	8222765	128.9	0	128.9			
11DDD077	Y2I-11	Isthmus	558978	8222656	33.4					
11DDH053		Hardstaff	558926	8220624	221.6	0	221.6			
11DDH054		Isthmus	559294	8222669	90.8					
11DDH055		Isthmus	559294	8222669						
11DDH056		Hardstaff	558926	8220624						
11DDH057		Isthmus	559294	8222669						
11DDH058		Hardstaff	558862	8220803		0	222			
11DDH059		Isthmus	558803	8222528						
11DDH060		Isthmus	559382	8222743						
11DDH061		Isthmus	558803	8222528						
11DDH062		Isthmus	559382	8222743						
11DDH063		Isthmus	559382	8222743						
11DDH064		Isthmus	558803	8222528						
11DDH065		Isthmus	558780	8222630						
11DDH066		Isthmus	558780	8222630						
11DDH067		Isthmus	558803	8222685						
11DDH068		Isthmus	558803	8222685						
11DDH069		Isthmus	558780	8222630						
11DDH070	> Y2I-7	Isthmus	558803	8222685	102				Stygo	
11DDH071		Isthmus	558844	8222576						
11DDH072			558872.86	8222606						
11DDH073	> Y2I-4	Isthmus	558844	8222576	42.6					
11DDH074		Isthmus	559382	8222743						
11DDH075	N	isthmus	558872.86	8222606	105				Stygo	
11DDH076	Y2I-25		0	0	40.7					
11DDH079	Y2I-19	Isthmus	559155	8222736	40.7					
11DDH080	Y2I-19	Isthmus	559155	8222736	147.1					
11DDH082	K		558972.6	8222637.2	40					
11DDH085	Y2I-8	Isthmus	558856	8222692	100					
11DDH087	V	Isthmus	558825	8222656	40					
C			559257.35	8222643.9						
D			559334.28	8222723.4						
E			559402.36	8222793.8						
H	???		559248.93	8222779						
I			559144.28	8222742.7						
ID-12A	Y2-12A	Hardstaff	558559	8220963	312.7			Angle resource hole	No collar, water level may be high due to hole being blocked at 20m	
ID-12B	Y2-12B	Hardstaff	558559	8220963	310.05	0	250		0.23m PVC collar	limit of camera cable 250m
ID-15		Isthmus	559173	8222690						
ID-16A	Y2-16A	Hardstaff	558355	8221292	274.4			Angle resource hole	0.21 PVC collar	
ID-16B	Y2-16B	Hardstaff	558355	8221292	236.7	0	56.65+		No collar	screen visible to 56.65, obscured to 127.7, blank to 236.7
ID-22B	Y2-22B	Hardstaff	558028	8221828	360	0	250		0.35m PVC collar	total depth drilled 360, screen only observed to 250m due to limit of camera cable
ID-27	Y2H-27	Hardstaff	559373	8220607	109.77				Blocked at 43m	
ID-28	Y2H-28	Hardstaff	559027	8220702	243.14				Blocked at 1m	
ID-29	Y2H-29	Hardstaff	559074	8220904	185.35				Blocked at 13m	
ID-30	Y2H-30	Hardstaff	558800	8220951	243				Blocked at 1.5m	
ID-31	Y2H-31	Hardstaff	558800	8221350	208.69				Blocked at 43m	
ID-32	Y2H-32	Hardstaff	558645	8221610	239.85				Blocked at 54m	
ID-33	Y2H-33	Hardstaff	559360	8220380	122.04				Blocked at 11m	
ID-33B	Y2H-33B	Hardstaff	559361	8220381	263.3	5.3	83.3		0.36m PVC collar	160.4
ID-6A	Y2-6A	Hardstaff	558776	8220590	296			Angle resource hole	Angled hole had mud dumped down it !	
ID-6B	Y2-6B	Hardstaff	558776	8220590	247	6	54		0.3m PVC collar	
						180	216		Tested interval	
ID-6C	Y2-6C	Hardstaff	558776	8220590	283.5			Angle geotech hole	No collar	
J			559032.17	8222698.7						
L			558879.82	8222563						
M			558953.58	8222689.4						
O			558800.32	8222531						
P			558901.53	8222707.5						
Q			558836.33	8222640.1						
R			558818.24	8222693.3						
S			558767.22	8222640.6						
Y2-1		Hardstaff	559273	8220327						
Y2-11		Hardstaff	558665	8220840						
Y2-13		Hardstaff	558650	8221080						
Y2-15		Hardstaff	558622	8221215						
Y2-17		Hardstaff	558507	8221320						
Y2-23		Hardstaff	558271	8221973						
Y2-24		Hardstaff	558050	8222100						
Y2-24A		Hardstaff	558095	8222305						
Y2-25		Hardstaff	558360	8222173						
Y2-27		Hardstaff	558603	8222233						
Y2-28		Hardstaff	558524	8222578						
Y2-8		Hardstaff	558818	8221113						
Y2-9		Hardstaff	558713	8221453						
Y2I-10		Isthmus	558913	8222722						
Y2I-14		Isthmus	559025	8222700						
Y2I-9		Isthmus	558920	8222655						
	Y2-22W	Hardstaff	558022	8221834	137.4	61	85.7	Water bore - uncased from 90.9		open hole uncased from 90.9



558,000 mE
558,500 mE
559,000 mE
559,500 mE
8,223,000 mN
8,222,500 mN
8,222,000 mN
8,221,500 mN
8,221,000 mN
8,220,500 mN
20,000 mN
E 04/1172
Dept of Minerals & Petroleum
WA
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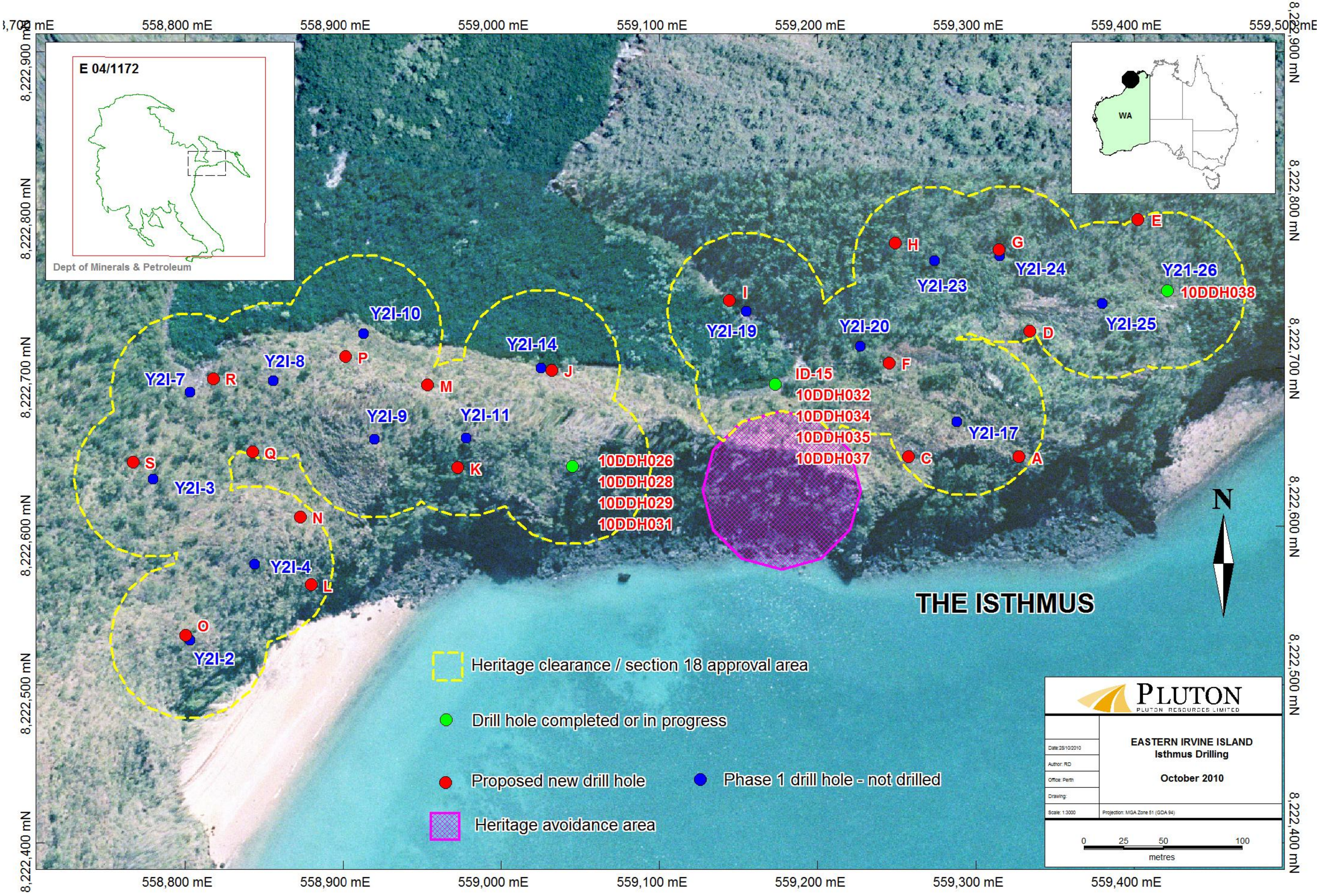
THE ISTHMUS
HARDSTAFF PENINSULA
Dedicated trog hole
Developed trog / stygo hole
Undeveloped trog / stygo hole
Drill site
10DDH052
10DDH051
10DDH044
11DDH062
10DDH035
10DDH034
11DDH054
10DDH069
10DDH066
10DDH031
10DDH029
10DDH047
10DDH042
10DDH064
10DDH073
10DDH030
10DDH033
ID-22B
10DDH027
10DDH023
10DDH024
ID-32
10DDH021
10DDH041
10DDH019
ID-16B
10DDH020
ID-12B
10DDH058
10DDH050
11DDH053
11DDH056
10DDH036
10DDH045
ID-33B
PLUTON
PLUTON RESOURCES LIMITED
EASTERN IRVINE ISLAND
Stygo / Trog sampling
successfully developed holes
as of
23 March 2011
Date: 11/4/2011
Author: RD
Office: Perth
Drawing:
Scale: 1:11500
Projection: MGA Zone 51 (GDA 94)
0
100
200
400
metres



E 04/1172
Dept of Minerals & Petroleum
WA
THE ISTHMUS
N
Heritage clearance / section 18 approval area
Drill hole completed or in progress
Proposed new drill hole
Phase 1 drill hole - not drilled
Heritage avoidance area
ID-15
10DDH032
10DDH034
10DDH035
10DDH037
10DDH026
10DDH028
10DDH029
10DDH031
10DDH038
Y2I-2
Y2I-3
Y2I-4
Y2I-7
Y2I-8
Y2I-9
Y2I-10
Y2I-11
Y2I-14
Y2I-17
Y2I-19
Y2I-20
Y2I-23
Y2I-24
Y2I-25
Y2I-26
A
C
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E
F
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J
K
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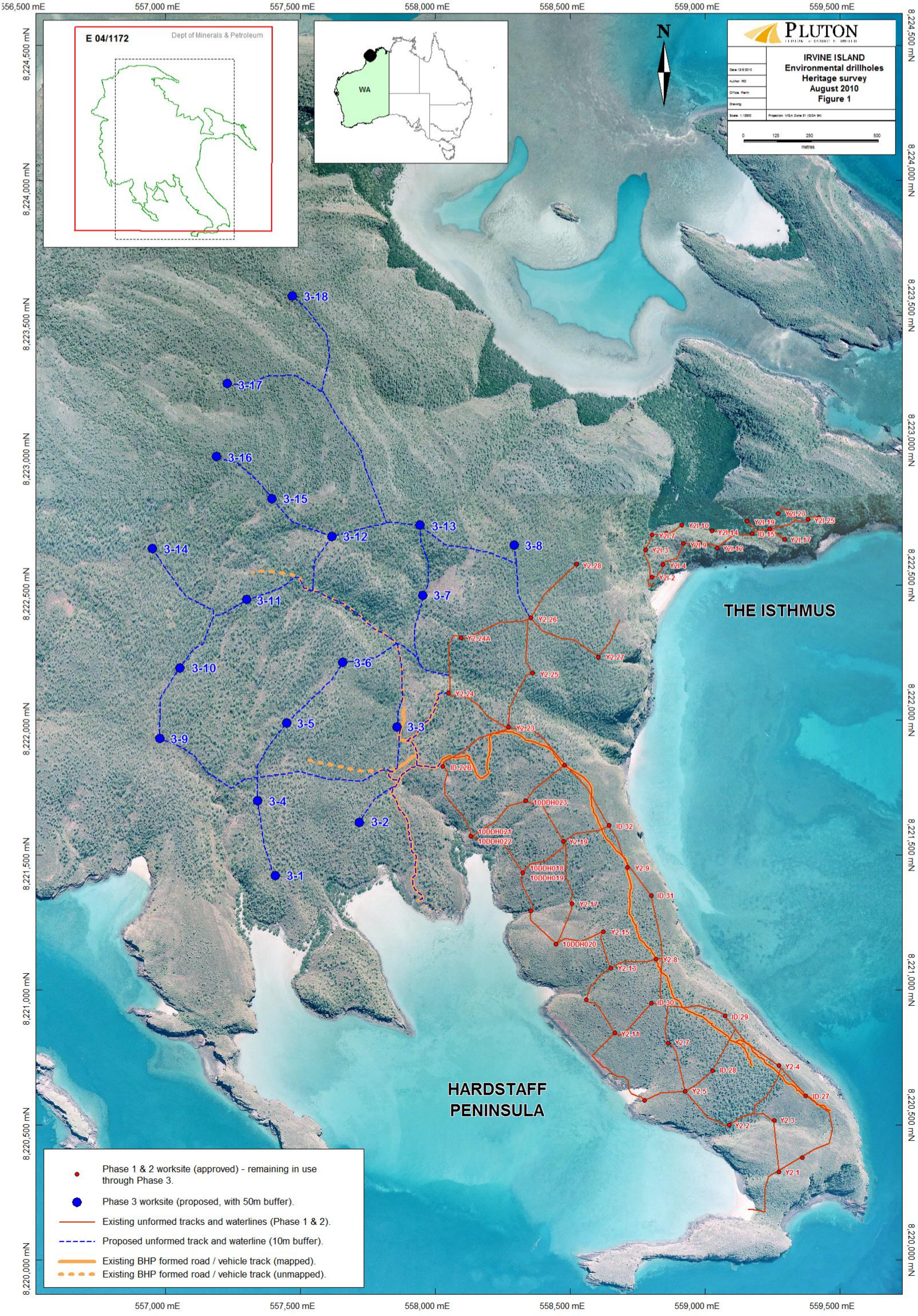
558,800 mE
558,900 mE
559,000 mE
559,100 mE
559,200 mE
559,300 mE
559,400 mE
8,222,900 mN
8,222,800 mN
8,222,700 mN
8,222,600 mN
8,222,500 mN
8,222,400 mN
PLUTON
PLUTON RESOURCES LIMITED
EASTERN IRVINE ISLAND
Isthmus Drilling
October 2010
Date:28/10/2010
Author: RD
Office: Perth
Drawing:
Scale: 1:3000
Projection: MGA Zone 51 (GDA 94)
0
25
50
100
metres



PLUTON
IRVINE ISLAND
Environmental drillholes
Heritage survey
August 2010
Figure 1
metres
E 04/1172
Dept of Minerals & Petroleum
WA
N
THE ISTHMUS
HARDSTAFF
PENINSULA
3-1
3-2
3-3
3-4
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3-16
3-17
3-18
556,500 mE
557,000 mE
557,500 mE
558,000 mE
558,500 mE
559,000 mE
559,500 mE
8,224,500 mN
8,224,000 mN
8,223,500 mN
8,223,000 mN
8,222,500 mN
8,222,000 mN
8,221,500 mN
8,221,000 mN
8,220,500 mN
8,220,000 mN
Phase 1 & 2 worksite (approved) - remaining in use through Phase 3.
Phase 3 worksite (proposed, with 50m buffer).
Existing unformed tracks and waterlines (Phase 1 & 2).
Proposed unformed track and waterline (10m buffer).
Existing BHP formed road / vehicle track (mapped).
Existing BHP formed road / vehicle track (unmapped).

4.3 Well construction and Development

4.3.1 Construction considerations

The drilling program on Irvine Island has multiple aims, so the groundwater installations and the testing program have been designed to take advantage of the intersection of the complete geological section proposed to be intersected in the mine operation.

There are several different bore construction configurations for the groundwater bores that meet specific monitoring objectives. These have been amended as required as the project has developed, and based on local variations in ground conditions and partly a reflection of improved capacity of the drillers as more bores have been drilled.

Groundwater bores on the island are required to provide an indication of groundwater level, aquifer permeability and hydrochemistry, and also provide baseline data for stygo-fauna as defined in the Draft EPA guidelines (2007). In addition, the bores provide the opportunity to sample troglofauna from above the water table.

4.3.2 Groundwater Bore Construction

Groundwater monitoring and investigation wells need to be able to provide a representative sample of groundwater. From the bores drilled on Irvine Island, attempts were made to remove drilling fluids by flushing each bore when it had been drilled to its final depth, and prior to the installation of piezometer casing.

As the mineral resource exploration bores on Irvine Island are typically drilled to greater depths than necessary for the groundwater investigations, there has been a need to adjust the monitoring bore construction technique to achieve routine groundwater installations that enable water level measurement and sampling

Groundwater monitoring wells comprise 50mm diameter PVC (Class18) casing and screen. Casing and screen are glued and screwed with stainless steel screws.

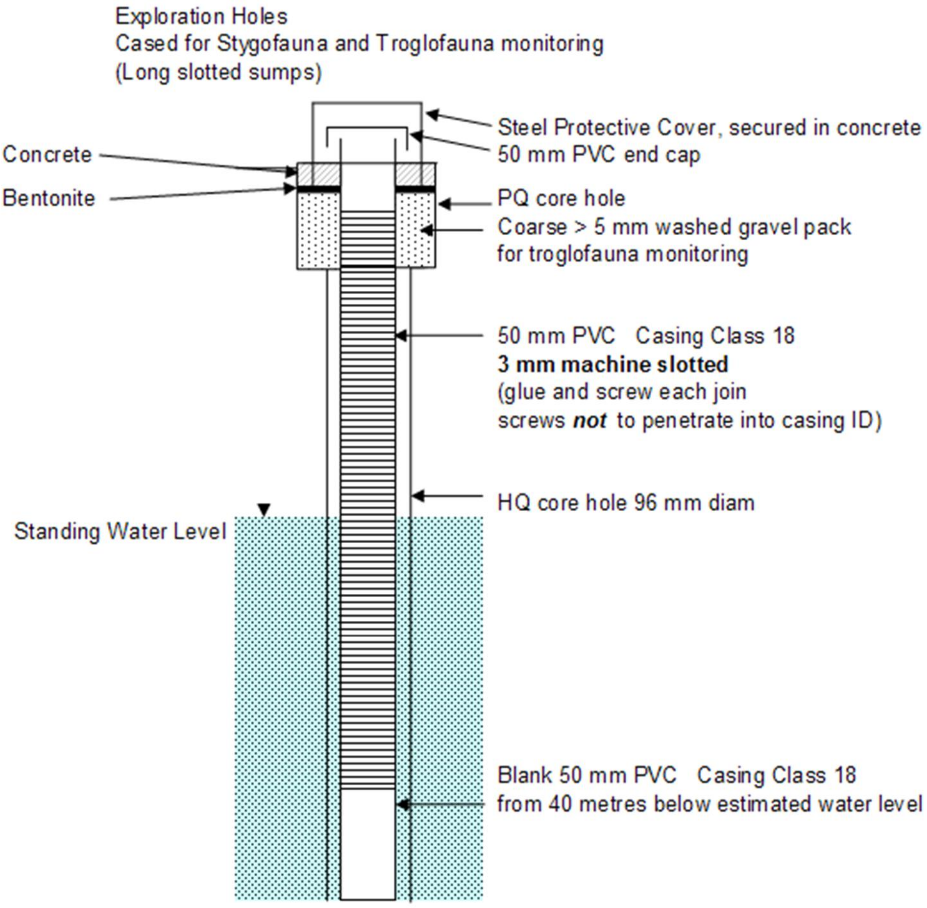
The screen location varies from bore to bore. A number of bores have been screened from the bottom of the bore to the surface, while in others the screen has been placed from around 30 - 40m below the water table, with a 6m sump. The latter having been converted from deep mineral exploration bores, they are backfilled from the base of the bore to the sump. Early bores in the program were constructed with screen intervals positioned around the interpreted water table depth while others have been slotted to the ground surface. The screen locations in selected bores are listed in

Table 1. These screened intervals provide access to the groundwater for testing of hydraulic conductivity and sampling.

It must be noted that these bores may straddle different formations and the hydrogeological data do not necessarily represent the groundwater characteristics (head or chemistry) of individual formations encountered by the bore.

The monitoring bores on Irvine Island include bores that constructed as shown in Figure 13. The upper intervals of bores designed as troglofauna holes have been drilled at wider diameter (PQ) than the deeper sections (HQ) to enable coarse (5mm) gravel pack around the slotted interval. A bentonite seal is placed above the screen. The bore construction has been agreed with Stratagen (stygofauna consultants) and applying the standards required by EPA (2007) for Environmental assessment of Subterranean Fauna..

Figure 13 Typical Monitoring bore construction



4.3.3 Well development

Groundwater monitoring and investigation wells need to be able to provide a representative groundwater sample. Apart from the physical disturbance caused by the turbulent conditions of drilling, the constructed wells need to stand long enough to enable the stygofauna (if present) to re-establish after (a three month period is adopted for this study as directed by Strategen)

While flushing exercise after drilling will remove the majority of drilling fluids, some is likely to remain in fractures and other defects. Relict drilling fluids, although biodegradable, have the potential to impact upon future subterranean fauna sampling, and so need to be removed as far as possible. Therefore the constructed boreholes were developed by air-lifting with a compressor. This procedure issued on the 7th December 2010 to Pluton field staff and drillers (See Appendix A) aims to produce piezometers that are free of drilling fluids, enabling satisfactory well conditions for sampling and for stygofauna monitoring where required.

Bores are developed by air-lifting using a compressor and suitable rated airline. If a measurable yield was obtained the bore was typically airlifted for a duration of 2 hours. Field parameters including Ec, pH dissolved oxygen and oxidation- reduction potential were measured periodically during development until the measured parameters stabilised and produced water that appears clear and free of drilling fluid or other contaminants, as described in Table 2. A groundwater sample was collected before airlifting is completed to allow characterisation of groundwater quality and confirm adequate purging of the bore.

Initial water level and changes in water level, especially the water level recovery after cessation iof development, was recorded in air lifted bores using a pressure transducer lowered on a steel cable into the borehole prior to the commencement of development. The data is later be used to estimate a bulk conductivity of the rockmass in the vicinity of the borehole (described in section 6.1).

In those wells with limited yield, after groundwater has been purged from the casing, the water level recovery was monitored and analysed as a rising head slug test. Groundwater samples were obtained by bailer the following day when water levels have recovered.

It should be noted that the requirement for the monitoring bores to have the upper 30 m of the hole slotted to allow troglofauna monitoring may result in reduced efficiency of the airlifting with the possibility of some re-circulation of water down the bore annulus. If this occurs it is recommended that the bores are bailed to obtain a groundwater sample and rising head tests completed to determine the aquifer parameters.

Several air-lifting events have been undertaken. A total of 26 bores have been airlifted with 19 being adequately developed and suitable for subterranean fauna monitoring. Unsuccessful bores included blocked bores and those where groundwater levels were too deep to develop.

The following table (Table 2) summaries the bores that have been airlifted to date (May 2011).

Table 2 Air Lift Results as of May 2011

Area	Site	Bore	Date Tested	Bore Depth	Screen Interval	SWL [mbTOC]	Airline [mbTOC]	Duration [hr]	Flow Rate [L/s]	Displaced Volume [kL]	Comment
Hardstaff	Y2-18	10DDH019	12/02/2011	266.4	37.7->67	37.33	80	3	0.5	5.4	No odour/sheen and only slight discolouration
Hardstaff	Y2-14	10DDH020	12/02/2011	263.3	5.3-83.3	56.15	80	2.25	0.15	1.22	Sample reasonably clear, free of odour
Hardstaff	Y2-22	ID22B	13/02/2011	250	0-250	52.73	80	1.25	Nil	-	Sample mostly clear but some greyish discolouration. Mild odour
Hardstaff	Y2-33	ID33B	11/02/2011	263.3	5.3-83.3	66.1	100	1	Nil	-	No water flow, some water vapour only. Sample red, viscous, odourous
Hardstaff	Y2-3	10DDH036	10/02/2011	143.5		39.14	60	4	Minor	-	Slight brown discoloration and slight artificial odour
Isthmus	Y2i-12	10DDH031	15/02/2011	211.3		40.53	70	2.25	~ 0.75	6.01	Water clear with slight yellow discolouration, minimal odour
Isthmus	Y2i-15	10DDH034	14/02/2011	18.8	0.8-18.8	2.73	15	2	0.4	2.88	Sample still murky grey, however assume this is as bore is constructed in mud flats and so sediment is naturally present
Hardstaff	Y2-5	11DDH053	14/3/11	221.6		49.81	80	2.5	Minor	-	Sample cleared well, no odour.

Hardstaff	Y2-7	11DDH058	14/3/11	-		48.82	55	2	Nil	-	Hand bailed sample. Water mostly clear, slight yellow/brown discolouration, no odour.
Hardstaff	Y2-2	10DDH045	15/3/11	-		4.32	35	2.25	~ 0.25	2.03	Unable to fit T-piece so flow measurement estimate only. Final sample clear & odourless.
Hardstaff	Y2-16	ID16B	15/3/11	236.7		10.18	40	1	Nil	-	Hand bailed sample. Water clear & odourless.
Hardstaff	Y2-12	ID12B	16/3/11	310.05		35.13	60	2.5	0.3		Final sample clear & odourless.
Hardstaff	Y2-10	10DDH023	16/3/11	274	4.6-112.6	76.29	110	1.75	Nil	-	Unable to locate water table following airlift (SWL > 100m) and unable to retrieve sample.
Hardstaff	Y2-20	10DDH021	17/3/11	265.5	6-73.5	10.93	40	2	0.4	2.88	Sample cleared well, slight grey discolouration and sulfur smell remain
Hardstaff	Y2-26	10DDH030	17/3/11	333.8	132.9-192.9	-	-	-	-	-	SWL > 100m, record show ~130m and so unable to airlift with current length of poly.
Isthmus	Y2i-25	11DDH062	18/3/11	-		60.7	100	1.5	Nil	-	Hand bailed sample. Silty brown, slight odour.
Isthmus	Site G	10DDH044	18/3/11	197.25	0-197.25	46.02	65	1	Nil	-	Hand bailed sample. Clearish brown with slight odour.

Isthmus	Y2i-23	10DDH052	18/3/11	128.9		33.47	69	1.75	0.35	2.21	Sample clear with slight brown discolouration, no odour.
Isthmus	Y2i-17	11DDH054	19/3/11	90.8		43.17	60	1	Nil	-	Hand bailed sample. Water murky red/brown, odourous.
Isthmus	Site A	10DDH042	19/3/11	93.6	45.6-81.6	42.25	60	1.25	0.35	1.58	Sample cleared well, slight grey discolouration remained, slight odour.
Isthmus	Y1i-15	10DDH035	19/3/11	144	6-36	4	25	2	~ 0.4	2.88	Sample mostly clear with some brown silt, no odour.
Isthmus	Y2i-3	-	22/3/11	-		13.24	40	2.5	~ 0.5	4.50	Sample clear & odourless.
Isthmus	Y2i-17	11DDH054	22/03/2011	90.8		40.5	80	2	0.45	3.24	Sample clear with slight red/brown discolouration, no odour.
Hardstaff	Y2-32	ID32	-	-		-	-	-	-	-	Did not attempt airlift - no 50mm casing installed
Hardstaff	Y2-21	10DDH027	-	-	104.1-152.1	-	-	-	-	-	Did not attempt airlift - hole collapsed near surface prior to gravel/cementing
Hardstaff	Y2-19	10DDH041	-	-	6.6-138.6	-	-	-	-	-	Did not attempt airlift - hole collapsed near surface prior to gravel/cementing

5. Groundwater Levels

The depth to groundwater reflects the topography, with water level controlled by sea level close to the coast. The water level is deeper than 100m along the north eastern edge of the Hardstaff Peninsula (eg bore ID32 (116m BGL) and 132.6m BGL in bore 10DDH030 north of Hardstaff peninsula.

Groundwater elevation approximates sea level in the bores measured around the Isthmus and Hardstaff Peninsula, although these will be mapped in greater detail when the results of the current field program are incorporated.

There appears to minor variation in groundwater levels between the different monitoring periods although with the limited data no trends are apparent. Likewise there are insufficient data to determine the vertical hydraulic gradient.

The available water level data Irvine Island groundwater monitoring bores is shown in Table 3.

Table 3: Groundwater levels July 2010 - March 2011

Bore hole / site no	site no	location	easting	northing	depth	screen from	screen to	Dipped Water Level (mbs)	Inspection Date	Measured Depth to Water	Date	Measured Depth to Water	Date	Measured Depth to Water	Date	Measured Depth to Water	Date
ID-27	Y2H-27	Hardstaff	559373	8220607	109.77				21/07/2010		30/11/2010		16/12/2010				
ID-28	Y2H-28	Hardstaff	559027	8220702	243.14						30/11/2010		19/12/2010				
ID-29	Y2H-29	Hardstaff	559074	8220904	185.35				21/07/2010		30/11/2010		19/12/2010				
ID-30	Y2H-30	Hardstaff	558800	8220951	243				20/07/2010		30/11/2010		19/12/2010				
ID-31	Y2H-31	Hardstaff	558800	8221350	208.69				21/07/2010		30/11/2010		19/12/2010				
ID-32	Y2H-32	Hardstaff	558645	8221610	239.85				21/07/2010	116.77	30/11/2010	115.3	19/12/2010				
ID-33	Y2H-33	Hardstaff	559360	8220380	122.04	5.3	83.3		21/07/2010		30/11/2010		16/12/2010				
ID-33B	Y2H-33B	Hardstaff	559361	8220381	263.3			63.83	21/07/2010	69.01	30/11/2010	69.36	16/12/2010	66.1	11/02/2011		
ID-22B	Y2-22B	Hardstaff	558028	8221828	360			51.48	21/07/2010	52.06	25/11/2010	51.35	17/12/2010	52.73	13/02/2011		
	Y2-22W	Hardstaff	558022	8221834	137.4	61	85.7		21/07/2010	52.44	25/11/2010	51.72	17/12/2010				
ID-12A	Y2-12A	Hardstaff	558559	8220963	312.7			13.46	20/07/2010	14.62	30/11/2010		20/12/2010				
ID-12B	Y2-12B	Hardstaff	558559	8220963	310.05	0	250	36.17	20/07/2010	36.44	30/11/2010	36.27	20/12/2010	35.13	16/03/2011		
ID-6A	Y2-6A	Hardstaff	558776	8220590	296				20/07/2010		30/11/2010		19/12/2010				
ID-6B	Y2-6B	Hardstaff	558776	8220590	247	6	216	13.3	20/07/2010	13.4	30/11/2010	13.9	19/12/2010				
ID-6C	Y2-6C	Hardstaff	558776	8220590	283.5			14.53	20/07/2010	4.72	30/11/2010		19/12/2010				
ID-16A	Y2-16A	Hardstaff	558355	8221292	274.4			9.85	20/07/2010	10.82	30/11/2010	10.45	19/12/2010				
ID-16B	Y2-16B	Hardstaff	558355	8221292	236.7	0	56.65+	10.37	20/07/2010	10.19	30/11/2010	9.87	19/12/2010	10.18	16/03/2011		
10DDH018	Y2-18A	Hardstaff	558325	8221433	291.4			38.84	20/07/2010	40.12	30/11/2010		20/12/2010				
10DDH019	Y2-18B	Hardstaff	558325	8221433	266.4	37.7	67?	37.41	20/07/2010	38.34	30/11/2010	37.68	20/12/2010	37.33	12/02/2011		
10DDH020	Y2-14B	Hardstaff	558448	8221170	263.3	5.3	83.3	55.78	20/07/2010	56.4	30/11/2010	55.96	19/12/2010	56.15	12/02/2011		
10DDH021	Y2-20B	Hardstaff	558132	8221569	265.5	1.5	73.5	11.57	5/08/2010	3.18	29/11/2010	11.55	17/12/2010	10.93	17/03/2011		
10DDH022	Y2-20A	Hardstaff	558132	8221569	414.5					10.17	29/11/2010	10.77	17/12/2010				
10DDH023	Y2-10	Hardstaff	558334	8221700	274.6	4.6	112.6			76.18	29/11/2010	75.96	17/12/2010	76.29	16/03/2011		
10DDH024	Y2-10	Hardstaff	558334	8221700	42.1						29/11/2010		17/12/2010				
10DDH025	Y2-21	Hardstaff	558480	8221833	131.5						29/11/2010		17/12/2010				
10DDH026	Y2I-12	Isthmus	559045	8222638	274.2						29/11/2010		18/12/2010				
10DDH027	Y2-21	Hardstaff	558480	8221833	206.1	104.1	152.1	132				113.25	17/12/2010				
10DDH028	Y2I-12	Isthmus	559045	8222638	40.8								18/12/2010				
10DDH029	Y2I-12	Isthmus	559045	8222638	68.4								18/12/2010				
10DDH030	Y2-26	Hardstaff	558354	8222378	333.8	132.9	192.9					132.64	19/12/2010				
10DDH031	Y2I-12	Isthmus	559045	8222638	211.3	?	215			39.73	25/11/2010	40.5	18/12/2010	40.53	15/02/2011		
10DDH032	Y2I-15	Isthmus	559173	8222690	159								18/12/2010				
10DDH033	Y2-26	Hardstaff	558354	8222378	??						30/11/2010		19/12/2010				
10DDH034	Y2I-15	Isthmus	559173	8222690	18.8	0.8	18.8			7.21	25/11/2010	6.78	18/12/2010	2.73	14/02/2011		
10DDH035	Y2I-15	Isthmus	559173	8222690	144	6	36			7.06	25/11/2010	6.51	18/12/2010	4.00	19/03/2011		
10DDH036	Y2-3	Hardstaff	559256	8220517	143.5					39.56	25/11/2010	40.05	16/12/2010	39.14	10/02/2011		
10DDH037	Y2I-15	Isthmus	559173	8222690	29.4								18/12/2010				
10DDH038	Site B	Isthmus	559421	8222749									21/12/2010				
10DDH039	Y2-3	Hardstaff	559256	8220517						40.98	30/11/2010	41.12	16/12/2010				
10DDH040	Site A	Isthmus	559327.19	8222644.14									18/12/2010				
10DDH041	Y2-19	Hardstaff	558474	8221550	264.6	6.6	138.6					95.53	19/12/2010				
10DDH042	Site A	Isthmus	559327.19	8222644.14	93.6	45.6	81.6			43.39	25/11/2010	41.93	18/12/2010				
10DDH043	Site G	Isthmus	559314.6	8222774.95									18/12/2010				
10DDH044	Site G	Isthmus	559314.6	8222774.95	197.25	0	197.25					46.18	18/12/2010	46.02	18/03/2011		
10DDH045	Y2-2	Hardstaff	559089	8220500								15.21	16/12/2010	4.32	15/03/2011		
10DDH046	F	Isthmus	559245.14	8222703.14								18.3	18/12/2010				
10DDH047	F	Isthmus	559245.14	8222703.14								18.58	18/12/2010				
10DDH048	Y2-4	Hardstaff	559273	8220719									19/12/2010				
10DDH049	Site H	Isthmus	559272	8222765								38.4	18/12/2010				
10DDH050	Y2-4	Hardstaff	559273	8220719									19/12/2010				
10DDH051	Site H	Isthmus	559272	8222765								15.2	18/12/2010				
10DDH052		Isthmus	559272	8222765	128.9							32.82	30/01/2011	33.47	18/03/2011		
11DDH053		Hardstaff	558926	8220624	221.6							50.78	27/01/2011	49.81	14/03/2011		
11DDH054		Isthmus	559294	8222669	90.8							40.33	30/01/2011	43.17	19/03/2011	40.5	22/03/2011
11DDH055		Isthmus	559294	8222669													
11DDH056		Hardstaff	558926	8220624													
11DDH057		Isthmus	559294	8222669													
11DDH058		Hardstaff	558862	8220803										48.82	14/03/2011		
11DDH059		Isthmus	558803	8222528									18/03/2011				
11DDH060		Isthmus	559382	8222743													
11DDH061		Isthmus	558803	8222528													
11DDH062		Isthmus	559382	8222743										60.35	17/03/2011	60.7	18/03/2011
11DDH063		Isthmus	559382	8222743													
11DDH064		Isthmus	558803	8222528											18/03/2011		
11DDH065		Isthmus	558780	8222630											15/03/2011		
11DDH066		Isthmus	558780	8222630										8.5	15/03/2011	13.24	22/03/2011
11DDH067		Isthmus	558803	8222685											18/03/2011		
11DDH068		Isthmus	558803	8222685										4.89	18/03/2011		
11DDH069		Isthmus	558780	8222630													

6. Aquifer Characterisation.

Existing bores have tested to provide hydrogeological information on the groundwater quality and hydraulic properties of the aquifers as described below.

6.1 Testing of Aquifer Hydraulic Properties

Aquifer hydraulic properties were obtained from 15 bores mostly in the Hardstaff Peninsula using the information from recovery of groundwater levels after airlifting (10 bores) and packer testing has been undertaken on five holes to test the bulk conductivity of intersected formations.

6.1.1 Airlift Recovery tests

During bore development by airlifting, changes in groundwater level, especially the water level recovery were recorded using a pressure transducer lowered into the borehole on a steel cable prior to the commencement of development. This data have been used to estimate a bulk hydraulic conductivity of the rockmass in the vicinity of the borehole.

Data from the transducers has been analysed using the Hvorslev technique to estimate the hydraulic properties of the formations though analysis of the groundwater level recovery in each bores. A summary of these results is included below as Table 4 and the detailed test analysis as in Appendix B below.

Table 4 Airlift Recovery Test Analysis

Bore	Curve Matching Solution	Screen Top (mbgl)	Screen Base (mbgl)	K (m/s) Maximum	K (M/S) Minimum	Screened Formation
10DDH045	Hvorslev*	0	153	4.84×10^{-9}	3.35×10^{-10}	Wonganin Sst, Sandfly Schist, Elgee Siltstone, Yampi Conglomerate
11DDH052**	Hvorslev*	0	129	2.88×10^{-8}	2.88×10^{-8}	Elgee Siltstone, Yampi Conglomerate
11DDH053	Hvorslev*	0	222	5.11×10^{-9}	2.37×10^{-10}	Wonganin Sst, Sandfly Schist, Elgee Siltstone, Yampi Conglomerate
11DDH058	Hvorslev*	0	222	2.04×10^{-8}	2.40×10^{-9}	Wonganin Sst, Sandfly Schist, Elgee Siltstone, Yampi Conglomerate
11DDH062	Hvorslev*	0	104	1.61×10^{-8}	1.61×10^{-8}	Sandfly Schist, Elgee Siltstone, Yampi Conglomerate
ID12B	Hvorslev*	0	250	2.31×10^{-8}	7.66×10^{-9}	Wonganin Sst, Sandfly Schist, Elgee Siltstone, Yampi Conglomerate
ID16B	Hvorslev*	0	127	9.32×10^{-9}	1.89×10^{-10}	Wonganin Sst
10DDH035	Hvorslev*	6	36	1.11×10^{-7}	2.32×10^{-8}	Sandfly Schist, Elgee Siltstone, Yampi Conglomerate
10DDH044	Hvorslev*	0	197	1.92×10^{-7}	7.54×10^{-8}	Wonganin Sst, Sandfly Schist, Elgee Siltstone, Yampi Conglomerate
Y2-6B	Hvorslev*	180	216	1.56×10^{-7}	1.56×10^{-7}	Yampi Conglomerate

* A mathematical solution by Hvorslev is used for determining the hydraulic conductivity of nonleaky confined aquifers. Analysis involves matching a straight line solution to water level displacement data collected during an overdamped slug test.
** Bad data match

Assumptions
Aquifer has infinite areal extent
Aquifer is homogeneous and of uniform thickness
Aquifer potentiometric surface is initially horizontal
Control well is fully or partially penetrating
A volume of water in injected or discharged instantaneously from the control well
Aquifer is nonleaky confined
Flow is steady
Test aquifer is properly isolated during construction

6.2 Packer Testing

Packer testing has been undertaken on five exploration holes (four in Hardstaff Peninsula and one on the Isthmus) in order to assess the aquifer properties and variation thorugh a vertical strata profile. This is done through pressure testing at a designated depth while the remainder of the bore is sealed off. Various depth intervals can be packer-tested on each bore.

Selected bores are packer tested immediately on completion of drilling while the drilling rig is still over the hole. This is because packer testing requires the drilling rig to raise drilling rods, pump water and raise and lower the packer during testing.

The testing procedure utilises a wireline single packer assembly, which is lowered to a pre-determined depth and inflated thus isolating the section of hole below the packer. A falling head test is then undertaken to assess the bulk conductivity of the section of hole beneath the packer. The packer is then repositioned higher in the hole, at the top of the next interval of interest, and the falling head test repeated. Table 5 summarises the holes and depth intervals (including formation) that were tested and the hydraulic conductivity values.

Analysis of the data allows the calculation of the conductivity of each formation or test interval. This data can then be used modelling and assessment purposes.

Table 5 Packer Testing Results to May 2011

Hole ID and date	Packer Interval	Formation	Hydraulic Conductivity (K)	Packer Type / comment
Y2I-15 17/10/2010	81.1 – 144	Yampi Member	3.1E-07 m/s	Single
	102.1 – 144	Elgee Siltstone	4.7E-07 m/s	Single
	123.1 – 144	Carbonaceous Shale	2.5E-06 m/s	Single
10DDH036 (Y2-3) 18/10/2010	72.1 – 143.5	Yampi Sandstone and Conglomerate	6.0E-05 m/s	Single, lost circulation zone distorting results
	102.1 – 143.5	Yampi Conglomerate and Mineralised Conglomerate	6.3E-06 m/s	Single, lost circulation zone distorting results
	123.1-144	Elgee Siltstone	9.7E-04 m/s	Single, lost circulation zone distorting results
10DDH041 (Y2-19) 23/11/2010	84.1-87.1	Wonganin SS	9.4E-07 m/s	Straddle
	210.1-213.1	Sandfly Schist	1.0E-06 m/s	Straddle
	228.1-264.6	Yampi	2.4E-05 m/s	Single
10DDH045 (4/12/2010)	69.1-72.1	Wonganin SS	2.5E-07 m/s	Straddle
	90.1-93.1	Sandfly Schist	5.5E-07 m/s	Straddle
	102.1-152.6	Yampi	6.5E-07 m/s	Single
11DDH062 25-28/2/2011	60.1-63.1	Elgee Siltstone	4.5E-07 m/s	Straddle
	78.1-81.1	PZ (partly mineralised)	6.2E-07 m/s	Straddle
	90.1-93.1	PZ (unmineralised)	1.6E-07 m/s	Straddle

6.2.1 Summary of aquifer properties

The aquifer testing using both the Hvorslev slug test method on airlifting and packer testing suggests that the hydraulic conductivity of the sequence in the Hardstaff Peninsula and the Isthmus is low with relatively consistent generally with values of 10^{-6}m/sec or lower.

Packer testing of one bore (10DDH036 (Y2-3)) has shown that there may be some higher permeability zones, as indicated by the tests and by loss of circulation during drilling.

7. Groundwater Chemistry

7.1 Analytical results

Groundwater samples were taken between October 2010 and March 2011 from a total of twenty two locations.

Samples were recovered at the completion of each air lift and the samples submitted for laboratory analysis at ALS Laboratories in Perth. Analysis is undertaken for pH, TDS, major ions, nitrate and selected metals (As, Cd, Cu, Cr, Pb, Fe, Ni, Zn). Field measurements of groundwater pH, EC, dissolved oxygen and ORp are also taken during bore development. pH (based on a limited number of field readings during development) typically ranges around 7.5 - 8.

The analytical results are summarised in Table 6 and Table 7.

The overall salinity is variable in the limited available analyses, with a range from 227 mg/L and 256 mg/L in several bores to as high as 41,400 mg/L, with a median of 23,150 mg/L. Spatial variations across the Hardstaff Peninsula or the Isthmus have not been identified. As many of the bores were sampled by airlifting of bores screened across long screen intervals, the vertical variation from individual bore samples is not possible.

The analyses have shown some variation of major analytes with the notable presence of sulphate in most samples.

Table 6: Groundwater Quality (Inorganics and Major Ions)

Field_ID	LocCode	Sampled_Date-Time	Bore depth	Screen from	screen to	TDS	Alkalinity (Bicarbonate)	Alkalinity (Carbonate)	Alkalinity (Hydroxide) as CaCO3	Alkalinity (total) as CaCO3	Bicarbonate Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Chloride	Sulphate (Filtered)	Sulphur as S (Filtered)	Sulphate	Nitrate (as N)	Nitrogen (Total Oxidised)	Nitrite (as N)	Calcium (Filtered)	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Anions Total	Cations Total	Ionic Balance	pH (Lab)
						mg/L	mg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	%	pH_Units
						5	1	1	1000	1	1	1	1	1	1	1	0.01	0.01	0.01	1	1	1	1	0.01	0.01	0.01	0.01
ANZECC (2000) Ecosystems Marine Water (95%)																											
Australian Drinking Water (2004)														*500*		*500*											
12	ID12B	16/03/2011	310.05	0	250	6740	-	-	<1000	54	54	<1	4710	-	-	404	<0.01	<0.01	<0.01	138	280	81	2340	142	134	3.07	7.84
16B	ID16B	15/03/2011	236.7	0	56.65+	3280	-	-	<1000	54	54	<1	2140	-	-	188	0.01	0.01	<0.01	101	144	32	1160	65.5	67.9	1.79	7.78
19	10DDH019	12/02/2011	266.4	37.7	67?	6970	66	<1	<1000	66	-	-	3860	-	-	239	0.02	0.02	<0.01	139	260	70	1780	115	107	3.47	7.6
20	10DDH020	12/02/2011	263.3	5.3	83.3	8290	64	<1	<1000	64	-	-	4660	-	-	359	0.02	0.02	<0.01	146	292	75	1900	140	116	9.53	7.63
21	10DDH021	17/03/2011	265.5	1.5	73.5	35,900	-	-	<1000	135	135	<1	17,800	-	-	*2280*	<0.01	<0.01	<0.01	623	1280	349	10,300	553	593	3.42	7.93
22	ID22B	13/02/2011	360	0	250	18,700	66	<1	<1000	66	-	-	11,400	-	-	*1360*	<0.01	<0.01	<0.01	679	844	146	5140	351	330	3	7.51
Y2-22	ID22B	20/10/2010	360	0	250	7220	40	<1	<1000	40	-	-	3110	*658*	219	-	<0.01	<0.01	<0.01	289	561	16	1030	102	106	1.64	6.76
31	10DDH031	15/02/2011	211.3	?	215	41,400	287	<1	<1000	287	-	-	20,300	-	-	*3010*	<0.01	<0.01	<0.01	508	1530	500	11,600	642	669	2.01	7.8
33	ID33B	11/02/2011	263.3	5.3	83.3	256	132	<1	<1000	132	-	-	42	-	-	7	1.09	1.09	<0.01	10	8	2	59	3.97	3.73	3.1	7.8
34	10DDH034	14/02/2011	18.8	0.8	18.8	230	<1	<1	<1000	<1	-	-	122	-	-	45	0.05	0.05	<0.01	11	8	4	69	4.4	4.31	1.03	4.4
35	10DDH035	19/03/2011	144	6	36	11,500	-	-	<1000	146	146	<1	7820	-	-	*805*	<0.01	<0.01	<0.01	192	518	158	4200	240	239	0.33	7.98
36a	10DDH036	10/02/2011	143.5			6140	48	<1	<1000	48	-	-	3400	-	-	220	0.03	0.08	0.05	304	152	49	1570	101	97.4	2	7.44
36b	10DDH036	11/02/2011	144.5			8810	5	<1	<1000	5	-	-	4800	-	-	*533*	0.06	0.25	0.19	413	259	71	2250	146	142	1.72	5.73
42	10DDH042	15/02/2011	93.6	45.6	81.6	16,000	758	<1	<1000	758	-	-	6560	-	-	317	<0.1	0.09	0.02	245	393	217	3200	207	189	4.42	7.84
42	10DDH042	19/03/2011	93.6	45.6	81.6	30,800	-	-	<1000	242	242	<1	19,000	-	-	*2580*	<0.01	<0.01	<0.01	388	1260	437	10,900	596	609	1.08	7.84
44	10DDH044	14/02/2011	197.25	0	197.25	21,800	138	<1	<1000	138	-	-	13,800	-	-	65	0.1	0.12	0.02	414	984	268	6930	394	410	1.89	7.37
44	10DDH044	18/03/2011	197.25	0	197.25	21,000	-	-	<1000	146	146	<1	12,500	-	-	*1020*	0.02	0.02	<0.01	375	814	216	5740	377	341	4.96	7.57
45	10DDH045	15/03/2011				12,900	-	-	<1000	10	10	<1	8230	-	-	*920*	0.12	0.13	0.01	322	555	107	4080	251	242	1.98	7.17
52	10DDH052	18/03/2011	128.9			25,600	-	-	<1000	94	94	<1	12,600	-	-	*1720*	0.02	0.02	<0.01	383	928	287	7750	394	440	5.54	7.8
53	11DDH053	9/02/2011	221.6			4760	52	<1	<1000	52	-	-	2420	-	-	206	<0.01	0.02	0.02	109	188	32	1140	73.5	71.5	1.38	7.47
53	11DDH053	14/03/2011	221.6			227	-	-	<1000	82	82	<1	62	-	-	10	0.03	0.08	0.05	25	6	3	42	3.58	3.62	0.54	8.06
54	11DDH054	22/03/2011	90.8			27,600	-	-	<1000	72	72	<1	15,200	-	-	*1700*	0.02	0.02	<0.01	344	1010	326	8570	465	482	1.8	7.69
58	11DDH058	14/03/2011				256	-	-	<1000	46	46	<1	76	-	-	16	0.07	0.09	0.03	20	5	7	45	3.42	3.55	1.99	7.92
62	11DDH062	18/03/2011				9250	-	-	<1000	188	188	<1	4270	-	-	480	<0.01	<0.01	<0.01	226	366	69	1990	134	130	1.73	7.67
ID-20B	ID20B	19/10/2010	265.5	1.5	73.5	23,900	154	<1	<1000	154	-	-	11,900	*1580*	526	-	0.01	0.01	<0.01	399	857	256	7970	372	444	8.83	7.66
ID-6B	ID6B	18/10/2010	247	6	216??	22,400	158	<1	<1000	158	-	-	11,000	*1480*	493	-	0.21	0.21	<0.01	509	862	191	7220	343	415	9.5	6.9
Y2I-3	11DDH066	22/03/2011				26,000	-	-	<1000	142	142	<1	14,900	-	-	*2110*	0.08	0.08	<0.01	346	953	344	8360	467	468	0.1	8.12

Table 7: Groundwater Quality (Metals)

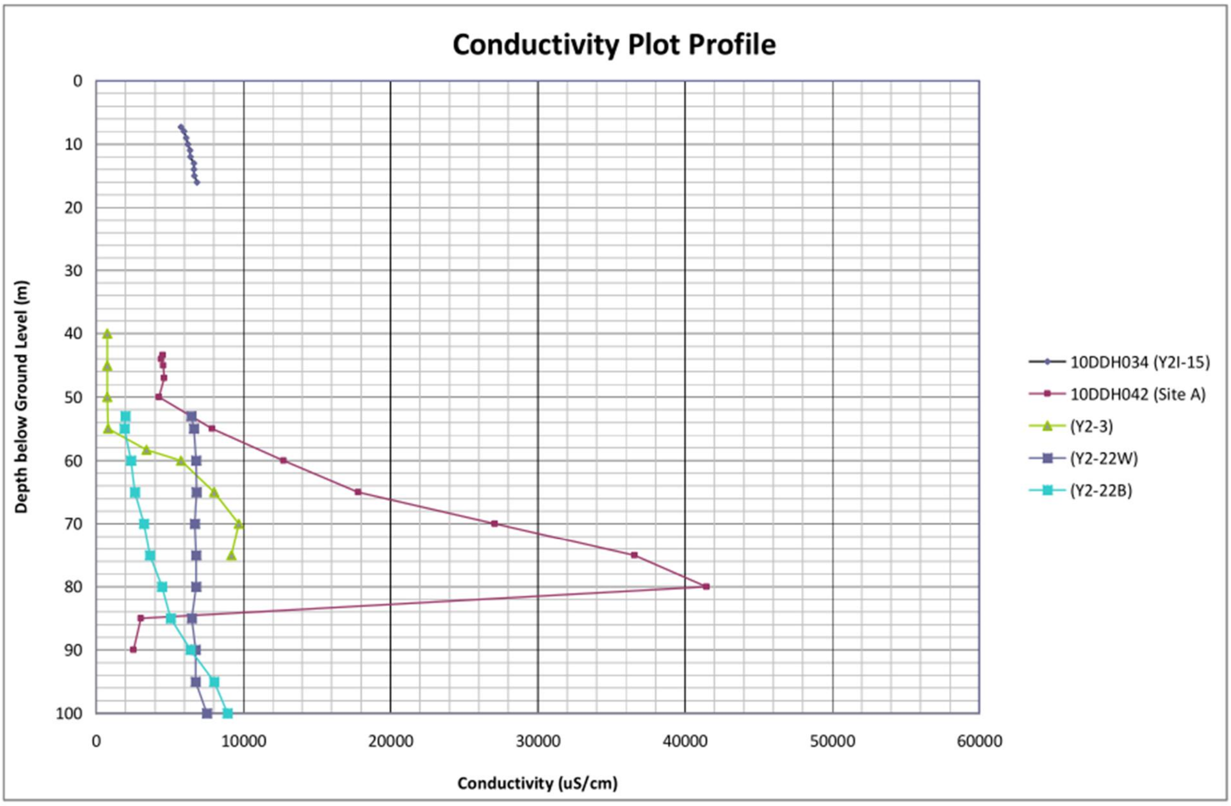
Field_ID	LocCode	Sampled_Date-Time	Bore depth	Screen from	screen to	Arsenic	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Nickel	Zinc
						mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
						0.001	0.0001	0.001	0.001	0.05	0.001	0.001	0.005
ANZECC (2000) Ecosystems Marine Water (95%)							**0.0055**	**0.0044**	**0.0013**		**0.0044**	**0.07**	**0.015**
Australian Drinking Water (2004)						*0.007*	*0.002*		*2*		*0.01*	*0.02*	
12	ID12B	16/03/2011	310.05	0	250	<0.001	<0.0001	<0.001	**0.003**	<0.05	<0.001	0.001	<0.005
16B	ID16B	15/03/2011	236.7	0	56.65+	0.003	<0.0001	<0.001	**0.003**	<0.05	<0.001	0.006	0.007
19	10DDH019	12/02/2011	266.4	37.7	67?	0.004	<0.0001	<0.001	**0.003**	0.48	<0.001	0.003	0.013
20	10DDH020	12/02/2011	263.3	5.3	83.3	0.001	<0.0001	<0.001	**0.005**	0.48	<0.001	0.008	**0.029**
21	10DDH021	17/03/2011	265.5	1.5	73.5	<0.001	<0.0001	<0.001	**0.009**	<0.05	<0.001	0.004	0.007
22	ID22B	13/02/2011	360	0	250	<0.001	<0.0001	<0.001	**0.006**	<0.05	<0.001	0.006	**0.039**
Y2-22	ID22B	20/10/2010	360	0	250	*0.016*	0.0002	<0.001	**0.008**	1.1	<0.001	0.004	0.013
31	10DDH031	15/02/2011	211.3	?	215	*<0.01*	<0.001	**<0.01**	**0.021**	<0.5	**<0.01**	<0.01	**<0.05**
33	ID33B	11/02/2011	263.3	5.3	83.3	<0.001	0.0005	0.002	**0.013**	2.15	<0.001	0.01	**1.6**
34	10DDH034	14/02/2011	18.8	0.8	18.8	*<0.01*	<0.001	**<0.01**	**0.06**	<0.5	**<0.01**	0.017	**0.089**
35	10DDH035	19/03/2011	144	6	36	*0.017*	<0.0001	<0.001	**0.006**	<0.05	<0.001	0.004	<0.005
36a	10DDH036	10/02/2011	143.5			0.001	0.0014	<0.001	**0.006**	<0.05	<0.001	0.005	**0.023**
36b	10DDH036	11/02/2011	144.5			0.001	<0.0001	<0.001	**0.007**	<0.05	<0.001	0.005	0.01
42	10DDH042	15/02/2011	93.6	45.6	81.6	*0.034*	0.0017	**<0.01**	**0.177**	7.78	**<0.01**	*0.038*	**6.22**
42	10DDH042	19/03/2011	93.6	45.6	81.6	*0.08*	<0.0001	<0.001	**0.024**	0.44	<0.001	0.004	0.007
44	10DDH044	14/02/2011	197.25	0	197.25	*0.011*	<0.001	**<0.01**	**0.04**	<0.5	**<0.01**	***0.073***	**<0.05**
44	10DDH044	18/03/2011	197.25	0	197.25	<0.001	<0.0001	<0.001	**0.006**	0.61	<0.001	*0.053*	0.006
45	10DDH045	15/03/2011				<0.001	0.0002	<0.001	**0.071**	0.11	<0.001	0.013	**0.02**
52	10DDH052	18/03/2011	128.9			*0.027*	0.0001	<0.001	**0.063**	3.14	<0.001	0.017	0.011
53	11DDH053	9/02/2011	221.6			0.003	<0.0001	<0.001	**0.016**	5.63	0.002	0.014	**0.019**
53	11DDH053	14/03/2011	221.6			<0.001	<0.0001	<0.001	<0.001	-	<0.001	0.005	0.006
54	11DDH054	22/03/2011	90.8			<0.001	0.0002	<0.001	**0.076**	0.11	<0.001	*0.021*	0.008
58	11DDH058	14/03/2011				<0.001	<0.0001	0.004	**0.002**	<0.05	<0.001	<0.001	<0.005
62	11DDH062	18/03/2011				0.004	<0.0001	<0.001	**0.01**	4.41	**0.009**	0.008	0.009
ID-20B	ID20B	19/10/2010	265.5	1.5	73.5	0.003	0.0004	<0.001	**0.02**	0.91	<0.001	*0.032*	0.011
ID-6B	ID6B	18/10/2010	247	6	216??	<0.001	<0.0001	<0.001	**0.049**	18.2	<0.001	0.019	0.009
Y2I-3	11DDH066	22/03/2011				<0.001	0.0001	<0.001	**0.018**	0.08	<0.001	0.012	0.006

7.1.1 Halocline Measurement

Based on the known geology and from knowledge from work undertaken on Koolan and Cockatoo Islands, it is hypothesised that a fresh water lens is likely to be present overlying more saline water at depth. The quality and depth of the freshwater lens will have important consequences for the island's water supply and could potentially influence the presence of stygofauna.

An attempt to identify the saline gradient through the formations was made by through running a saline profile on bores that are fully developed and are either uncased or have slotted screens for the entire casing length. Saline profiles were run on a number of bores by using a salinity probe dipper. Results for the profiles are illustrated below as Figure 14. The measurements are in us/cm which is an indicator of salinity.

Figure 14 Saline Profile of Selected Wells



The above graph illustrates that all the wells show some degree of increasing salinity with depth. Site A (bore 10DDH042 located on the Isthmus at a ground elevation of around RL 50m, shows signs of sea-water intrusion with conductivities increasing significantly beyond around 50 mbgl (metres below ground level). The maximum salinity being measured at around 80 mbgl of 40,000 µs/cm, equivalent to a salinity (as Total Dissolved Solids (TDS)) of around 26,800 mg/L (sea-water ≈35,000 mg/L). The screen interval at Site A is between 45 and 81 mbgl, therefore the saline gradient exhibited in the well is likely to representative of the saline gradient in the actual formation. The salinity of the sample taken after airlifting of this well was 16,000 mg/L, suggesting the likely mixing of waters from different aquifer intervals.

Evidence of a salt water wedge is present from bore Y2-3 (Bore 10DDH036) located at the southern end of the Hardstaff Peninsula, which shows increase salinity down the bore. The elevation of the bore is around 65-70m AHD so the increased salinity from around 60m in the bore roughly equates to Sea level.

Other haloclines are inconclusive although there is a gradual increase in EC from around 60m in Y2-22B (bore no ID22B). The elevation of this bore is approximately 50m AHD and is located approximately 300m inland near the northern end of the Hardstaff Peninsula. The gradient of the salt water wedge is not conclusive from this limited data.

8. Tidal Movement and Acid Sulphate Soil Potential

8.1 Preliminary consideration of mangrove hydrology

One of the requirements of the study for the PER will be to assess the potential impact of pit dewatering on the mangrove adjacent to the Isthmus Deposit. The dependence of the mangrove on fresh or sea water or the degree and frequency of tidal ingress into the mangrove is not known.

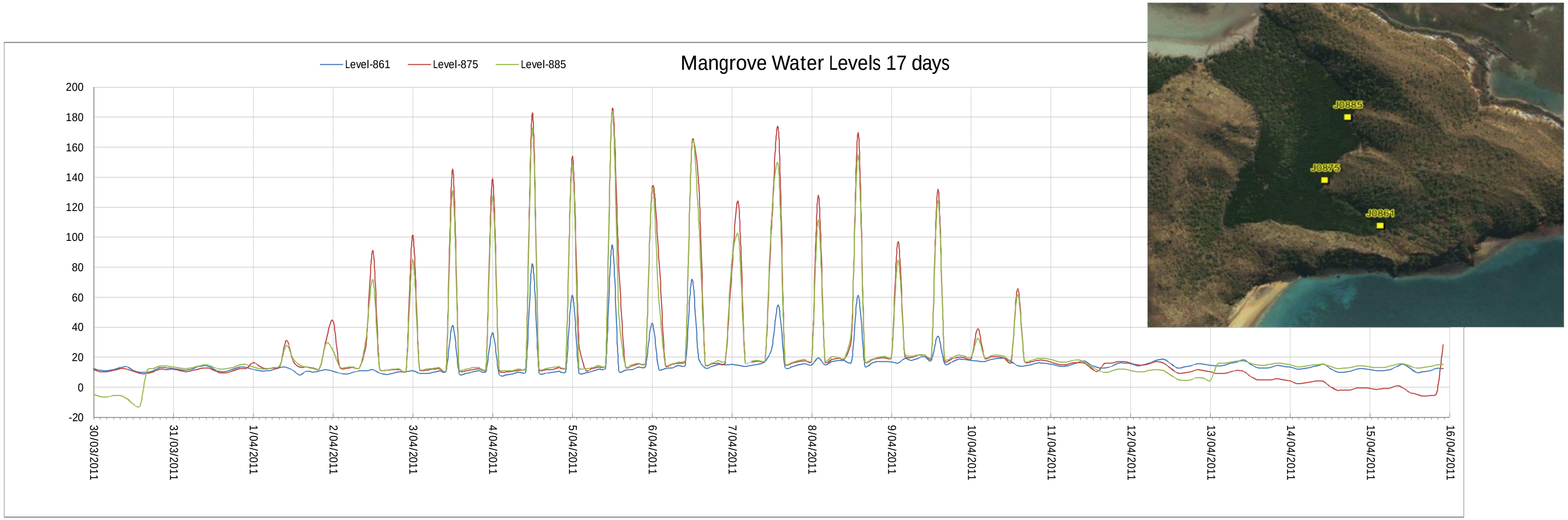
In order to quantify the tidal movement around the mangroves, three water level transducers have been strategically installed at the locations shown on Figure 15. The three transducers were secured to mangrove roots at low tide. These recorded sea-water levels every 120 minutes from 28th February to 25th May 2011. Downloaded data is plotted for the entire duration of the monitoring period and for a selected period of high tides in early April in Figure 16. The graphs show water level fluctuation over the three month period above the original position of the transducer (they are not referenced to AHD). High tides cause water level rise up to 2.6m above logger height. Loggers 885 and 875 generally recording similar water levels, with water levels at 861 being around 1m shallower.

The temporal patterns in all three pressure transducers indicate that there is a tidal cycle of approximately 14 days with nine day periods of inundation separated by five day periods in which there is no inundation. On a daily basis, there is a tidal rise and fall in water levels for 1-2 data points (i.e inundation over an approximate 4 hour period (<6hours)), with two inundations every 24 hours .

A number of groundwater level observations on the Isthmus in the vicinity of the mangroves, suggests that the groundwater level is approximately sea level although this will require confirmation by survey data. It appears that the groundwater forms the hydraulic "basement" to the mangrove zone (rather than providing an ongoing groundwater flux) to maintain the saturated conditions in the mangrove

Figure 15 Location of Water level Transducers to Assess Tidal Movement

* This document is in a draft and not a final issued form. The contents of this draft document including any opinions, conclusions or recommendations contained in or which may be implied from this draft document must not in any way whatsoever be relied upon. GHD reserves the right, at any time with or without notice, to amend, modify or retract any part or all of the draft document including any opinions, conclusions, or recommendations contained therein. Unauthorised use of this draft document in any form whatsoever is strictly prohibited. To the maximum extent permitted by law, GHD disclaims any responsibility for liability howsoever arising from or in connection with this draft document.


Mangrove Water Levels 17 days
Level-861
Level-875
Level-885
200
180
160
140
120
100
80
60
40
20
0
-20
30/03/2011
31/03/2011
1/04/2011
2/04/2011
3/04/2011
4/04/2011
5/04/2011
6/04/2011
7/04/2011
8/04/2011
9/04/2011
10/04/2011
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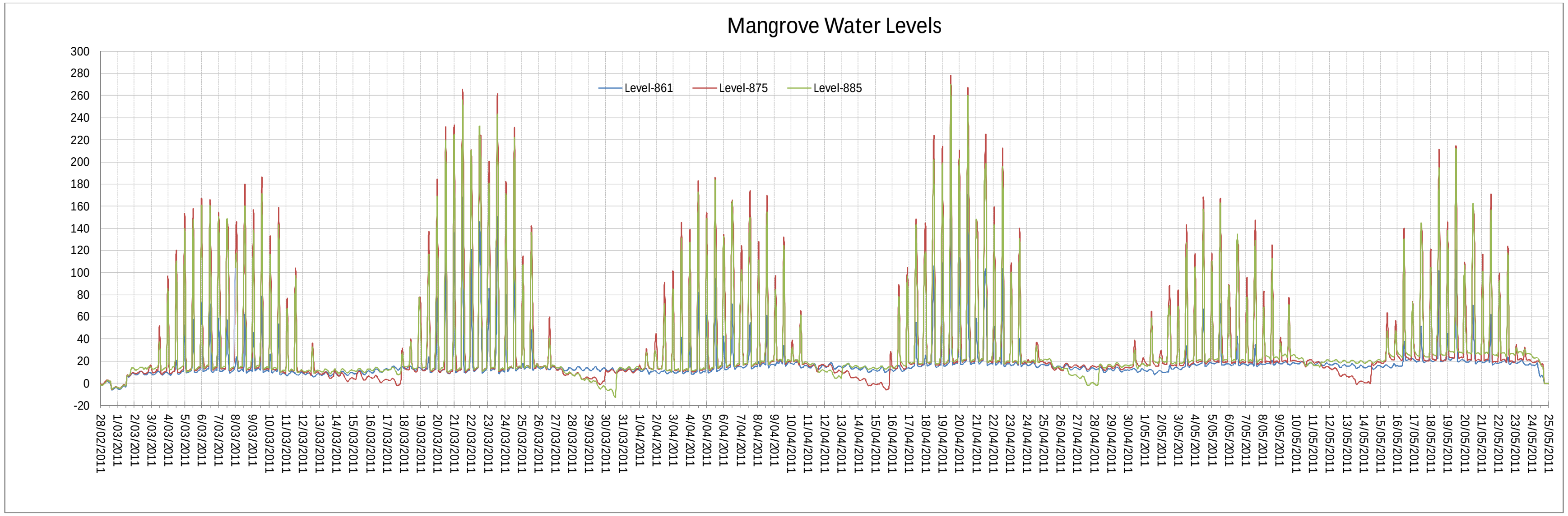
J0885
J0875
J0861


Mangrove Water Levels
Level-861
Level-875
Level-885
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
28/02/2011
25/05/2011

8.2 ASS Background Information & Rationale

The classification of ASS includes both actual acid sulfate soils (AASS) and potential acid sulfate soils (PASS). AASS are soils that generate acidity, whereas PASS are soils that have the potential to generate acidity.

ASS are soils containing naturally-occurring, fine-grained metal sulphides typically pyrite (FeS2), formed under saturated, anoxic/reducing conditions. They generally occur in Quaternary (1.8 Ma – Present) marine or estuarine sediments, predominantly confined to coastal lowlands (elevations generally below 5 mAHD).

Although soils described above represent typical conditions where ASS occurs, the presence of ASS materials is should be established through field investigations

Given that the mangrove area on Irvine Island is low lying, usually waterlogged, contains high organic content in sediments, and contains relatively recent deposits of iron oxides, ASS may be expected within the proposed project area.

8.2.1 Potential Risks of AASS and PASS

When PASS are disturbed, either by excavation or lowering of the watertable below natural seasonal levels, sulfides present are exposed to air, allowing oxidisation and consequently, the formation of sulfuric acid (H_2SO_4). AASS are capable of generating acidity *in-situ* in their natural state; disturbance is not required for acidic discharges to develop.

As a result of the presence of AASS, or the oxidation of PASS, surrounding land (soil) and nearby waterways may become acidic (pH<6.5). Under acidic conditions, metals such as aluminium (generally at pH<4.5) and iron, as well as trace heavy metals (including arsenic), become more mobile in the environment and can be taken up by infiltrating waters. As a result, surface and/or groundwater concentrations of these metals may reach concentrations which have the potential to cause acute or chronic toxicity to sensitive terrestrial and aquatic plants and animals.

8.2.2 ASS Risk Mapping

The Department of Environment and Conservation (DEC) provides limited ASS risk mapping for Western Australia via Landgate's Shared Land Information Platform (SLIP). There are no DEC ASS risk maps available for Irvine Island.

Similarly, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) also have ASS risk mapping available online through ASRIS (Australian Soil Resource Information System). This system offers the probability of ASS occurring in a certain landscape and specifies with what confidence level. There is no CSIRO ASS risk mapping in the immediate Y2I-19 area.

8.3 Soil Testing for ASS

8.3.1 Soil Sampling

The Acid Sulphate generation potential of the mangrove was assessed by sampling the mangrove sediments in the area adjacent to bore Y2I-19. The sample was taken with a hand auger, removing sediment samples from a depth of between 0.4 m and 0.5 m.

The laboratory results are presented as and indicate that the sediment has a net acidity of 22 moles per tonne. This is above the Department of Environment and Conservation (DEC) guideline of 18 moles per tonne and therefore has the potential to generate acid if exposed through actions such as dewatering. It should be noted however that the sample showed a high buffering capacity of almost ten times the net acidity. This is likely to be largely a result of the saline conditions of the sediment. Further sampling will need to be undertaken to assess the impacts that potential dewatering may have when the mine planning is finalised.

One subsurface ASS sample (0.1 - 0.2 m depth) was collected from the mangroves on Irvine Island at the Y2I-19 location. The sample was analysed in a NATA accredited laboratory (ALS Laboratory Perth) for pH_F and pH_{FOX} screening. The sample was then analysed for Suspension Peroxide Oxidation Combined Acidity & Sulfur (SPOCAS) and Chromium Reducible Sulfur (CRS) by ALS Laboratory Perth. Soil results were assessed against the DEC net acidity action criteria (DEC 2009).

8.3.2 Soil Sampling Results

Results from the soil sampling are summarised in Table 8.

Table 8 SPOCAS and CRS Results

Date sampled	Sample ID	Depth (m)	pH_F	pH_{FOX}	Delta pH	Net acidity (mol H^+/t)	S_{CR} (%S)
3/3/2011	Y2I-19	0.1-0.2	8.4	5.9	2.5	22	0.012

The pH screening results and SPOCAS/CRS results suggest that the soil within the immediate vicinity of Y2I-19 contain ASS, in the form of PASS. The pH_F of the soil is alkaline, however acidifies to pH 5.9 when reacted with hydrogen peroxide (pH_{FOX}). This change in pH (delta pH) occurs as the soil undergoes oxidation and releases acidity.

The SPOCAS analysis indicates that the soil has some acid generating capability, recording a net acidity of 22 mol H^+/t. This result exceeds the DEC's net acidity criteria (for sands) of 18.7 mol H^+/t. The S_{CR} result confirms the soil has acid generating capability, and that the source of the acidity may not be from organic sources but from a source of inorganic sulfur (i.e. pyrite).

It is important to note however that there is a high amount of acid neutralising capacity (ANC) in the soil. There is almost 10 times the amount of ANC to net acidity suggesting that if oxidised, the soil's inherent ANC may buffer most (if not all) acid generation. The relative rates of buffering will depend on the kinetics of the reactions occurring and further testing via kinetic NAG and/or ABCC would be required to confirm the likely buffering potential of the material.

8.4 Preliminary Assessment of ASS potential

Based on the results obtained as part of this limited sampling, soil within the immediate vicinity of Y2I-19 contains PASS and may oxidise to produce acidity given any excavation and/or dewatering. The risk of significant impacts (based on the results of the sample taken being representative of the material in the mangrove area) is low as the material has high ANC potential and sea water would act as a natural buffer to low levels of acidity. However further investigation and testing (possibly kinetic testing) would be required to confirm this assumption is valid for the wider mangrove area if disturbance of these materials is anticipated. Accordingly, an ASS management and/or groundwater management plan with reference to the DEC guidelines may be required for any excavations and/or dewatering that will impact the mangrove areas.

Given that there has only been one sample analysed and that sample returned a net acidity exceeding the DEC's action criteria, it is recommended that if dewatering and/or excavations are proposed that will impact the mangrove area, additional ASS focused intrusive investigations (and installation of additional groundwater monitoring wells) are carried out in and around the project area. Further investigations are required to allow greater lateral and vertical delineation of the ASS zones and an understanding of groundwater geochemistry.

9. Water Supply Bore Testing

Bore WM Y2-22 has been drilled as a water supply bore, and an observation bore completed adjacent to the bore (ID 22B). The water supply bore is 137.4 m deep, screened from 61 – 85.7 m and open hole from 90.9m. It has been equipped with a submersible pump.

The water supply bore was tested in July 2010 to assess its potential yield and its long term water quality. From the July pump test, it appears that the bore may be capable of pumping ~0.25 L/s. A 46 minute test was undertaken on the 20 October. In this test, the salinity appeared to stabilise at around 8 mS/cm (brackish, ≈5,000 mg/L as TDS). Salinity profiling suggested a relatively consistent salinity to a depth of 100m.

To test the bore sufficiently to assess reliability of supply and justify equipment for permanent use, a longer duration pump test of 48 hours is recommended.

10. Estimation of Groundwater inflows

10.1 Introduction

Mining at Irvine Island will be below the water table to depths of 820 m RL on the Hardstaff Peninsula. The extent of drawdown required and the dewatering inflow volume are important components of the project planning. Furthermore, the potential impact on environmental features (particularly the mangroves) needs to be addressed.

The stratigraphy and structure of the sequence at Irvine Island, the connection to the sea, and the mine footprint over time, influences the dewatering inflow volume, the extent of drawdown and potential impacts on environment.

The sequence generally dips westwards and there is also a slight plunge northwards. Based on experience from mining of the similar formations in the nearby islands by GHD suggests that low permeability units like the Elgee Siltstone beneath the ore zone and the Sandfly Schist above, limit the mining drawdown impacts across strike and the drawdown cones tend to extend along strike.

Dewatering and drawdown at Irvine Island are therefore considered likely to be strongly influenced by the orientation of the Elgee siltstone. The potential mining area may be in connection with the sea along strike to the south to the peninsula and to the north where the Elgee Siltstone continues below sea level. To the western side of the peninsula the potential connection of the mining area will depend on the mine plan adopted and the site hydrogeology, particularly the hydraulic properties of the Sandfly Schist which overlies the orebody.

The geological model and nominal pit shells (AMC, 2011) were used to develop a numerical groundwater model for the Hardstaff Peninsula using the MODFLOW package. These models provide:

- Preliminary estimate of groundwater inflows (i.e. rates, volumes) into the proposed mine over the development period; and
- Preliminary estimates of groundwater drawdown surrounding the proposed mine over the development period.

Modelling has not yet been done for the Isthmus. A brief description of the model design and results for Hardstaff Peninsula are summarised below.

10.2 Numerical Modelling

The Hardstaff Peninsula model was based on topography (top of layer 1) and geology for the lower layers. Hydrogeological units mirrored geological units, thus the hydrogeological units included the Wonganin Sandstone, the Sandfly Siltstone, the Yampi Member, and the Elgee Siltstone. The configuration of the layers is based on geological surfaces provided by AMC. The aquifer properties (hydraulic conductivity) applied in the model were based on averages of field test results presented in (GHD, 2011 198812).

The pit geometry based on the pit shell (r27_08_shell.dxf) provided by AMC .

The model was run as a steady state model to provide initial conditions before mining is likely to commence. A further time varying (transient) simulation was undertaken with pit progression based on the mining schedule to cover the 14 years for the schedule for 3,5,7,10 design depths (provided by AMC).

The simulations applied a nominal level for high tide of 1005 m to form the basis for general head boundary elevations for the steady state model. A nominal recharge value of 5% of annual average rainfall (~1000 mm) was applied across the model (50 mm/year). The model is sensitive to changes in recharge and this may provide a parameter which can be altered to improve calibration (see sensitivity analysis below).

Modelled heads in the deeper layers are fairly flat, as they are dominated by the close connection of the Yampi with the sea, whereas the shallower horizons tend to follow the topography. As described earlier in this report, the position of the monitoring screens or sections of open hole cross a number of hydrogeological units and elevations need to be confirmed. Installation of additional groundwater monitoring bores screened in discrete units across the peninsular may also assist in providing a more appropriate coverage for calibrating the groundwater model. At present the steady state model calibration requires additional work as modelled groundwater heads vary significantly from those observed on the site ranging from 0.5 m to 13 m error (with both positive and negative errors). At present the steady state model only provides a solution calibrated to general water levels associated to a conceptual model based on the observations of groundwater levels.

10.3 Model Parameter Sensitivity Analyses

Sensitivity analyses were undertaken on key model parameters and the results of these are provided below in

Table 9. Further model calibration could undoubtedly provide better solutions for the steady state model, however, given the preliminary nature of this groundwater model, no further calibration was undertaken. Further calibration would benefit from data from additional groundwater monitoring bores as described above.

Table 9 Model Parameter Sensitivity Analysis

Model Run	252	255	256	253	254	257	258	259	260
Parameter Variation	Original	Kh /10	Kh x 10	Kh/Kv /3	Kh/Kv x 3.3	Recharge x 10	Recharge x 2	GHB 1000	GHB 995
Wonganin Sandstone K (m/day)	0.05	0.05	0.05	0.005	0.5	0.05	0.05	0.05	0.05
Sandfly Schist and Siltstone K (m/day)	0.07	0.07	0.07	0.007	0.7	0.07	0.07	0.07	0.07

Model Run	252	255	256	253	254	257	258	259	260
Yampi Member K (m/day)	0.06	0.06	0.06	0.006	0.6	0.06	0.06	0.06	0.06
Elgee Siltstone K (m/day)	0.04	0.04	0.04	0.004	0.4	0.04	0.04	0.04	0.04
Kh/Kv	10	3	1	3	10	10	10	10	10
Recharge (mm/year)	50	50	50	50	50	500	100	100	100
GHB	1005	1005	1005	1005	1005	1005	1005	1000	995
Residual Error	1.73E+03	1.81E+03	1.86E+03	8.20E+03	2.01E+03	9.87E+03	1.60E+03	2.45E+03	4.00E+03
Mean Error	-3.053	-3.371	-3.371	9.116	-4.31	10.938	-1.579	-3.985	-7.444
Mean Abs Error	5.348	5.365	5.365	10.951	5.278	11.797	5.416	6.472	8.507
RMS	6.708	6.866	6.866	13.928	7.234	15.285	6.458	7.99	10.199
Range in heads	16.94	16.94	16.94	16.94	16.94	16.94	16.94	16.94	16.94
Scaled RMS error	40%	41%	41%	82%	43%	90%	38%	47%	60%

10.4 Hardstaff Peninsula – Preliminary Estimated inflows

The transient model estimated a total of 20.8GL over the 16 year model (Table 10). Each modelled time step represented the period over which the mine reached a particular elevation (eg a two year time step for years 3 & 4 when the mine elevation is 890m AHD). Additional sensitivity on the influence of the general head boundary elevation was undertaken using the 16 year model.

Table 10 Transient model results

Year	Mine elevation modelled	GL/year	L/s
1	1050		
2	1010		
3	930	1.3	42
4	890	1.5	47

Year	Mine elevation modelled	GL/year	L/s
5	890	1.5	47
6	880	1.5	47
7	880	1.5	47
8	880	1.5	47
9	880	1.5	47
10	850	1.5	48
11	850	1.5	48
12	850	1.5	48
13	830	1.5	48
14	830	1.5	48
15	830	1.5	48
16	820	1.5	48

(Model266 using those parameters expressed above in Model258)

10.5 Hardstaff Peninsula – Preliminary groundwater drawdown estimates (Transient Modelling Results)

Groundwater drawdowns over time were calculated by subtracting the static model outputs versus the transient model outputs. Drawdowns along the Hardstaff Peninsula are controlled by (i) the geometry of the pit floor and (ii) the geometry of the coast. The calculated drawdowns inland from the Hardstaff Peninsula were observed to vary from:

- 10 m drawdown contour extending up to 655 m north west of the pit shell and the 9 m drawdown extending beyond model boundary (>1km from the pit shell) for the 930 m pit floor stage; to
- 12 m drawdown contour extending up to 650 m north west of the pit shell and the 11 m drawdown extending beyond model boundary (>1km from the pit shell) for the final 820 m pit floor stage.

11. References

AMC, 2011

EPA 2007: Sampling methods and Survey Considerations for Subterrranean Fauna in Western Australia. Environment Protection Authority, Western Australia. Guidance for the Assessment of Environmental Factors, No 54a (Draft)

GHD, 2011, Report for Irvine Island Mine Pre-Feasibility Study, Groundwater Investigations, July 2011

Stocklmayer, V., 1990. Yampi Sound iron ore, in Geology of the Mineral Deposits of Australia and Papua New Guinea (Ed. F.E. Hughes), pp. 903-906, (The Australasian Institute of Mining and Metallurgy: Melbourne).

Appendix A

Bore Development Instructions

The following directions were provided to drillers for Well construction and monitoring:

Monitoring Well Construction Procedure:

- Following completion of drilling to the target depth, and prior to the installation of piezometer casing, drilling fluids should be flushed from the hole. This is done by flushing of clean water through the centre of the HQ casing once the inner-tubing has been removed at the completed hole depth.
- Volumes per metre are approximately 7 litres for the HQ rods. Therefore a 100 m hole would require flushing with 1,400 L of clean water (2 water tank volumes).
- Following flushing, 50 mm glue and screw linked PVC piezometer casing should be installed. The limited annulus of the drilled holes does not allow for the installation of a gravel-pack.

Monitoring Well Air-lifting Procedure:

The flushing exercise after drilling should remove the majority of drilling fluids, however some added fluids could remain in fractures and other defects. In order to further remove drilling fluids, the boreholes should be developed by airlifting. That is, injection of air using a compressor to displace bore water and encourage the flushing of drilling fluids and their evacuation from the bore. Airlifting is undertaken by the following procedure:

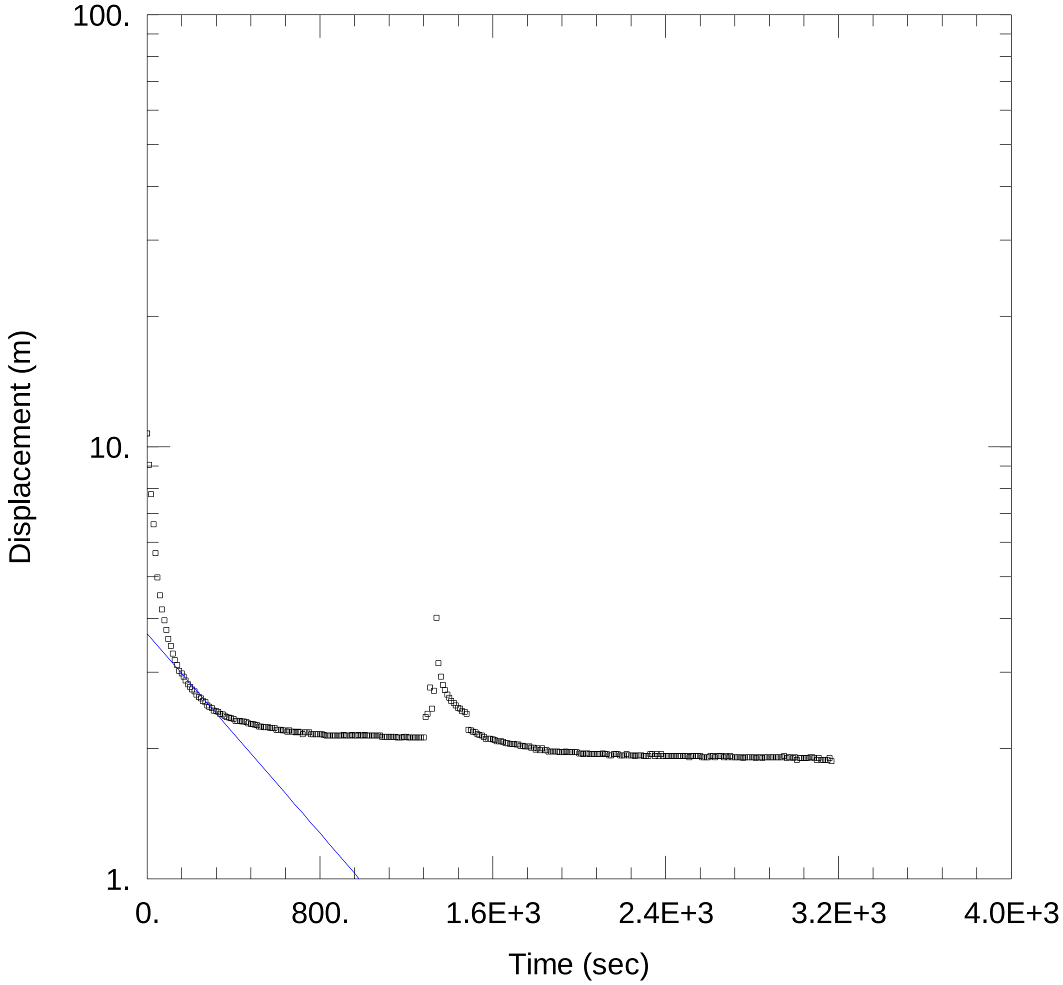
- Mobilisation of a 100 psi/62.5 cfm compressor to the bore sire.
- Installation of a 1" airline (poly-pipe) in the hole to the appropriate depth. The airline is securely fixed at the surface to avoid the poly-pipe from blowing out of hole during airlifting. The airline is connected to the compressor by means of an appropriate air couplings with whip checks.
- Air development produces the best results when the submergence ratio of the airline is around 60%. For example if the static water level (SWL) is 30 m, the airline should be run to 75 m. The airline should extend to the bottom of the screen or 40 metres below the static water table, whichever is shallower.
- Field parameters are to be measured periodically during development and development should be continued until the measured parameters stabilise and produced water appears clear and free of drilling fluid or other contaminants.
- Groundwater samples should be collected at the end of each airlift to allow characterisation of groundwater quality and confirm adequate purging of the bore.
- Changes in groundwater level, especially the water level recovery, should be recorded using a pressure transducer lowered on a steel cable into the borehole prior to the commencement of development. This data can be used to estimate a bulk conductivity of the rockmass in the vicinity of the borehole. Stygofauna Bore construction and sampling

Appendix B

Airlift Test Analysis (Aqtesolve Plots)

Recovery Test ID16B

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set: G:\...\ID16B Late Hvorslev.aqt
Date: 04/20/11 Time: 13:56:59

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 9.323E-9 m/sec y0 = 3.69 m

AQUIFER DATA

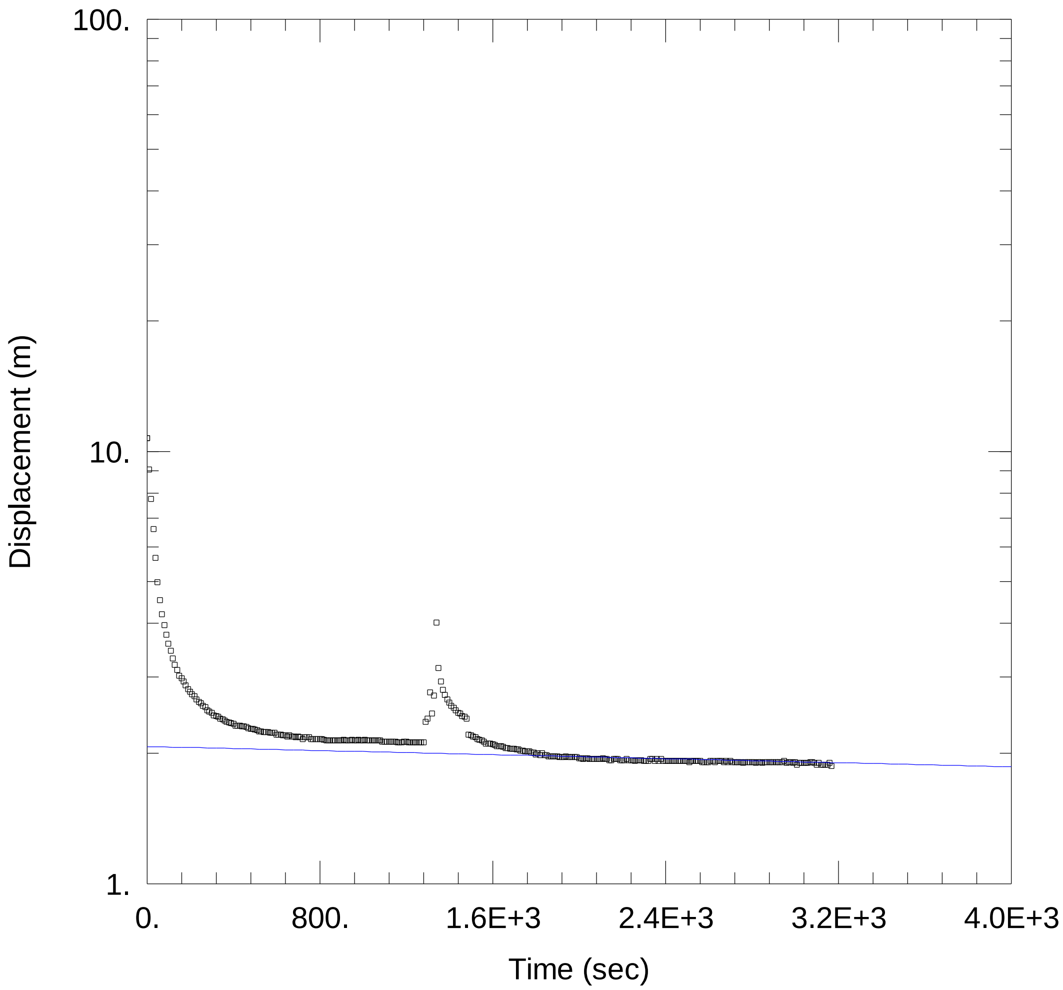
Saturated Thickness: 226.5 Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (ID16B)

Initial Displacement: 10.74 m
Static Water Column Height: 226.5 m
Total Well Penetration Depth: 226.5 m
Screen Length: 226.5 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test ID16B

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set:
Date: 04/20/11 Time: 13:54:55

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 1.89E-10 m/sec y0 = 2.075 m

AQUIFER DATA

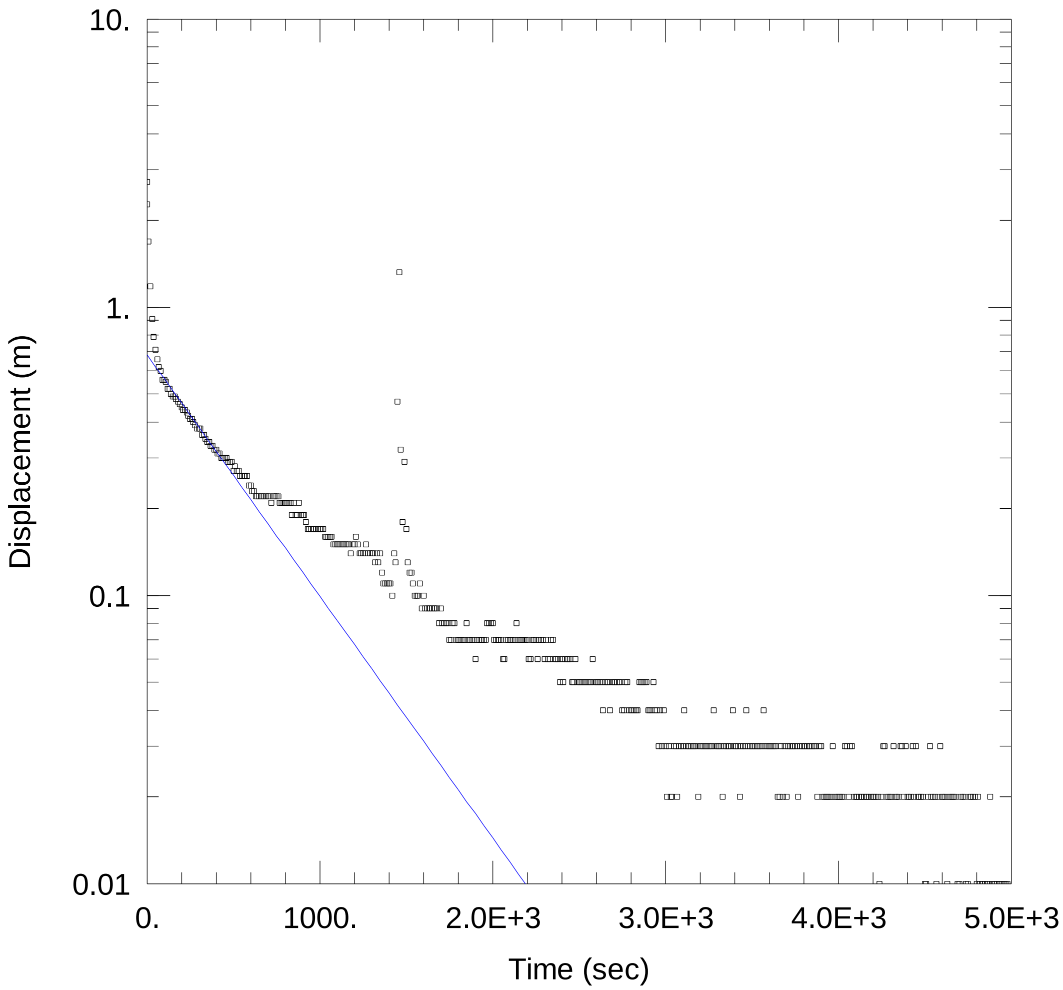
Saturated Thickness: 226.5 Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (ID16B)

Initial Displacement: 10.74 m
Static Water Column Height: 226.5 m
Total Well Penetration Depth: 226.5 m
Screen Length: 226.5 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test ID12B

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set: G:\...\ID12B Late Hvorslev.aqt
Date: 04/20/11 Time: 14:40:50

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 2.381E-8 m/sec y0 = 0.6841 m

AQUIFER DATA

Saturated Thickness: 233.! Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

Initial Displacement: 2.27 m
Static Water Column Height: 214.9 m
Total Well Penetration Depth: 214.9 m
Screen Length: 214.9 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

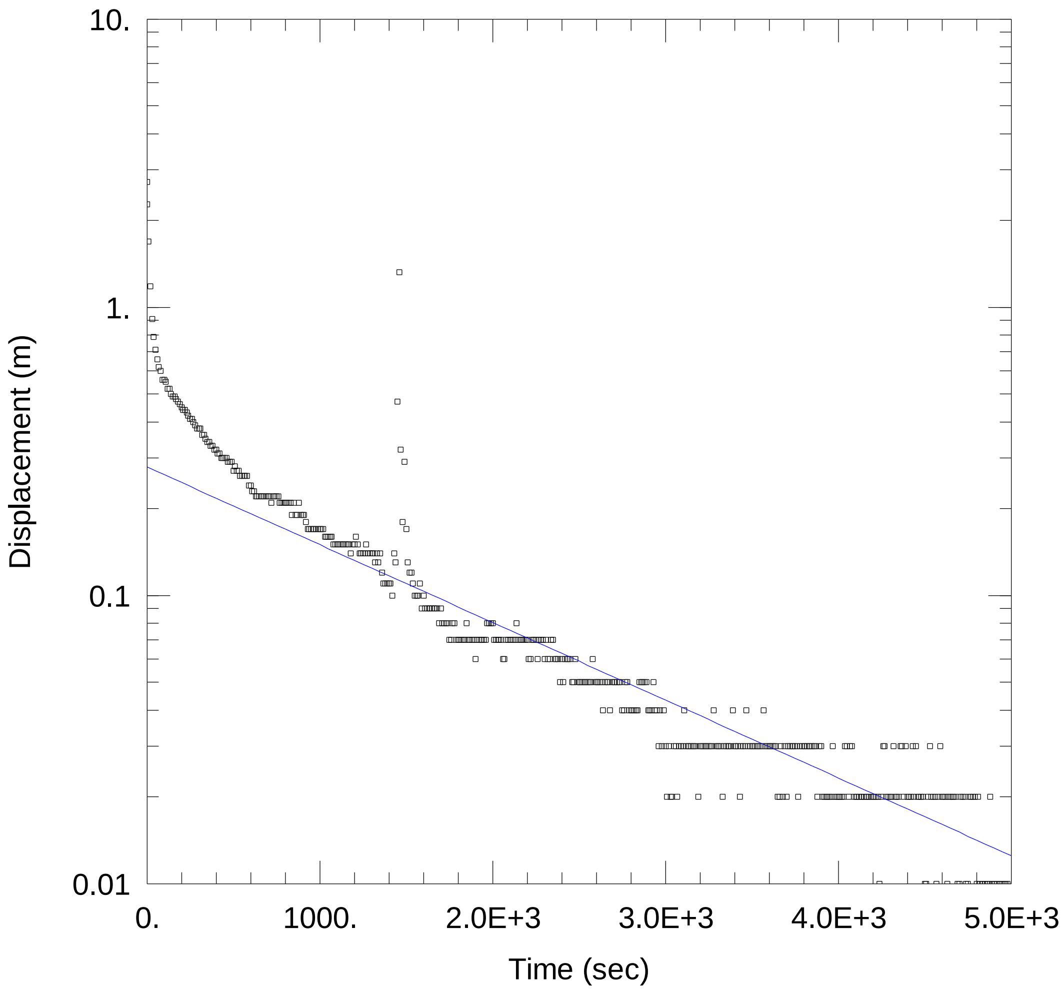
Recovery Test ID12B

Prepared By:
GHD

Prepared For:
Pluton Resources

Project:
312559600

Location:
Irvine Island



Data Set:
Date: 04/20/11 Time: 14:18:04

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 7.659E-9 m/sec y0 = 0.2788 m

AQUIFER DATA

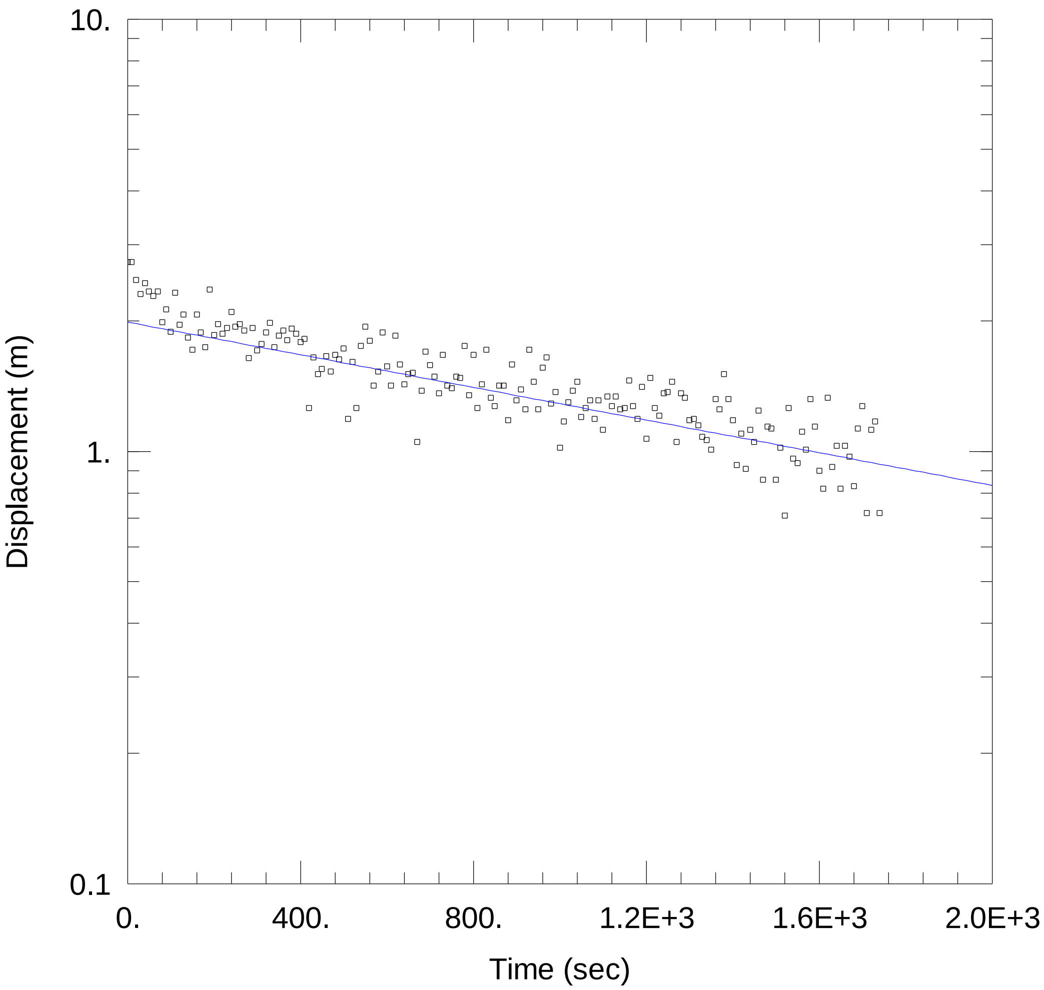
Saturated Thickness: 233.8 Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

Initial Displacement: 2.27 m
Static Water Column Height: 214.9 m
Total Well Penetration Depth: 214.9 m
Screen Length: 214.9 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test (11DDH062)

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set:
Date: 04/20/11 Time: 17:14:12

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 1.608E-8 m/sec y0 = 1.989 m

AQUIFER DATA

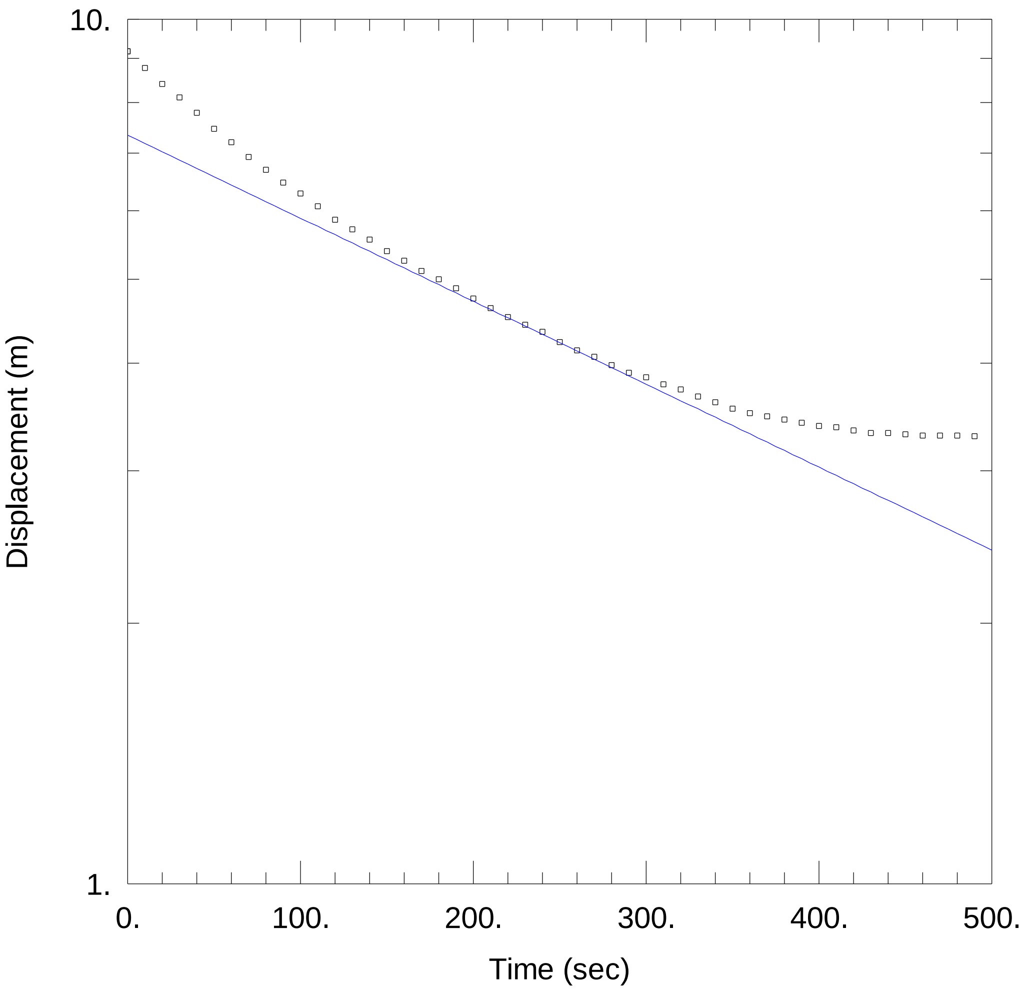
Saturated Thickness: 42.9(Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (11DDH062)

Initial Displacement: 2.74 m
Static Water Column Height: 42.98 m
Total Well Penetration Depth: 42.98 m
Screen Length: 42.98 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test 11DDH058

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set: G:\...\11DDH058 Late Hvorslev.aqt
Date: 04/19/11 Time: 15:48:33

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 2.037E-8 m/sec y0 = 7.338 m

AQUIFER DATA

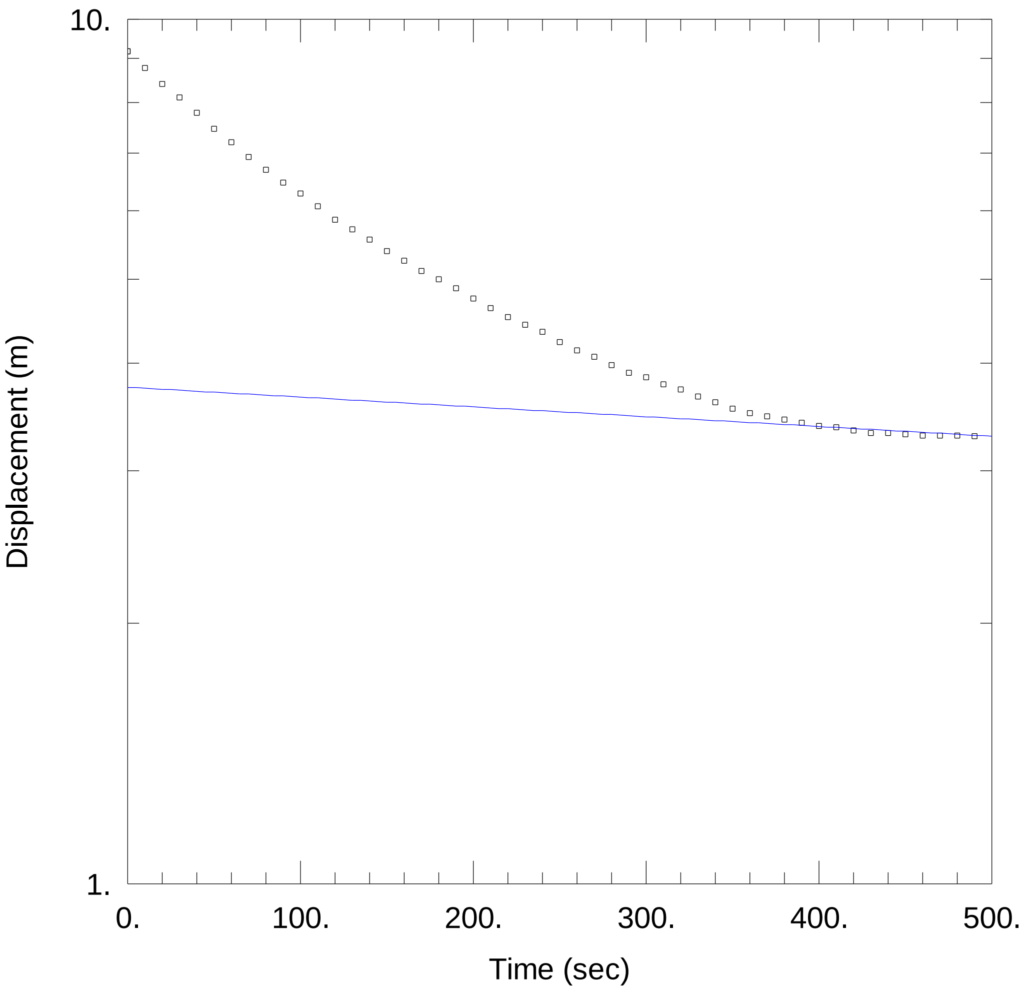
Saturated Thickness: 172.4 Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

Initial Displacement: 9.17 m
Static Water Column Height: 172.4 m
Total Well Penetration Depth: 172.4 m
Screen Length: 172.4 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test 11DDH058

Prepared By:	Prepared For:
GHD	Pluton Resources
Project:	Location:
312559600	Irvine Island



Data Set:
Date: 04/19/11 Time: 13:08:53

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 2.404E-9 m/sec y0 = 3.749 m

AQUIFER DATA

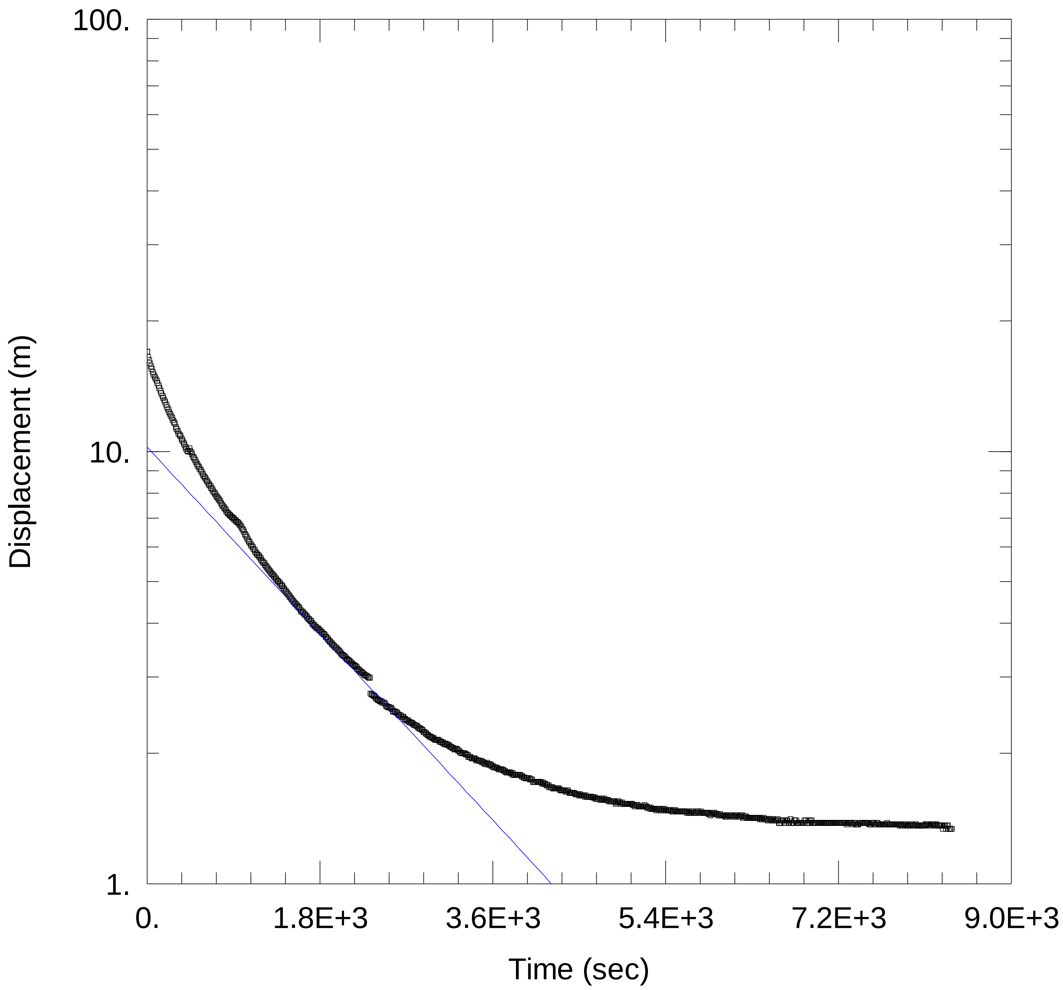
Saturated Thickness: 172.4 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

Initial Displacement: 9.17 m
Static Water Column Height: 172.4 m
Total Well Penetration Depth: 172.4 m
Screen Length: 172.4 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test (11DDH053)

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set: G:\...\11DDH053 Late Hvor.aqt
Date: 04/21/11 Time: 12:09:48

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 5.107E-9 m/sec y0 = 10.23 m

AQUIFER DATA

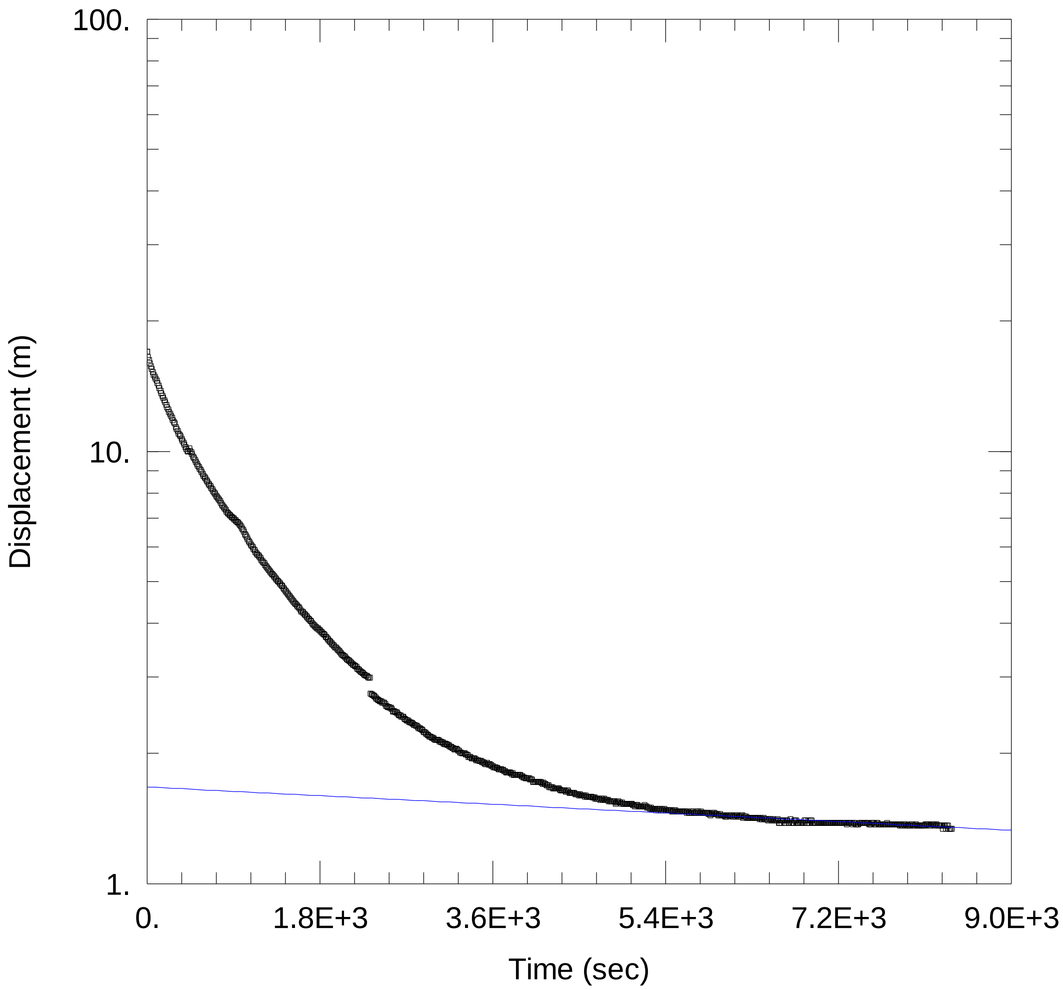
Saturated Thickness: 171.8 Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (11DDH053)

Initial Displacement: 16.98 m
Static Water Column Height: 171.8 m
Total Well Penetration Depth: 171.8 m
Screen Length: 171.8 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test (11DDH053)

Prepared By:	Prepared For:
GHD	Pluton Resources
Project:	Location:
312559600	Irvine Island



Data Set:
Date: 04/21/11 Time: 12:08:33

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 2.368E-10 m/sec y0 = 1.672 m

AQUIFER DATA

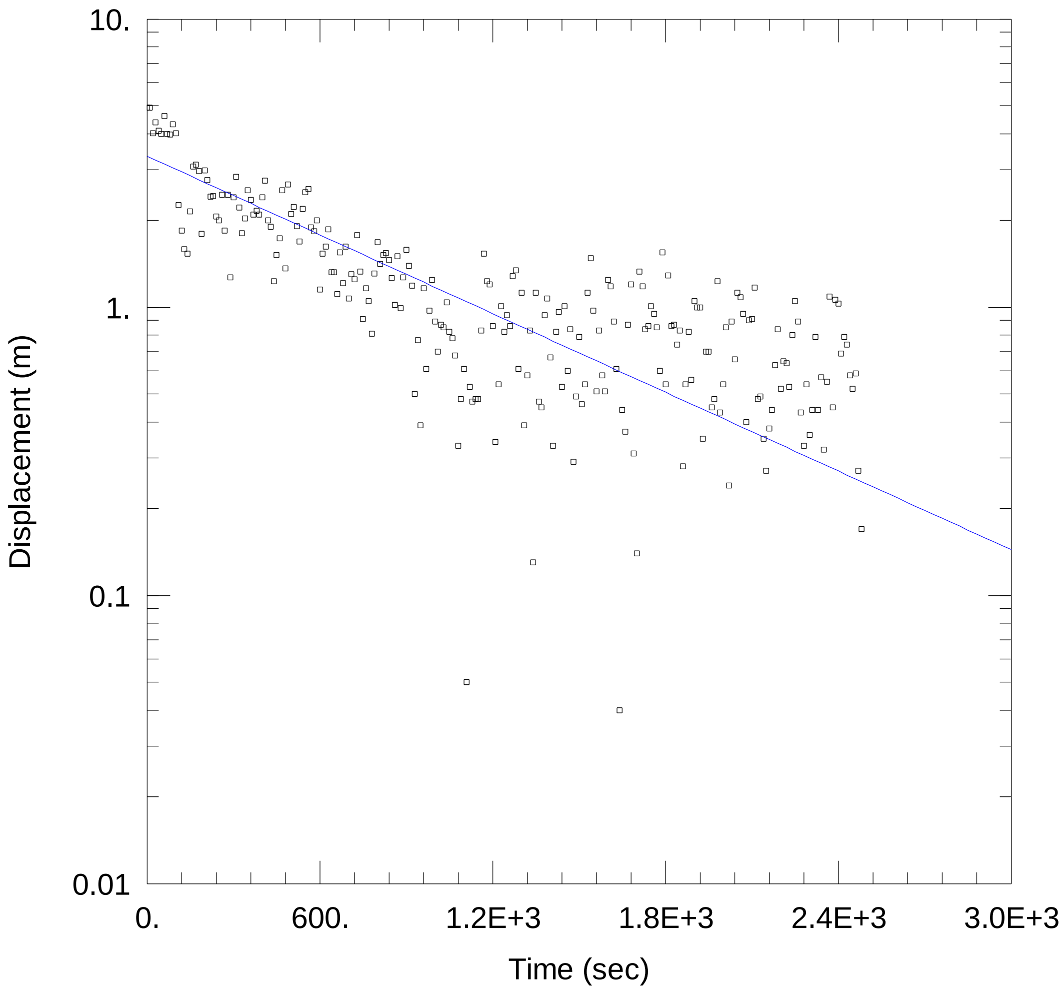
Saturated Thickness: 171.8 Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (11DDH053)

Initial Displacement: 16.98 m
Static Water Column Height: 171.8 m
Total Well Penetration Depth: 171.8 m
Screen Length: 171.8 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test (11DDH052)

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set:
Date: 04/21/11 Time: 11:15:56

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 2.88E-8 m/sec y0 = 3.341 m

AQUIFER DATA

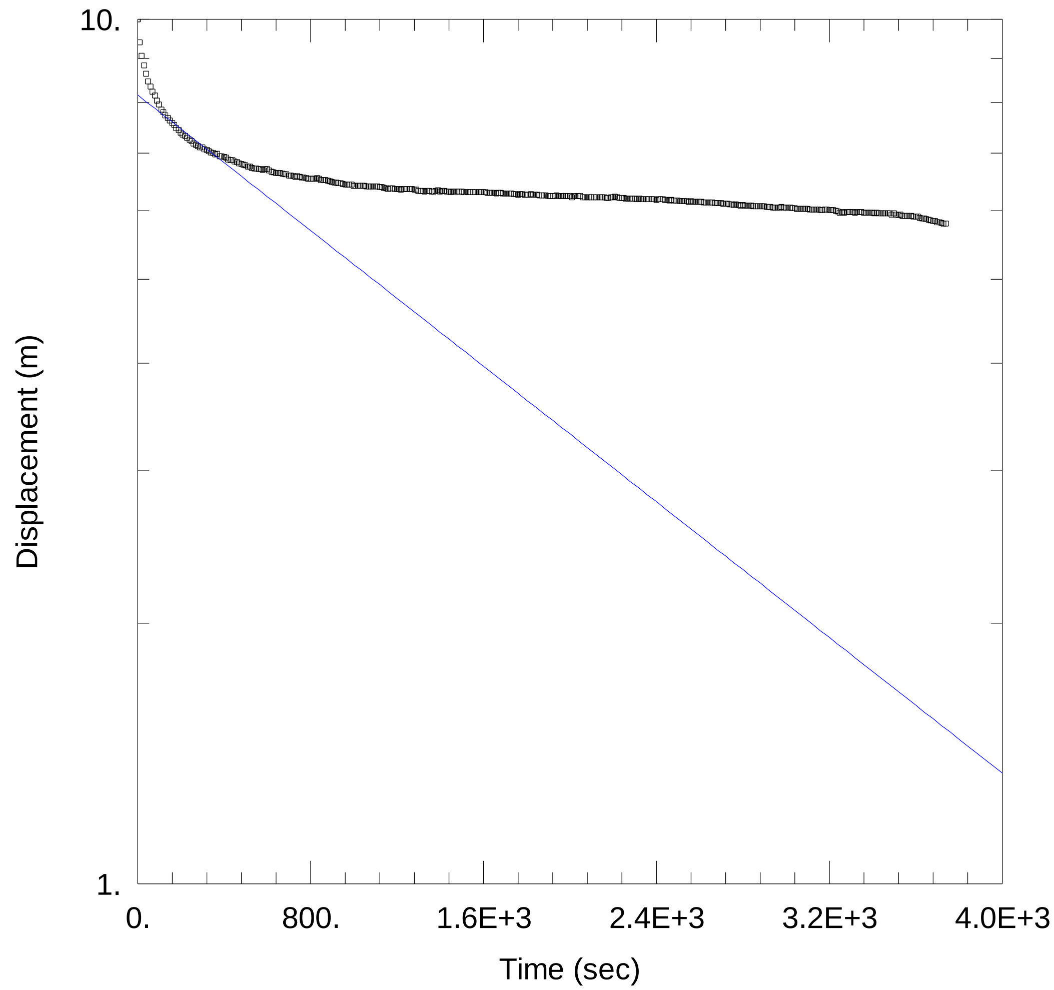
Saturated Thickness: 95.4 Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (11DDH052)

Initial Displacement: 4.93 m
Static Water Column Height: 86.53 m
Total Well Penetration Depth: 86.53 m
Screen Length: 86.53 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test 10DDH045

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set: G:\...\10DDH045 Late Hvorslev.aqt
Date: 04/20/11 Time: 13:20:05

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 4.841E-9 m/sec y0 = 8.17 m

AQUIFER DATA

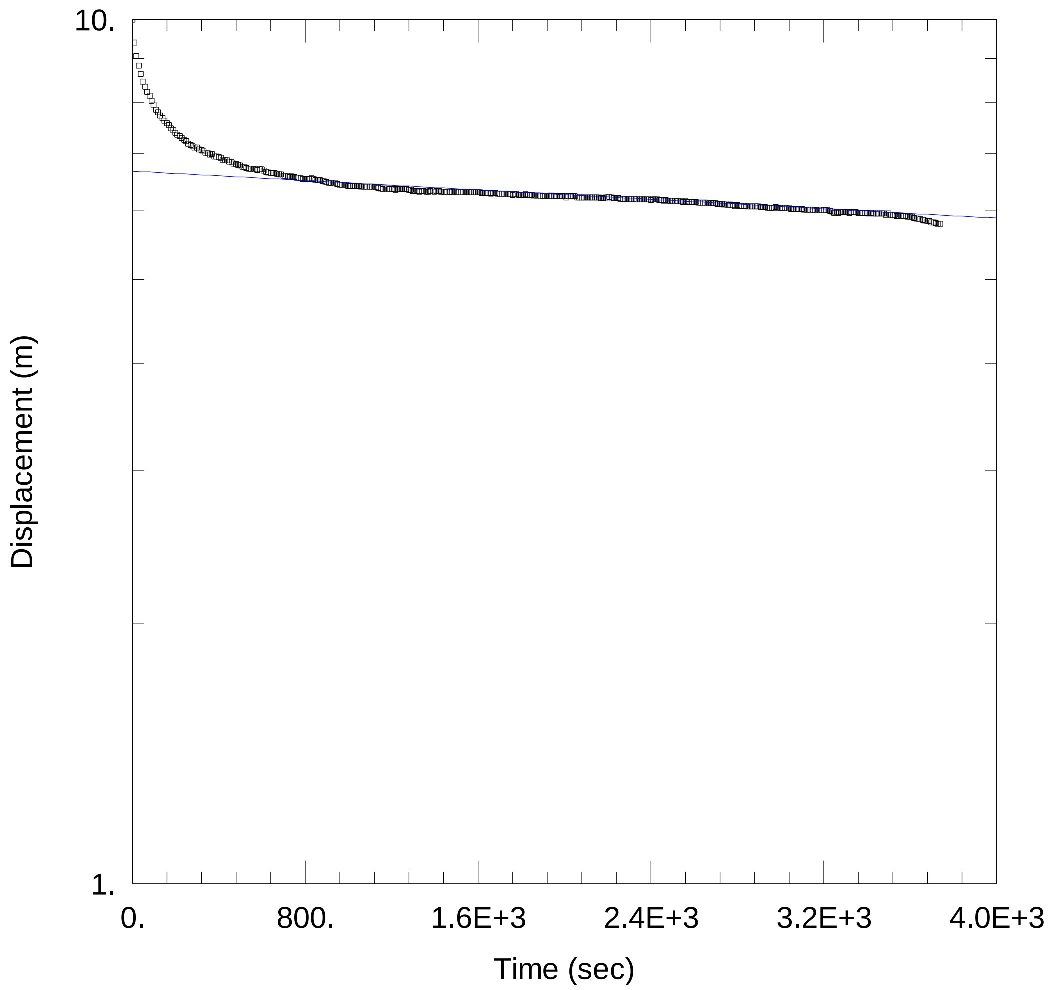
Saturated Thickness: 148.3 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (10DDH045)

Initial Displacement: 9.99 m
Static Water Column Height: 148.3 m
Total Well Penetration Depth: 148.3 m
Screen Length: 148.3 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test 10DDH045

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set:
Date: 04/20/11 Time: 13:18:02

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 3.353E-10 m/sec y0 = 6.671 m

AQUIFER DATA

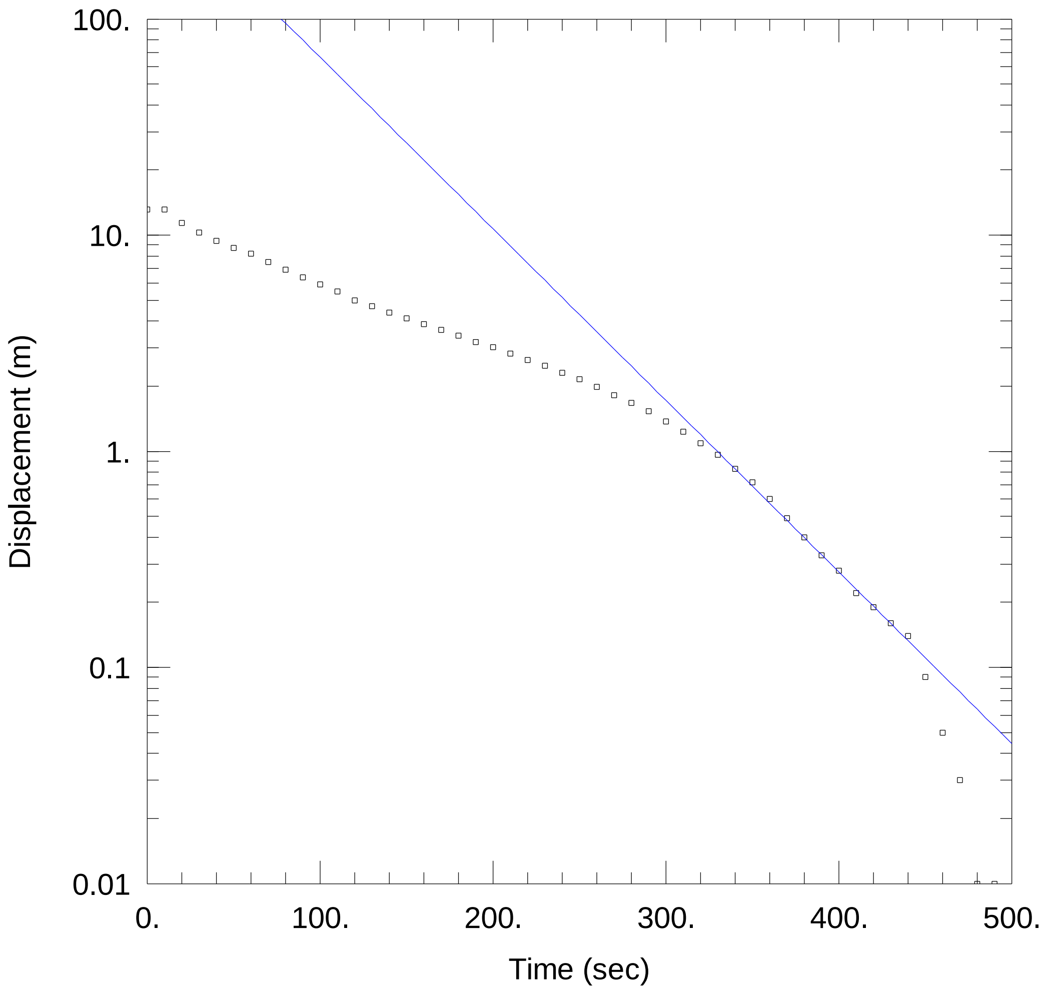
Saturated Thickness: 148.3 Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (10DDH045)

Initial Displacement: 9.99 m
Static Water Column Height: 148.3 m
Total Well Penetration Depth: 148.3 m
Screen Length: 148.3 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test (10DDH044)

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set: G:\...\10DDH044 Mid Hvorslev.aqt
Date: 04/21/11 Time: 10:59:27

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 1.921E-7 m/sec y0 = 414.2 m

AQUIFER DATA

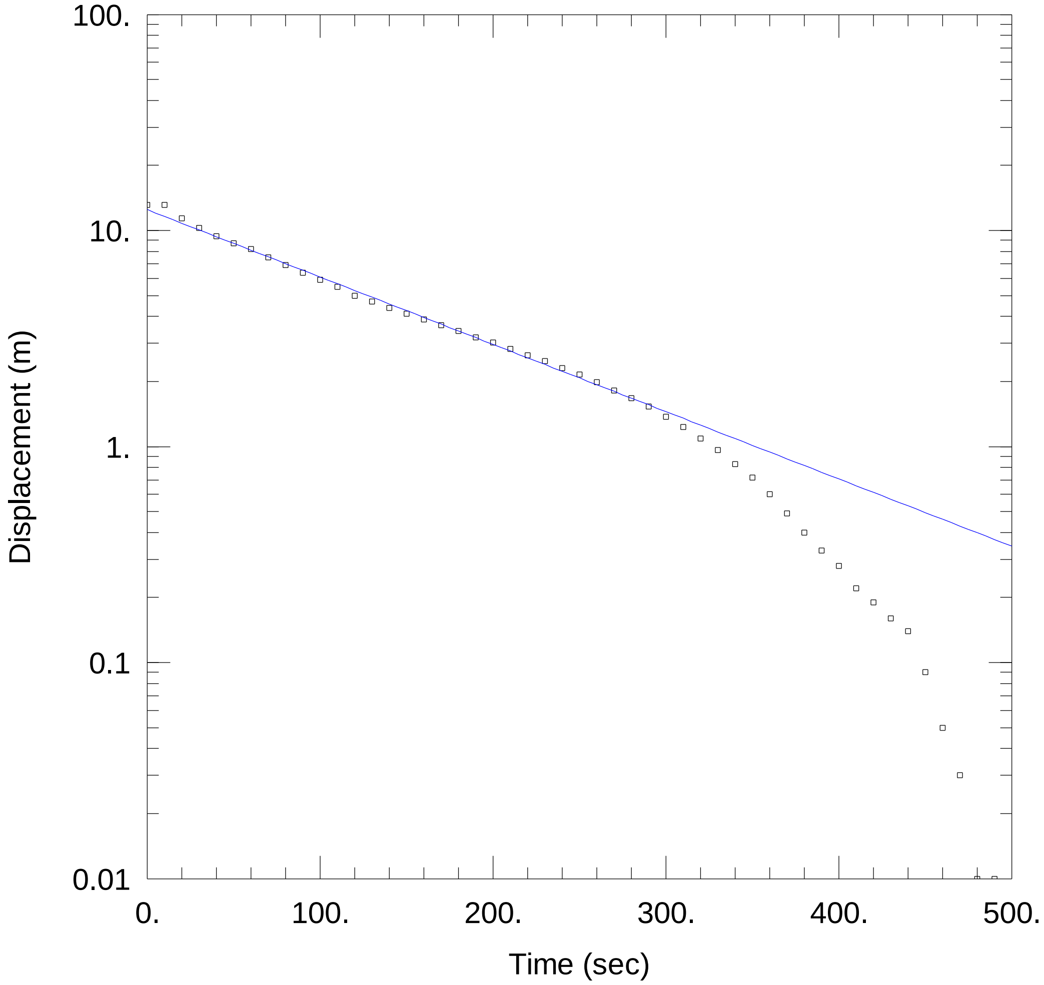
Saturated Thickness: 151.2 Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (10DDH044)

Initial Displacement: 13.15 m
Static Water Column Height: 151.2 m
Total Well Penetration Depth: 151.2 m
Screen Length: 151.2 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test (10DDH044)

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set:
Date: 04/21/11 Time: 10:58:14

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 7.541E-8 m/sec y0 = 12.48 m

AQUIFER DATA

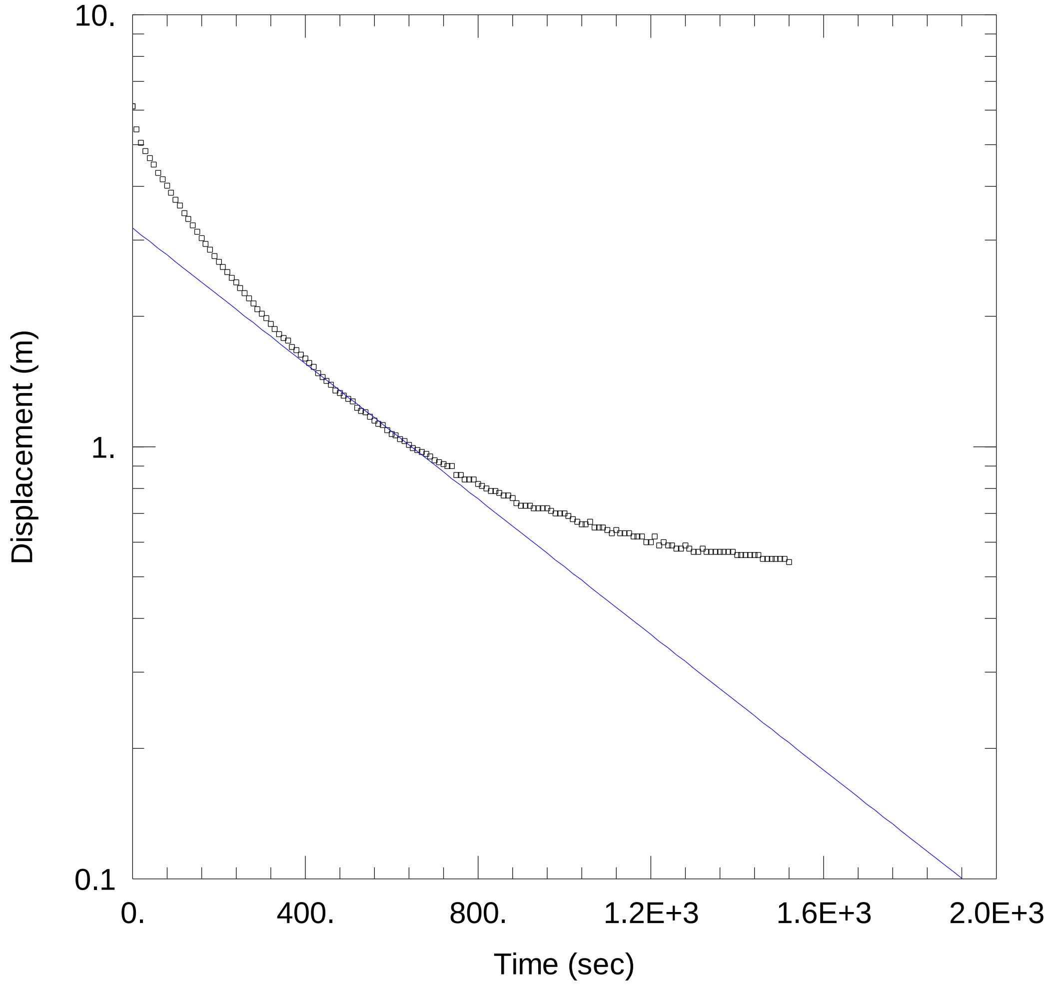
Saturated Thickness: 151.2 Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (10DDH044)

Initial Displacement: 13.15 m
Static Water Column Height: 151.2 m
Total Well Penetration Depth: 151.2 m
Screen Length: 151.2 m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test (10DDH035)

Prepared By: GHD	Prepared For: Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set: G:\...\10DDH035 Late Hvorslev.aqt
Date: 04/21/11 Time: 11:36:01

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 1.114E-7 m/sec y0 = 3.205 m

AQUIFER DATA

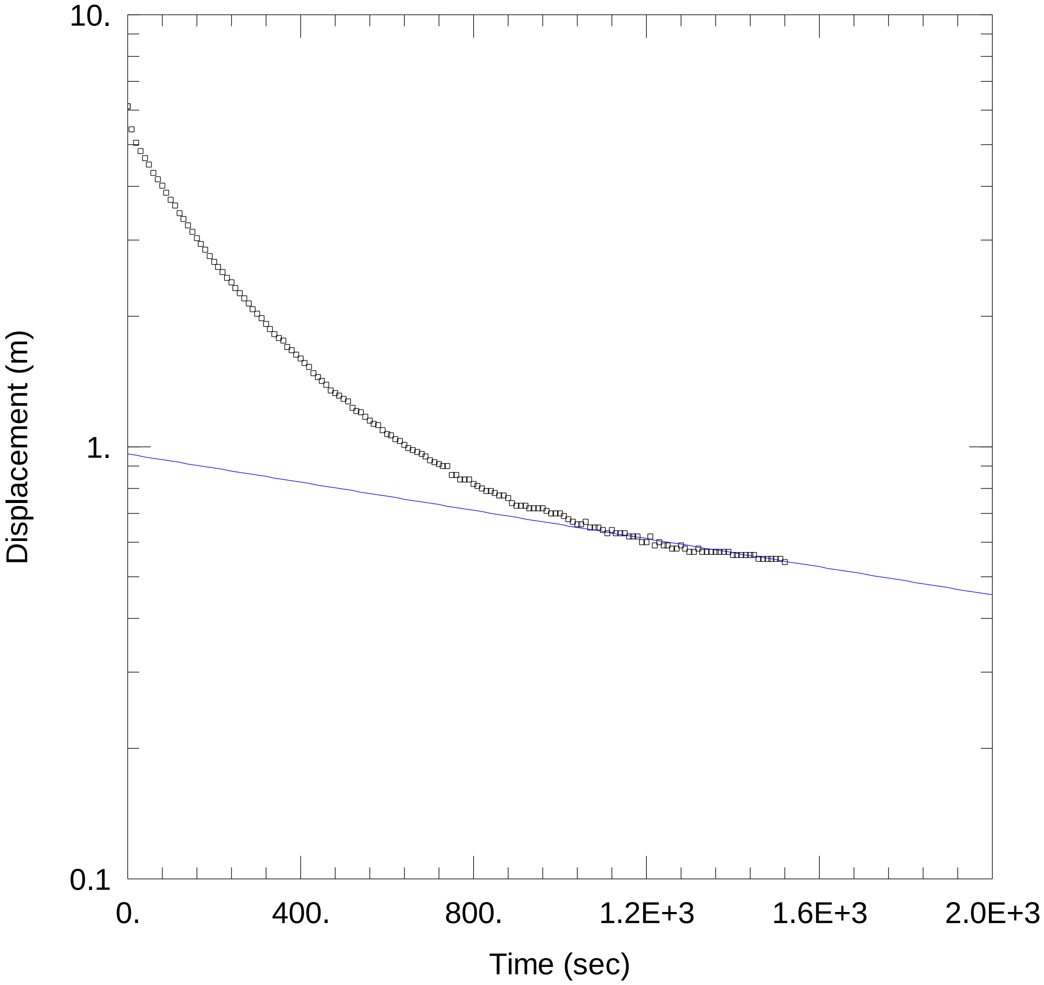
Saturated Thickness: 140. Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (10DDH035)

Initial Displacement: 6.12 m
Static Water Column Height: 32. m
Total Well Penetration Depth: 32. m
Screen Length: 30. m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Recovery Test (10DDH035)

Prepared By:	Prepared For:
GHD	Pluton Resources
Project: 312559600	Location: Irvine Island



Data Set:
Date: 04/21/11 Time: 11:35:06

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 2.318E-8 m/sec y0 = 0.9608 m

AQUIFER DATA

Saturated Thickness: 140. Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (10DDH035)

Initial Displacement: 6.12 m
Static Water Column Height: 32. m
Total Well Penetration Depth: 32. m
Screen Length: 30. m
Casing Radius: 0.025 m
Well Radius: 0.0625 m

Appendix C

Acid Sulphate Soil Results

CERTIFICATE OF ANALYSIS

Work Order	: **EP1101307**	Page	: 1 of 4
Client	: **GHD SERVICES PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR ANTHONY BOOTH	Contact	: Tracy Presland
Address	: GHD HOUSE PO BOX 3106 PERTH WA, AUSTRALIA 6832	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: Anthony.Booth@ghd.com	E-mail	: Tracy.Presland@alsglobal.com
Telephone	: +61 08 6222 8222	Telephone	: 08 9209 7604
Facsimile	: +61 08 9429 6555	Facsimile	: 08 9209 7600
Project	: 6126669	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 03-MAR-2011
Sampler	: Carsten Kraut	Issue Date	: 09-MAR-2011
Site	: Irvine Island Resources		
		No. of samples received	: 1
Quote number	: EN/005/10	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Leanne Cooper	Acid Sulfate Soils Supervisor	Perth ASS

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.**
- **Retained Acidity not required because pH KCl greater than or equal to 4.5**

Analytical Results

Sub-Matrix: **SOIL**			*Client sample ID*	**Y2I-19 mangrove**	----	----	----	----
			Client sampling date / time	03-MAR-2011 08:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP1101307-001**	**----**	**----**	**----**	**----**
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	**0.012**	----	----	----	----
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	**8.8**	----	----	----	----
pH OX (23B)	----	0.1	pH Unit	**7.3**	----	----	----	----
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	----	----	----	----
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	----	----	----	----
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	----	----	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	<0.005	----	----	----	----
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	<0.005	----	----	----	----
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	<0.005	----	----	----	----
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	**0.006**	----	----	----	----
Peroxide Sulfur (23De)	----	0.005	% S	**0.04**	----	----	----	----
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	**0.04**	----	----	----	----
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	**22**	----	----	----	----
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	**0.15**	----	----	----	----
Peroxide Calcium (23Wh)	----	0.005	% Ca	**0.24**	----	----	----	----
Acid Reacted Calcium (23X)	----	0.005	% Ca	**0.10**	----	----	----	----
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	**49**	----	----	----	----
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	**0.08**	----	----	----	----
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	**0.06**	----	----	----	----
Peroxide Magnesium (23Tm)	----	0.005	% Mg	**0.10**	----	----	----	----
Acid Reacted Magnesium (23U)	----	0.005	% Mg	**0.04**	----	----	----	----
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	**31**	----	----	----	----
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	**0.05**	----	----	----	----
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	**1.02**	----	----	----	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	**205**	----	----	----	----

Analytical Results

Sub-Matrix: SOIL			Client sample ID	Y2I-19 mangrove	----	----	----	----
			Client sampling date / time	03-MAR-2011 08:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP1101307-001	----	----	----	----
EA029-F: Excess Acid Neutralising Capacity - Continued								
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S	**0.33**	----	----	----	----
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	----	----	----	----
Net Acidity (sulfur units)	----	0.02	% S	<0.02	----	----	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	<10	----	----	----	----
Liming Rate	----	1	kg CaCO3/t	<1	----	----	----	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.04**	----	----	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**22**	----	----	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	**2**	----	----	----	----

GHD

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A						07/07/2011