Shire of Roebourne

Geotechnical soil and groundwater investigation

May 2013

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1. Introduction

The Shire of Roebourne has engaged GHD Pty Ltd (GHD) to undertake an assessment and provisional field investigation to develop an understanding of the ground and groundwater characteristics of the town of Roebourne.

The objective of this study is to assist the Shire of Roebourne (the Shire) in the development of a local structure plan for Roebourne to assist broad ranging strategic land use planning and provide a framework for the responsible future development across the study area. The recently established Ngarluma Aboriginal Sustainable Housing (NASH) Project will provide approximately 400 new residential lots and this study will assist in setting out constraints for this development with respect to ground and groundwater conditions.

In response to the requirements set out in the Request for Tender, this study comprises the following stages:

Stage 1 – Desktop Assessment; and,

Stage 2 –Site Investigation

The Stage 1 – Desktop Assessment resulted in the compilation of a series of maps to indicate ground and groundwater conditions and a potential development (buildability) constraint map for Roebourne.

The Stage 2 site investigation includes the excavation of test pits and assessment of the Acid Sulphate Soils in targeted areas of the project area. The results were used to update the maps produced in the desktop assessment.

2. Information sources

2.1 References

Information presented in the following publications were the primary information sources for this assessment:

Local Water Management Strategy, Ngarluma Aboriginal Sustainable Housing (GHD, 2010). This report consideration of all water resources in water planning, integration of water and land use planning, the sustainable and equitable use of all water sources for community, industry and the environment and a whole of catchment integration of human water use and natural water processes.

Environmental Assessment, NASH Site, Roebourne (Coffey Environments 2009). This report provides a description of the existing environmental attributes of the site and examines the possible opportunities and constraints to the proposed development of the site. Based on the results of the desktop and field investigations, Coffey Environments considers that the NASH site in Roebourne could support the proposed development.

Preliminary Engineering Servicing Report; North West Coastal Highway Roebourne (Wood & Grieve Engineers 2010). This report advised on engineering services such as site access, earthworks, water supply, sewerage, stormwater drainage, power supply, and telecommunications.

Shire of Roebourne Town Planning Scheme No.8; (Department of Planning 2011) this report set out the Shire of Roebourne's planning aims and intentions for the Roebourne area.

The Environment and Natural Resources Statement of Planning Policy No. 2 (WAPC, 2003) sets out a planning response to environmental and natural resource management issues within the framework of the State Planning Strategy.

Payne, A.L. and Tille, P.J. (1992). An inventory and condition survey of the Roebourne Plains and surrounds, Western Australia. Western Australian Department of Agriculture, Technical Bulletin No. 83.

GSWA, Geological Survey of Western Australia (1979). 1:50,000, Roebourne Urban Geology, Sheet 2356 III

2.2 Investigation contact

In addition to the published references, Table 1 presents the contacts approached and outcomes of discussions on historical problems with ground and groundwater conditions.

Table 1 Information sources and outcomes

Organisation	Full name	Date	Outcome
Department of Environment & Conservation	Geoffrey Banks	21/11/2012	Received information about schedule 1 areas
Department of Environment & Conservation	Trudy Parker	6/11/2012	Received contact for GIS information
Department of Water	Natalie Leach	7/11/2012	Received GIS and Win data sets.
Department of Water	Cam Pattrick	19/11/2012	Received GIS and Win data sets.
Department of Water	Lindsay Preece	20/11/2012	Received GIS and Win data sets.

Organisation	Full name	Date	Outcome
Landgate	Julie Duxbury	31/10/2012	Received background mapping
Ngarluma Housing Development	Patrick Churnside	6/11/2012	Received information about useful reports which were commissioned for the Ngarluma housing development
Shire Of Roebourne	Craig Davey	5/11/2012	Spoke about catchment boundaries / extents
Shire Of Roebourne	Jan Steenkamp	6/11/2012	Spoke about known ground to ground water problems/Received LIDAR
Shire Of Roebourne	Chris Van Tonder	8/11/2012	Received background planning information
Water Corporation	Frank Kroll	15/11/2012	Spoke about known flooding problems (Water Corporation did not have any flooding reports available)

2.3 Roebourne site investigation

An initial Roebourne townsite visit was undertaken by a GHD Engineer on the 27th of November 2012. The objectives of the visit were to identify visible potential Gilgai soils and assess the accessibility of proposed test pit locations.

A subsequent site visit was undertaken on the 21st March 2013. As described in 4, four test pits were excavated and soil samples taken.

3. Desktop study

3.1 Location

Roebourne is located on the North West Coast Highway (NWCH) in the Pilbara region of Western Australia. It is 39 km east of Karratha, 202 km south of Port Hedland and 1,563 km North of Perth and situated on the banks of the Harding River. At the 2006 census, Roebourne had a population of 857.

A conceptual development plan is currently being developed by Shire of Roebourne, which identifies areas of potential future residential and industrial development. The potential staging of this development is indicated on Table 2 and shown in Figure 1. The outline of the proposed structure plan defines the study area of this investigation.

Table 2 Land use for Roebourne townsite

Area ID	Description	Area Size	Current Land use	Intended Land Use
1 – 3	Extension of Jager Street Industrial Estate	25 ha	Rural	Industrial area
4	NASH development north of Cleaverville Road	36.5 ha	Rural	Residential
4a	NASH development south of Cleaverville Road	5.4 ha	Rural	Residential
5	West of area 4a and infill west and south of Roebourne Cemetery	13.5 ha	Rural	Residential
6	West of Mt Welcome	8.4 ha	Rural	Residential
7	Next to old Roebourne Town	5.2 ha	Rural	Residential
7a (infill)	Next to old Roebourne Town	10.4 ha	Rural	Residential
8	South of Mt Welcome	17.2 ha	Rural	Residential
9	South of Mt Welcome	12.9 ha	Rural	Residential
10	West of Mt Welcome	12.6 ha	Rural	Residential
Caravan park area	Caravan park area	10.3 ha	Rural	Residential

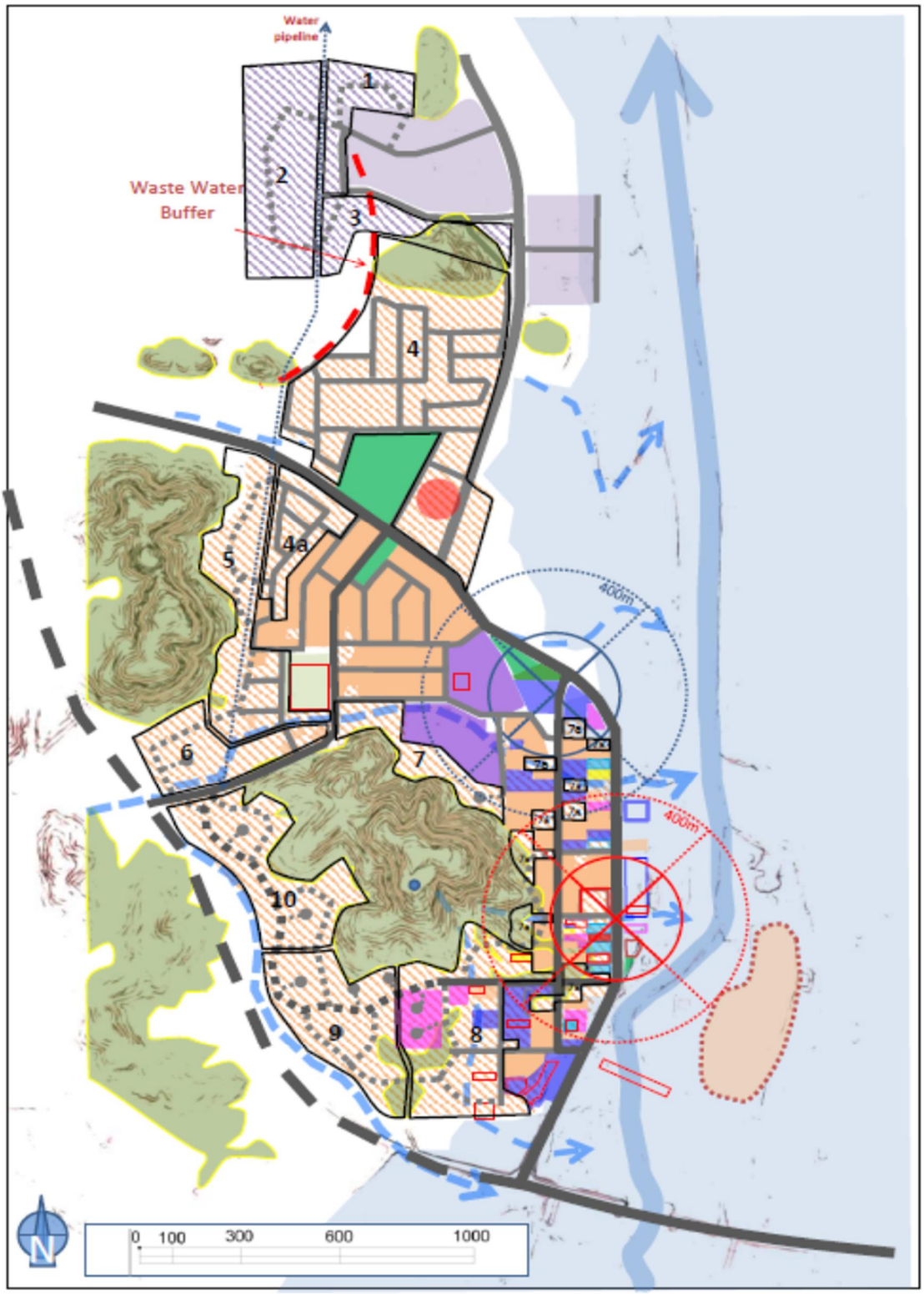


Figure 1 Proposed Structure Plan: potential staged development

3.2 Climate

The climate is characterised as arid and tropical with summer rain (Beard, 1990). The neighbouring operational meteorological station is Roebourne station 004035, approximately 0.9 km from the town centre. Cyclone season extends from 1st January to 30th April. Mean maximum daily temperatures recorded at Roebourne vary from 39.2°C in December and 27.4°C in July, and mean minimum daily temperatures vary from 26.2°C in January to 13.6°C in July (BoM, 2011).

The Annual rainfall was 287.8 mm with an average of 16 rain days. The highest rainfall was received in February and March (BoM, 2010). Monthly climate information is shown in Figure 2.

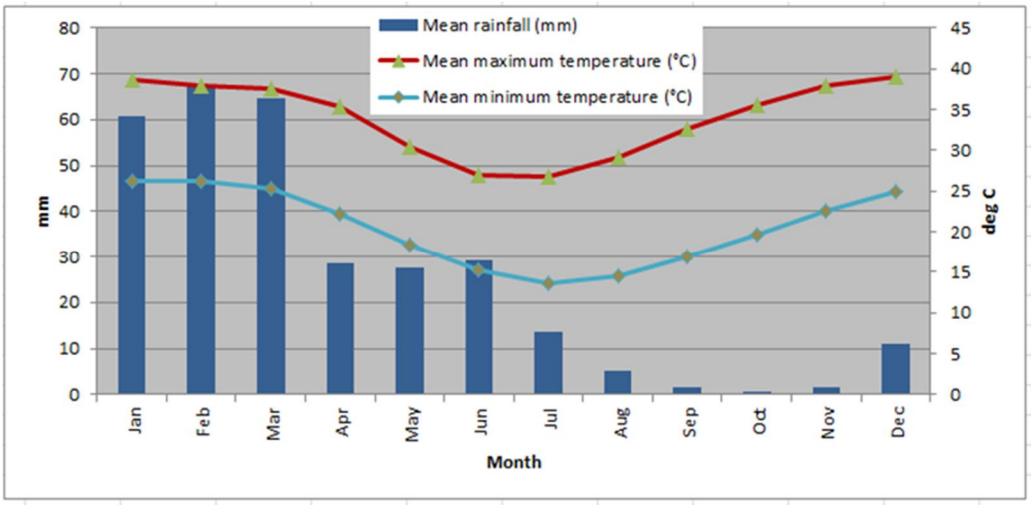


Figure 2 Climate averages from 1887 – 2010, (BoM, 2010)

3.3 Topography

A LIDAR elevation model of the study area and surrounding land was generated at 1 m contours and is shown in Figure 3.

The topography to the north of Mount Welcome ranges between approximately 6 m AHD and 36 m AHD. The majority of the site has a gentle topography described as rolling low hills, with the major topographic feature being a ridge running east-west in the northern part. The majority of the site drains to the east and is without substantial natural drainage channels.

The topography to the south of Mount Welcome ranges from 2 m AHD to 68 m AHD, and comprises rolling low hills which gently grades from Mount Welcome to the southwest and the east of the catchment towards the Harding River. The majority of the site drains to the east, toward the Harding River.

3.4 Geology

Throughout Roebourne exists a red to brown silty sand which forms the flat-lying to gently undulating 'red soil plains' and includes a variety of sediment types. The probable maximum thickness is estimated to be 30 m (GSWA, 1979).

The sand is generally composed of unsorted to poorly sorted, fine to coarse, frosted, angular to sub-rounded quartz grains; and small, but significant, quantities of limonite, feldspar and rock fragments. Grain size and silt content vary considerably, and small amounts of clay and gravel are commonly present (GSWA, 1979).

The 1:50,000 Roebourne Urban Geology Sheet (GSWA, 1979) reports that one of the major engineering problems with the silty sand unit is the presence of expansive clays in the clayey sand sub unit. This is described further in Section 3.4.1.

The Roebourne 1:100,000 Geological map sheet (GSWA, 2003) indicates the Roebourne townsite is underlain by predominantly mafic and ultramafic basalts and gabbros overlain by quaternary aged alluvium and colluvium comprising sand, silt, clay and occasional gravels.

The northern townsite is situated over the Regal Formation which consists of unaltered to metamorphosed volcanic rocks, pyroclastics and other sedimentary rocks. The southern townsite consists of distinct Archaean gabbro metamorphosed rock which is intruded by melanocratic granite rock. The Archaean gabbro and granite rock are variable and have a wide

range of engineering properties. They are generally strong and stable when fresh, but near the surface are commonly weakened and less stable due to weathering.

No particular problems with foundations or cuttings have been noted in this rock, but weathering along joints may cause localised difficulties (GSWA, 1979).

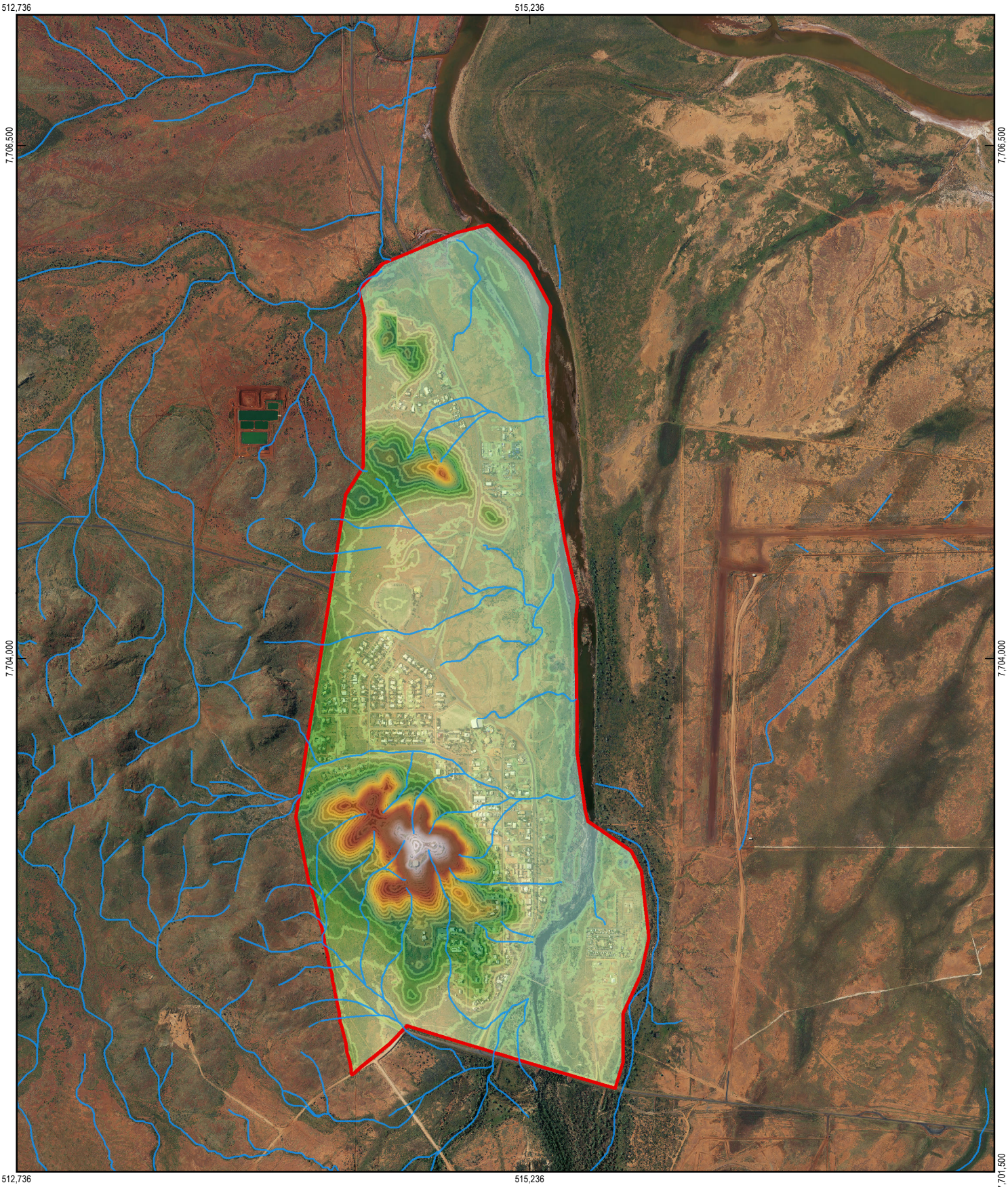
The geology, as presented on the 1:100,000 Geological map sheet (GSWA, 2003) is presented on Figure 4

3.4.1 Soils

Jennings and Mabbutt (1977) prepared a soil landscape map of the physiographic outlines and regions of Australia. The Roebourne townsite falls in the Fortescue Province Zone 281 and the De Grey-Roebourne Lowlands soil landscape is classified by DAFWA as:

'Alluvial plains and sandplains (and some floodplains and stony plains) on alluvial and marine deposits over rocks of the northern Pilbara Craton. Red deep sandy duplexes with Red loamy earths and some Red/brown noncracking clays, Cracking clays, Red sandy earths and Red deep loamy duplexes. Spinifex grasslands with kanji and tussock grasslands.'

The DAFWA Land Types are presented in Figure 5.



LEGEND

Hydrography (DoW)

Roebourne Study Area

Elevation

High : 68.5614

Low : 1.96401

1:25,000 (at A4)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: MGA50

N

Shire of Roebourne
Local Structure Plan Input

Job Number	61-28812
Revision	0
Date	31 OCT 2010

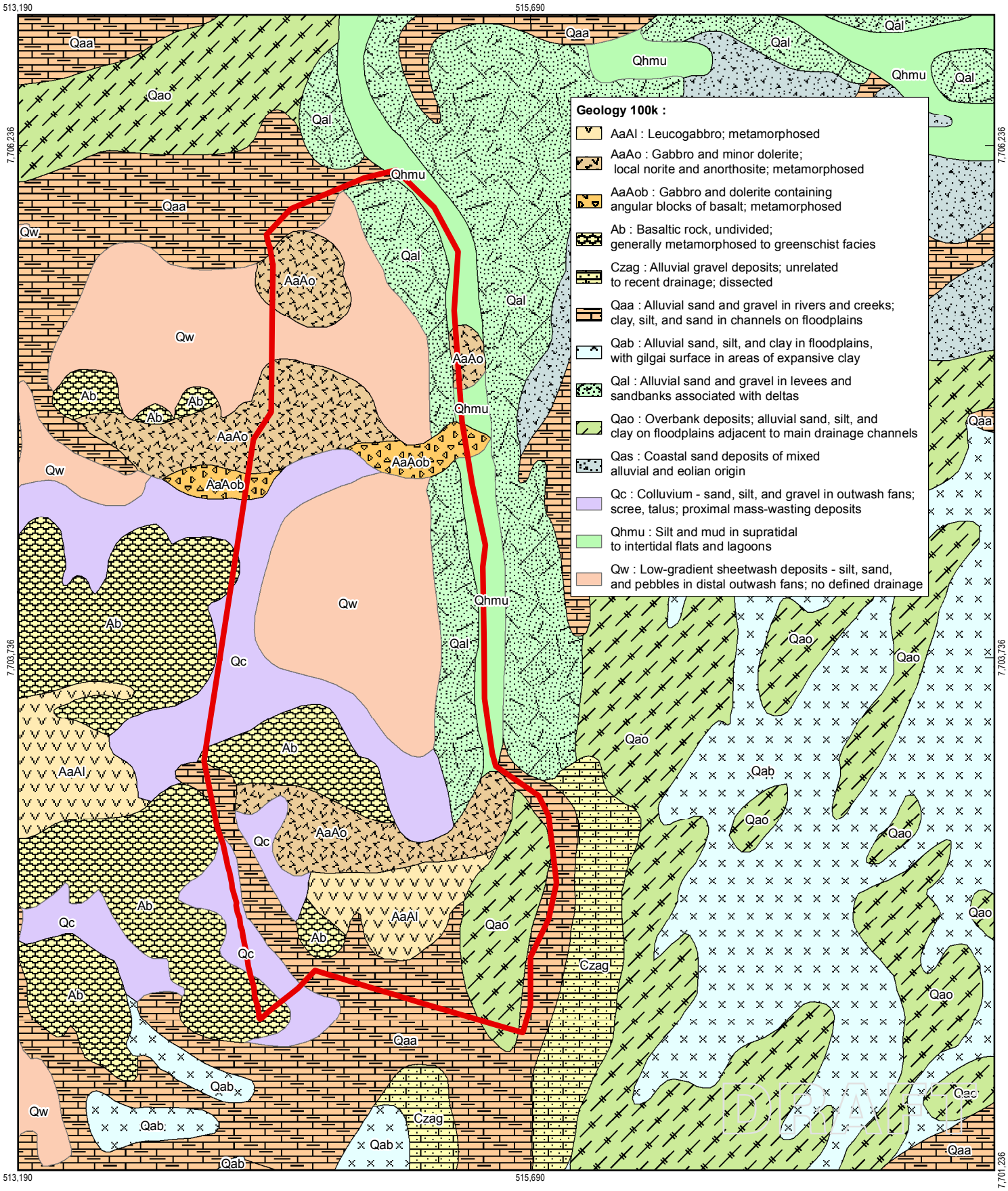
Topography & Existing Drainage

Figure 3

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

G:\61\28812\GIS\Maps\MXD\6128812_G003_Rev0.mxd

Data Source: GHD: Study Area - 20121101, Contours - 20121113, Elevation 20121113; Landgate: Roebourne Mosaic - 2012; DOW:Hydrography - 20121101. Created by: scorrigan, vdinh



1:25,000 (at A4)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: MGA 50

N

Shire of Roebourne
Local Structure Plan Input

Job Number 61-28812
Revision 0
Date 02 NOV 2012

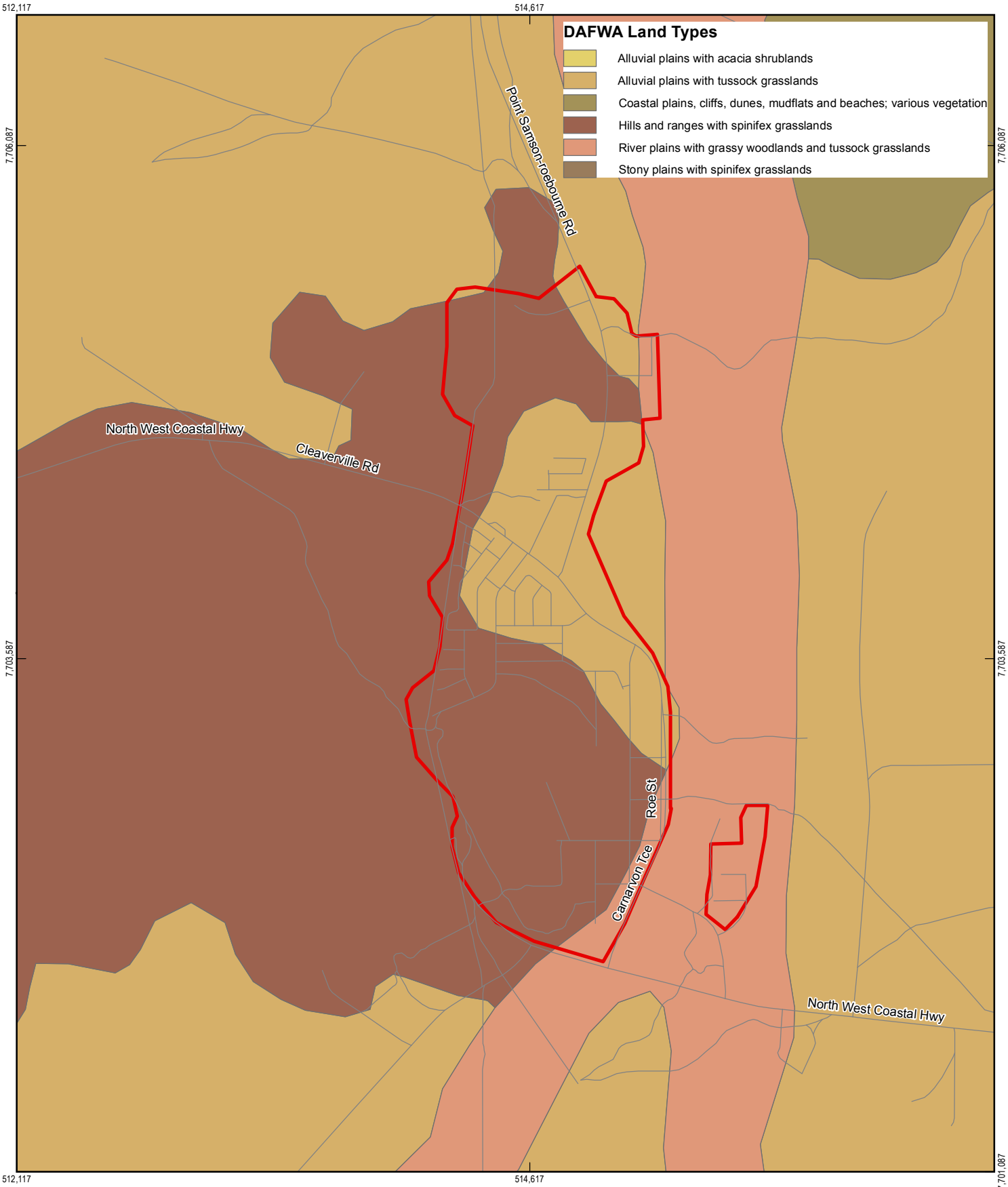
Geology

Figure 4

G:\61\28812\GIS\Maps\MXD\6128812_G002_Rev0.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data Source: GHD: Study Area - 20121102; DOIR: Geology 100k Roebourne 1st Edition - 20121102. Created by: scorrigan, vdinh



LEGEND

Road

Roebourne Study Area

1:25,000 (at A4)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator

Horizontal Datum: Geocentric Datum of Australia (GDA)

Grid: MGA 50

N

Shire of Roebourne

Local Structure Plan Input

Job Number 61-28812

Revision 0

Date 07 DEC 2010

Soils

Figure 5

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GHD House, 239 Adelaide Terrace Perth WA 6004 T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data Source: GHD: Study Area - 20121101; DAFWA: Landsystem - 20121207; Landgate:Roads - 20121114, Roebourne Mosaic - 2012; GA: 250K Topo Series 3 - 2006. Created by: scorrigan

3.5 Gilgai soil

Gilgai is surface microrelief associated with soils containing shrink-swell clays. Gilgai surface features may occur in the more clayey parts of units which are found extensively on the eastern side of the Harding River (around and south of the Roebourne airport). The soil units which occur on the western side of the river (Qw and Qc) are derived from the basalts and gabbro's, which both tend to weather to a high plasticity clay. On this basis the presence of Gilgai soils cannot be ruled out on the western side of the Harding River, below the townsite.

Softer ground with intermittent cracking lines were identified in the area indicated in Figure 6 by the GHD Engineer during the 27th November, 2012, site visit. This suggests that high plasticity or Gilgai soils may exist in this area and further field investigation may be considered to conclusively establish the existence of Gilgai soil in this area.

In general, no particular area in the study area is expected to present more favourable geotechnical conditions than another. However the impacts of high plasticity or Gilgai soils on residential housing are well recognised and can be designed for by the proper detailing of foundations (depths, widths, reinforcement).

The field investigation described in Section 4 includes a description of the shallow soils excavated at test pit locations.

3.6 Acid Sulphate Soil

Acid sulphate soils (ASS) are naturally occurring soils and sediments containing iron sulphides, most commonly pyrite. When ASS is exposed to air the iron sulphides in the soil react with oxygen and water to produce a variety of iron compounds and sulphuric acid. Initially a chemical reaction, the process is accelerated by soil bacteria. The resulting acid can release other substances, including heavy metals, from the soil and into the surrounding environment. Typically the soils are benign, until they become oxidized and can develop acidic properties with the potential to mobilise heavy metals into groundwater.

A review of Department of Environment and Conservation (DEC) ASS risk mapping available through the Landgate Shared Land Information Portal (SLIP) was undertaken. The ASS risk mapping is reproduced as Figure 7.

The risk mapping indicates that the majority of the site overlies an area of no known ASS risk within 3 m of the natural soil surface. This classification means that no ASS sampling has been undertaken in this area by the DEC. It does not mean that there is conclusively no ASS in the area. Areas around the perimeter of the site have been classified as Moderate to Low ASS disturbance risk, with isolated High to Moderate ASS disturbance risk closer to the south \ southwest boundary and towards the Harding River.

Intrusive ASS investigations were undertaken at four locations across the townsite to characterise the ASS risk at these locations. These investigations and their results are further discussed in Section 4.2.2.

3.7 Groundwater

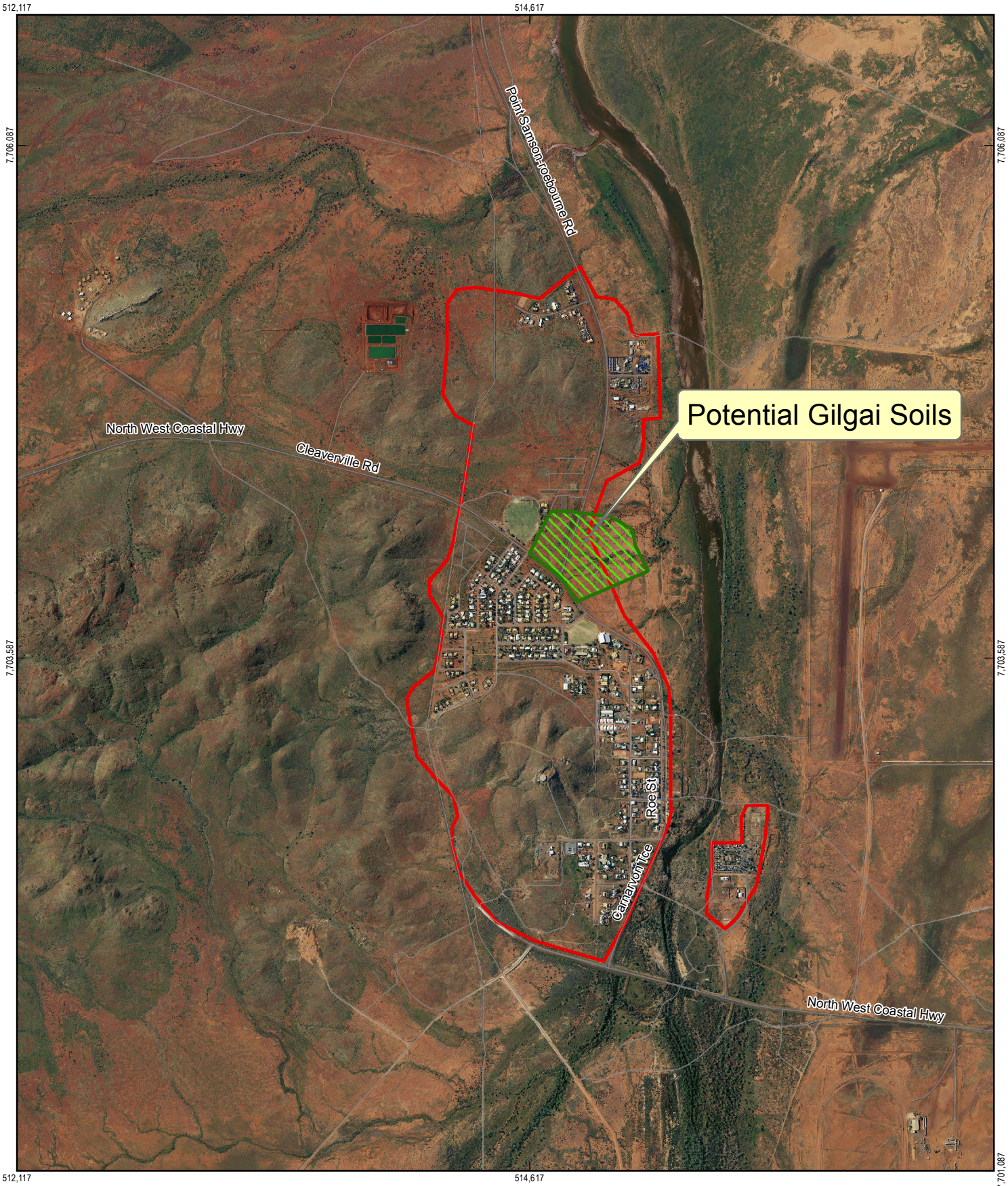
The (DoW) WIN database indicates there were 129 ground water bores located within 10 km of the town centre. Of these, only two are located within the study area (WIN Site 20054898 and 20054899 (Hotel Well). The bore in the Northern section (20054898) has an MGL level of 8.84 m below ground surface and the Southern Precinct (20054899) has an MGL level of 6.86 m below ground surface.

With the current groundwater level information, it is not possible to construct a contour map of depth to water across the study area.

No groundwater quality data is available for 20054898, and groundwater from 20058999 (Hotel Well) is brackish at 1,700 mg/L total dissolved solids. This correlates with the WIN database which indicates that groundwater under the site is reported to be brackish having total dissolved solids (TDS) of 1,000 - 3,000 mg/L (DoW, 2009c). In contrast, the 1:50,000 Roebourne Urban Geology Sheet (GSWA, 1979) reports that groundwater of domestic or good stock quality can be obtained from most of the Roebourne area. Supplies are mainly drawn from alluvium and calcrete along the rivers and major creeks, while small supplies may also be obtained from fractured Precambrian rock, or at the base of long colluvial slopes.

With only two registered bores within the study area, it is not clear that this broad conclusion is necessarily representative of the entire study area.

As indicated in a discussion with the Shire of Roebourne on the 6th November, there were no reports of problems relating to high groundwater levels in the study area.



LEGEND

- Gilgai Soils
- Road
- Roebourne Study Area

1:25,000 (at A4)

0 250 500 1,000 1,500 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: MGA 50

N

GHD

powered by SLIP ENABLER

Shire of Roebourne
Local Structure Plan Input

Job Number	61-28812
Revision	0
Date	31 OCT 2010

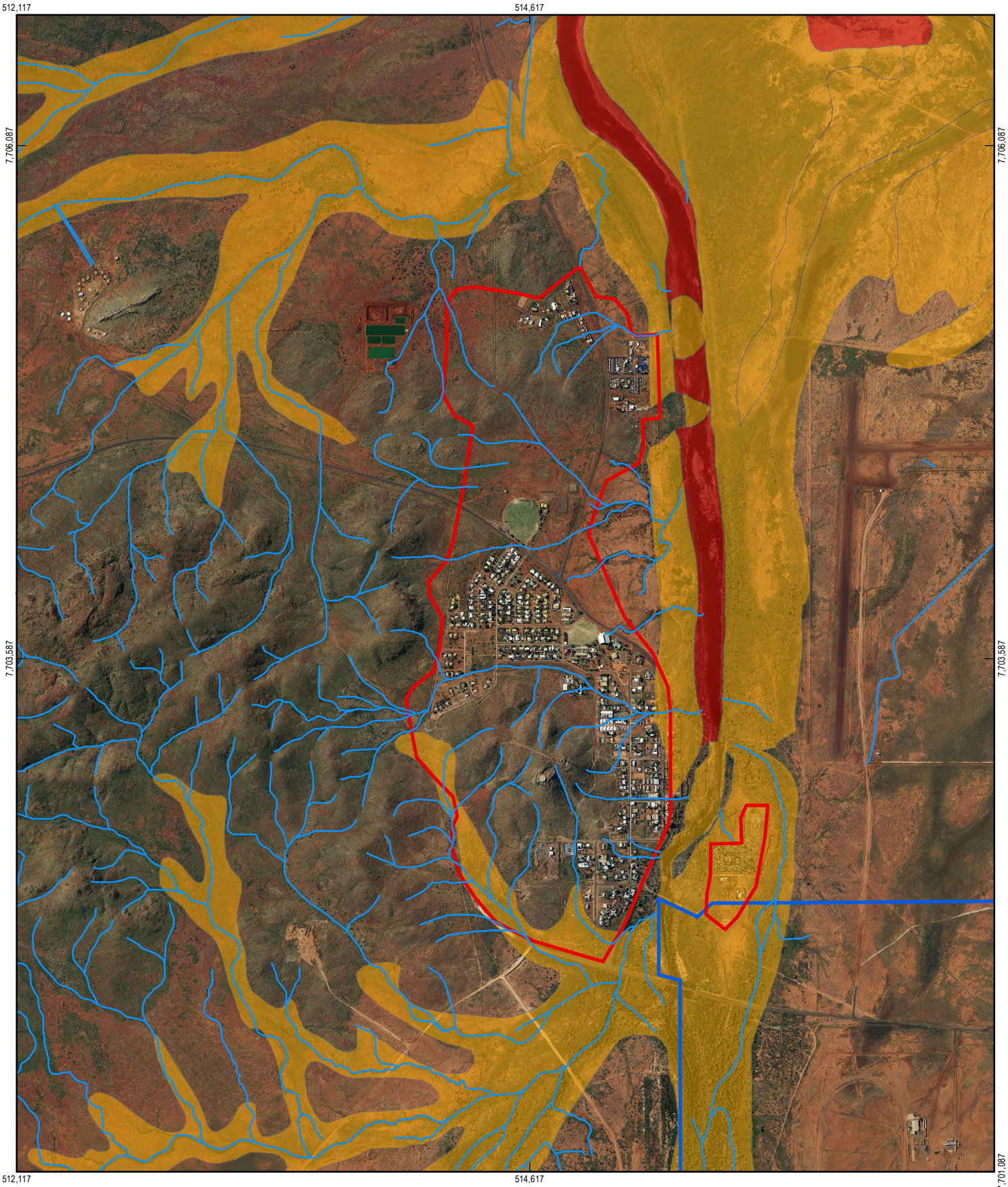
Potential Gilgai Soils Location

Figure 6

G:\61\28812\GIS\Maps\MXD\20121210\6128812_G007_Rev0.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data Source: GHD: Study Area - 20121101; Landgate:Roads - 20121114, Roebourne Mosaic - 2012; GA: 250K Topo Series 3 - 2006. Created by: scorrigan, vdinh



LEGEND

Hydrography
Roebourne Study Area
Public Drinking Water Areas

ASS Risk Map

High to moderate ASS disturbance risk (<3m from surface)
Moderate to low ASS disturbance risk (<3m from surface)

1:25,000 (at A4)
0 125 250 500 750 1,000
Metres
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: MGA 50

N

GHD

powered by SLIP ENABLER

Shire of Roebourne
Local Structure Plan Input

Job Number 61-28812
Revision 1
Date 7 DEC 2012

Potential Acid Sulphate Soils

Figure 7

G:\61\28812\GIS\Maps\MXD\20121210\6128812_G008_Rev0.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data Source: GHD: Study Area- 20121101, DEC: ASS Risk Map - 20121102, DoW: Public Drinking Water Areas - 20121102 -; Landgate: Hydrography & Roebourne 2012 Mosaic

Created by: scorrigan,vdinh

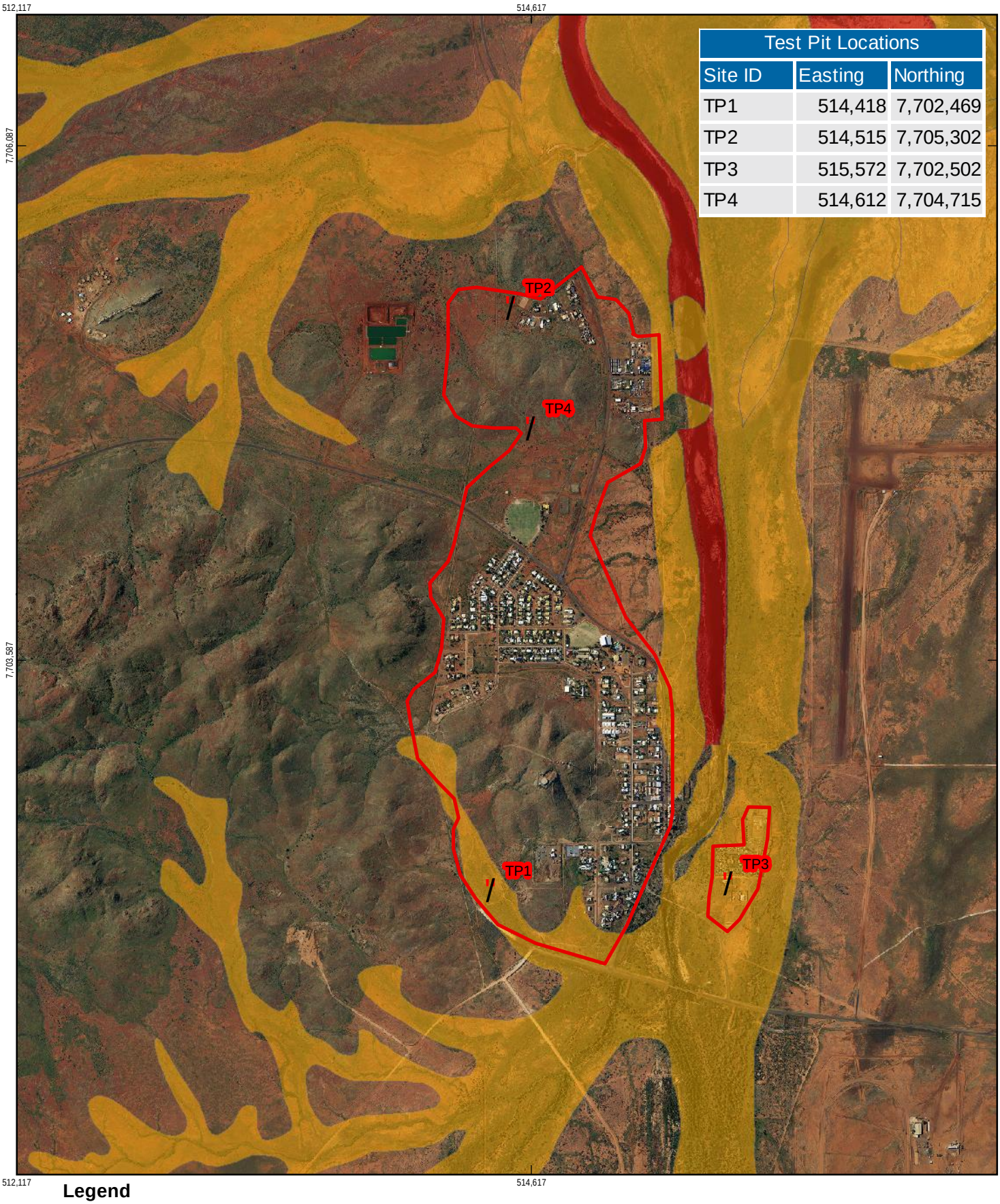
4. Site investigation

Following the desk-top assessment, a site investigation was undertaken with the aim of determining the soil quality, in particular the Acid Sulphate Soil potential, for four key areas.

The investigation areas are illustrated on Figure 8 and a rational for choosing these locations is provided below as Table 3.

Table 3 Site investigation (test pit) locations

Site ID	Easting	Northing	Reason location chosen
TP1	514,418	7,702,469	Representative of southern part of study area. Close to drainage line and within an area identified as moderate to low ASS risk (DEC). Representative of DAFRA Land Type "Hills and ranges with spinifex grasslands".
TP2	514,515	7,705,302	Representative of northern part of study area. Representative of DAFRA Land Type "Hills and ranges with spinifex grasslands".
TP3	515,572	7,702,502	Representative of eastern part of study area (Caravan Park). Within main drainage line and within an area identified as moderate to low ASS risk (DEC). Representative of DAFRA Land Type "River plains with grassy woodlands and tussock grasslands".
TP4	514,612	7,704,715	Representative of central part of study area. Close to drainage line. Representative of DAFRA Land Type "Alluvial plains with tussock grasslands".



Test Pit Locations		
Site ID	Easting	Northing
TP1	514,418	7,702,469
TP2	514,515	7,705,302
TP3	515,572	7,702,502
TP4	514,612	7,704,715

Legend

- Test Pit Locations
- Roebourne Future Development
- High to moderate ASS disturbance risk (<3m from surface)
- Moderate to low ASS disturbance risk (<3m from surface)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: KAR 94

Shire of Roebourne
Local Structure Plan Input

Job Number 61-28812
Revision 0
Date 09 APR 2013

Investigation Locations

Figure 08

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

G:\61\28812\GIS\Maps\MXD\20121210\6128812_G010_Rev3.mxd

Data Source: GHD: Study Area- 20121101, Potential Test Pits-20121115 -; Landgate: Hydrography & Roebourne 2012 Mosaic
Created by: scorrigan

4.1 Methodology

All test pits were excavated with a 10T backhoe operated by BGC Contracting under the supervision of a GHD engineer. Test pits were excavated to a depth of 2 m or until refusal.

Soil was sampled every half a meter in order to be assessed for potential ASS. Soil samples were also geological logged.

4.2 Results

4.2.1 Groundwater

Test pit logs are presented in Appendix B. With the exception of TP2, all pits encountered consolidated material resulting in termination of the test pit before the target depth was reached.

Groundwater was not encountered in any of the test pits excavated. Given the test pitting was undertaken in March, when groundwater levels should normally be near their highest, it can be concluded the depth to water is greater than the 1.5 to 2.0 metre depths excavated.

4.2.2 ASS

Samples were collected at 0.5 m intervals to a maximum depth of 2.0 m. A total of 19 primary samples were collected from the four test pit locations. Samples were submitted to ALS for pH_F and pH_{FOX} rapid screening. The laboratory results are presented as Appendix C, and the assessment methodology is presented in Appendix D.

ASS Summary

Based on the results of the ASS pH screening investigation works undertaken to date, GHD considers the general ASS risk to a depth of 2 metres below ground level (m bgl) for the site to be low.

In general, the geology encountered was varying thicknesses of gravelly sand, sand and clayey sands. The pH testing results indicate that the samples analysed are naturally neutral tending alkaline soils. The majority of the Δ pH values indicate that the potential for the generation of acidity upon oxidation is low. There were however five samples collected from the gravelly sand, sand with gravel and clayey sand lithological units (TP1: 0-2m and TP2: 0m) that may be indicative of PASS (Δ pH > 2), with values between 2.2 and 3.9.

The remaining 14 samples which were analysed for ASS pH tests did not exhibit evidence that they contained AASS or PASS. Of the 19 samples analysed for pH screening test, 8 returned negative Δ pH values indicating that if these soils were allowed to oxidise (by means of excavation and/or dewatering), it is highly unlikely that acid generation would result. The negative Δ pH values actually infer that the soil pH would increase following oxidation, which may be explained by excess soil buffering capacity assumed to be derived from weathered calcrete (calcium carbonate) found in excess within some of the test pits (TP1 and TP2).

Sample TP1 – 1.5-2m, the most indicative of containing PASS based on results from the preliminary pH screening tests, was analysed for SPOCAS and CRS and returned net acidity excluding ANC and CRS value below the DEC action criteria of 18.7 mol H+/t. In addition, the sample contained a very high ANC value. These results indicate this sample does not contain PASS. Based on the information above, GHD therefore considers the general ASS risk to a depth of 2 metres below ground level (m bgl) for the site to be low. Furthermore, PASS is generally found at or below the groundwater table (DEC, 2013). Groundwater across the site is generally deeper than 6 m bgl further supporting the idea that the ASS risk within 2 m below natural ground level is low.

It should also be noted that the ASS pH testing carried out was limited to the four test pits excavated to a maximum depth of 2 m bgl. It should be understood that the low ASS risk classification indicated by GHD is based on the extrapolation of results from these locations to the whole site (i.e. the results are representative of the broader site area).

At this time, an ASS Management Plan (ASSMP) is not required for any shallow excavations to a maximum depth of 2 m bgl near the test pits locations. However, this assumption should be revised should changes to the depth or area of excavation be altered. Under these circumstances, additional sampling may need to be required. If any additional sampling and lab results indicate a potential ASS risk then an ASSMP would be required to be prepared and implemented prior to the commencement of any excavation.

5. Risk assessment

A risk assessment management table is presented on Table 4. The risk assessment methodology to identify, analyse and evaluate the potential risks associated with ground and groundwater interception is based on the AS/NZS 4360:2004 Risk Management standard, which is described in more detail in Appendix A

It is noted that the risk assessment table is not possible to complete fully until the in gaps identified in the Gap analysis are minimised according to the scope proposed in Section 6.

Table 4 Risk assessment and management measures

Source of Risk	Impact	Management Measures	Conse-quence	Like-liood	Risk Rating
Ground to groundwater separation	Mobilisation of nutrients and contaminants	Due to the soil properties of the area and the depth to groundwater, it is anticipated that there will be little interaction with groundwater. Therefore, there is no proposed groundwater management strategy.	3	1	Low (3)
Degrade groundwater quality	Mobilisation of nutrients and contaminants	Due to the brackish nature of the ground water extraction is not recommended and there for no water monitoring is proposed	3	3	Medium (9)
The potential existence of Gilgai Soils	Shrinkage and swelling of clays	Further investigations required see section 7 provisional Investigation measures. Designed for by the proper detailing of foundations.	3	3	Medium (9)
The potential to disturb Acid Sulphate Soils	Significant environmental and economic Loss of biodiversity in wetlands Contamination of groundwater. Release of heavy metals and other contaminants	No remediation work is required as there is no known risk of Acid Sulfate Soils being encountered during shallow excavation within the study area. The risk increases closer to the Harding River, outside the study area.	5	1	Medium (5)

6. Gap analysis

A geotechnical and ground water gap analysis was undertaken in regards to developing the future constraints for the Roebourne townsite are summarised in the sections presented below.

6.1 Groundwater

No groundwater contour data are available and further investigation is required if groundwater levels over the entire Roebourne Townsite area are required. There are only 2 bores within the Townsite area with groundwater levels in DoWs WIN database, and a further 127 bores within a 10 km radius of the area. Groundwater was not encountered in any of the four test pits excavated in March, 2013. Given that test pitting was undertaken when groundwater levels should normally be near their maximum, it can be assumed the depth to water at these locations is greater than the 1.5 to 2.0 metre depths excavated.

Based on the current level of information available, it is not possible to generate accurate groundwater contours or make specific comment on the likely groundwater conditions within the study area.

An understanding of groundwater levels is generally necessary to determine groundwater management requirements for development, such as subsurface drainage or importation of fill, and to ensure a minimum 1.2 m separation between the maximum groundwater level (MGL) and building floor slabs.

6.2 Gilgai soil

The possible presence of either Gilgai soils or high plasticity and expansive clays was highlighted from a review of the back ground geology.

6.3 ASS Soils

The Roebourne townsite is classified as "**moderate to low risk**" in terms of Acid Sulfate Soils based on the geology and soils mapping and site investigation.

The Department of Environment and Conservation (DEC) advise that a low risk rating may indicate that the alignment overlies an area of no known ASS risk within 3 metres of the natural soil surface or that no ASS sampling has been undertaken in this area by the DEC.

Additionally, when using ASS risk maps, the following must always be kept in mind: •

- Extreme variations in the nature and distribution of ASS can be expected; and •
- Depth to the ASS layer can be highly variable. The depths indicated should be used as a guide only and are not suitable for specific assessment of development potential.

Therefore, the mapping and sampling does not indicate conclusively that there is no ASS in the general study area. In cases like this, an intrusive preliminary ASS investigation in higher ASS risk across the study area is recommended to assist in determining a more site-specific ASS risk.

7. References

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Appendices

Appendix A – Risk assessment methodology

Risk Assessment Methodology

Roebourne Ground and Groundwater Risk Assessment

The risk assessment methodology used to identify, analyse and evaluate the potential environmental risks associated with groundwater interception is based on the AS/NZS 4360:2004 Risk Management standard.

The first step in conducting a risk assessment is to determine and rate:

- Likelihood – defined as the likelihood of an environmental impact or event occurring, measured on a scale of 1 to 5, as indicated in Table 1; and
- Consequence – defined as the consequence of an environmental impact or event occurring, measured on a scale of 1 to 5, as indicated in Table 2.

Table 1 Likelihood Assessment

Rating	Description	Definition
1	Rare	The event may occur only in exceptional circumstances.
2	Unlikely	The event could occur at some time.
3	Possible	The event should occur at some time.
4	Likely	The event will probably occur in most circumstances.
5	Almost Certain	The event is expected to occur in most circumstances.

Table 2 Consequence Assessment

Rating	Descriptor	Definition
1	Negligible	No environmental harm.
2	Minor	Insignificant environmental harm.
3	Moderate	Moderate environmental harm.
4	Major	Substantial environmental harm.
5	Severe	High degree of environmental harm.

The Consequence and Likelihood ratings are then plotted on the Risk Assessment Matrix (Table 3). The final risk level assigned is a product of the consequence and likelihood scores. The higher the risk score, the higher the priority for management of the identified issue is; the lower the risk score the lower the priority for management is.

Table 3 Risk assessment matrix

		Consequence				
		Negligible	Minor	Moderate	Major	Severe
Likelihood		1	2	3	4	5
Almost Certain	5	5 Medium	10 High	15 High	20 Extreme	25 Extreme
Likely	4	4 Low	8 Medium	12 High	16 Extreme	20 Extreme
Possible	3	3 Low	6 Medium	9 Medium	12 High	15 High
Unlikely	2	2 Low	4 Low	6 Medium	8 Medium	10 High
Rare	1	1 Low	2 Low	3 Low	4 Low	5 Medium

Table 4 describes the level of management and possible actions required for each risk assessment rating.

Table 4 Indicative Management Actions for Each Risk Assessment Rating

Risk Rating Description	Risk Rating Number	Indicative Management Action
Extreme	**16-25**	Risk unacceptable. Alternative management action required.
High	**10-15**	Risk accepted provided appropriate management responsibilities specified.
Medium	**5-9**	Risk acceptable. Managed by specific monitoring or response procedures.
Low	**1-4**	Risk negligible. Managed by routine procedures, unlikely to need specific application of resources.

Appendix B – Test pit logs

TEST PIT LOG

ENVIRONMENTAL

ID: TP1

Page: 1 of 1

Client: Shire of Roebourne
Project: Roebourne geotechnical and groundwater investigation
Project No.: 6128812
Location: Roebourne
Date Drilled: 21/03/2013 to: 21/03/2013

Contractor: BGC
Machine: 10T Backhoe
Total Depth (m): 2
Bucket Width (mm): 500
Pit Width (m): 0.5 Length (m): 4

Easting: 514418
Northing: 7702469
Grid Ref: GDA94_MGA_zone_50

Logged by: AS Checked by: AO

EXCAVATION									
Depth (m)	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
					Ground Surface:				0.00
0.0		TP1_0m			SAND trace GRAVEL SAND trace GRAVEL (SW); Dark Brown; Well graded, sub-rounded fine size grains; Comprised of quartz and pea gravel; Recovered as residual soil; Distinct lower boundary.(NATURAL),Dark Brown;,No odour;	D		No odour	0.00 -0.10
					gravelly SAND gravelly SAND (SP); Light Brown; Poorly graded (gap graded), sub-angular medium sized grains; Comprised of quartz; Recovered as residual soil; Gradational lower boundary.(NATURAL),Light Brown;,Roots and wood fragments; No odour;	D			0.10 -0.50
		TP1_0.5-1.m			SAND with GRAVEL SAND with GRAVEL (SP); Light Brown; Poorly graded (uniform), sub-angular medium sized grains; Comprised of quartz and clacrete; Recovered as residual soil; Gradational lower boundary.(NATURAL),Light Brown;,Rootlets;No odour;	D		Rootlets;No odour;	0.50 -1.00
1.0		TP1_1-1.5m			gravelly SAND gravelly SAND (SP); Light Brown; Poorly graded (gap graded), sub-angular medium sized grains; Comprised of quartz and clacrete; Recovered as residual soil; Gradational lower boundary.(NATURAL),Light Brown;,Rootlets;No odour;	D		Rootlets;No odour;	1.00 -1.50
		TP1_1.5-2m			SAND with GRAVEL SAND with GRAVEL (SP); Light Brown; Poorly graded (uniform), sub-angular medium sized grains; Comprised of quartz and clacrete; Recovered as residual soil; Gradational lower boundary.(NATURAL),Light Brown;,Rootlets;No odour;	D		Rootlets;No odour;	1.50 -2.00
2.0									2.00

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:

Granular Soils
(VL) Very Loose
(L) Loose
(MD) Medium Dense
(D) Dense
(VD) Very Dense

Cohesive Soils
(VS) Very Soft
(S) Soft
(F) Firm
(ST) Stiff
(VST) Very Stiff
(H) Hard

TEST PIT LOG

ENVIRONMENTAL

ID: TP2

Page: 1 of 1

Client: Shire of Roebourne
Project: Roebourne geotechnical and groundwater investigation
Project No.: 6128812
Location: Roebourne
Date Drilled: 21/03/2013 to: 21/03/2013

Contractor: BGC
Machine: 10T Backhoe
Total Depth (m): 2
Bucket Width (mm): 500
Pit Width (m): 0.5 Length (m): 4

Easting: 514515
Northing: 7705302
Grid Ref: GDA94_MGA_zone_50

Logged by: AS Checked by: AO

EXCAVATION									
Depth (m)	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
					Ground Surface:				0.00
0.0		TP2_0m			clayey SAND clayey SAND (SC); Orange-Brown; Well graded, sub-rounded fine size grains; Comprised of quartz and pea gravel; Recovered as residual soil; Distinct lower boundary.(NATURAL),Orange-Brown;,No odour;	D		No odour	0.00 -0.10
					SAND SAND (SW); Red-Black; Well graded, sub-angular medium sized grains; Comprised of quartz; Recovered as residual soil; Distinct lower boundary. (NATURAL),Red-Black;,Rootlets;No odour;	D			0.10 -0.50
		TP2_0.5-1.m			SAND SAND (SW); Red-Black; Well graded, sub-angular medium sized grains; Comprised of quartz; Recovered as residual soil; Distinct lower boundary. (NATURAL),Red-Black;,Rootlets;No odour;	D		Rootlets;No odour;	0.50 -1.00
1.0		TP2_1-1.5m			CLAY with SAND CLAY with SAND (CL, CI); Red-Brown; Medium plasticity; Firm; Recovered as residual soil; Distinct lower boundary.(NATURAL),Red-Brown;,No odour;	W		No odour	1.00 -1.50
		TP2_1.5-2m			SAND SAND (SW); Red-Black; Well graded, sub-angular medium sized grains; Comprised of quartz; Recovered as residual soil; Distinct lower boundary. (NATURAL),Red-Black;,No odour;	D		No odour	1.50 -2.00
2.0									2.00

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:

Granular Soils
(VL) Very Loose
(L) Loose
(MD) Medium Dense
(D) Dense
(VD) Very Dense

Cohesive Soils
(VS) Very Soft
(S) Soft
(F) Firm
(ST) Stiff
(VST) Very Stiff
(H) Hard

TEST PIT LOG

ENVIRONMENTAL

ID: TP3

Page: 1 of 1

Client: Shire of Roebourne
Project: Roebourne geotechnical and groundwater investigation
Project No.: 6128812
Location: Roebourne
Date Drilled: 21/03/2013 to: 21/03/2013

Contractor: BGC
Machine: 10T Backhoe
Total Depth (m): 1.5
Bucket Width (mm): 500
Pit Width (m): 0.5 Length (m): 4

Easting: 515572
Northing: 7702502
Grid Ref: GDA94_MGA_zone_50
Logged by: AS Checked by: AO

EXCAVATION									
Depth (m)	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
					Ground Surface:				0.00
0.0		TP3_0m			SAND with GRAVEL SAND with GRAVEL (SW); Dark Brown; Well graded, sub-rounded fine size grains; Comprised of quartz and rock fragments; Recovered as residual soil; Distinct lower boundary.(NATURAL),Dark Brown;,No odour;	D		No odour	0.00 -0.10
					clayey GRAVEL clayey GRAVEL (GC); Red-Brown; Poorly graded (gap graded), sub-angular medium sized grains; Comprised of quartz and rock fragments; Recovered as residual soil; Distinct lower boundary.(NATURAL),Red-Brown;,No odour;	M			0.10 -0.50
		TP3_0.5-1.m			gravelly SAND gravelly SAND (SP); Red-Brown; Poorly graded (gap graded), sub-angular coarse sized grains; Comprised of quartz and rock fragments; Recovered as residual soil; Distinct lower boundary.(NATURAL),Red-Brown;,No odour;	D		No odour	0.50 -1.00
1.0		TP3_1-1.5m			clayey GRAVEL clayey GRAVEL (GC); Light Brown; Poorly graded (gap graded), sub-angular medium sized grains; Comprised of quartz and rock fragments; Recovered as residual soil; Distinct lower boundary.(NATURAL),Light Brown;,No odour;	M		No odour	1.00 -1.50
2.0									1.50

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:

Granular Soils
(VL) Very Loose
(L) Loose
(MD) Medium Dense
(D) Dense
(VD) Very Dense

Cohesive Soils
(VS) Very Soft
(S) Soft
(F) Firm
(ST) Stiff
(VST) Very Stiff
(H) Hard

TEST PIT LOG

ENVIRONMENTAL

ID: TP4

Page: 1 of 1

Client: Shire of Roebourne
Project: Roebourne geotechnical and groundwater investigation
Project No.: 6128812
Location: Roebourne
Date Drilled: 21/03/2013 to: 21/03/2013

Contractor: BGC
Machine: 10T Backhoe
Total Depth (m): 2
Bucket Width (mm): 500
Pit Width (m): 0.5 Length (m): 4

Easting: 514418
Northing: 7702469
Grid Ref: GDA94_MGA_zone_50

Logged by: AS Checked by: AO

EXCAVATION									
Depth (m)	PID (ppm)	Sample ID	Water	Graphic Log	LITHOLOGICAL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture	Consistency	COMMENTS/CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Elevation / Depth (m)
					Ground Surface:				0.00
0.0		TP4_0m			clayey SAND clayey SAND (SC); Orange-Brown; Well graded, sub-rounded fine size grains; Comprised of quartz and pea gravel; Recovered as residual soil; Distinct lower boundary.(NATURAL),Orange-Brown;,No odour;	D		No odour	0.00 -0.10
					SAND SAND (SW); Dark Red; Well graded, sub-angular medium sized grains; Comprised of quartz; Recovered as residual soil; Distinct lower boundary. (NATURAL),Dark Red;,No odour;	D			0.10 -0.50
		TP4_0.5-1.m			SAND with GRAVEL SAND with GRAVEL (SP); Dark Red; Poorly graded (gap graded), sub-angular medium sized grains; Comprised of quartz and calcrete; Recovered as residual soil; Distinct lower boundary.(NATURAL),Dark Red;,No odour;	D		No odour	0.50 -1.00
1.0		TP4_1-1.5m			SAND with GRAVEL SAND with GRAVEL (SP); Dark Red; Poorly graded (gap graded), sub-angular medium sized grains; Comprised of quartz and calcrete; Recovered as residual soil; Distinct lower boundary.(NATURAL),Dark Red;,No odour;	D		No odour	1.00 -1.50
		TP4_1.5-2m			SAND with GRAVEL SAND with GRAVEL (SP); Dark Red; Poorly graded (gap graded), sub-angular medium sized grains; Comprised of quartz and calcrete; Recovered as residual soil; Distinct lower boundary.(NATURAL),Dark Red;,No odour;	D		No odour	1.50 -2.00
2.0									2.00

NOTES:

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993. This log is not intended for geotechnical purposes.

Moisture Abbreviations:
D Dry
M Moist
W Wet

Consistency:

Granular Soils
(VL) Very Loose
(L) Loose
(MD) Medium Dense
(D) Dense
(VD) Very Dense

Cohesive Soils
(VS) Very Soft
(S) Soft
(F) Firm
(ST) Stiff
(VST) Very Stiff
(H) Hard

Appendix C – Soil sampling laboratory results

SOIL	EP1302128	ROEBOURNE ASS TESTING			6128812	ASS - Field				pH			Acidity Trail						Sulfur Trail				Excess ANC			CRS	Acid Base Accounting						
						pHF	pHFox	ΔpH	Reaction rate	pH KCl	pH OX	ΔpH	TAA	TPA	TSA	s-TAA	s-TPA	s-TSA	KCl Extractable Sulfur	Peroxide Sulfur	POS	a-POS	Excess ANC	a - Excess ANC	s - Excess ANC	Chromium Reducible Sulphur	ANC Fineness Factor	s-Net Acidity	a-Net Acidity	Liming Rate	s-Net Acidity excl ANC	a-Net Acidity excl ANC	Liming Rate excl ANC
						pH Unit	pH Unit			pH Unit	pH Unit		mole H+ / t	mole H+ / t	mole H+ / t	% pyrite S	% pyrite S	% pyrite S	% S	% S	% S	mole H+ / t	% CaCO3	mole H+ / t	% S	%	-	% S	mole H+ / t	kg CaCO3/t	% S	mole H+ / t	kg CaCO3/t
						0.1	0.1			0.1	0.1		2	2	2	0.005	0.005	0.005	0.005	0.005	0.005	5	0.02	10	0.02	0.005	0.5	0.02	10	1	0.02	10	1
						≤4	≤ 4	≥ 2		≤ 4	≤ 4	≥ 2	≥ 18.7	≥ 18.7	≥ 18.7	≥ 0.03	≥ 0.03	≥ 0.03			≥ 0.03	≥ 18.7				≥ 0.03					≥ 0.03	≥ 18.7	
	Sampled_Date-Time	Sample ID	Depth From	Depth To	Lithology																												
EP1302128001	21/03/2013	TP1	0	0	SAND trace GRAVEL; dark brown	8.5	7.8	0.7	Extreme																								
EP1302128002	21/03/2013	TP1	0	0.5	gravelly SAND; light brown	9.1	6.5	2.6	Strong																								
EP1302128003	21/03/2013	TP1	0.5	1	SAND with GRAVEL, light brown	9.2	6.5	2.7	Moderate																								
EP1302128004	21/03/2013	TP1	1	1.5	gravelly SAND, light brown	9.6	6.5	3.1	Slight																								
EP1302128005	21/03/2013	TP1	1.5	2	SAND with GRAVEL, light brown	9.4	5.5	3.9	Slight	9.4	8.6	0.8	<2	<2	<2	<0.005	<0.005	<0.005	0.01	0.02	0.01	7	73.6	14700	23.5	<0.005	1.5	<0.02	<10	<1	<0.02	<10	1
EP1302128006	21/03/2013	TP2	0	0	clayey SAND, orange-brown	8.6	6.4	2.2	Extreme																								
EP1302128007	21/03/2013	TP2	0	0.5	SAND, red-black	9.1	9	0.1	Extreme																								
EP1302128008	21/03/2013	TP2	0.5	1	SAND, red-black	8.5	9	-0.5	Extreme																								
EP1302128009	21/03/2013	TP2	1	1.5	CLAY with SAND, red-brown	8.4	8.6	-0.2	Extreme																								
EP1302128010	21/03/2013	TP2	1.5	2	SAND, red-black	8.4	8.9	-0.5	Extreme																								
EP1302128011	21/03/2013	TP3	0	0	SAND with GRAVEL, dark brown	8.4	6.6	1.8	Extreme																								
EP1302128012	21/03/2013	TP3	0	0.5	clayey GRAVEL, red-brown	8.9	8.3	0.6	Extreme																								
EP1302128013	21/03/2013	TP3	0.5	1	gravelly SAND, red-brown	8.8	8.8	0	Extreme																								
EP1302128014	21/03/2013	TP3	1	1.5	clayey GRAVEL, light brown	8.3	8.7	-0.4	Extreme																								
EP1302128015	21/03/2013	TP4	0	0	clayey SAND, orange-brown	7.8	6.9	0.9	Strong																								
EP1302128016	21/03/2013	TP4	0	0.5	SAND, dark red	7.3	7.5	-0.2	Extreme																								
EP1302128017	21/03/2013	TP4	0.5	1	SAND with GRAVEL, dark red	7.8	8	-0.2	Extreme																								
EP1302128018	21/03/2013	TP4	1	1.5	SAND with GRAVEL, dark red	8.6	8.9	-0.3	Extreme																								
EP1302128019	21/03/2013	TP4	1.5	2	SAND with GRAVEL, dark red	8.8	9.2	-0.4	Extreme																								

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP1302128**	Page	: 1 of 6
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: WILSON LEE	Contact	: Scott James
Address	: 239 ADELAIDE TERRACE PERTH WA 6004	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: wilson.lee@ghd.com	E-mail	: perth.enviro.services@alsglobal.com
Telephone	: +61 08 6222 8222	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9429 6555	Facsimile	: +61-8-9209 7600
Project	: 6128812- ROEBOURNE ASS TESTING	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 6128812		
C-O-C number	: ----	Date Samples Received	: 26-MAR-2013
Sampler	: W.L.	Issue Date	: 27-MAR-2013
Site	: ----		
		No. of samples received	: 19
Quote number	: EN/005/12	No. of samples analysed	: 19

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 Accredited Laboratory 825

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 Carey	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 insufficient 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

- **ASS: EA037 (Rapid Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Strong; 4 - Extreme**
- **EA037 ASS Field Screening: NATA accreditation does not cover performance of this service.**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP1_0m	TP1_0-0.5m	TP1_0.5-1.m	TP1_1-1.5m	TP1_1.5-2m
			Client sampling date / time	21-MAR-2013 15:00	21-MAR-2013 15:00	21-MAR-2013 15:00	21-MAR-2013 15:00	21-MAR-2013 15:00
Compound	CAS Number	LOR	Unit	EP1302128-001	EP1302128-002	EP1302128-003	EP1302128-004	EP1302128-005
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**8.5**	**9.1**	**9.2**	**9.6**	**9.4**
pH (Fox)	----	0.1	pH Unit	**7.8**	**6.5**	**6.5**	**6.5**	**5.5**
Reaction Rate	----	1	-	**Extreme**	**Strong**	**Moderate**	**Slight**	**Slight**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP2_0m	TP2_0-0.5m	TP2_0.5-1.m	TP2_1-1.5m	TP2_1.5-2m
			Client sampling date / time	21-MAR-2013 15:00	21-MAR-2013 15:00	21-MAR-2013 15:00	21-MAR-2013 15:00	21-MAR-2013 15:00
Compound	CAS Number	LOR	Unit	EP1302128-006	EP1302128-007	EP1302128-008	EP1302128-009	EP1302128-010
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**8.6**	**9.1**	**8.5**	**8.4**	**8.4**
pH (Fox)	----	0.1	pH Unit	**6.4**	**9.0**	**9.0**	**8.6**	**8.9**
Reaction Rate	----	1	-	**Extreme**	**Extreme**	**Extreme**	**Extreme**	**Extreme**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP3_0m	TP3_0-0.5m	TP3_0.5-1.m	TP3_1-1.5m	TP4_0m
			Client sampling date / time	21-MAR-2013 15:00	21-MAR-2013 15:00	21-MAR-2013 15:00	21-MAR-2013 15:00	21-MAR-2013 15:00
Compound	CAS Number	LOR	Unit	EP1302128-011	EP1302128-012	EP1302128-013	EP1302128-014	EP1302128-015
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**8.4**	**8.9**	**8.8**	**8.3**	**7.8**
pH (Fox)	----	0.1	pH Unit	**6.6**	**8.3**	**8.8**	**8.7**	**6.9**
Reaction Rate	----	1	-	**Extreme**	**Extreme**	**Extreme**	**Extreme**	**Strong**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP4_0-0.5m	TP4_0.5-1.m	TP4_1-1.5m	TP4_1.5-2m	----
			Client sampling date / time	21-MAR-2013 15:00	21-MAR-2013 15:00	21-MAR-2013 15:00	21-MAR-2013 15:00	----
Compound	CAS Number	LOR	Unit	EP1302128-016	EP1302128-017	EP1302128-018	EP1302128-019	----
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**7.3**	**7.8**	**8.6**	**8.8**	----
pH (Fox)	----	0.1	pH Unit	**7.5**	**8.0**	**8.9**	**9.2**	----
Reaction Rate	----	1	-	**Extreme**	**Extreme**	**Extreme**	**Extreme**	----

Environmental Division

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EP1302128**	Page	: 1 of 5
Client	: GHD PTY LTD	Laboratory	: Environmental Division Perth
Contact	: WILSON LEE	Contact	: Scott James
Address	: 239 ADELAIDE TERRACE PERTH WA 6004	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: wilson.lee@ghd.com	E-mail	: perth.enviro.services@alsglobal.com
Telephone	: +61 08 6222 8222	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9429 6555	Facsimile	: +61-8-9209 7600
Project	: 6128812- ROEBOURNE ASS TESTING	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 26-MAR-2013
Sampler	: W.L.	Issue Date	: 27-MAR-2013
Order number	: 6128812		
		No. of samples received	: 19
Quote number	: EN/005/12	No. of samples analysed	: 19

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 Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non -volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA037: Ass Field Screening Analysis							
Snap Lock Bag - frozen (EA037)							
TP1_0m, TP1_0-0.5m, TP1_0.5-1.m, TP1_1-1.5m, TP1_1.5-2m, TP2_0m, TP2_0-0.5m, TP2_0.5-1.m, TP2_1-1.5m, TP2_1.5-2m, TP3_0m, TP3_0-0.5m, TP3_0.5-1.m, TP3_1-1.5m, TP4_0m, TP4_0-0.5m, TP4_0.5-1.m, TP4_1-1.5m, TP4_1.5-2m	**21-MAR-2013**	**26-MAR-2013**	17-SEP-2013	✓	**27-MAR-2013**	17-SEP-2013	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
ASS Field Screening Analysis	EA037	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
ASS Field Screening Analysis	EA037	SOIL	Acid Sulfate Soils Laboratory Methods Guidelines, version 2.1 June 2004. As received samples are tested for pH field and pH fox and assessed for a reaction rating.

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW 846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**
- **For all matrices, no Matrix Spike outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

- **No Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EP1302128**	Page	: 1 of 4
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: WILSON LEE	Contact	: Scott James
Address	: 239 ADELAIDE TERRACE PERTH WA 6004	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: wilson.lee@ghd.com	E-mail	: perth.enviro.services@alsglobal.com
Telephone	: +61 08 6222 8222	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9429 6555	Facsimile	: +61-8-9209 7600
Project	: 6128812- ROEBOURNE ASS TESTING	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 26-MAR-2013
Sampler	: W.L.	Issue Date	: 27-MAR-2013
Order number	: 6128812		
		No. of samples received	: 19
Quote number	: EN/005/12	No. of samples analysed	: 19

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

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 Carey	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 insufficient 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.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA037: Ass Field Screening Analysis (QC Lot: 2793241)									
EP1302128-001	TP1_0m	EA037: pH (F)	----	0.1	pH Unit	8.5	8.6	1.4	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	7.8	7.9	1.8	0% - 20%
EP1302128-010	TP2_1.5-2m	EA037: pH (F)	----	0.1	pH Unit	8.4	8.5	1.6	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	8.9	9.0	1.1	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

- **No Method Blank (MB) or Laboratory Control Spike (SCS) Results are required to be reported.**

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) Results are required to be reported.**

Matrix Spike (MS) and Matrix Spike Duplicate (MSD) Report

The quality control term Matrix Spike (MS) and Matrix Spike Duplicate (MSD) refers to intralaboratory split samples spiked with a representative set of target analytes. The purpose of these QC parameters are to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP1302734**	Page	: 1 of 4
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: FERN BEAVIS	Contact	: Scott James
Address	: 239 ADELAIDE TERRACE PERTH WA 6004	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: fern.beavis@ghd.com	E-mail	: perth.enviro.services@alsglobal.com
Telephone	: +61 08 6222 8222	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9429 6555	Facsimile	: +61-8-9209 7600
Project	: Ex EP1302128 Roebourne ASS Testing	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 6128812		
C-O-C number	: ----	Date Samples Received	: 17-APR-2013
Sampler	: wl	Issue Date	: 22-APR-2013
Site	: ----		
		No. of samples received	: 1
Quote number	: EN/005/12	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 Accredited Laboratory 825

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 Carey	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 insufficient 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

- **ASS: EA029 (SPOCAS): 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.**
- **ASS: EA029 (SPOCAS): Retained Acidity not required because pH KCl greater than or equal to 4.5**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP1-1.5-2m	----	----	----	----
			Client sampling date / time	21-MAR-2013 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP1302734-001	----	----	----	----
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	----	----	----	----
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	**9.4**	----	----	----	----
pH OX (23B)	----	0.1	pH Unit	**8.6**	----	----	----	----
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	**0.01**	----	----	----	----
Peroxide Sulfur (23De)	----	0.005	% S	**0.02**	----	----	----	----
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	**0.01**	----	----	----	----
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	**7**	----	----	----	----
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	**0.22**	----	----	----	----
Peroxide Calcium (23Wh)	----	0.005	% Ca	**30.6**	----	----	----	----
Acid Reacted Calcium (23X)	----	0.005	% Ca	**30.4**	----	----	----	----
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	**15200**	----	----	----	----
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	**24.3**	----	----	----	----
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	**0.04**	----	----	----	----
Peroxide Magnesium (23Tm)	----	0.005	% Mg	**0.50**	----	----	----	----
Acid Reacted Magnesium (23U)	----	0.005	% Mg	**0.47**	----	----	----	----
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	**384**	----	----	----	----
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	**0.62**	----	----	----	----
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	**73.6**	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP1-1.5-2m	----	----	----	----
			Client sampling date / time	21-MAR-2013 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP1302734-001	----	----	----	----
EA029-F: Excess Acid Neutralising Capacity - Continued								
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	**14700**	----	----	----	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S	**23.5**	----	----	----	----
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	<0.02	----	----	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	----	----	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	**1**	----	----	----	----

Environmental Division

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EP1302734**	Page	: 1 of 5
Client	: GHD PTY LTD	Laboratory	: Environmental Division Perth
Contact	: FERN BEAVIS	Contact	: Scott James
Address	: 239 ADELAIDE TERRACE PERTH WA 6004	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: fern.beavis@ghd.com	E-mail	: perth.enviro.services@alsglobal.com
Telephone	: +61 08 6222 8222	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9429 6555	Facsimile	: +61-8-9209 7600
Project	: Ex EP1302128 Roebourne ASS Testing	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 17-APR-2013
Sampler	: wl	Issue Date	: 22-APR-2013
Order number	: 6128812		
		No. of samples received	: 1
Quote number	: EN/005/12	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 Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA026 : Chromium Reducible Sulfur							
Pulp Bag (EA026) TP1-1.5-2m	**21-MAR-2013**	**17-APR-2013**	21-MAR-2014	✓	**22-APR-2013**	16-JUL-2013	✓
EA029-H: Acid Base Accounting							
Pulp Bag (EA029) TP1-1.5-2m	**21-MAR-2013**	**17-APR-2013**	21-MAR-2014	✓	**22-APR-2013**	16-JUL-2013	✓
EA029-B: Acidity Trail							
Pulp Bag (EA029) TP1-1.5-2m	**21-MAR-2013**	**17-APR-2013**	21-MAR-2014	✓	**22-APR-2013**	16-JUL-2013	✓
EA029-D: Calcium Values							
Pulp Bag (EA029) TP1-1.5-2m	**21-MAR-2013**	**17-APR-2013**	21-MAR-2014	✓	**22-APR-2013**	16-JUL-2013	✓
EA029-F: Excess Acid Neutralising Capacity							
Pulp Bag (EA029) TP1-1.5-2m	**21-MAR-2013**	**17-APR-2013**	21-MAR-2014	✓	**22-APR-2013**	16-JUL-2013	✓
EA029-E: Magnesium Values							
Pulp Bag (EA029) TP1-1.5-2m	**21-MAR-2013**	**17-APR-2013**	21-MAR-2014	✓	**22-APR-2013**	16-JUL-2013	✓
EA029-A: pH Measurements							
Pulp Bag (EA029) TP1-1.5-2m	**21-MAR-2013**	**17-APR-2013**	21-MAR-2014	✓	**22-APR-2013**	16-JUL-2013	✓
EA029-G: Retained Acidity							
Pulp Bag (EA029) TP1-1.5-2m	**21-MAR-2013**	**17-APR-2013**	21-MAR-2014	✓	**22-APR-2013**	16-JUL-2013	✓
EA029-C: Sulfur Trail							
Pulp Bag (EA029) TP1-1.5-2m	**21-MAR-2013**	**17-APR-2013**	21-MAR-2014	✓	**22-APR-2013**	16-JUL-2013	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Chromium Reducible Sulphur	EA026	1	1	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	1	1	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Chromium Reducible Sulphur	EA026	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Chromium Reducible Sulphur	EA026	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Chromium Reducible Sulphur	EA026	SOIL	Sullivan et al (1998) The CRS method converts reduced inorganic sulfur to H2S by CrCl2 solution ; the evolved H2S is trapped in a zinc acetate solution as ZnS which is quantified by iodometric titration.
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	SOIL	Ahern et al 2004 - a suspension peroxide oxidation method following the 'sulfur trail' by determining the level of 1M KCL extractable sulfur and the sulfur level after oxidation of soil sulphides. The 'acidity trail' is followed by measurement of TAA, TPA and TSA. Liming Rate is based on results for samples as submitted and incorporates a minimum safety factor of 1.5.

Preparation Methods	Method	Matrix	Method Descriptions
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW 846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**
- **For all matrices, no Matrix Spike outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

- **No Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EP1302734**	Page	: 1 of 6
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: FERN BEAVIS	Contact	: Scott James
Address	: 239 ADELAIDE TERRACE PERTH WA 6004	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: fern.beavis@ghd.com	E-mail	: perth.enviro.services@alsglobal.com
Telephone	: +61 08 6222 8222	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9429 6555	Facsimile	: +61-8-9209 7600
Project	: Ex EP1302128 Roebourne ASS Testing	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 17-APR-2013
Sampler	: wl	Issue Date	: 22-APR-2013
Order number	: 6128812		
		No. of samples received	: 1
Quote number	: EN/005/12	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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

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 Carey	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 insufficient 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.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA026 : Chromium Reducible Sulfur (QC Lot: 2825697)									
EP1302734-001	TP1-1.5-2m	EA026: Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	0.0	No Limit
EA029-A: pH Measurements (QC Lot: 2825698)									
EP1302734-001	TP1-1.5-2m	EA029: pH KCl (23A)	----	0.1	pH Unit	9.4	9.4	0.0	0% - 20%
		EA029: pH OX (23B)	----	0.1	pH Unit	8.6	8.7	1.5	0% - 20%
EA029-B: Acidity Trail (QC Lot: 2825698)									
EP1302734-001	TP1-1.5-2m	EA029: sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	<0.005	<0.005	0.0	No Limit
		EA029: sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	<0.005	<0.005	0.0	No Limit
		EA029: sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	<0.005	<0.005	0.0	No Limit
		EA029: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA029: Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA029: Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	<2	0.0	No Limit
EA029-C: Sulfur Trail (QC Lot: 2825698)									
EP1302734-001	TP1-1.5-2m	EA029: KCl Extractable Sulfur (23Ce)	----	0.005	% S	0.01	0.01	0.0	No Limit
		EA029: Peroxide Sulfur (23De)	----	0.005	% S	0.02	0.02	0.0	No Limit
		EA029: Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	0.01	0.01	0.0	No Limit
		EA029: acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	7	8	0.0	No Limit
EA029-D: Calcium Values (QC Lot: 2825698)									
EP1302734-001	TP1-1.5-2m	EA029: KCl Extractable Calcium (23Vh)	----	0.005	% Ca	0.22	0.22	0.0	0% - 20%
		EA029: Peroxide Calcium (23Wh)	----	0.005	% Ca	30.6	28.8	6.3	0% - 20%
		EA029: Acid Reacted Calcium (23X)	----	0.005	% Ca	30.4	28.5	6.4	0% - 20%
		EA029: sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	24.3	22.8	6.4	0% - 20%
		EA029: acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	15200	14200	6.4	0% - 20%
EA029-E: Magnesium Values (QC Lot: 2825698)									
EP1302734-001	TP1-1.5-2m	EA029: KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	0.04	0.03	0.0	No Limit
		EA029: Peroxide Magnesium (23Tm)	----	0.005	% Mg	0.50	0.47	6.0	0% - 20%
		EA029: Acid Reacted Magnesium (23U)	----	0.005	% Mg	0.47	0.44	6.3	0% - 20%
		EA029: sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	0.62	0.58	6.3	0% - 20%
		EA029: Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	384	360	6.3	0% - 20%
EA029-F: Excess Acid Neutralising Capacity (QC Lot: 2825698)									
EP1302734-001	TP1-1.5-2m	EA029: Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	73.6	73.4	0.2	0% - 20%

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA029-F: Excess Acid Neutralising Capacity (QC Lot: 2825698) - continued									
EP1302734-001	TP1-1.5-2m	EA029: sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S	23.5	23.5	0.2	0% - 20%
		EA029: acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	14700	14700	0.2	0% - 20%
EA029-H: Acid Base Accounting (QC Lot: 2825698)									
EP1302734-001	TP1-1.5-2m	EA029: ANC Fineness Factor	----	0.5	-	1.5	1.5	0.0	No Limit
		EA029: Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	0.0	No Limit
		EA029: Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	0.0	No Limit
		EA029: Liming Rate	----	1	kg CaCO3/t	<1	<1	0.0	No Limit
		EA029: Liming Rate excluding ANC	----	1	kg CaCO3/t	1	1	0.0	No Limit
		EA029: Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	0.0	No Limit
		EA029: Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA026 : Chromium Reducible Sulfur (QCLot: 2825697)								
EA026: Chromium Reducible Sulphur	----	0.005	%	<0.005	.199 %	97.8	83.1	121
EA029-A: pH Measurements (QCLot: 2825698)								
EA029: pH KCl (23A)	----	0.1	pH Unit	----	7 pH Unit	100	70	130
EA029: pH OX (23B)	----	0.1	pH Unit	----	7 pH Unit	100	70	130
EA029-B: Acidity Trail (QCLot: 2825698)								
EA029: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	73.0756 mole H+ / t	95.7	70	130
EA029: Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	73.7217 mole H+ / t	114	70	130
EA029: sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	<0.005	----	----	----	----
EA029: sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	<0.005	----	----	----	----
EA029: sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	<0.005	----	----	----	----
EA029-C: Sulfur Trail (QCLot: 2825698)								
EA029: KCl Extractable Sulfur (23Ce)	----	0.005	% S	<0.005	.0215 % S	128	70	130
EA029: Peroxide Sulfur (23De)	----	0.005	% S	<0.005	.0506 % S	94.1	70	130
EA029: Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	<0.005	----	----	----	----
EA029: acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	<5	----	----	----	----
EA029-D: Calcium Values (QCLot: 2825698)								
EA029: KCl Extractable Calcium (23Vh)	----	0.005	% Ca	<0.005	.2554 % Ca	100	70	130
EA029: Peroxide Calcium (23Wh)	----	0.005	% Ca	<0.005	.3301 % Ca	99.8	70	130
EA029: Acid Reacted Calcium (23X)	----	0.005	% Ca	<0.005	----	----	----	----
EA029: acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	<5	----	----	----	----
EA029: sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	<0.005	----	----	----	----
EA029-E: Magnesium Values (QCLot: 2825698)								
EA029: KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	<0.005	.0499 % Mg	97.0	70	130
EA029: Peroxide Magnesium (23Tm)	----	0.005	% Mg	<0.005	.0523 % Mg	103	70	130
EA029: Acid Reacted Magnesium (23U)	----	0.005	% Mg	<0.005	----	----	----	----
EA029: Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	<5	----	----	----	----
EA029: sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	<0.005	----	----	----	----

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) Results are required to be reported.**

Matrix Spike (MS) and Matrix Spike Duplicate (MSD) Report

The quality control term Matrix Spike (MS) and Matrix Spike Duplicate (MSD) refers to intralaboratory split samples spiked with a representative set of target analytes. The purpose of these QC parameters are to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

Appendix D – ASS methodology and results

ASS Risk Mapping

The desktop assessment is a preliminary appraisal of the ASS risk within the project area.

A review of Department of Environment and Conservation (DEC) ASS risk mapping available through the Landgate Shared Land Information Portal (SLIP) was undertaken.

The risk mapping indicates that the majority of the site overlies an area of no known ASS risk within 3 m of the natural soil surface. This classification means that no ASS sampling has been undertaken in this area by the DEC. It does not mean that there is conclusively no ASS in the area. Areas around the perimeter of the site have been classified as Moderate to Low ASS disturbance risk, with isolated High to Moderate ASS disturbance risk areas in the nearby vicinity of the site.

pH Screening Results

A total of 19 primary samples (collected from four test pit locations) were submitted to ALS for pH_F and pH_{FOX} rapid screening. Samples were collected at 0.5 m intervals to a maximum depth of 2.0 m.

Values for pH_F ranged from 7.3 to 9.6 (average of 8.6) with values for pH_{FOX} ranging from 5.5 to 9.2 (average of 7.8). The ΔpH, (which is defined as pH_F minus pH_{FOX}) ranged between -0.5 and 3.9 (average of -0.5).

The results indicate that the samples analysed are naturally neutral tending alkaline soils. However, review of the Δ pH values showed a limited number of Δ pH results >2 pH units, indicating that the soils may have some potential to generate additional acidity upon oxidation. Of the 19 samples analysed, 8 returned negative Δ pH values indicating that if these soils were allowed to oxidise (by means of excavation and/or dewatering), it is highly unlikely that acid generation would result. The negative Δ pH values actually infer that the soil pH would increase following oxidation. Based on the pH_{FOX} and Δ pH results, the soils do not appear to contain materials with a high ASS risk, and significant PASS is not considered likely.

Below is a summary of samples that are likely to be potential ASS based on ASS pH screening criteria outlined by the DEC (2009). A total of five samples indicate PASS may be present. A summary of the pH screening results for the site are presented in Tables 1 and 2 below.

Table 1 Summary of the pH Screening Results

Parameter	pH_F	pH_{FOX}	ΔpH
Minimum	7.3	5.5	-0.5
Maximum	9.6	9.2	3.9
Average	8.6	7.8	0.8

Table 2 Indications of AASS and PASS

Parameter and trigger level		Indication
$4.0 < pH_F \leq 5.5$	0%	Acidic Soil
$pH_F \leq 4.0$	0%	AASS
$pH_{FOX} < 4.0$	0%	PASS likely
ΔpH > 2.0	26% (5 samples)	PASS likely

The results presented in Tables 1 and 2 indicate the following:

- The pH screening results are indicative of no acidic soil or actual ASS materials being present at the locations sampled. The ΔpH screening criteria was exceeded in 5 of the samples tested.
- Samples deemed as 'topsoil' (those within the top 0.3 m of the soil profile) are likely to have already undergone oxidation through natural wetting and drying cycles, and are therefore considered to be unlikely to present an PASS risk.
- In general, the field screening results suggest that alkaline soils are present, however a limited number of ΔpH results > 2 pH units indicate that the soils may have some potential to generate additional acidity upon oxidation. Based on the pHFOX and ΔpH results, the soils do not appear to contain materials with a high ASS risk, and significant PASS is not considered likely.

Confirmatory Laboratory Results: SPOCAS and CRS

Given that the soils are a mixture of fine to coarse textured materials, the adopted net acidity action criteria for this assessment is conservatively 18.7 mol H^+/tonne.

Confirmatory Suspension Peroxide Oxidisable Combined Acidity and Sulfate (SPOCAS) and Chromium Reducible Sulfur (CRS) testing was scheduled on the sample which was identified as having the lowest pH_{FOX} result and the highest ΔpH (TP1 – 1.5-2m). The comparison between SPOCAS and S_{CR} test results can help to identify where acidity indicated by SPOCAS does not relate to a sulfidic or metalliferous source. A summary of the SPOCAS and CRS lab results are provided in Table 3. A larger summary table of the full laboratory analytical results and a copy of the associated laboratory certificates are presented in Table 3.

Table 3 Summary of SPOCAS and CRS Results

Sample ID	Depth From (m bgl)	Depth To (m bgl)	Lithology	TAA	TPA	TSA	s-POS	a-POS	Excess ANC	CRS	a-Net Acidity excluding ANC
				mol H+/t			% S	mol H+/t		%	mol H+/t
				≥18.7	**≥18.7**	**≥18.7**	**≥0.03**	**≥18.7**	-	**≥0.03**	**≥18.7**
TP1	1.5	2	Sand with gravel	<2	<2	<2	0.01	7	14,700	<0.005	<10

The results indicate the following:

- The sample analysed for SPOCAS was below both the laboratory LOR (<10 mol H+/tonne) and the net acidity action criteria of 18.7 mol H+/t.
- The Titratable Actual Acidity (TAA) value, a measure of actual acidity was below both the laboratory LOR (<2 mol H+/tonne). This indicates that the soil contains negligible existing acidity.
- The Titratable Potential Acidity (TPA) value, a measure of potential acidity, was below the LOR (< 2 mol H+/tonne). This indicates that the soil contains negligible potential acidity.
- The Peroxide Oxidisable Sulfur (SPOS) value, an estimation of soil sulfide content, was 0.01 %S, which is below the action criteria value of >0.03 %S. This indicates that there are low amounts of sulfides within the samples analysed (and subsequently there is a low potential for sulfidic acidity generation).

- Acid neutralising capacity (ANC) was analysed due to the laboratory pHox value being greater than 6.5. The ANC value was 14,700 mol H+/tonne (CaCO3 equivalent) which would provide significant buffering capacity in the event of any acid generation.
- Chromium Reducible Sulfur (CRS) analysis was also completed on the sample to give an accurate indication of any potential inorganic sulfides. The CRS value returned below the LOR (<0.005 %S).

Summary

In general, the geology encountered was varying thicknesses of gravelly sand, sand and clayey sands. The pH testing results indicate that the samples analysed are naturally neutral tending alkaline soils. The majority of the Δ pH values indicate that the potential for the generation of acidity upon oxidation is low. There were however five samples collected from the gravelly sand, sand with gravel and clayey sand lithological units (TP1: 0-2m and TP2: 0m) that may be indicative of PASS (Δ pH > 2), with values between 2.2 and 3.9.

The remaining 14 samples which were analysed for ASS pH tests did not exhibit evidence that they contained AASS or PASS. Of the 19 samples analysed for pH screening test, 8 returned negative Δ pH values indicating that if these soils were allowed to oxidise (by means of excavation and/or dewatering), it is highly unlikely that acid generation would result. The negative Δ pH values actually infer that the soil pH would increase following oxidation, which may be explained by excess soil buffering capacity assumed to be derived from weathered calcrete (calcium carbonate) found in excess within some of the test pits (TP1 and TP2).

Sample TP1 – 1.5-2m, the most indicative of containing PASS based on results from the preliminary pH screening tests, was analysed for SPOCAS and CRS and returned net acidity excluding ANC and CRS value below the DEC action criteria of 18.7 mol H+/t. In addition, the sample contained a very high ANC value. These results indicate this sample does not contain PASS. Based on the information above, GHD therefore considers the general ASS risk to a depth of 2 metres below ground level (m bgl) for the site to be low. Furthermore, PASS is generally found at or below the groundwater table (DEC, 2013). Groundwater across the site is generally deeper than 6 m bgl further supporting the idea that the ASS risk within 2 m below natural ground level is low.

It should also be noted that the ASS pH testing carried out was limited to the four test pits excavated to a maximum depth of 2 m bgl. It should be understood that the low ASS risk classification indicated by GHD is based on the extrapolation of results from these locations to the whole site (i.e. the results are representative of the broader site area).

At this time, an ASS Management Plan (ASSMP) is not required for any shallow excavations to a maximum depth of 2 m bgl near the test pits locations. However, this assumption should be revised should changes to the depth or area of excavation be altered. Under these circumstances, additional sampling may need to be required. If any additional sampling and lab results indicate a potential ASS risk then an ASSMP would be required to be prepared and implemented prior to the commencement of any excavation.

GHD

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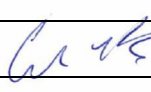
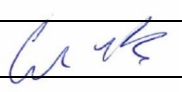
0	Adam Osbaldeston	Carsten Kraut		Carsten Kraut		2 May 2013

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