STAGE A: ACID SULFATE SOILS INVESTIGATION - MARDIE SALT PROJECT

PREPARED FOR BC IRON LIMITED

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QUALITY STATEMENT

PROJECT MANAGER		PROJECT TECHNICAL LEAD
Matt Braimbridge		Matt Braimbridge

PREPARED BY		
Tala Al-Obaidi	.....	12/09/2017
CHECKED BY		
Bronwyn Smedley	.....	13/09/2017
REVIEWED BY		
David Jasper	.....	13/10/2017
APPROVED FOR ISSUE BY		
Matt Braimbridge	.....	16/10/2017

PERTH
41 Bishop Street, JOLIMONT, WA 6014
TEL +61 (08) 9388 8799

REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
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Executive Summary

BC Iron Limited (BC Iron) is looking to develop the Mardie Salt Project (the Project), which is a potential sodium chloride (NaCl) salt production project located between Dampier and Onslow in the north-west of Western Australia (WA). Based on preliminary mapping, the Project area was considered to be of 'moderate to high' risk with respect to Acid Sulfate Soils (ASS). Stantec Australia Pty Ltd (Stantec) were commissioned by BC Iron to undertake a Stage A ASS Investigation of the Project area to identify the potential presence / absence of ASS and facilitate planning for future assessment (Stage B), if required. The assessment has been conducted in accordance with the Department of Environment Regulation (DER) 2015 ***Guidelines for Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes*** (DER, 2015).

A preliminary site inspection involved logging, sampling and analysis (field pH (pH_F) and field pH peroxide (pH_{FOX})) of 18 'near surface' soil profiles within potential disturbance areas associated with the Project. The profiles were sampled to a maximum depth of 1 metre below ground level (mbgl). The soil locations targeted for sampling were derived from previous geotechnical sampling points located within the Project area.

Field observations of the surface soil profiles indicated no signs of ASS potential or presence. Field analysis of soil pH_F indictated all soil profiles were circum-neutral to strongly alkaline, and were consistent in pH_F throughout the sample locations and with depth (to 1 mbgl). Under soil pH_{FOX} testing, soil samples at the majority of sample locations reported a substantial increase in pH at all depths analysed, and were considered to have an 'extreme' reaction vigour when tested. Samples that experienced a decline in pH_{FOX} relative to pH_F, all reported a pH_{FOX} above pH 6.0, and were considered to have a 'low' to 'moderate' reaction when tested.

The highly alkaline conditions indicate that the surface soil profiles within the Project area are not likely to be classed as Potentially Acid Sulfate Soils (PASS). Although an extreme reaction to the pH_{FOX} test was observed for the majority of samples, the reaction was likely to have been associated with other soil constituents such as organic matter or manganese, and is not considered to be problematic with respect to ASS as it caused samples to become more alkaline rather than acidic.

Due to the low ASS risk of surface soils within the Project area, further investigations into the presence of ASS is not considered necessary, unless disturbance is planned at greater depths (>1 mbgl) or outside the current area of investigation.

Abbreviations

AHD	Australian Height Datum
ASS	Acid sulfate soils
BC Iron	BC Iron Limited
BoM	Bureau of Meteorology
cm	Centimetres
DAFWA	Department of Agriculture and Food Western Australia
DER	Department of Environment Regulation
km	Kilometres
km^2	Square kilometres
m	Metres
mbgl	Metres below ground level
mm	Millimetres
mm/yr	Millimetres per year
Mtpa	Million tonnes per annum
NaCl	Sodium chloride
PASS	Potentially acid sulfate soils
pH_F	Soil pH measured in a deionised water suspension
pH_{FOX}	Soil pH measured in a 30% hydrogen peroxide suspension
Stantec	Stantec Australia Pty Ltd
WA	Western Australia

°C	Degrees Celsius
%	Percent

BC Iron Limited

Stage A: Acid Sulfate Soils Investigation - Mardie Salt Project

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1. Introduction

BC Iron Limited (BC Iron) is looking to develop the Mardie Salt Project (the Project), which is a potential sodium chloride (NaCl) salt production project located between Dampier and Onslow in the north-west of Western Australia (WA) (BC Iron, 2017) (**Figure 1-1; Figure 1-2**). The Project area is located in Australia's major solar salt producing region, and covers a total area of 832 square kilometres (km^2).

Stantec Australia Pty Ltd (Stantec) were commissioned by BC Iron to undertake a Stage A Acid Sulfate Soils (ASS) Investigation of the Project area to identify any ASS or potentially acid sulfate soils (PASS) risk associated within the proposed disturbance area. The assessment has been conducted in accordance with the Department of Environment Regulation (DER) *2015 Guidelines for Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes* (DER, 2015).

1.1 Project Description

The Project envisages to develop a 3.0 to 3.5 million tonnes per annum (Mtpa) operation, producing high purity industrial-grade NaCl salt from seawater via a solar evaporation, crystallisation and raw salt purification (BC Iron, 2017). This will involve the construction of:

- a fixed seawater pump station (installed at the mouth of the tidal creek);
- a settling pond;
- nine concentrator ponds (utilising a continuous flow methodology); and
- 12 crystalliser ponds.

The evaporation ponds are proposed to be constructed on coastal mudflats by grading clay materials from the surface and importing general fill and stone material to form bund walls. Pond bases will be constructed from *in-situ* local clays (BC Iron, 2017). The pond surfaces will be at a nominal 3 metres (m) Australian Height Datum (AHD).

Salt is assumed to be harvested via a dry harvesting method. This will involve using a dedicated harvester that runs along the top of the salt crust and cuts into the floor, conveying the harvested salt into a truck running alongside the harvester (BC Iron, 2017).

1.2 Report Scope and Objectives

The main objective of the Stage A investigation is to complete a desktop assessment and preliminary site inspection / sampling program to identify the potential presence / absence of ASS and facilitate planning for future assessment (Stage B), if required. The specific objectives of the Stage A ASS Investigation include:

- A desktop assessment of ASS risk maps, geomorphic and geological information;
- A desktop and visual assessment of topography, geomorphology, surface water and hydrology;
- A desktop and visual assessment of prevalent plant communities; and
- Preliminary logging, sampling and analysis of the 'near surface' soil profile in targeted potential disturbance areas.

Figure 1-1: Regional location of the Project area

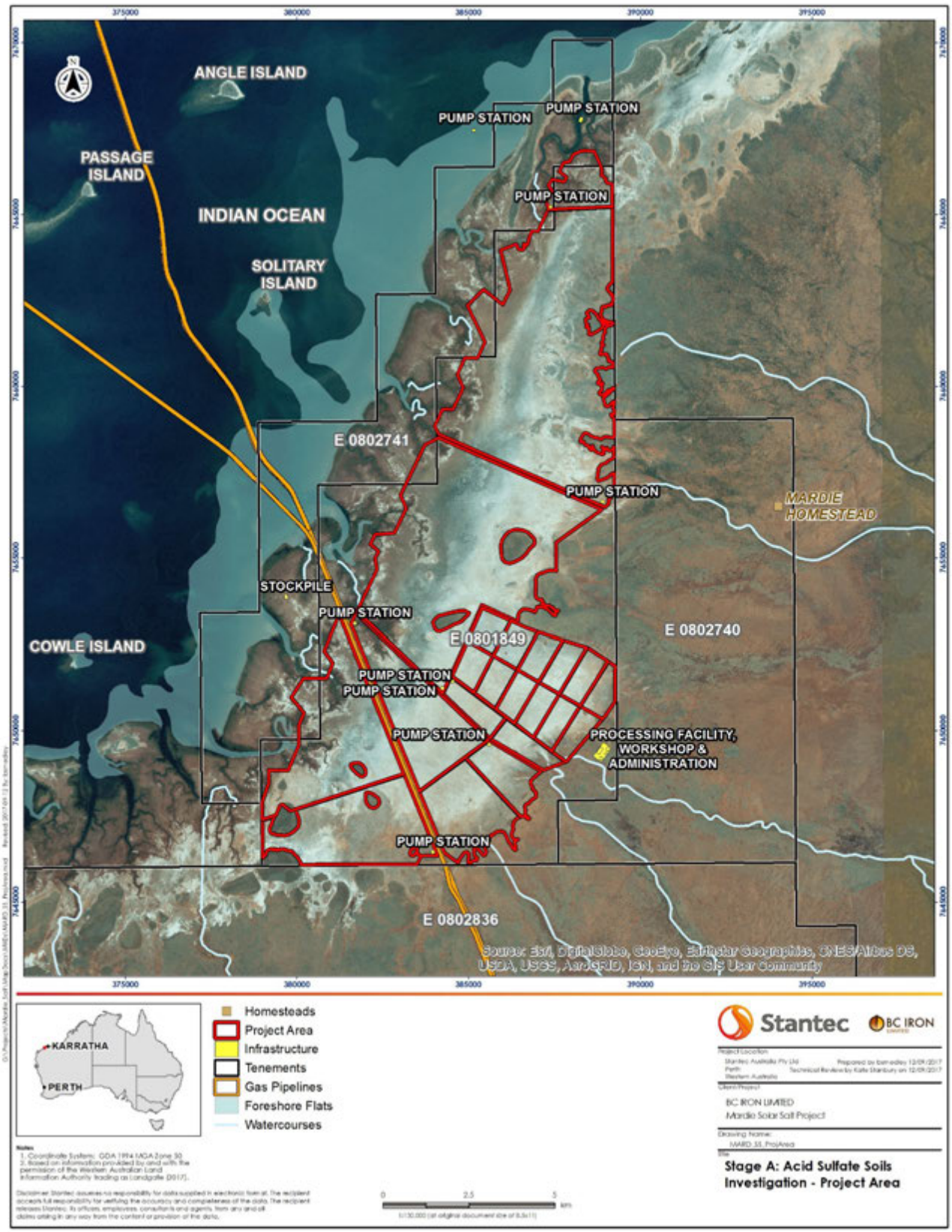

Figure 1-2: The Project area

2. Background Information Review

2.1 Climate

The Project area is located within the Pilbara region of Western Australia, and is characterised as having a hot dry and windy climate with a predicable dry season (BC Iron, 2017).

The closest Bureau of Meteorology (BoM) weather station to the Project area is Mardie Station (station number 005008) (BoM, 2017). The long-term average annual rainfall recorded between 1956 and 2017 is 277 mm/yr, with the majority received between January and June each year. Peak rainfall is recorded in February at an average of 63 mm (**Figure 2-1**). Rainfall received across August to December is minimal, ranging from an average of 0.9 mm in October to 14 mm in July. The mean maximum temperatures ranges from 37.9 degrees Celsius (°C) in January to 27.7°C in July. Mean minimum temperatures range from 25.3°C in February to 11.8°C in July (BoM, 2017).

Annual evaporation rates across the Project area were estimated by BC Iron (2017), using pan evaporation data collected across weathered stations at Dampier Salt (71.2 km north-east) and Learmonth (239.9 km south-west). The assumed annual evaporation rate for the Project area was found to be 3,248 mm/yr, which is significantly higher than annual rainfall received in the area.

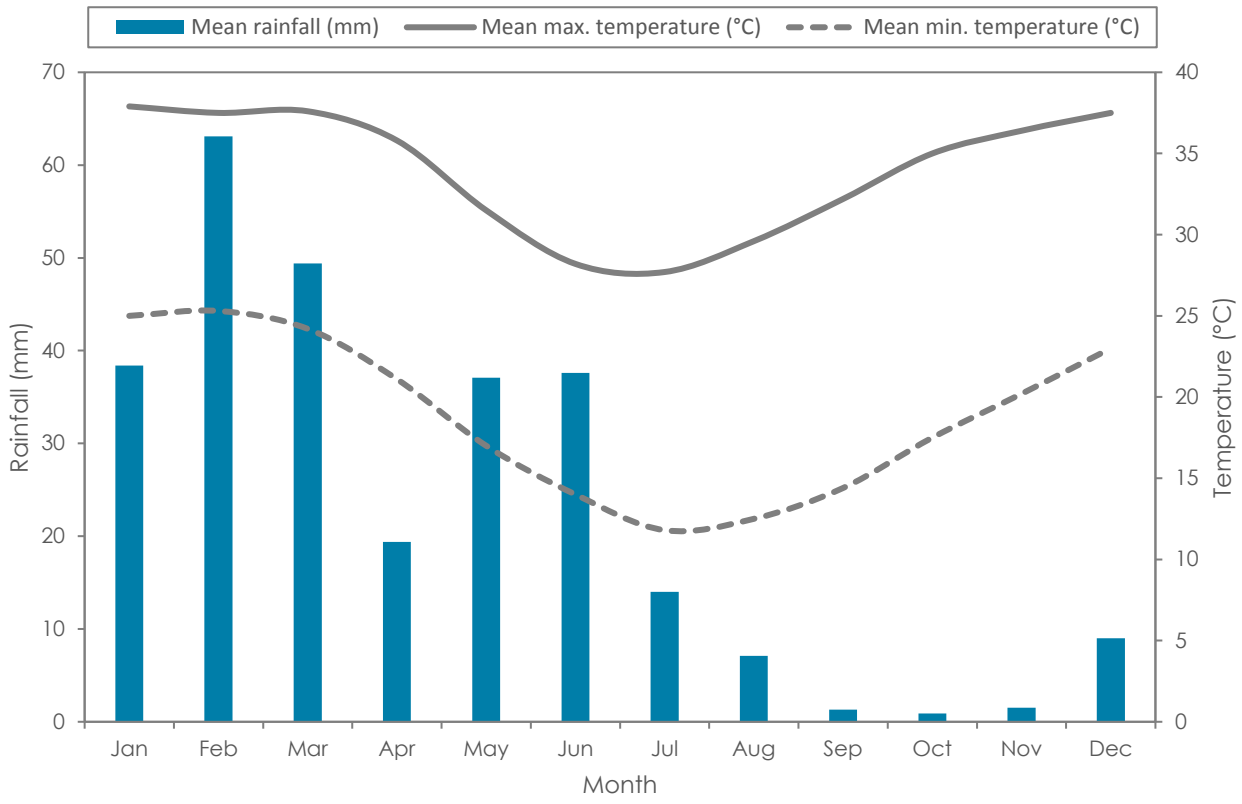

Figure 2-1: Long term climate data (1956 to 2017) recorded at the Mardie Weather Station (station number: 005008)

2.2 Land Systems and Regional Soils

An assessment of land systems provides an indication of the occurrence and distribution of soil-landscape-vegetation associations within and surrounding the Project Area (Van Vreeswyk *et al.*, 2004). Land systems across the Pilbara region have been mapped by the Natural Resources Assessment Group of the former Department of Agriculture (now Department of Agriculture and Food Western Australia, DAFWA).

Two land systems are located within the Project area (**Table 2-1**, **Figure 2-2**). The majority of the Project area is situated within the Littoral land system, which is characterised by flat plains (bare coastal mudflats and samphire flats), sandy islands, and coastal dunes and beaches. The vegetation typical for this land system comprises samphire low shrublands, sparse *Acacia* shrublands and mangrove forests. The surface geology (i.e. regolith) associated with the Littoral land system generally includes quaternary coastal mud and silty loam, and aeolian sand. The remaining area of the Project lies within the Onslow land system. This system is described as undulating sandplains, dunes and level clay plains, and has a surface geology dominated by quaternary sand, silt and clay. Vegetation within the Onslow land system comprises soft spinifex grasslands and minor tussock grasslands.

Table 2-1: Land systems within the Project area

Land System	Description
Littoral LS	Bare coastal mudflats (unvegetated), samphire flats, sandy islands, coastal dunes and beaches, supporting samphire low shrublands, sparse *Acacia* shrublands and mangrove forests. Surface geology comprises quaternary coastal mud and silty loam, and aeolian sand.
Onslow LS	Undulating sandplains, dunes and level clay plains supporting soft spinifex grasslands and minor tussock grasslands. Surface geology comprises quaternary sand, silt and clay.

Source: Landgate (2015)

Based on the reference Soil Units mapped by ASRIS (2014), two types of soil units are presented within the Project area (**Table 2-2**, **Figure 2-3**). The soils within the area are generally dominated by saline loams with shelly sands. These soils are associated with salt flats, tidal swamps and coastal dune sands. Soils to the east and south of the Project area are typically dominated by hard alkaline red soils.

Table 2-2: Regional soil units located within the Project area

Soil Unit	Description
SV8 unit	Salt flats, tidal swamps, and coastal dune sands. Chief soils are saline loams with shelly sands. Small areas of calcareous earths and shallow loams are associated with marls.
Oc72 unit	Plains dominated by hard alkaline red soils.

Source: ASRIS 2014

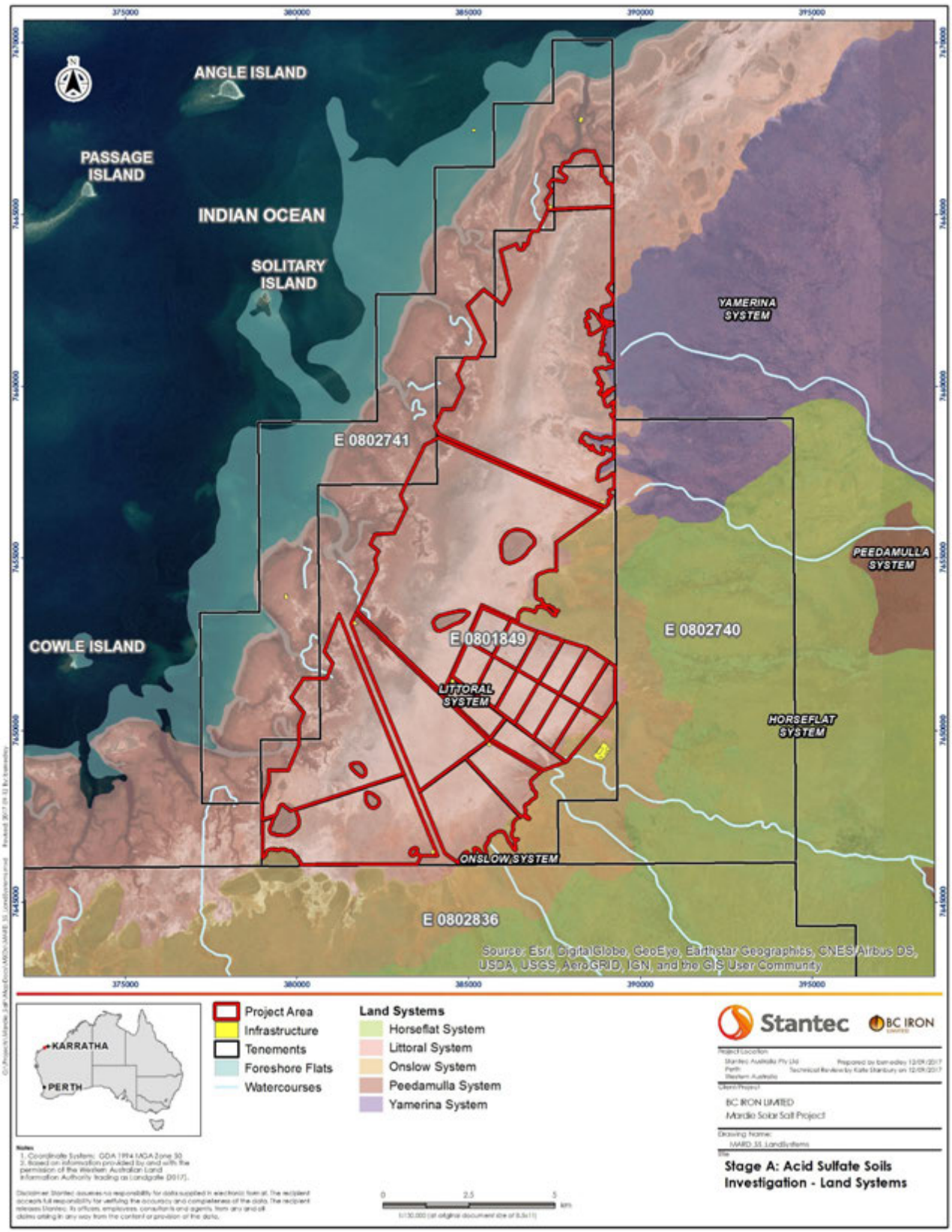

Figure 2-2: Land systems within the Project area

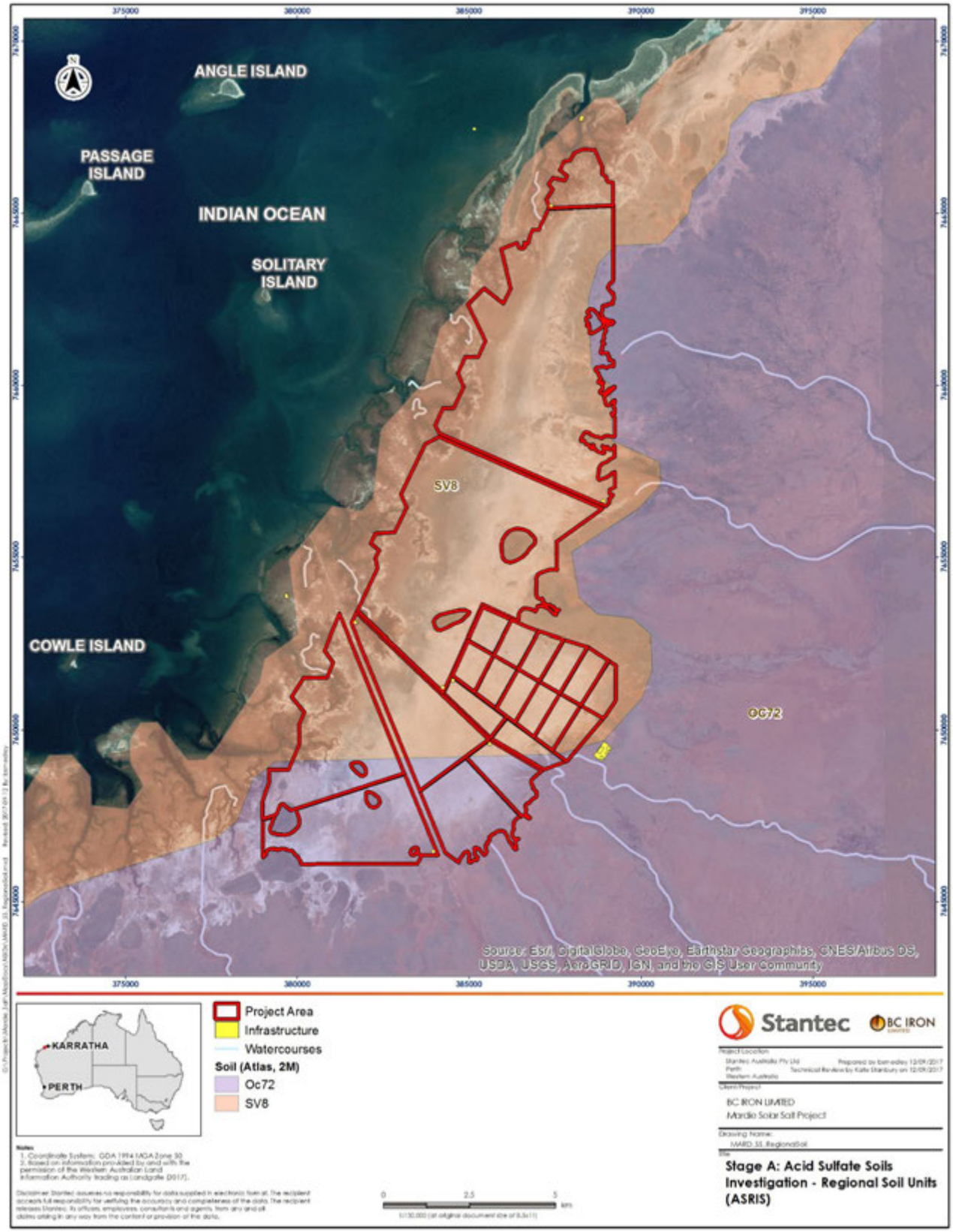

Figure 2-3: Soil units within the Project area

2.3 Surface Geology and Topography

The majority of the Project area is characterised by coastal silt and evaporite material of estuarine, lagoonal and lacustrine deposits (Qe lithology) (**Figure 2-4**). Further away from the coastline, the area is dominated by channel and flood plain alluvium (locally calcreted) of gravel, sand, silt and clay (Qa lithology); and clay-silt-sand with sheet and nodular kankar (Qrc lithology).

The Project area is typically low in the landscape, ranging between 1.5 m and 2.0 m AHD with minimal gradients (down to 0.02%) (BC Iron, 2017) (**Figure 2-5**). Localised areas of higher elevation (to approximately 10 m AHD) exist across the sand mounds that are present within the Project area.

2.4 Surface Water and Hydrology

The Project area is situated within the Coastal and Peters Creek catchments (**Figure 2-6**). The Coastal catchment is part of the Fortescue River basin while the Peters Creek catchment is situated within the Onslow Coast basin. Various creek lines within these catchments flow from the east into the broader region of the Project area, before draining into the Indian Ocean.

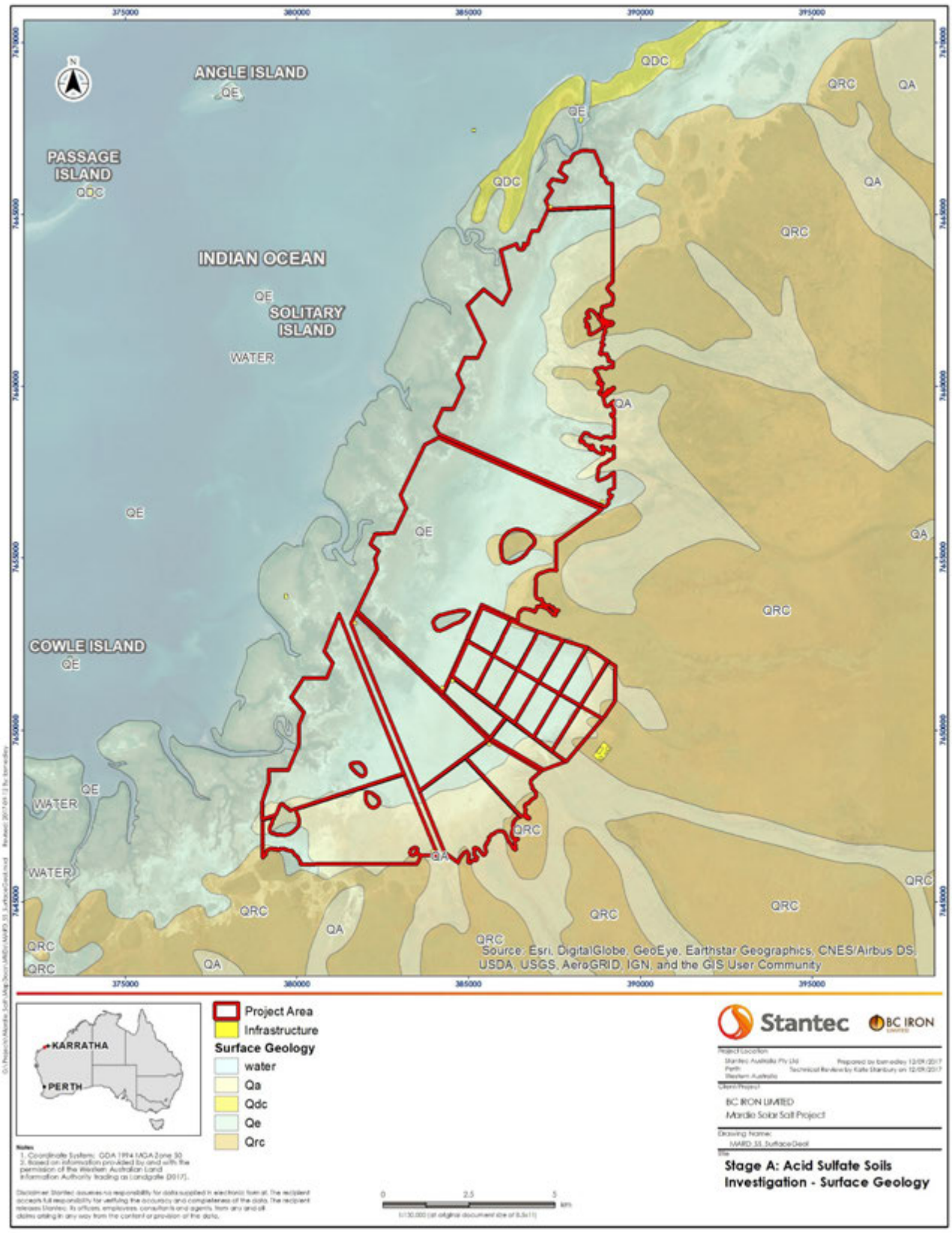

Figure 2-4: Surface geology within and surrounding the Project area

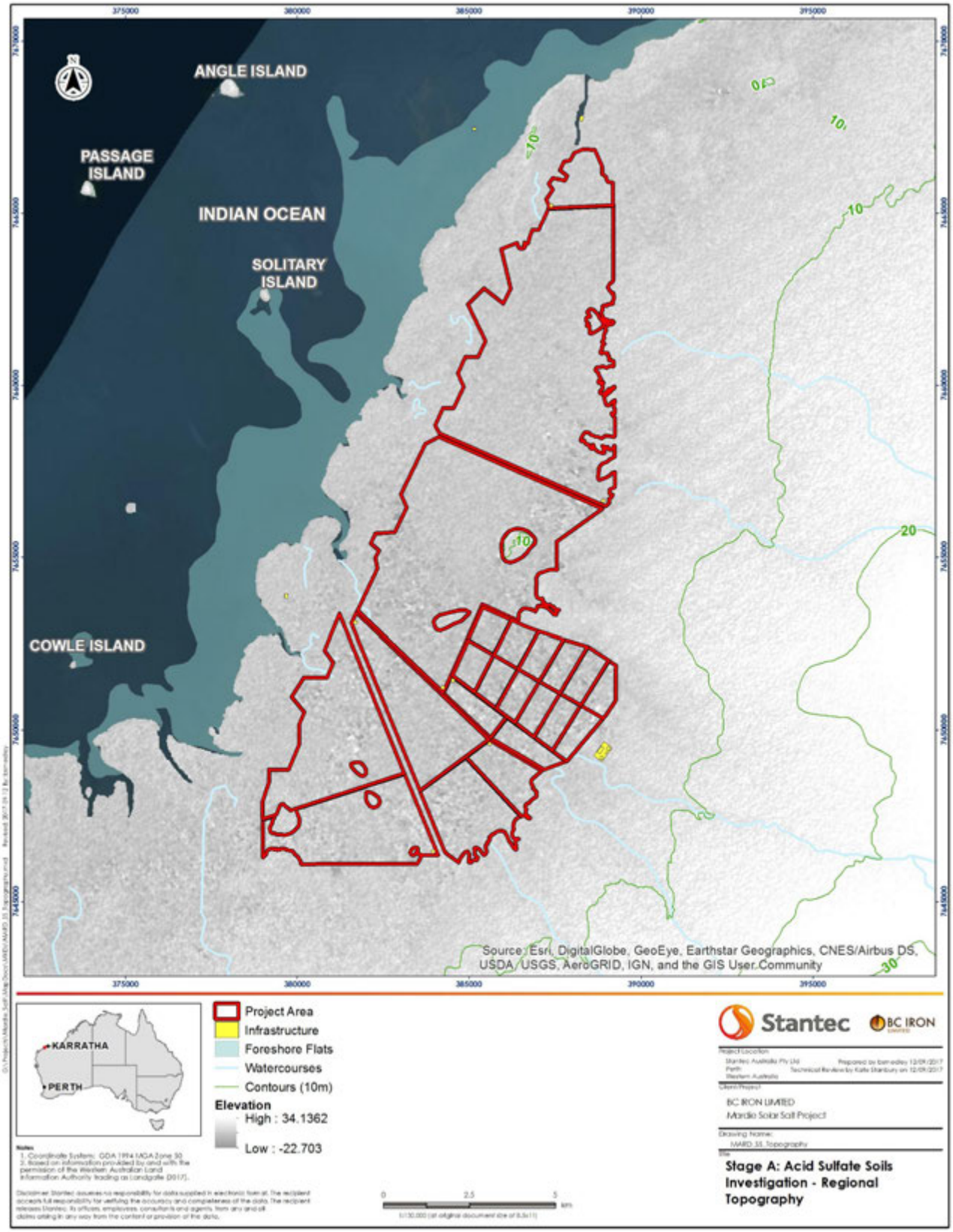

Figure 2-5: Topography of the Project area

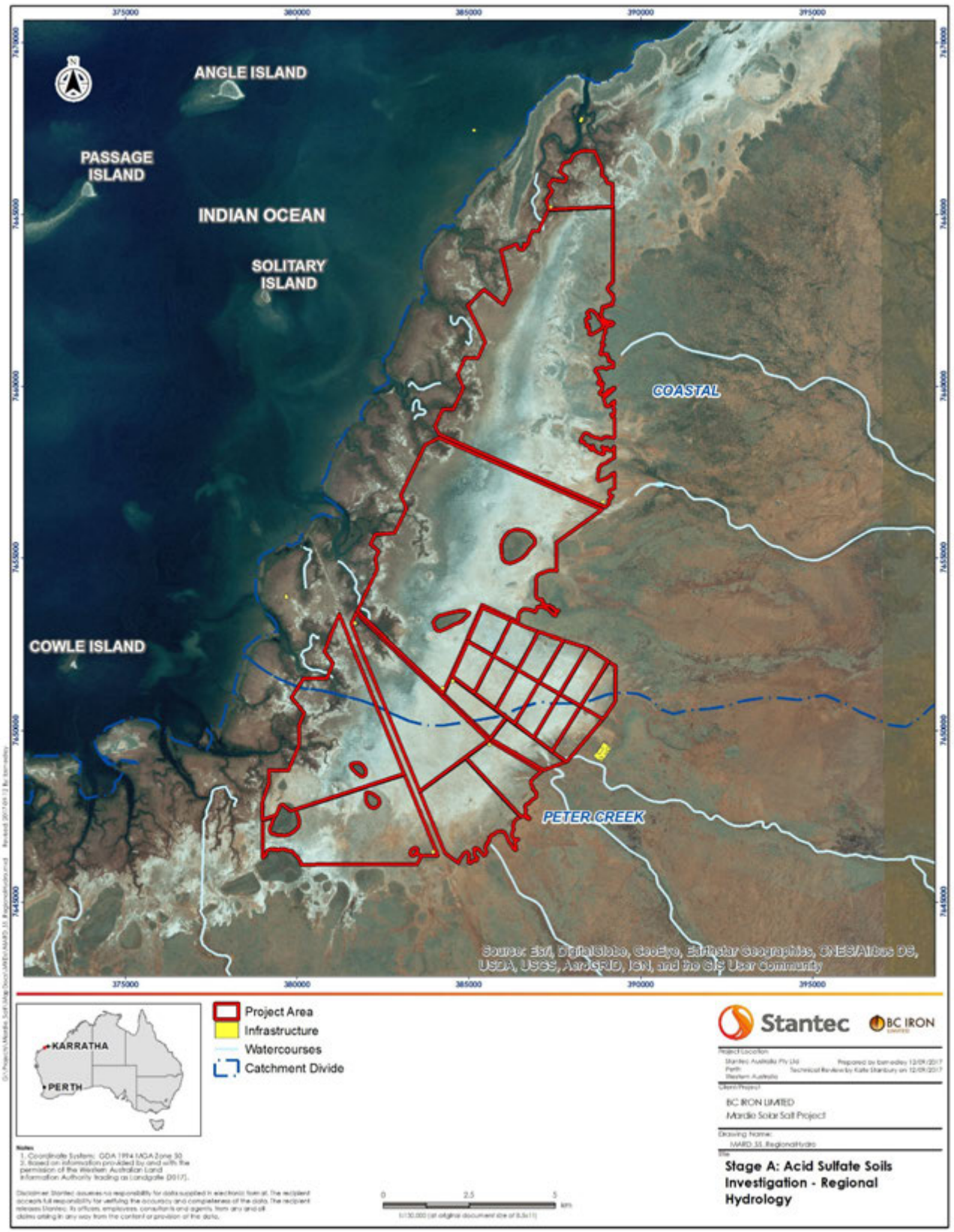

Figure 2-6: Surface hydrology of the Project area

2.5 ASS Risk Mapping

A preliminary assessment of ASS risk provides an indication if proposed works are in an area where there is a known ASS risk (DER, 2015). ASS risk maps have been published by the DER for most coastal regions of WA where high and moderate to low probability of ASS occurrence has been identified (DER, 2015).

Shallow ASS are widespread across coastal regions of WA, and are known to occur in tidal, intertidal and supratidal flats along the northern coastline, including the Pilbara and Kimberley coasts (DER, 2015). As a result, the vast majority of the Project area has been assigned a risk category of 'high to moderate' (**Figure 2-7**). However, small isolated areas located within the Project area have been classed as 'moderate to low' risk. These areas are associated with sand mounds present within the area. One of the proposed infrastructure areas (Processing Facility, Workshop and Administration area) was not mapped under the Class 1 and 2 ratings, but is considered to be of 'low ASS probability' based on data sourced from ASRIS (2014).

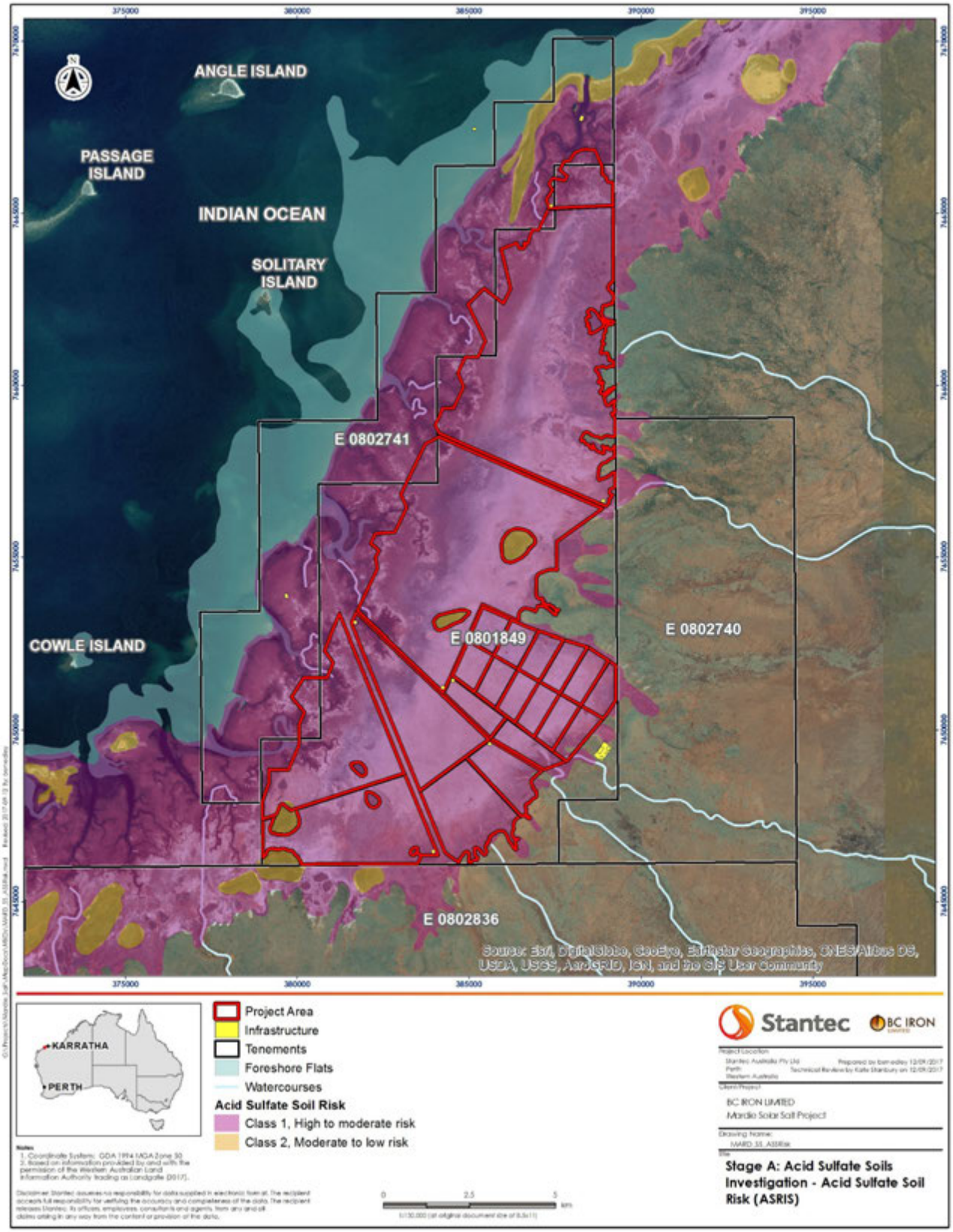

Figure 2-7: Risk mapping of ASS within the Project area

3. Field Survey Methods

3.1 Soil Sampling and Field Analysis

A preliminary site inspection was completed by Stantec personnel in mid-August 2017. The sampling survey comprised logging, sampling and analysis of 18 'near surface' soil profiles within the potential disturbance areas (**Table 3-1**). The soil locations targeted for sampling were derived from previous geotechnical sampling points located within the Project area (**Figure 3-1**).

Table 3-1: Sample locations within the Project area chosen for ASS assessment

Sample Location ID	Land System	Zone	Easting (mE)	Northing (mN)
MS0013	Littoral LS	50 K	387315	7665152
MS0020		50 K	384565	7659336
MS0023		50 K	382843	7655727
MS0028		50 K	379182	7648847
MS0030		50 K	383839	7646371
MS0033		50 K	383124	7648718
MS0034		50 K	383560	7651645
MS0039		50 K	385159	7651101
MS0043		50 K	387433	7649396
MS0047	Onslow LS	50 K	389062	7652012
MS0053	Littoral LS	50 K	385373	7653597
MS0057		50 K	386421	7651773
MS0068		50 K	389175	7663016
MS0069		50 K	386146	7657724
MS0070	Onslow LS	50 K	388985	7649317
MS0077	Littoral LS	50 K	381699	7653135
MS0078		50 K	385593	7649607
MS0081		50 K	388912	7656661

At each target sampling location, soil was hand augered to a maximum depth of 1 m below ground level (mbgl), and pH was measured (see **Section 3.2**). A field description of the soil surface and profile, including any variations in soil properties with depth, was also recorded at each sample site. Results of the field assessment are presented in **Appendix A**. Detailed field descriptions are provided in **Appendix B**.

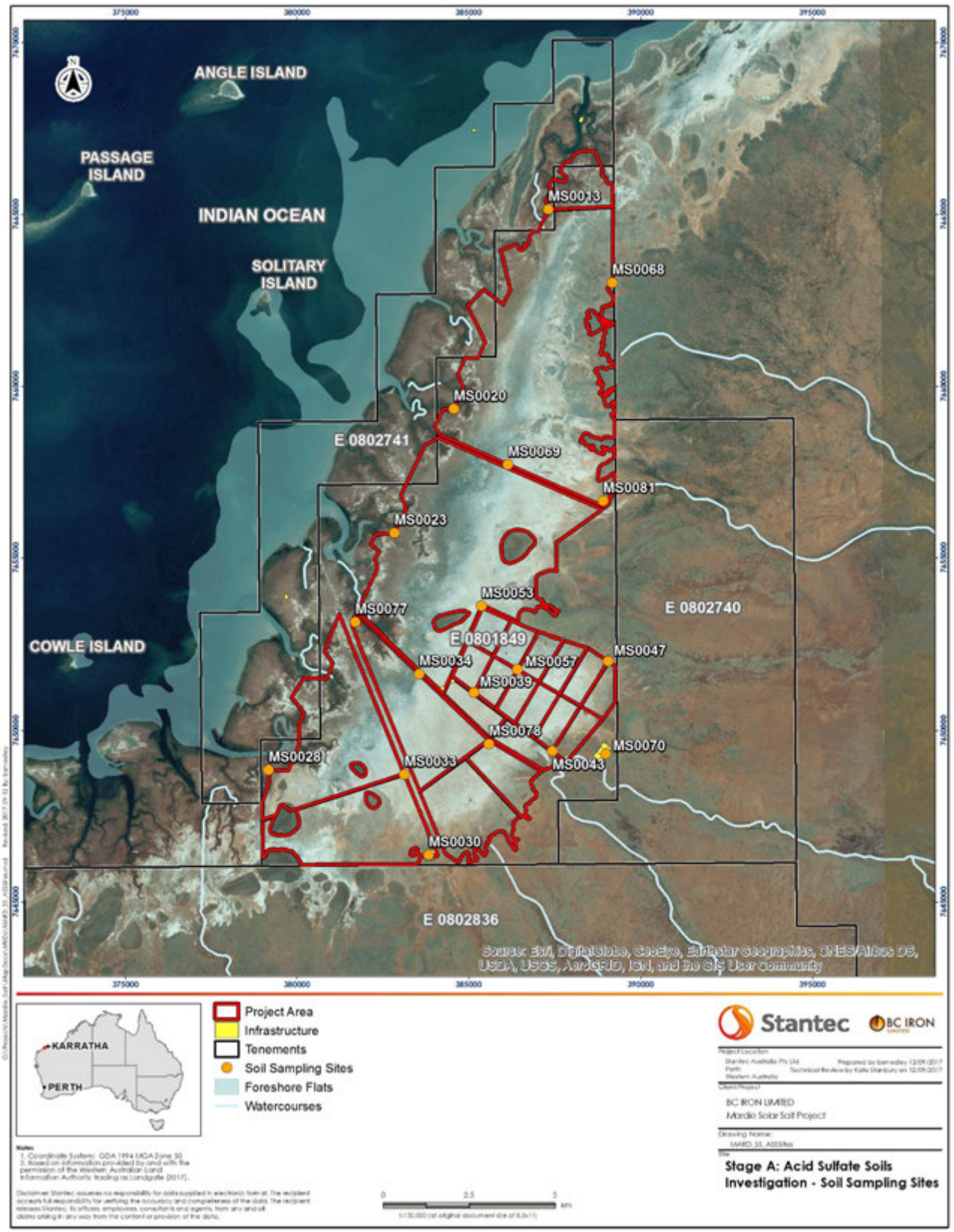

Figure 3-1: Soil sample locations within the Project area

3.2 Procedure for Assessing ASS Risk

The procedure for assessing ASS risk has been derived from the DER *2015 Guidelines for Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes* (DER, 2015). In accordance with those Guidelines, this report provides a preliminary assessment of ASS risk, based on site knowledge, field observations and field pH tests.

Field pH testing involved measuring field pH (pH_F) and field pH peroxide (pH_{FOX}) at 0.25 m intervals (i.e. 0, 0.25, 0.5, 0.75 and 1.0 mbgl), if accessible. A qualitative rating for pH_{FOX} reactiveness (i.e. low, moderate, high or extreme vigour) was assigned to each sample interval.

The pH_F test measures the existing acidity of a soil:water (deionised) paste, and is used to help identify if ASS are present. The pH_{FOX} test (using hydrogen peroxide of pH 5.5 and 30% strength) is used to indicate the presence of iron sulfides or PASS. The methods for undertaking these field tests were adapted from DER (2015). It should be noted that field pH tests of soil are indicative only, and do not provide a quantitative assessment for determining the presence or absence of ASS. Laboratory analysis is needed to quantify the amount of existing, plus potential, acidity (DER, 2015). However, for the purposes of this assessment, laboratory analysis is not required.

4. Results

4.1 Field Observations

The soils sampled within the Project area were generally found to be red-brown silty sands to silty clays with no visible signs of mottling. Few shell fragments, minor salt precipitation, and gravel (variable in abundance) were common across the sample site surfaces. The majority of soil profiles showed little variation in field properties with depth (up to 1.0 mbgl). Angular gypsum crystals up to 3 cm in size were observed in the subsoil (0.5 to 0.7 mbgl) of sample site MS0034 (**Figure 4-1**). Several soil profiles located within or in close proximity to the proposed crystalliser ponds were found to have a clay hardpan or limestone sub-layer between 0.5 to 1.0 mbgl.

Soils from sampling sites along the western side of the Project area (i.e. closer to the tidal flats) generally had a greater moisture content and a shallower groundwater table (typically around 0.5 to 0.7 mbgl) relative to the other sampling sites. All soil profiles were damp to saturated, excluding site MS0070 which was very dry, loosely coherent and relatively sandy in texture (**Figure 4-2**). Site MS0070 was the only sampling site that contained notable vegetation cover, with vegetation consisting of spinifex shrubs. None to negligible amounts of organic matter were observed across the sampling sites. Detailed field observations, including photos of surface soils sampled, are presented in **Appendix B**.

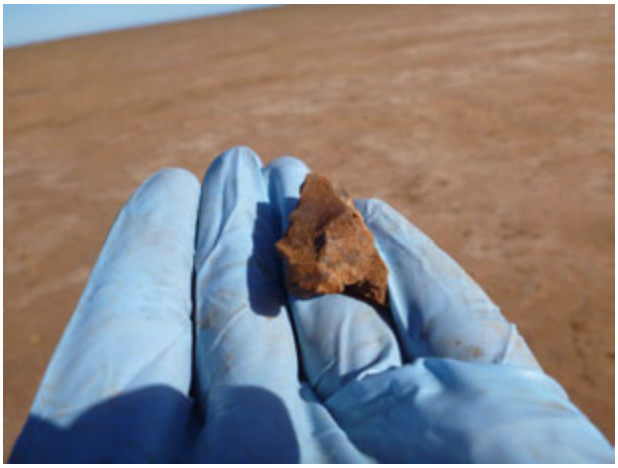

Figure 4-1: Gypsum crystals present within the sub-soil at sample location MS0034

Figure 4-2: Soil texture and vegetation present at sample location MS0070

4.2 Field pH

4.2.1 pH_F

The pH_F of all samples analysed ranged from circum-neutral to strongly alkaline (6.96 to 9.83 pH units) (detailed data in **Appendix A**). As soil depth increased, pH_F was generally found to either increase slightly or remain unchanged relative to that observed at the soil surface. Only site MS0034 reported a decline in pH_F with depth, declining from pH 9.83 at 0.5 mbgl to pH 8.53 at 0.75 mbgl (then increasing back to pH 9.48 at 1.0 mbgl).

4.2.2 pH_{FOX}

Of the 18 soil profiles assessed, 11 profiles (MS0013, MS0028, MS0030, MS0043, MS0047, MS0068, MS0069, MS0070, MS0077, MS0078 and MS0081) reported a pH_{FOX} that was substantially higher than pH_F at all depths (**Appendix A**). In addition, the reaction vigour of these soil samples to the hydrogen peroxide were considered to be 'Extreme'. The extreme reaction may be attributed to the presence of material (e.g. organic matter or other soil constituents) with the potential to be oxidised within these soil profiles. As discussed in the DER Guidelines, these soils are not likely to be PASS.

The remaining seven profiles (MS0020, MS0023, MS0033, MS0034, MS0039, MS0053 and MS0057) reported a pH_{FOX} higher than pH_F near the surface of the profile, and a lower pH_{FOX} relative to pH_F as depth increased (**Appendix A**). The depth to which the pH_{FOX} became relative lower is variable across these soil profiles, ranging from 0.25 to 1.0 mbgl. The differences between pH_{FOX} and pH_F ranged between a negative pH unit change of -0.2 to -1.8. However, all pH_{FOX} results for these samples remained above pH 6, ranging from pH 6.52 to 9.63. Where pH_{FOX} was lower than pH_F, the reactivity of the sample was generally considered to be 'low' to 'moderate'. The low reactively suggests that the presence of sulfides is unlikely and that the drop in pH_{FOX} may be attributed to the initial pH of the peroxide solution. These results also suggest that these soils are not likely to be PASS.

5. Key Findings and Recommendations for Future Assessment

Based on field observations, the surface soil profiles within the Project area were generally dominated by finer grained soil-particles, and contained minor shell fragments, organic matter and salt precipitation. The majority of areas sampled were damp to saturated, with a shallow groundwater table, particularly for sample sites located closer to the tidal flats. Although the high soil moisture content and shallow groundwater depth may indicate the potential for ASS, no signs of changes in soil colouration or odour was observed throughout the soil profiles. Field pH results for soils sampled within the Project area were found to have the following characteristics:

- Samples reported a circum-neutral to strongly alkaline pH_F, with small changes in soil pH_F with depth;
- The majority of soil profiles (11 out of 18) reported a higher pH_{FOX} relative to pH_F at all depths analysed, although the reactivity of these samples to the peroxide was considered to be 'extreme', this reaction may be due to the presence of organic matter or other soil constituents (e.g. manganese); and
- The remaining seven soil profiles reported a lower pH_{FOX} relative to pH_F at sub-surface depths (from 0.25 to 1.0 mbgl), but remained above pH 6.0 (ranging from pH 6.52 to 9.63). Where pH_{FOX} was relatively low, the reactively of these samples to the peroxide was generally considered to be 'low' to 'moderate'.

The highly alkaline conditions indicate that the surface soil profiles within the Project area are not likely to be PASS. Although an extreme reaction to the pH_{FOX} test was observed for the majority of samples, the reaction was likely to have been associated with other soil constituents such as organic matter or manganese, and is not considered to be problematic with respect to ASS as it caused samples to become more alkaline rather than acidic.

Due to the low ASS risk of surface soils within the Project area, further investigations into the presence of ASS is not considered necessary, unless disturbance is planned at greater depths (>1 mbgl) or outside the current area of investigation.

6. References

ASRIS (2014). *Australian Soil Resource Information System*. Department of Agriculture, Forestry and Fisheries Australia, and CSIRO Land and Water. Data available at: http://www.asris.csiro.au/.

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Van Vreeswyk, A.M., Leighton, K.A., Payne, A.L., & Hennig, P. (2004). *An inventory and condition survey of the Pilbara region, Western Australia.* Department of Agriculture and Food, Western Australia, Perth. Technical Bulletin 92.

Appendices

Appendix A Field Results and Figures

A.1 Soil pH_F and pH_{FOX} results (raw data) for soils sampled within the Project area

Sample Site	Depth (m)	pH_F [1]	pH_{FOX} [2]	Vigour [3]
MS0013	0	7.92	9.13	X
	0.25	8.41	10.60	X
	0.5	8.39	10.51	X
	0.75	8.37	10.55	X
	1.0	8.05	10.44	X
MS0020	0	6.96	7.91	X
	0.25	7.38	8.85	X
	0.5	7.30	9.02	X
	0.75	7.29	6.52	L
	1.0	7.30	6.56	L
MS0023	0	8.93	9.61	X
	0.25	9.14	10.36	X
	0.5	9.14	10.11	X
	0.75	9.08	10.00	X
	1.0	8.95	8.19	L
MS0028	0	7.82	9.47	X
	0.25	8.46	10.12	X
	0.5	8.14	9.75	X
	0.75	8.44	9.57	X
MS0030	0	7.52	9.68	X
	0.25	8.52	11.45	X
	0.5	8.70	11.93	X
	0.75	8.38	11.99	X
MS0033	0	7.09	8.60	X
	0.25	7.22	6.91	M
	0.5	7.30	6.76	L
MS0034	0	9.13	9.24	X
	0.25	9.77	8.13	H
	0.5	9.83	9.63	X
	0.75	8.53	7.77	L
	1.0	9.48	7.83	L
MS0039	0	8.97	9.65	X
	0.25	9.25	8.95	H
	0.5	9.31	7.43	L
	0.75	9.16	7.51	L
	1.0	8.98	7.52	L
MS0043	0	8.14	9.83	X
	0.25	8.90	10.46	X
	0.5	8.76	11.13	X
	0.75	8.70	9.89	X
MS0047	0	8.16	10.33	X

Sample Site	Depth (m)	pH_F [1]	pH_{FOX} [2]	Vigour [3]
	0.25	8.58	11.87	X
MS0053	0	8.24	9.38	H
	0.25	8.71	9.37	H
	0.5	8.82	7.43	L
MS0057	0	7.58	8.90	X
	0.25	8.01	8.68	X
	0.5	8.18	7.09	M
	0.75	7.87	7.45	M
MS0068	0	8.23	11.62	X
MS0069	0	8.46	11.86	X
	0.25	8.6	11.43	X
	0.5	8.62	11.60	X
	0.75	8.52	10.49	X
MS0070	0	8.91	12.98	X
	0.25	8.96	12.69	X
MS0077	0	8.30	8.91	X
	0.25	8.67	9.94	X
	0.5	8.70	10.08	X
MS0078	0	8.54	9.75	X
	0.25	8.53	9.91	X
	0.5	8.23	10.03	X
	0.75	8.30	9.42	X
MS0081	0	8.46	11.86	X
	0.25	8.60	11.43	X
	0.5	8.62	11.60	X
	0.75	8.52	10.49	X

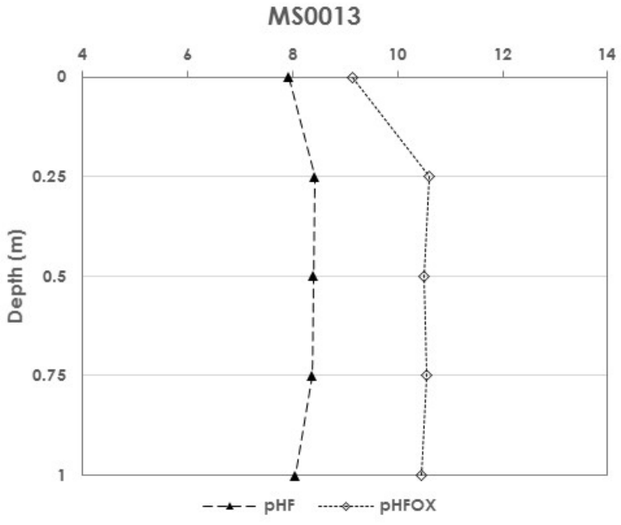
Notes:

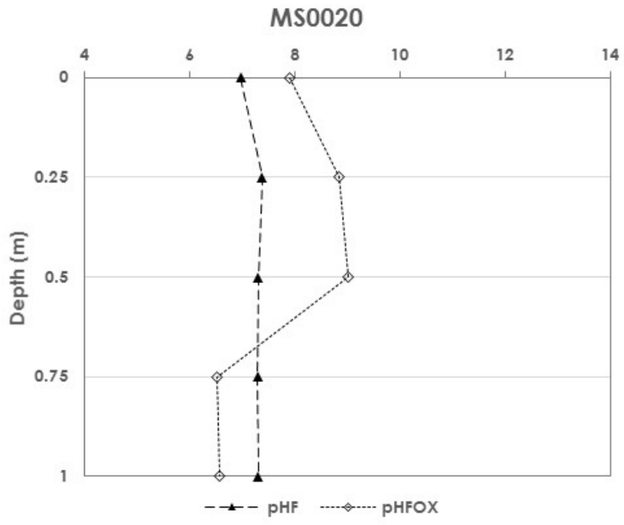
[1] Soil pH measured using a soil:water paste with deionised water.

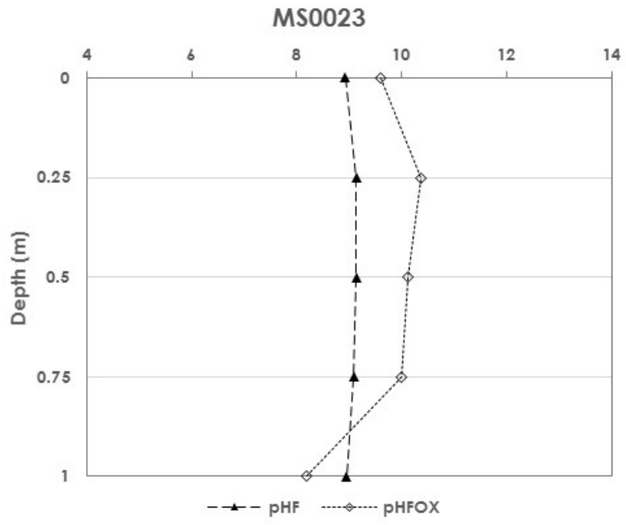
[2] soil pH measured using hydrogen peroxide solution (30% strength).

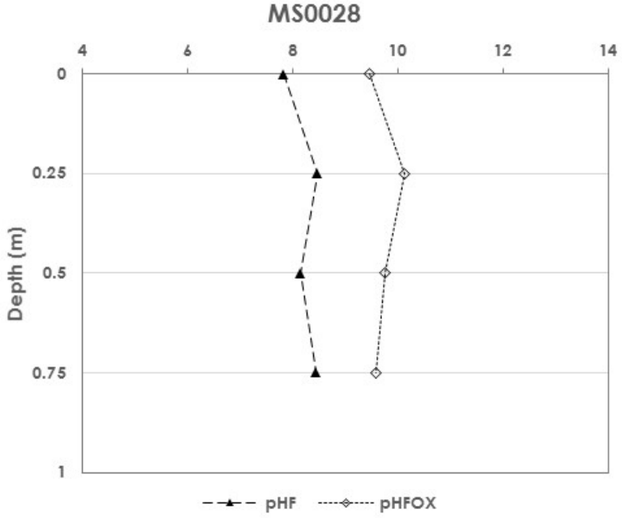
[3] Denotes reactiveness of soil sample when hydrogen peroxide solution is applied. Qualitative rating assigned: L = Low, M = Medium, H = High or X = Extreme.

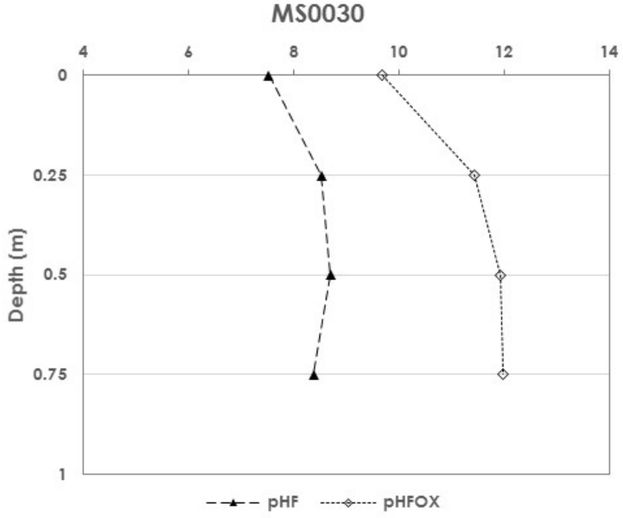
A.2 Soil pH_F and pH_{FOX} charts for sample locations MS0013 to MS033

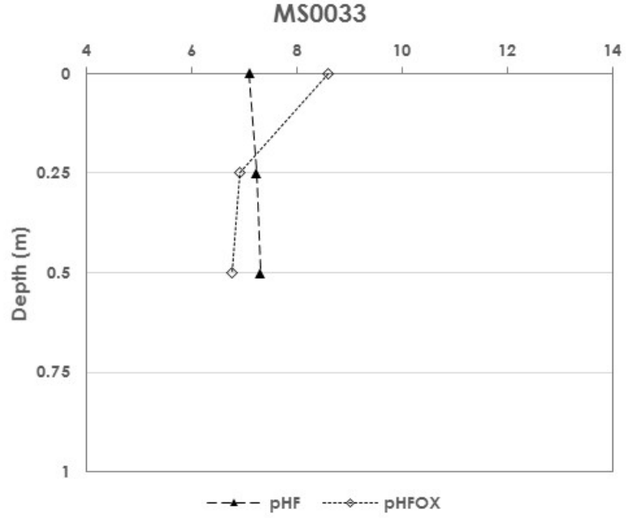




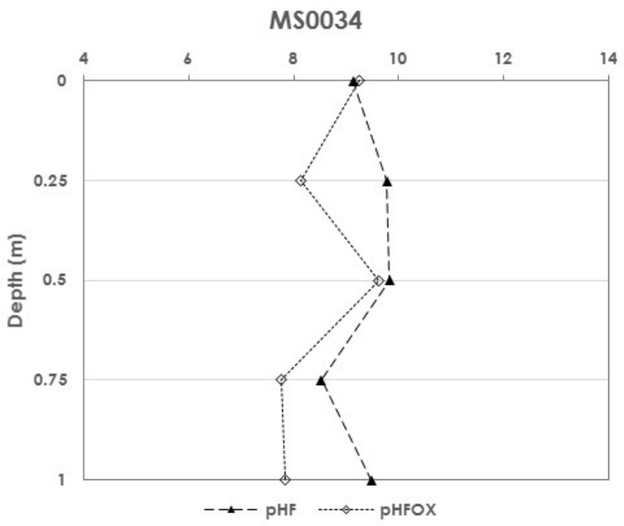


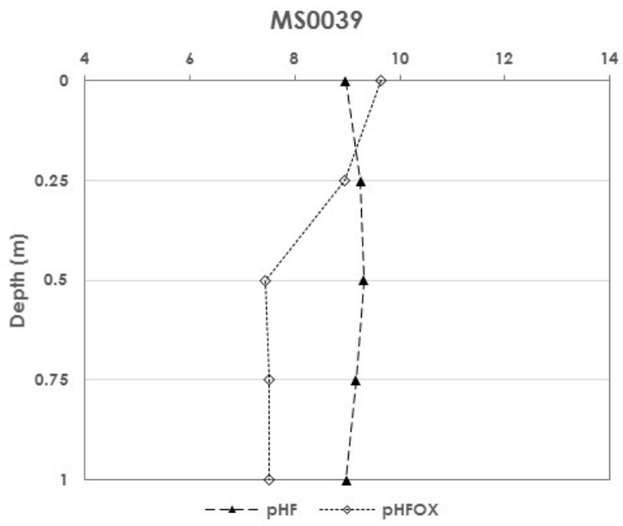


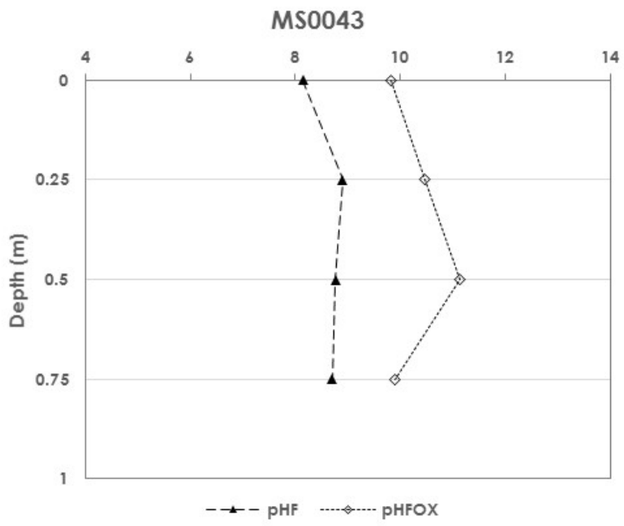


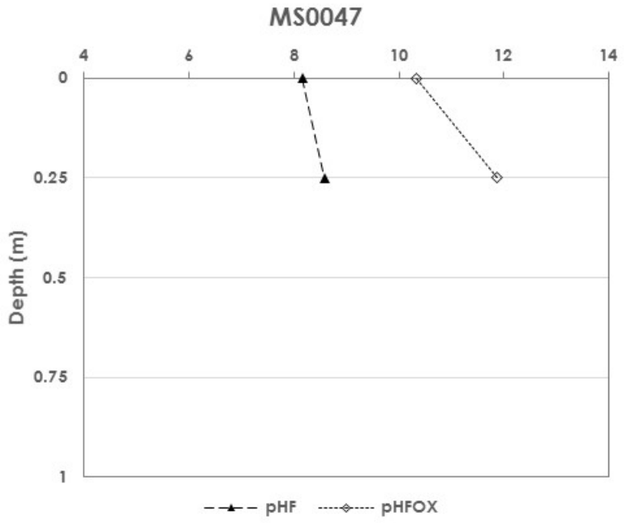


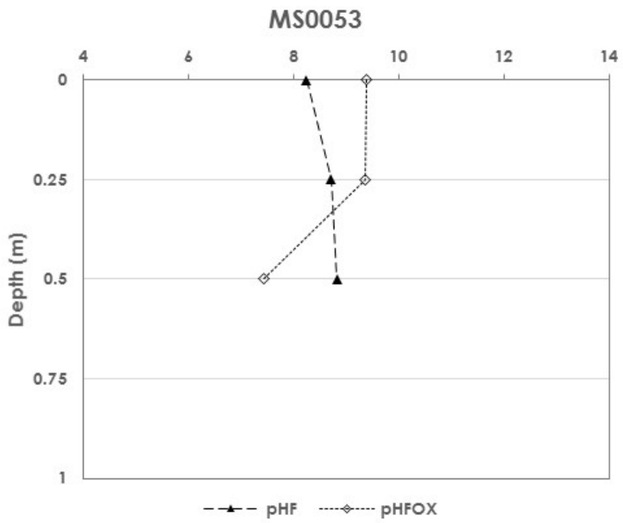
A.3 Soil pH_F and pH_{FOX} charts for sample locations MS0034 to MS0057

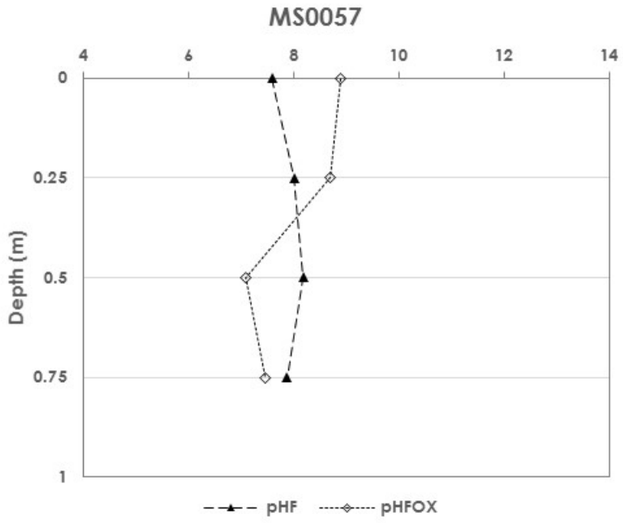




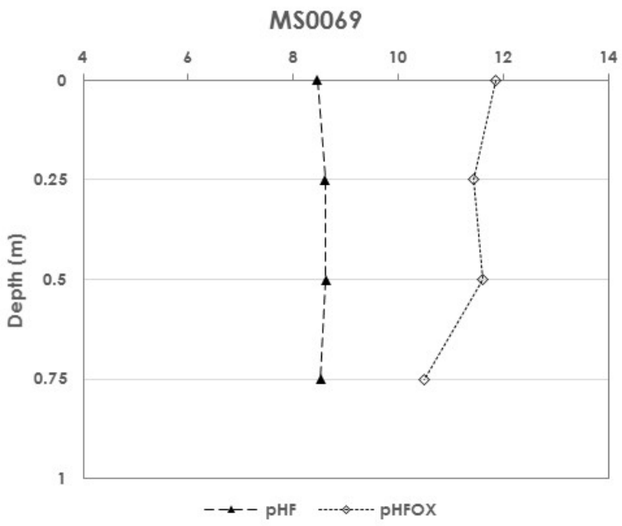


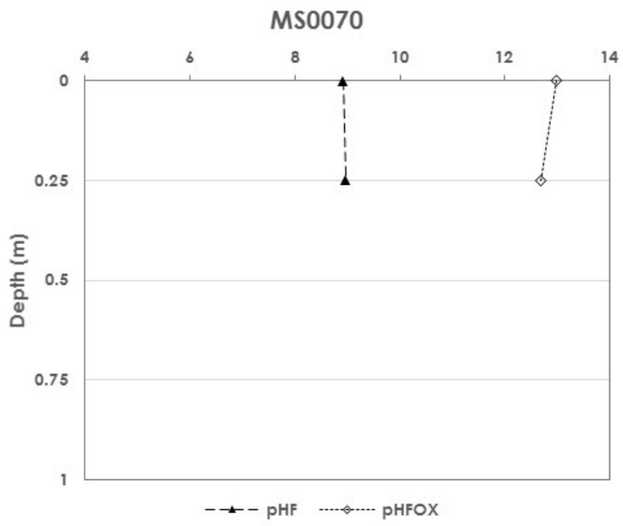


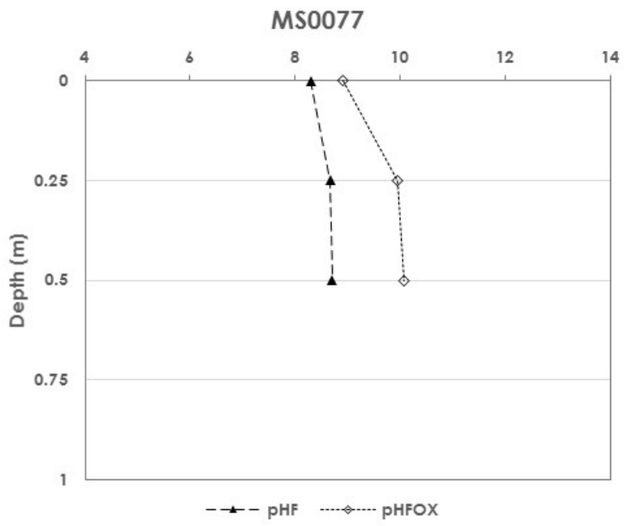


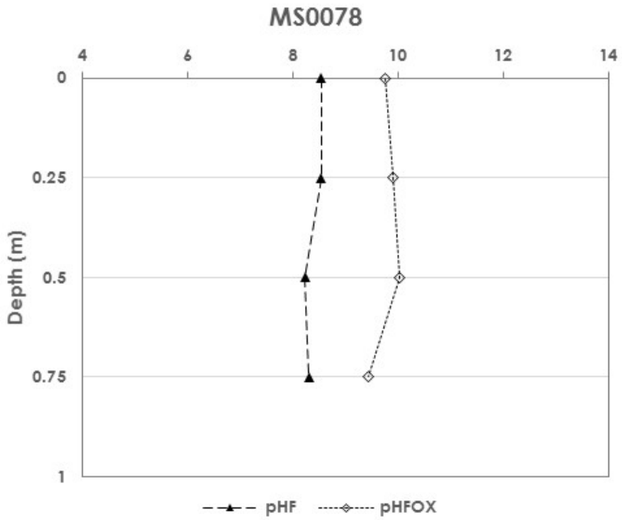


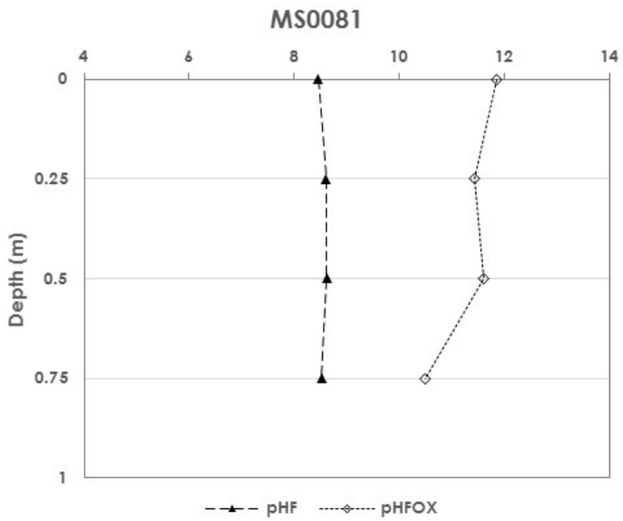
A.4 Soil pH_F and pH_{FOX} charts for sample locations MS0069 to MS0081











Appendix B Field Sample Descriptions

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Site ID: MS0013

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	15 August 2017	**Coordinates:**	**Easting:** 387315 mE	**Northing:**	7665152 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-1: Soil surface at Site MS0013

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0013	*0 m*: Red-brown silt with abundant gravel and shell fragments on surface. Damp. No signs of mottling. No organic matter present. *0.25 to 1.0 m*: Red-brown silty clay with no mottling. Damp. Highly coherent. Water table at approximately 0.9 mbgl.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil		

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Site ID: MS0020

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	15 August 2017	**Coordinates:**	**Easting:** 384565 mE	**Northing:**	7659336 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-2: Soil surface at Site MS0020

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0020	Red-brown silty clay with very few shell fragments. Damp. Minor salt precipitation and surface crusting / cracking on surface. No signs of mottling throughout profile. No organic matter present. Water table at approximately 0.8 mbgl.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil		

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Site ID: MS0023

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	15 August 2017	**Coordinates:**	**Easting:** 384565 mE	**Northing:**	7655727 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-3: Soil surface at Site MS0023

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0023	Red-brown silty clay with no signs of mottling. Salt precipitation present on surface. No organic matter present. Water table at approximately 0.65 mbgl.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil		

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Site ID: MS0028

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	15 August 2017	**Coordinates:**	**Easting:** 379182 mE	**Northing:**	7648847 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-4: Soil surface at Site MS0028

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0028	Red-brown silty clay with abundant shells. No signs of mottling throughout profile. No organic matter present. Water table at approximately 0.5 mbgl. Unable to sample soil at 1.0 m due to high moisture content and mud-like consistency of the soil. As a result, the sample was not able to be collected by the auger.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil (not sampled)		

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Site ID: MS0030

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	16 August 2017	**Coordinates:**	**Easting:** 383839 mE	**Northing:**	7646371 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-5: Soil surface at Site MS0030

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0030	*0 to 0.25 m*: Red-brown silty/sandy clay with no mottling. Damp. Medium to fined grained soil particles. No organic matter present. *0.25 to 0.75 m*: Red-brown silty/gravel clay with no mottling. Moderately coherent. Damp. No organic matter present. Refusal at approximately 0.75 mbgl. Unable to sample soil at 1.0 m.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil (not sampled)		

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Site ID: MS0033

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	15 August 2017	**Coordinates:**	**Easting:** 383124 mE	**Northing:**	7648718 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-6: Soil surface at Site MS0033

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0033	Red-brown silty clay with very few stone-sized coarse fragments. Damp. No signs of mottling throughout profile. No organic matter present. Water table at approximately 0.5 mbgl. Unable to sample soil deeper than 0.5 m due to high moisture content and mud-like consistency of the soil. As a result, the sample was not able to be collected by the auger.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil (not sampled)		
1.0 mbgl:	Subsoil (not sampled)		

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Site ID: MS0034

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	16 August 2017	**Coordinates:**	**Easting:** 383560 mE	**Northing:**	7651645 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-7: Soil surface at Site MS0034

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0034	Red-brown silty clay with very few shell fragments. Algal mat on surface with minor salt precipitation. Damp. No signs of mottling throughout profile. No organic matter present. Angular gypsum crystals (up to 3 cm in size) present between 0.5 and 0.7 m. Water table at approximately 0.7 mbgl.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil		

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Site ID: MS0039

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	16 August 2017	**Coordinates:**	**Easting:** 385159 mE	**Northing:**	7651101 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-8: Soil surface at Site MS0039

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0039	Red-brown silty clay with very few shell fragments, quartz gravel and organic material on surface. Damp. No signs of mottling throughout profile. Potential clay hardpan sub-layer at 0.6 mbgl. Water table at approximately 0.6 mbgl.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil		

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Site ID: MS0043

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	16 August 2017	**Coordinates:**	**Easting:** 387433 mE	**Northing:**	7649396 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-9: Soil surface at Site MS0043

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0043	Red-brown silty clay. Salt crust with very few organic matter present on surface. Damp. No signs of mottling throughout profile. Extremely high coherency. Refusal at 0.75 mbgl due to potential clay hardpan layer. Unable to sample soil at 1.0 m.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil (not sampled)		

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Site ID: MS0047

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	16 August 2017	**Coordinates:**	**Easting:** 389062 mE	**Northing:**	7652012 mN
Location:	Mardie Salt Project	**Land System:**	Onslow land system		

Plate B-10: Soil surface at Site MS0047

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0047	*0 to 0.15 m*: Red-brown silt with abundant fine to medium sized gravel (<25 mm). Damp. No signs of mottling. No organic matter present. *0.15 to 0.25 m*: Red-brown silty sand with abundant gravel. Medium to fine grained soil particles. Damp. No signs of mottling. No organic matter present. Refusal below 0.25 mbgl.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil (not sampled)		
0.75 *mbgl:*	Subsoil (not sampled)		
1.0 mbgl:	Subsoil (not sampled)		

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Site ID: MS0053

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	16 August 2017	**Coordinates:**	**Easting:** 385373 mE	**Northing:**	7653597 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-11: Soil surface at Site MS0053

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0053	Red-brown silty clay with very few shell fragments. Minor salt precipitation on surface. Damp. No signs of mottling. No organic matter present. Sampling location is situated near exposed limestone (potentially historic reef). Refusal at 0.6 m due to limestone sub-layer.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil (not sampled)		
1.0 mbgl:	Subsoil (not sampled)		

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Site ID: MS0057

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	16 August 2017	**Coordinates:**	**Easting:** 386421 mE	**Northing:**	7651773 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-12: Soil surface at Site MS0057

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0057	Red-brown silty clay. Very few fine to medium gravel (<25 mm) and minor salt precipitation present on surface. Damp. No signs of mottling. No organic matter present. Moderately coherent in upper 0.4 m, becoming extremely coherent to a depth of 0.75 m.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil (not sampled)		

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Site ID: MS0068

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	15 August 2017	**Coordinates:**	**Easting:** 389175 mE	**Northing:**	7663016 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-13: Soil surface at Site MS0068

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0068	Red-brown silt with abundant gravel and cobble-sized coarse fragments on surface. Damp. No signs of mottling. No organic matter present. Refusal at 0.2 mbgl.
0.25 mbgl:	Topsoil (not sampled)		
0.5 mbgl:	Subsoil (not sampled)		
0.75 *mbgl:*	Subsoil (not sampled)		
1.0 mbgl:	Subsoil (not sampled)		

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Site ID: MS0069

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	15 August 2017	**Coordinates:**	**Easting:** 386146 mE	**Northing:**	7657724 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-14: Soil surface at Site MS0069

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0069	Red-brown silty clay with very few shell fragments and minor salt precipitation on surface. Damp. No signs of mottling. No organic matter present. Water table at approximately 0.75 mbgl. Unable to sample soil at 1.0 mbgl due to high moisture content and mud-like consistency of the soil. As a result, the sample was not able to be collected by the auger.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil (not sampled)		

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Site ID: MS0070

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	15 August 2017	**Coordinates:**	**Easting:** 388985 mE	**Northing:**	7649317 mN
Location:	Mardie Salt Project	**Land System:**	Onslow land system		

Plate B-15: Soil surface at Site MS0070

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0070	Red-brown silty sand with no mottling. Medium to fine grained soil particles. Few organic matter and roots present throughout profile. Very dry. Unable to sample soil deeper than 0.25 mbgl due to the loose coherency of the soil profile.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil (not sampled)		
0.75 *mbgl:*	Subsoil (not sampled)		
1.0 mbgl:	Subsoil (not sampled)		

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Site ID: MS0077

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	15 August 2017	**Coordinates:**	**Easting:** 381699 mE	**Northing:**	7653135 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-16: Soil surface at Site MS0077

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0077	Red-brown silty clay with very few broken shell fragments. Damp. No signs of mottling. No organic matter present. Water table at approximately 0.5 mbgl. Unable to sample soil below 0.5 mbgl due to high moisture content and mud-like consistency of the soil. As a result, the sample was not able to be collected by the auger.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil (not sampled)		
1.0 mbgl:	Subsoil (not sampled)		

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Site ID: MS0078

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	16 August 2017	**Coordinates:**	**Easting:** 385593 mE	**Northing:**	7649607 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-17: Soil surface at Site MS0078

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0078	Red-brown silty clay with very few gravel-sized coarse fragments and minor salt precipitation on surface. Damp. No signs of mottling. No organic matter present. Extremely high coherency. No signs of water level occurring within profile. Unable to sample soil below 0.75 mbgl as subsoil was too hard / compact for hand augering.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil (not sampled)		

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Stantec Australia
41 Bishop Street, Jolimont, WA 6014
www.stantec.com

TEL +61 (08) 9388 8799
FAX : +61 (08) 9388 8633
ABN: 17 007 820 322

Site ID: MS0081

Client:	BC Iron Limited	**Datum:**	UTM, GDA 94, Zone 50 K		
Date:	15 August 2017	**Coordinates:**	**Easting:** 388912 mE	**Northing:**	9656661 mN
Location:	Mardie Salt Project	**Land System:**	Littoral land system		

Plate B-18: Soil surface at Site MS0081

Profile description:

Depth	Material	Sample ID	Description
0 mbgl:	Topsoil	MS0081	*0 to 0.2 m*: Red-brown silty sand with abundant shells and gravel-sized coarse fragments on surface. Damp. No signs of mottling. No organic matter present. *0.2 to 0.5 m*: red-brown silty clay. Damp. No signs of mottling. No organic matter present. Moderately coherent. 0.5 to 0.75 m: red-brown silty clay with abundant gravel sized coarse fragments. Damp. No signs of mottling. No organic matter present. Moderately coherent. Refusal at 0.75 mbgl due to the very high gravel content in subsoil.
0.25 mbgl:	Topsoil		
0.5 mbgl:	Subsoil		
0.75 *mbgl:*	Subsoil		
1.0 mbgl:	Subsoil (not sampled)		

Perth
41 Bishop Street,
JOLIMONT, WA 6014
Tel +61 (08) 9388 8799

http://au.mwhglobal.com/

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