Acid Sulphate Soil Investigation of Southern Yellagonga Regional Park

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2 ACKNOWLEDGEMENTS

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2.1 FRONTISPIECE

Plate 1. Wallubuenup Swamp at the southern end of Yellagonga Regional Park.

This report should be referenced as follows.

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3 CONTENTS

4 EXECUTIVE SUMMARY

In October 2010 and April 2011, the immediate surrounds of the channel linking Lake Goollelal and Wallubuenup Swamp were investigated for the presence of acid sulphate soils (ASS). The likelihood of ASS had been identified in previous Yellagonga Regional Park water monitoring programs due to high metal concentrations, indicative ratios of sulphate to chloride and low pH.

A total of 32 samples were collected and analysed using Static Net Acidity Generation Tests.

No evidence of ASS was identified south of Whitfords Avenue, however >60% of samples collected north of Whitfords Avenue were positive for ASS. This supports the water quality monitoring suggestions of ASS contamination of the drain network.

It is recommended that now the area of interest has been identified that a full investigation is conducted to allow management of the problem.

5 INTRODUCTION

Acid sulphate soil (ASS) is the term used to describe soils and sediments containing iron sulphides, predominately iron pyrites (DoE, 2003). In an anaerobic (no oxygen) environment these iron sulphide rich sediments remain benign (referred to as Potentially ASS or PASS). However when exposed to an oxygenated environment, chemical and biological processes cause the oxidation of the sulphides resulting in the production of sulphuric acid. The acidity can cause metals in surrounding geologies to dissolve. When the buffering capacity of the receiving environment is exceeded heavy metal/metalloid contamination and acidification occur (DEC, 2009). ASS disturbance and exposure has the potential to contaminate soil, water and air, causing harm to human health and ecological integrity e.g. loss of biodiversity, riparian vegetation, water quality deterioration, groundwater contamination, corrosion of infrastructure, and in humans skin irritation and respiratory problems (NWPASS, 2000).

Fifty six years ago it was acknowledged that Acid Sulphate Soils (ASS) were present in Australia. Twenty six years ago, concern was raised in relation to the potential impacts of ASS after it was found to be responsible for the occurrence of massive fish kills in Tweed River, NSW. More recently it has been estimated that there are 40 000 km^2 of pyritic sediments in coastal regions of Australia (NWPASS, 2000). In response to the multi-dimensional threat that ASS potentially poses, there are National and State level legislation, polices and guidelines detailing how ASS should be investigated, identified, managed and treated (DEC, 2009).

The Swan Coastal Plain, situated on the Western Australian coastline is of particular concern. The organic and pyritic rich sediments of lands that were formerly wetlands and existing groundwater dependant wetlands are sources of PASS (Appleyard, Wong, Willis-Jones, Angeloni & Watkins, 2004). Extremely poor buffering capacity in Swan Coastal Plain sands (particularly Bassendean sands) can increase susceptibility to even small quantities of ASS. The two main activities threatening to convert PASS to ASS in wetland ecosystems in the northern areas of Perth are urban development and draw down from groundwater extraction (Appleyard et al., 2004). Further compounding the effect of draw down from groundwater extraction is a 20 year decline in mean annual rainfall, reducing recharge of the superficial aquifer. These circumstances led to a drying event in Lake Jandabup in the late 1990's causing acidification and consequential loss of ecological integrity (Sommer & Horwitz, 2001). Another example of ASS exposure on the Swan Coastal Plain is Spoonbill Reserve in the City of Stirling, where urban development caused acidification of groundwater and resulted in risks to human health from metal exposure (Somesan, McCullough & Lund, 2008).

The aim of this study was to identify possible sources of PASS/ASS in the southern end of Yellagonga Regional Park, specifically around Site 5 ($Drain_{Goollelal}$) identified in previous studies by the authors as showing signs of ASS discharges (see Lund et al. 2009 and Newport et al. 2011). This is Project C in the proposals presented to the City of Joondalup.

6 METHODS

6.1 SAMPLING SITES

Yellagonga Regional Park is situated approximately 20 km north of Perth CBD and 6 km east of the Indian Ocean, on the Swan Coastal Plain. Yellagonga consists of a series of groundwater fed interdunal wetlands and swamps. These wetlands and swamps are linked throughout the park via a natural drainage line where surface waters flow northward and groundwater flows north-westerly. Lake Goollelal lies at the southern boundary where it then flows into Wallubuenup Swamp through to Beenyup Swamp and then into Lake Joondalup at the northern boundary. Yellagonga Park was historically used for in part and surrounded by agriculture. More recently, former agricultural land is being redeveloped for housing. Lund et al. (2009) found evidence of ASS in the southern portion of the Yellagonga chain, suspecting the origin to be in the vicinity of a site used in previous studies known as $\text{Drain}_{\text{Gollelal,}}$ this site is where the drain from Lake Goollelal enters into the southern end of Wallubuenup Swamp (Figure 1.).

Wallubuenup Swamp is regionally significant as it contains the oldest deposits of organic material (Pleistocene) on the Swan Coastal Plain. These Pleistocene sediments have been preserved by the laying down of a sulphate rich seawater sediment during the Holocene period (DEC, City of Joondalup & City of Wanneroo, 2003). The sediment origins mean that they should be treated with great caution when conducting activities which can potentially result in exposing or disturbing the sediments (NWPASS, 2000).

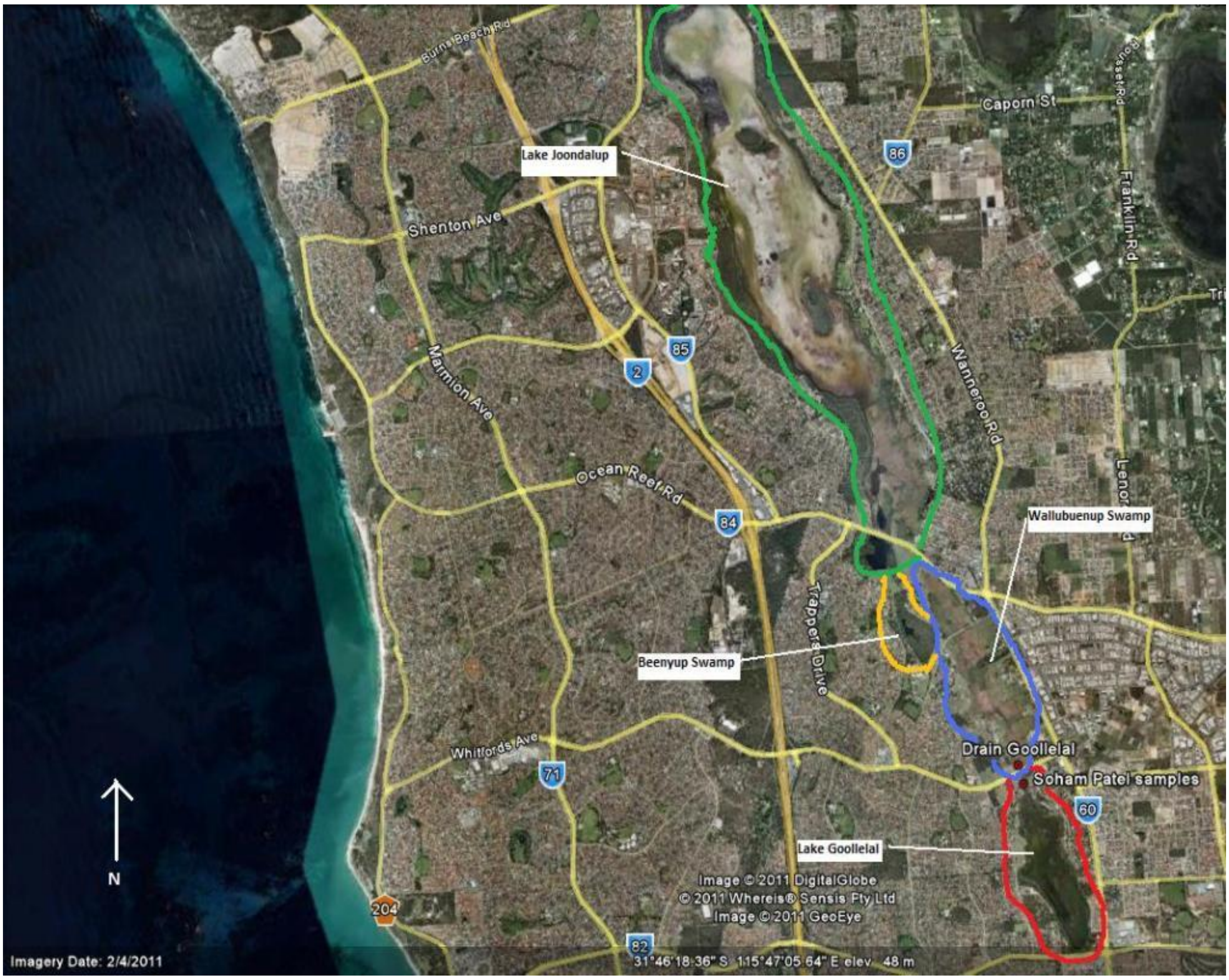

Figure 1. Map illustrating the interconnectedness of the Yellagonga Regional Park wetlands and swamps illustrating where the sampling sites were located in relation to the rest of the park.

6.2 FIELD SAMPLING

A total of thirty two sediment samples have been collected from the drain to the north of Lake Goollelal to the southern Wallubuenup Swamp. Nineteen sediment samples were collected south of Whitfords Avenue on the 14/10/2010 with 13 collected to the north on 21/4/2011. The second set of samples were based around $\text{Drain}_{\text{Gollelal}}$ as used in the Yellagonga monitoring report (Figure 1.; Newport et al. 2011).

Sediment samples were collected by firstly identifying the drain channel, then placing a $1m^2$ quadrant down, from which three sediment samples were collected using an acrylic 50 mm diameter 'corer' pushed into the soil to a 100 mm depth. The three replicates were placed in a labelled zip lock bag where they were mixed thoroughly to provide a homogenous composite sample for later analysis. Samples were collected along transects perpendicular to the channel arranged to maximise the chances of finding ASS in soils that could potentially drain into the channel. A GPS co-ordinate was recorded at each sample site.

6.3 LABORATORY ANALYSIS

The samples were dried in an oven at 105°C to a constant weight. An aliquot of each sample was then ground to a fine powder. Samples were then used to conduct the Static Net Acid Generation Procedure, at the Edith Cowan University laboratory, using the Acid Base Accounting (ABA) Test Procedures (Ed. Mills, n.d.).

7 RESULTS AND DISCUSSION

7.1 FIELD OBSERVATIONS

The DEC guideline Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes (2009) clearly outlines the preliminary processes in identifying Potential Acid Sulphate Soils (PASS). After identifying an area as having a level of risk due to geomorphology and hydrology of a region (this was discussed in section 3.1 Sampling Sites defining Wallubuenup Swamp as a high PASS risk area) the next step is to conduct field observations consisting of vegetation, soil and water characteristics. The investigation site was dry during the period of sediment collection therefore water and sediment field observations were taken from $\text{Drain}_{\text{South}}$ and $\text{Drain}_{\text{Mid}}$ immediately to the north (Newport et al. 2011).

7.1.1 VEGETATION

The vegetation community throughout the region was dominated by paperbarks (*Melaleuca sp.*), *Typhus orientalis* and couch grasses, all indicative of PASS as they are salt and acid tolerant liking waterlogged/wet environments (Figure 2.; DEC, 2009).

Figure 2. Photograph taken on the 28th March, 2011 of the investigation sight illustrating dominant vegetation in the area as being paperbarks (*Melaleuca sp.*), *Typhus orientalis* and couch grasses.

7.1.2 SOIL

The soil characteristics observed were predominately waterlogged sediments that range in colour from grey to black when disturbed (Figure 3.). It was also observed to be very “sticky” whilst traversing through to collect water samples and produced a strong odour of hydrogen sulphide. These are characteristics indicative of PASS as described by the DEC guideline (2009) and illustrated photographically in Figure 3.

Figure 3. Photograph taken on the 28th March, 2011 approximately 550 m north of the investigation site which captures disturbance and the grey to black coloured sediments.

7.1.3 WATER

The images below were captured at $Drain_{South}$ clearly showing the presence of iron floc and precipitation observed in the waters (Figure 4.). These observations were supported by results from the water monitoring program of high iron concentrations and low pH found at $Drain_{South}$ (Newport et al. 2011).

Figure 4. Photograph taken on the 19th July, 2011 illustrating the presence of iron precipitate and floc in waters nearby the investigation site.

In conclusion, the field observations for vegetation, soil and water characterisation of the area all consist of indicators of PASS, according to the DEC guideline (2009).

7.2 ANALYSIS OF SEDIMENTS

Samples that had a final Net Acid Generation (NAG) pH greater than 4.5 were negative for Net Acid Production Potential (NAPP). As illustrated in Table 1 all sediment samples collected between Lake Goollelal and south of Whitfords Avenue were negative. In contrast, approximately 61% of the sediment samples collected from southern Wallubuenup Swamp, north of Whitfords Avenue were positive and classified as potentially acid forming sediments (Table1). Of the eight sediments positive for PASS four samples had high NAPPs with 4W1 having the highest NAPP (Table 1).

Table 1. The Final Net Acid Generation (NAG), Net Acid Production Potential and Classification of Each Sediment Sample Collected from South to North in the Landscape

Site	Final NAG pH	NAPP (kg H_2SO_4 t^{-1})	Classification*
E1	7.37	Negative	Non acid forming
D3	6.99	Negative	Non acid forming
D2	6.53	Negative	Non acid forming
D1	7.12	Negative	Non acid forming
C3	6.93	Negative	Non acid forming
C2	7.36	Negative	Non acid forming
C1	6.79	Negative	Non acid forming
B3	4.9	Negative	Non acid forming
B2	7.22	Negative	Non acid forming
B1	7.38	Negative	Non acid forming
A9	6.29	Negative	Non acid forming
A8	6.56	Negative	Non acid forming
A7	6.82	Negative	Non acid forming
A6	6.3	Negative	Non acid forming
A5	6.97	Negative	Non acid forming
A4	6.94	Negative	Non acid forming
A3	8.17	Negative	Non acid forming
A2	7.24	Negative	Non acid forming
A1	6.7	Negative	Non acid forming
1C1	3.09	14.21	Potentially acid forming
2C	6.1	Negative	Non acid forming
2E1	4.61	Negative	Non acid forming
2E2	3.53	6.67	Potentially acid forming

Site	Final NAG pH	NAPP (kg H_2SO_4 t^{-1})	Classification*
2W1	3.66	5.78	Potentially acid forming
3C	3.94	4.76	Potentially acid forming
3E1	4.5	Negative	Non acid forming
3E2	4.3	0.7	Potentially acid forming
3W1	3.08	14.2	Potentially acid forming
4C	4.64	Negative	Non acid forming
4E1	4.53	Negative	Non acid forming
4W1	3.24	23.12	Potentially acid forming
4W2	3.15	12.15	Potentially acid forming

NOTE: * Classification taken from EPA Victoria (July 2009).

Figure 5. is a visual representation of the results obtained from this investigation. Red sample sites are those that had a final NAG pH less than 4.5 and were classified as PASS. Amber highlights those sediment samples which represented a risk of PASS and had a final NAG pH greater than 4.5 but less than 5.0. Finally green was allocated to those sediment samples which had a final NAG pH greater than 5.0 (Figure 5.).

Figure 5. Location of each sediment sample collected in the landscape with visual representation of PASS in red, risk of PASS in amber and negative for PASS in green.

8 CONCLUSIONS AND RECOMMENDATIONS

In conclusion, this investigation found positive results for PASS and indicators of ASS in the geomorphology, hydrology, vegetation community structure, water quality and soil characteristics of areas around $\text{Drain}_{\text{Goollelal}}$. No indications of PASS were found south of Whitfords Avenue.

Limitations to the study mainly concern the limiting of sampling to only surface layers. The use of NAG testing to determine ASS is a relatively simple method of assessment.

Yellagonga Regional Park management plan aims to protect and conserve ecological integrity of the system. Disturbance and exposure of these sediments present risk of harm to the ecosystem and human health through heavy metal contamination, deoxygenating water, and acidification (NWPASS, 2000 & DEC, 2009). Due to the extent of negative impacts that can result from ASS disturbance, there are clear state guidelines and policies which guide investigation, identification, management and treatment of ASS (see DEC, 2009). Therefore it is of importance that the next step be to further investigate and identify PASS and ASS within the Yellagonga Regional Park in accordance with the state guideline (DEC, 2009) and with the aim of high resolution mapping of ASS and PASS to better manage and treat when necessary.

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