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REPORT ON ACID SULPHATE SOIL MANAGEMENT PLAN

PROPOSED NORTHERN EXTENSION OF GERROA SAND QUARRY GERROA AND BEACH ROADS, GERROA

Prepared for
CLEARY BROS (BOMBO) PTY LTD

Project 37673B
June 2006

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1. INTRODUCTION

This report presents an Acid Sulphate Soil Management Plan (ASSMP) prepared for use in the pre-commencement, excavation and restoration phases of the proposed Northern Extension of the Gerroa Sand Quarry at Gerroa and Beach Roads, Gerroa. The ASSMP was requested by Cleary Bros (Bombo) Pty Ltd (CB), the operators of the quarry.

It is understood that CB is seeking approval from the Minister for Planning to extract sand from an area extending some 800 m to 900 m northeast of the existing dredge pond area, over a period of about 15 years.

The assessment comprised a review of published and unpublished data relevant to the existing quarry and surrounding areas, a visit by a senior geotechnical engineer, cone penetration testing and boring with sampling, followed by chemical and physical testing of selected samples. The details of the field work and subsequent analysis are given below and include reference, where appropriate, to the previous assessments and data.

The ASSMP was prepared to provide:

- pre-commencement monitoring methodology;
- an inspection protocol during excavation;
- methodology for on-site treatment and management of acid sulphate soils (ASS);
- water/leachate quality targets for the excavation, restoration and post-restoration periods.

As required by the Department of Environment and Conservation (NSW) in the Director General's Requirement, the ASSMP has been developed with reference to the guidelines presented by the NSW Acid Sulphate Soil Management Advisory Committee (ASSMAC) Acid Sulphate Soil Manual (1998), together with the Guidelines for Fresh and Marine Water Quality (ANZECC 2000) and where appropriate, the Queensland Acid Sulphate Soil Technical Manual (2002).

2. PREVIOUS INVESTIGATION

The preparation of the ASSMP follows recommendations made by Douglas Partners Pty Ltd (DP) in the ***Report on Geotechnical Assessment, Proposed Northern Extension of Gerroa Sand Quarry, Gerroa and Beach Roads*** (Project 37673, dated 22 March 2005). This report summarised investigations by both DP and others which identified ASS conditions within the existing quarry and the proposed quarry extension areas.

The relevant investigation by others comprised:

- periodic rainfall, dredge pond level and, groundwater monitoring bore data collected by CB;
- groundwater and surface water testing during 2005 and 2006 by Earth2Water Pty Ltd (E2W) and Enviromanagers Pty Ltd;
- materials testing carried out by Coffey Partners International Pty Ltd (Job No. SC568/1, July 1990);
- materials testing carried out by Network Geotechnics Pty Ltd (Job No. W2099/1, July 2000).

3. SITE DESCRIPTION

The site for assessment comprises an irregularly shaped area, generally ranging from 80 m to 160 m wide, extending some 800 m to 900 m in a north-eastern direction from the current northern extent of the operating dredge pond (Drawing 1). The site lies at the western side of Gerroa Road and is approximately 600 m from the current beachfront.

Natural surface levels relative to Australian Height Datum (AHD) range from RL 1, adjacent to a drainage canal (an extension of Blue Angle Creek) near the northern end of the proposed extraction area, to RL 5 – RL 7 (AHD) along the Gerroa Road frontage. Although the ground surface generally slopes to the west from the Gerroa Road frontage, there are no distinct water courses within the site area and the sand dune profile form a ready infiltration zone for rainfall.

Within the current dredge pond at the southern end of the proposed extraction area, sand extraction has been carried out to depths of up to about 4 m below dredge pond water level, corresponding to about 10 m below the level of Gerroa Road.

Limited clearing of vegetation has taken place progressively in front of the current extraction face beyond which the proposed extension area is densely tree covered for a length of about 200 m, thence partially tree covered or cleared over the remaining sections (Drawing 1).

4. GEOLOGICAL AND HYDROGEOLOGICAL SETTING

Reference to the Wollongong 1:250 000 Geological Series Sheet indicates that the existing Gerroa Sand Quarry and proposed Northern Extension lie within the drainage basin of Crooked River which discharges to the Shoalhaven Bight approximately 3.5 km to the northeast.

The basin is bounded to the north-west (at about the alignment of the South Coast Railway some 1.5 km to the northwest) by a topographic bedrock high of Berry Siltstone of Permian age. An east-trending spur of this bedrock high also extends to near the intersection of Gerroa and Beach Roads. The bedrock is overlain by sediments of Quaternary (Holocene) age, which may be separated into the following broad deposition modes in order of surface occurrence from the present day beach:

- beach ridges located between the current seafront and the eastern side of Gerroa Road comprising aeolian sand. The beach ridge system controls the local creek drainage which flows northeast before joining the Crooked River.
- low, aeolian sand dunes extending 100 m to 500 m from the beach ridges.

- aeolian sand sheets extending 100 m to in excess of 1 km inland from the low dunes.
- fluvial and back dune lagoonal sediments comprising inter-banded sands, clay and mud. These deposits within Foys Swamp extend westerly from the edge of the sand sheet to the South Coast Railway.

The Gerroa Sand Quarry and the proposed Northern Extension Area are located at the rear of the beach ridge system on low sand dune and sand sheet deposits.

The CB monitoring bores in the Gerroa Sand Quarry and the area extending north-east to adjacent to the Crooked River indicate moderate variation in groundwater levels but a consistent, north-east trending flow gradient (about 0.3%) adjacent to the dredge pond, possibly reflecting the topographic bedrock high adjacent to southern side of Beach Road. Elsewhere, there is a generally easterly-trending flow gradient of about 0.1% - 0.2% towards the shore but with local apparent even flatter gradients and reversals of gradient, suggesting that groundwater mounding within the dunes sheds both eastward to the sea and westward to the main drainage canal which continues northward as Blue Angle Creek and thence Crooked River (both of which are tidal).

The CB measurements of the existing dredge pond level for the periods 1993 to 2000 and 2005 to 2006 indicated that:

- the yearly maximum dredge pond level in years of less than median rainfall moved within a limited range (about RL 1.7 – 1.9) with an average maximum of about RL 1.8.
- the increase in dredge pond level corresponded closely with the rainfall in excess of the median value.
- the yearly minimum dredge pond level moved within a limited range (about RL 0.95 – 1.4).
- the minimum dredge pond level (RL 0.95) was 0.45 m above mean sea level.
- the minimum dredge pond level is approximately that of the main canal adjacent to the closest approach of the proposed quarry extension.
- the maximum dredge pond level (about RL 2.2) occurred during the year of highest rainfall (1998) indicating the rapid effect of rainfall on the groundwater regime.
- for daily rainfall events generally in excess of 100 mm or close spaced rainfall events totalling about 100 mm there was a similar rise in the dredge pond level.

- high dredge pond levels declined rapidly towards the minimum (base) level between August 1999 (an above average rainfall period) and June 2000 (within a below average rainfall period).

Measurement of the pH of the dredge pond water, drainage canal water (at Blue Angle Creek) and groundwater in the CB monitoring bores has been carried out on a regular basis since 1993. The monitoring of the dredge pond, main canal and the monitoring bores WM 3 & 3A, WM 4, WM 5 and WM 6 in or near the proposed Northern Extension Area indicated:

- the dredge pond pH has generally moved with the range 6.0 – 9.0 (moderately acidic to strongly alkaline) in comparison with a range of 5.0 – 8.5 (very strongly acidic to strongly alkaline) for the monitoring bores.
- the lowest dredge pond pH values were measured in the period of heavy rainfall at the end of July 1998 and extreme rainfall in mid August 1998. This may reflect the flushing of organic acids or oxidised pyritic material from the sand aquifer.
- the minimum pH levels (pH = 5.9) in the monitoring bore WM 3 may be an indicator of pyrite oxidation or the presence of organic acid complexes.
- the pH of Blue Angle Creek at the flood gates at the northern end of the CB property (i.e. north of the proposed quarry extension) generally ranged between 6.6 and 7.8, but with a lower pH reading of 4.8 being associated with transient stream flushing event during wet weather. For comparison, pH readings as low as 3.2 have been recorded in drains within Foys Swamp, upstream (west) of the proposed quarry extension area.

Field measurements of Total Dissolved Solids (TDS) and Dissolved Oxygen (DO) have also been undertaken by E2W and others in the dredge pond, main canal and at Blue Angle Creek. The results (see Appendix A) indicate:

- TDS values in the ranges 200 - 439 mg/L, 552 - 4574 mg/L and 263 – 14619 mg/L in the dredge pond, main canal and Blue Angle Creek respectively. The highest value at Blue Angle Creek was recorded at high tide and may indicate substantial mixing with seawater.
- DO values in the ranges 65% - 100%, 24% – 100% and 26% – 92% in the dredge pond, main canal and Blue Angle Creek, respectively.

5. BACKGROUND ACID SULPHATE SOIL INFORMATION

Coastal, low-lying alluvial soils, lying below about RL 12, may contain framboidal pyrite or other sulphides. These are rounded, microbially generated microscopic mineral grains, which are stable in soils below the water table, or in dense clay-rich soils that are periodically re-wetted. In such situations, where the sulphides are kept out of contact with air, they are relatively stable, and generally in "equilibrium" with the local environment. Soils, which have appreciable pyrite or other sulphides which have not yet reacted significantly with air, are referred to as Potential Acid Sulphate Soils, or PASS.

If sulphide-bearing or pyritic soils are disturbed by excavation, thereby allowing ready access of the sulphides to oxygen in the air, a spontaneous or irreversible natural oxidation reaction takes place. This results in the generation of sulphuric acid or acid sulphates. Pyritic soils, which have begun to generate acid, are referred to as Actual Acid Sulphate Soils (AASS). The acid is transported by water, and if allowed to build up in sufficient concentration, poses a direct environmental threat to organisms that come in contact with such waters.

Additionally, increasingly acidic waters can dissolve many metal ions which would otherwise remain insoluble and hence not available for uptake by organisms. These ions include aluminium and iron, plus a suite of heavy metals such as zinc, lead and cadmium, which at elevated levels can be toxic to plants, animals and humans.

The measure of acidity in waters is pH; pure neutral water has a pH of 7; pH values below 7 are acidic, pH values above 7 are basic or alkaline. The pH scale is logarithmic so a decrease of 1 pH unit represents a 10-fold increase in the concentration of hydrogen ions, which is the measure acidity. Further, the actual pH level is important because each metal has its own critical solubility, so a decrease in pH from 6 to 5 may be more undesirable than a pH decrease from 5 to 4 if, say, 5.5 is the critical pH for solubilisation.

Most organisms can cope with pH in the range 5.5 to 8.5 - pH values in natural waters below 5 are undesirable; below 4, they are generally unacceptable.

6. POTENTIAL FOR ACID SULPHATE SOILS

Details of the results of field screening and laboratory testing of the DP and previous investigations are given in Appendix A. The distribution of test locations and pyritic sulphur contents are additionally shown on Drawings 2, 3 and 4.

In general, positive field indicators for acid sulphate soils (after ASSMAC, 1998) are considered to be:

- a field pH (pH_F) of ⩽ 4 for AASS.
- for PASS, in the peroxide test one or more of; a change in colour from grey to brown tones, effervescence, the release of sulphur smelling gases, the lowering of the pH by at least one unit and a final pH ($pH_{FOX)}$) <3.5 and preferably <3.

For a disturbance of greater than 1000 tonnes, an oxidisable sulphur content of 0.03% or equivalent total potential acidity (TPA) or total actual acidity (TAA) determined by laboratory testing is the threshold criteria for preparation of a detailed ASSMP.

The geological model for Northern Extension Area resource, as summarised in Drawings 3 and 4, comprises an upper, very fine to fine grained dune sand (Unit 1) underlain by generally medium to coarse grained sands of beach and tidal inlet deposits (Units 2 and 4). Clayey materials (Unit 3 and possibly the upper section of Unit 5) of lagoonal or back swamp depositional mode, which are likely to include sulphidic materials, form semi-continuous lenses to 3 m thick within the south-western section of the area, but are discontinuous and generally less than 1 m thick in the remaining sections.

The resource is partially affected by the presence of potential acid soils, mostly within the deeper sections of Unit 4 which may include pyritic materials eroded from the underlying Unit 5 during the marine transgression leading to the current sea level. The positive indicators PASS within Unit 1 are considered to be anomalous to the aeolian deposition mode and may result from clayey particles blown from the Foys Swamp area, which is recorded on acid sulphate risk maps as being of high probability of acid sulphate soil conditions.

Materials from Units 1, 2 and 4 form the recoverable resource. The processing of the very fine to fine grained sands of Unit 1 with the underlying Units 2 and 4 sands, which extend to depths of 17 m, is expected (on the basis of the satisfactory performance of the Gerroa Sand Quarry and testing) to produce fine concrete aggregate and reduce pyritic materials to acceptable levels. Testing of Total Oxidisable Sulphur (TOS) content of processed sand stockpiles during the period October 2003 and December 2004 indicated TOS values in the range 0.019% and 0.027%.

7. ACID SULPHATE SOIL RISK

As the previous sand extraction within Units 1 and 2 has been satisfactorily managed, the risk associated with the acid sulphate soils and continued extraction of these units should also be expected to result in a satisfactory outcome. However, as a consequence of the exceedance of the ***Action Criteria*** in some Unit 1 materials (although considered to be anomalous results) and in some Unit 2 and Unit 4 samples, together with the significant volume of the proposed excavation, a detailed Acid Sulphate Soil Management Plan (ASSMP) is required. Planning and management options should therefore assume that, unless otherwise indicated by site-specific testing before or during excavation, all materials of estuarine origin (Units 2, 3 and 4) and the site in general need to be tested and/or monitored. The excavated Unit 4 materials, which pose the greatest acid sulphate soil risk at this site, may require specific processing such as sluicing or hydrocycloning, the extent of which will need to be determined during the on-going extraction operation.

It is considered that an appropriate ASSMP should include:

- continuation of the current surface, groundwater and dredge pond water quality monitoring prior to, during and subsequent to the extraction process.
- additional testing of the acid sulphate soil potential to supplement the results of the investigations to date. This testing should be progressively carried out to permit selection of the final extraction areas and relevant treatment methods for the individual sections and/or units within the resource.

- on-going monitoring of the feed stock and finished product to confirm the effectiveness of the processing methodology in satisfying aggregate specification limits and licence requirements.
- monitoring of the pyritic content of the reject fine materials in order to provide assessment of concentration of oxidisable sulphur in the materials strategically buried below water. In the event of unexpected levels of acid generation, the sulphur content would be used to determine an initial neutralisation dosing rate.
- controlled placement of reject materials, including sulphidic fines and the oversize shell component from the processing (to assist in pH buffering) within the basal section of the dredge pond. The burial of these materials with non-sulphidic material may be appropriate.
- ensuring access to suitable quantities of buffering materials for addition to the dredge pond if modification of the pH is required on the basis of the on-going testing.

It is considered that the implementation the controls and procedures of the ASSMP will ensure that ASS related issues will be handled in an appropriate manner and in accordance with the relevant legislation.

8. RESPONSIBILITIES

The CB project manager (PM) is responsible for the correct implementation of the ASS protocols presented in the ASSMP. With respect to ASS management, the PM is responsible for on-site monitoring. To this end, an independent, suitably qualified consultant should inspect the site, on both regular and random basis, and carry out sampling and/or in-situ measurements as are necessary to check compliance with the ASSMP.

As a guide, the following inspection/monitoring regime is suggested:

Stockpiles of processed sand	Daily for pH of leachate (if any) from processed sand stockpile and weekly (or more frequently as necessary) for indication of sulphur content (trigger for additional testing for ASS management and requirements for fine concrete aggregate).

Dredge pond water quality and level	Weekly and prior to any discharge.
Groundwater monitoring bores and streams	Monthly.

It is independent consultant's responsibility to inform the PM immediately on discovery of non-compliance or exceedence and to detail appropriate remedial measures. The requirements of ASS management are in addition to, but do not over-ride any standard procedure such as safety considerations. Where conflict results, or may result from, the implementation of the ASS management against other performance criteria including occupational health and safety, it is the contractor's responsibility to obtain directives from the PM. However, in all cases, legislative requirements must be paramount.

9. MANAGEMENT STRATEGY

The management strategy selected for the excavated or dredged sand (including PASS) is for the removal of pyritic fines and oversize materials (predominantly shells) by washing and potentially sluicing or cycloning, subject to the need to reduce pyritic content to levels suitable for use of the processed sand as fine concrete aggregate) with return of the reject material to the dredge pond for burial below the permanent groundwater table. This strategy continues the current methods of extraction and treatment practice that has successfully managed the acid sulphate risk during the quarrying of Units 1 and 2 to date.

Observation of the working method within the Gerroa Sand Quarry, which lies within an equivalent stratigraphic sequence, indicates that:

- water removed from the pond during dredging is returned almost directly to the pond via run-off from the discharge/processing area or via rapid infiltration of the sand profile about the working area.
- the working method does not lead to the extraction and disposal of the groundwater from the site. Rather, the pond water is recycled rapidly during the sand extraction process with possible minor additional evaporation. The records of the dredge pond pH indicates that if pyritic material is present within the sand resource, then the exposure time during extraction, processing and stockpiling, is insufficient to cause complete oxidation and increase in the

water acidity in comparison with the pH of the groundwater sampled from the nearby monitoring bores. Alternatively, as suggested by the current testing, relatively benign pH could signify generally low pyrite content and a buffering of the system by included shells.

It is anticipated that the stripped organics affected topsoil or silty sand will be reused in rehabilitation works and that reject (fines and larger shell fragments) materials will be placed into the completed dredged area. Consideration will need to be given to any requirement for capping of these materials to promote or maintain an anaerobic deposition environment.

An ASSMP template providing methodology for remediating or controlling the generation of acid, in those cases where excavation of (potential) acid sulphate soils is unavoidable, based on currently available data, is included in Appendix B. The following sections provide a background for recommendations and requirements included within the ASSMP.

9.1 Areas of Disturbance

It is expected that an excavation face ranging from 80 m to 160 m wide will be progressively moved northward from the current dredge pond over a period of some 15 years. Excavation depths of up to 17 m will potentially be developed to recover materials from Units 1, 2 and 4 within the area shown on Drawings 1 and 2. The closest approach of the extraction area to the main canal will be 40 m.

The proposed extraction of the sand resource will need to consider the long-term stability of the dredge pond, such that there is no migration of the batters of the completed pond outside of the nominated resource and to this end, it is suggested that an average excavation slope of not greater than 25° (about 2.1H:1V) below water level be employed during winning of product.

9.2 Neutralising Materials

The sand to be quarried from Units 1, 2 and 4 within the Northern Extension Area will contain significant proportions of shells which provide a natural buffering capacity to extraction and replacement operations. Coffey Partners International Pty Ltd previously determined the shell content (see Table 1) of samples selected from Bores CB 201, CB 204 and CB 206 within or adjacent to the proposed extraction area.

Table 1 – Summary of Carbonate Content Testing

Location	Depth	Unit	Shell >1.18mm (%)	Shell <1.18mm (%)
CB201	3.0 – 5.0	2	-	8.2
	4.9 – 5.4	2	10.2	6.2
CB204	0 – 1.0	1 - 2	-	7.5
	2.0 – 5.0	2	1.0	2.6
CB206	6.0 – 8.0	2	34.9	20.3
	8.0 – 10.0	4	12.0	6.3
	10.0 -13.0	4	1.0	1.6

As a consequence of the natural carbonate content provided by the shells and the successful management of acid sulphate soil environmental risks to date, it is anticipated that there will be minimal or no requirement for addition of neutralising materials during the excavation, treatment and restoration phases of the quarry development. However, considering the precautionary principal, it is suggested that:

- for the case of unexpected acidic leaching from stockpiled dredged and/or processed product, the bases of processing and stockpile areas should be graded and/or bunded to ensure runoff returns to the dredge pond and should be prepared with a guard layer incorporating fine aglime.
- stores of aglime and quicklime should held on site for any cases where leachate needs ‘finishing’ before discharge to the dredge pond and/or unexpected flow to natural waterways (there is one over-flow drain near the south-western corner of the current dredge pond which has never been used and the current site is bunded to RL 3.2 to prevent flooding or runoff to surface water) or modification of the dredge pond water is required. Aglime is non-corrosive and requires no special handling techniques. Quicklime is dangerous to use, being very reactive and corrosive (caustic), and special handling and safety procedures are required. When mixed with water, the reaction generates substantial heat, so the lime should be slowly added to a large amount of water.
- shells recovered from the processing are returned with the fines and clay materials recovered from Unit 3 to the dredge pond. As a significantly greater buffering capacity is

obtained from fine shell particles, it is suggested that consideration be given to (where possible) the grinding of recovered shells to a particle size of less than 2 mm prior to return to the dredge pond.

9.3 Pre-Excavation Measures

Pre-excavation measures designed to reduce the risk of acid release to natural and forming part of the ASSMP for the site include:

- continuation of the surface water (main canal and Blue Angle Creek), groundwater and dredge pond water quality monitoring for subsequent comparison during the excavation, materials processing and restoration phases. The installation of additional groundwater monitoring bores between the proposed extraction area and the main canal and Gerroa Road is also appropriate.
- on-going testing of the acid sulphate soil potential within the proposed excavation depths to supplement the results of the previous investigations and to confirm the relevant processing methodology and buffering capacity of the individual sections and/or units within the quarry area as finally developed.
- initially, the preparation at least one, gently sloping, bunded and lined stockpile/processing area of sufficient size to accept the excavated or dredged products at the proposed production rate. The area should incorporating a limed guard layer, surface water diversions and should be either bunded off using non-ASS material, or a circumferential drain dug to collect and localise any leachate and direct it back to the dredge pond.

9.4 Excavation, Processing and Placement Procedures

The sand resource includes two distinct excavation environments; up to 4 m of very loose to very dense, very fine grained and fine grained sand and silty sand (Unit 1) lying above the water table and up to 13 m of fine grained sand (remainder of Unit 1) and medium dense to very dense, medium to coarse grained sand (Units 2 and 4).

The excavation of the profile above the water table should be stripped of topsoil and root affected sand (totalling an average of about 0.5 m in the current bores) by dozer operation, with the subsequent winning of materials either by an excavator loading into trucks or allowing the material to fall into the dredge pond as the underling materials are removed (i.e. the process currently in use within the Gerroa Sand Quarry).

The Queensland Acid Sulphate Soil Technical Manual – Soil Management Guidelines [2002] describes methods for enhancing the removal of sulphidic fines during dredging. Those appropriate or potentially appropriate to the Gerroa site include:

- the use of a 'cutter suction dredge', particularly for clayey bands;
- ensuring dredge material that contains significant amounts of sulphidic clay lenses or coffee rock layers also contains sufficient sand to ensure the break-up of clumps of clay and coffee rock;
- dredging continuous peat or clay horizons separately, and handle them independently at the discharge point by strategic reburial or neutralisation; when basement clays or continuous clay horizons are intersected, there is greater potential for the material to form clay balls;
- increasing the water-to-solids ratio if dredging materials high in sulphides or organic matter; pausing repeatedly, or pump slugs of water at each end of the dredge's cutting arc;
- the use of pumps and pumping arrays that produce high turbulence in the flow, as this will promote abrasion and liberation in the pipeline;
- ensuring a turbulent flow by incorporating tight bends or right angles in the pipe;
- increasing the residence time in the pipeline by increasing its length;
- keeping the discharge area relatively small and water in it turbulent to ensure that the fines remain in suspension and do not settle out and concentrate near the discharge point;
- having a swamp dozer or excavator available for shaping the discharge area, keeping the sulphidic fines overflow in one well-defined steep, fast flowing channel all the way to the point of discharge to the permanent sulphidic fines storage location;
- maintaining attention at the discharge point to prevent the build up of fines 'fans' that drain through previously washed sands, leaving the fines buried in the processed materials; and

- flushing the sluicing channel with excess water at shut down to help prevent the exposure of fines over nights and weekends, resulting in acidification.

Where it is economic to remove the clays of Unit 3 to provide access to the underlying sand (Unit 4), it is probable that the soft to stiff clay would require the use of a cutter-suction type dredge, possibly with the assistance of a long-reach excavator mounted on a barge or working from the head of the excavation. The excavated clays (expected to be PASS) will be placed below water level (which is not expected to vary from the previously monitored range in levels) within the worked-out section of the existing dredge pond together with the reject materials returned directly to the dredge pond from the sand processing (by washing, sluicing and/or hydrocyloning). The clay should preferably be placed directly in the final burial locations or otherwise placed within two days to prevent significant oxidation or if not, treated prior to disposal.

It is noted that a water column depth of 4 m above the buried materials is preferred on the basis of Queensland experience (***Queensland Acid Sulphate Soil Technical Manual*** – Soil Management Guidelines [2002]) so as to minimise oxidation potential in the long-term. Subject to final assessment of the sulphidic fines won from processing and variations of oxygen concentrations with depth, consideration may need to be given to any requirement for capping of these materials to promote or maintain an anaerobic deposition environment.

It is anticipated that in the long-term, the completed dredge pond will be restored as a water body equivalent of a sheltered basin structure with:

- a 6H:1V batter for required beach zones in accordance with current approvals.
- a 2H:1V to 3H:1V maximum batter where re-vegetation and maintenance is required above the beach zone.
- an underwater maximum batter of 4H:1V (compared to a maximum of 2.1H:1V dredging slope) at depths greater than 1 m below extreme low water level.

The placement of materials as part of any restoration will need to be carried out so as not to disturb previously placed sulphidic materials and any capping materials.

The current Development Consent specifies that CB must undertake random sampling and analyses of the washed sand that is dredged and extracted, to determine the effectiveness of the removal of any acid sulphate material from the sand product (i.e. the Total Oxidisable Sulphur content should be less than 0.03%). This is equivalent to the performance criteria for the processed sand as proposed in the ***Queensland Acid Sulphate Soil Technical Manual*** – Soil Management Guidelines [2002]), where only residual levels of sulphides or pyrite are to remain, are (unless permitted by industry standards for concrete manufacture).

For statistical confidence, the Queensland guidelines indicate a testing regime with:

- a target of ≤18 moles H^+/tonne (0.03%S);
- no sample shall exceed 25 moles H^+/tonne (0.04%S);
- if any single sample exceeds 18 moles H^+/tonne (0.03%S), then the average of any six consecutive samples (including the exceeding sample) shall have an average not exceeding 25 moles H^+/tonne (0.03%S);
- if more than one sample in any six consecutive samples exceeds 25 moles H^+/tonne (0.03%S), then the average of any six consecutive samples (including the exceeding samples) shall have an average content not exceeding 16 moles H^+/tonne (0.03%S).

As the proposed extraction will extend deeper into the sedimentary sequence with ASS risk, it is suggested that samples of washed sand should be taken and laboratory analysed using the SPOCAS method at an initial testing frequency of one per 1000 m^3 of processed sand to demonstrate compliance with the performance criteria for both ASS and concrete standards (i.e. verification testing). Note that the testing/reporting period is generally of the order of 10 days.

In those cases where the acceptable level of sulphides in the processed sands for an end use in concrete is higher than performance criteria/action levels, the sand must be appropriately contained (and leachate or runoff collected and managed) as with any other ASS.

9.5 Water and Leachate Monitoring, Treatment and Discharge

If left unmanaged, the acidity and heavy metals released by oxidation of ASS materials may be transported by water. Such water can contaminate both groundwater and surface water, eventually entering waterways and the ocean.

The aim of the ASSMP is to minimise the impact on the environment and to ensure that ASS leachate, which enter and mix with natural waters, meet acceptable guidelines. In addition, one of the measures of the performance of the management procedures lies in the water quality of leachate and surface runoff from processed sand stockpiles and the quality of local groundwater (including the dredge pondage) into which leachate has mixed. Continued monitoring of the water mass up-gradient and downstream of the dredge pond will be required to demonstrate that target criteria are met.

Flowing leachate from processed stockpiles should be monitored daily; if washing has been carried out correctly, spot neutralisation should not be required. Neutralisation should be carried out with a calcium hydroxide solution made from CaO or quicklime slurry; there is a natural limit to the pH in solution of around 12.2, and the neutralisation product is gypsum. The use of MgO is not recommended as the magnesium sulphate product is highly soluble, and can generate water with unacceptably high total dissolved solids (TDS).

The current EPA Licence and Development Consent require:

- a monitoring of discharged water at the overflow pipe from the dredge pond.
- monitoring of groundwater levels and water quality in the monitoring bores in and around the quarry and in the dredge pond, monthly and following any periods of extreme wet weather.
- water quality testing will include, as a minimum, conductivity (a measure of total dissolved solids) plus pH and in the event that acid sulphate material is detected the possible requirement for monitoring of additional water quality parameters.

Applicable target water criteria (after ANZECC 2000 or NSW Clean Waters Regulations 1972 where no ANZECC Guidelines are available) are for surface discharge (unlikely on the basis of the bunded nature of the site and no use of the discharge channel to date) or for potential subsurface migration of water from the existing or proposed dredge pond to the groundwater or the "fresh" water canal system into either the existing overflow channel or the adjacent main canal.

i) pH between 6.5 and 9.0
ii) Dissolved oxygen (DO) > 6 mg/L (> 80 – 90% saturation)
iii) Total dissolved solids (TDS) < 1500 mg/L
iv) Total suspended solids (TSS) < 50 mg/L
v) Fe (total) < 0.5 mg/L and Al (total) < 0.055 mg/L for pH > 6.5.

The available chemical testing (see Appendix A) indicates that the water within the current dredge pond meets all but the Fe (total) value (which is expected to be naturally elevated in the geological environment including acid sulphate materials and weathering of pyritic iron which forms an accessory mineral of the underlying bedrock of the Berry Formation) and is generally of higher quality than the groundwater and surface water in adjacent waterways that pass through the backdune AASS and PASS deposits of Foys Swamp.

At the flood gates to the north of the proposed extraction area, Blue Angle Creek is tidal and the main canal is subject to marine water mixing. Consequently, additional consideration needs to be given to the target water criteria for marine water:

i) pH < 0.2 unit change;
ii) Dissolved oxygen (DO) > 6 mg/L;
iii) Total dissolved solids (TDS) > 1500 mg/L.

It is noted that the available chemical testing results of samples from Blue Angle Creek and the main canal vary widely in comparison to the criteria, inferred to be as a result of tidal mixing and rainfall.

Discharges (if required) should meet quality requirements, be controlled and preferably during substantial flows in the natural water systems. All water quality indicators should be checked before proposed discharge, to allow for any additional remediation if required to meet the criteria defined above. Just prior to discharge, pH and DO should also be checked.

10. CONTINGENCY PLANNING

The ASSMAC Guidelines (1998) indicate a range of contingency elements for inclusion in management plans. Field operation elements such as provision of immediate response to non-conformances, the holding of adequate materials on site and testing to confirm the adequacy of remedial measures, together with reporting requirements are include within the detailed ASSMP (Appendix B).

Contingency measures are included within the site excavation, monitoring, treatment and reporting protocols which are designed to provide an early detection of a non-conformance and a consequent corrective action. Any modification of the protocols required to meet unexpected conditions shall be agreed to by the PM. Monitoring shall be used to confirm the effectiveness of any changes.

The principal contingency during quarrying is by control of water/treated leachate within the dredge pond and any (unexpected) discharged from the site. The discharge of water/leachate will be halted where a non-conformance is identified, the source investigated and corrective actions implemented. Where remedial action fails or monitoring results indicate on-going failure of the management strategy to meet performance criteria, the excavation should cease during resolution of the required change in methodology.

11. LIMITATIONS

This report has been prepared for the exclusive use by CB for specific application to the proposed Northern Extension of the Gerroa Sand Quarry. This report's conclusions or recommendations do not apply if the nature, design or location of the facilities is changed. If changes are contemplated, DP must review them to assess their impact on this report's applicability.

DOUGLAS PARTNERS PTY LTD

Reviewed by

G R Wilson
Principal

Michael J Thom
Principal

REFERENCES

Stone Y, Ahern C R, and Blunden B (1998). ***Acid Sulfate Soils Manual 1998***. Acid Soil Management Advisory Committee, Wollingbar, NSW, Australia.

Dear S E, Moore N G, Dobos S K, Watling K M and Ahern Cr (2002). Soil Management Guidelines. In ***Queensland Acid Sulphate Soil Technical Manual***. Department of Natural Resources and Mines, Indooroopilly, Queensland, Australia.

Australian and New Zealand Environment and Conservation Council. (2000). Australian Water Quality Guideline for Fresh and Marine Waters.

APPENDIX A
Notes Relating to this Report
Summary of Previous Screening and ASS Laboratory Tests
Summary of Chemical Testing of Surface and Groundwater

Douglas Partners
Geotechnics • Environment • Groundwater

NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, Geotechnical Site Investigations Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descent into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond-tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" — Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7

  as 4, 6, 7
  N = 13

- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm

  as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil.

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test 6.4.1.

In the tests, a 35 mm diameter rod with a cone-tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: —

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0—50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%—2% are commonly encountered in sands and very soft clays rising to 4%—10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:—

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6) \text{ N (blows per 300 mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:—

$$q_c = (12 \text{ to } 18)\, c_u$$

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat-ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Bore Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems;

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions — the potential for this will depend partly on bore spacing and sampling frequency
- changes in policy or interpretation of policy by statutory authorities
- the actions of contractors responding to commercial pressures.

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Table A1 – Summary of Screening and Analytical Results (DP 2005 Testing Program)

Location	Depth (m)	Unit	Field Screening Tests				sPOCAS Test	
			Natural pH_F	Oxidised pH_{FOX}	pH_F - pH_{FOX}	Effervescence	S_{pos}%	S_{TPA}%
Bore 201	0.5	1	6.2	5.9	0.3	S		
	1.0	1	6.4	6.2	0.2	S		
	1.5	1	6.5	6.2	0.3	S		
	2.0	1	6.6	5.8	0.8	S		
	3.0	1	6.7	6.3	0.4	S		
	4.0	1	7.0	6.4	0.6	S		
	5.0	2	7.9	7.7	0.2	S	0.03	<0.01
	6.0	2	7.8	7.9	-0.1	S		
	7.0	2	7.9	8.2	-0.3	S		
	8.0	2	8.2	7.7	0.5	S		
	9.0	2	8.4	7.4	1.0	S		
	10.0	4	8.1	5.9	2.2	S		
	11.0	4	8.1	5.6	2.5	S		
	12.0	4	8.0	4.7	3.3	S		
	13.0	4	7.9	2.5	5.4	M	0.32	<0.01
Bore 202	0.5	1	8.3	4.8	3.5	S	0.08	<0.01
	1.0	1	8.3	5.8	2.5	S		
	1.0	1	7.9	5.6	2.3	S		
	1.5	1	8.0	5.8	2.2	S		
	2.0	1	6.8	7.0	-0.2	S		
	3.0	1	6.9	6.8	0.1	S		
	4.0	2	7.4	6.8	0.6	S		
	5.0	2	8.2	7.4	0.8	S		
	6.0	2	7.9	7.4	0.5	S		
	7.0	2	7.7	7.6	0.1	S		
	9.0	2	7.7	7.7	0.0	S		
	10.0	4	7.7	5.6	2.1	S		
	11.0	4	7.7	4.8	2.9	S - M		
	12.0	4	7.7	5.9	1.8	S		
	13.0	4	6.6	6.2	0.4	S		
	14.0	4	6.8	6.2	0.6	S		
	15.0	4	7.0	6.2	0.8	S		
Bore 203	0.5	1	7.5	6.0	0.5	S		
	1.0	1	7.2	6.1	1.1	S		
	1.5	1	7.3	6.0	1.3	S		
	2.0	1	7.3	6.4	0.9	S		
	3.0	1	7.7	6.5	1.2	S		
	4.0	1	7.4	6.5	0.9	S		
	5.0	1	7.4	6.5	0.9	S	0.09	<0.01
	6.0	1	7.4	6.8	0.6	S		
	7.0	1	7.9	7.4	0.5	S		
	8.0	2	7.7	7.5	0.2	S		
	9.0	2	7.5	6.8	0.7	S		
	10.0	2	7.4	7.1	0.3	S		
	11.0	2	7.6	7.5	0.1	S		
	12.0	4	7.9	7.2	0.7	S		
	13.0	4	7.9	7.2	0.7	S		
	14.0	4	7.9	7.0	0.9	S		
	15.0	4	7.9	6.9	1.0	S		

Table A1 – Summary of Screening and Analytical Results (DP 2005 Testing Program) (Continued)

Location	Depth (m)	Unit	Field Screening Tests				sPOCAS Test	
			Natural pH_F	Oxidised pH_{FOX}	pH_F - pH_{FOX}	Effervescence	S_{pos}%	S_{TPA}%
Bore 204	1	0.5	7.3	6.2	1.1	S		
	1	1.0	7.4	6.2	1.2	S		
	1	1.5	7.4	6.5	0.9	S		
	1	2.0	7.4	6.2	1.2	S		
	1	2.5	7.4	6.1	1.3	S		
	1	3.0	7.3	6.1	1.2	S		
	1	4.0	7.2	6.1	1.1	S		
	1	5.0	7.9	7.9	0.0	S		
	2	6.0	7.9	7.1	0.8	S		
	2	7.0	8.2	7.3	0.9	S		
	2	8.0	8.2	7.7	0.5	S		
	2	10.0	6.3	6.4	-0.1	S		
	4	11.0	6.2	6.4	-0.2	S		
	4	12.0	6.5	6.4	0.1	S		
	4	13.0	6.6	6.5	0.1	S		
	4	14.0	7.7	6.5	1.2	M	0.89	0.47
	5	15.0	7.8	6.5	1.3	V		

Note: Bold indicates positive indicator S = Slight M = Moderate V = Vigorous

Table A2 (Continued) – Summary of Screening and Analytical Results (Previous Testing Programs)

Location	Material Type	Depth (m)	Field Screening Tests			Test Value	
			Natural pH_F	pH_{FOX}	$pH_{F\ minus}\ pH_{FOX}$	S_{pos}%	S_{cr}%
D8	SC	1.7 – 2.0	6.1	2.6	3.5		0.312
D9	SC	2.3 – 2.5	6.2	1.3	4.9		
D10	SC	1.9 – 2.4	5.8	0.9	4.9		0.709
D11	C	2.5 – 2.6	6.7	0.8	5.9		
D12	C	2.4 – 2.9	6.8	0.8	6.0		
D13	C/SC	1.4 – 1.8	6.1	1.7	4.4		0.595
D14	C	2.3 – 2.5	6.1	0.9	5.2		
D15	SC	2.2 – 2.5	6.6	2.0	4.6		
D16	C	3.8 – 4.1	6.4	0.7	5.7		1.98

Note: Bold indicates positive indicator S = sand/silty sand/sandy silt C = Clay/clayey silt SC = Clayey sand/sandy clay

Analytical Report - Enviro-Managers	
Client:	**Cleary Bros (Bombo) Pty Ltd**
	Springhill Rd
Contact Name:	**Mr Ron Bryant**
Client Reference:	**Gerroa Bores**

NR = No Result - Dry

Notes	Report Number:	W05/0186	W05/0186	W05/0186	W05/0186	W05/0186	W05/0186	W05/0186	W05/0671	W05/0671	W05/0671	W05/0671	W05/0671	W05/0671	W05/0671	W05/0671	W05/0671	W05/0671
Results:	Sample Received:	20/01/05	20/01/05	20/01/05	20/01/05	20/01/05	20/01/05	20/01/05	24/02/05	24/02/05	24/02/05	24/02/05	24/02/05	24/02/05	24/02/05	24/02/05	24/02/05	24/02/05
Client Id		Ex Works	BH 1	BH 7	BH 9	BH 11	B/Angel Creek	BH 12	Ex.Works	Bore Hole 1	Bore Hole 2	Bore Hole 4	Bore Hole 5	Bore Hole 6	Bore Hole 7	Bore Hole 9	Bore Hole 11	lue Angle Cree
Laboratory Id		W11016/001	W11016/002	W11016/003	W11016/004	W11016/005	W11016/006	W11016/007	W11511/001	W11511/002	W11511/003	W11511/004	W11511/005	W11511/006	W11511/007	W11511/008	W11511/009	W11511/010
Conductivity (uS/cm)																		
Method:APHA 2510 B	*Units:uS/cm@25℃*	560	1030	160	860	1110	+20000	430	540	370	NR	NR	NR	NR	150	380	1510	810
Groundwater level (RL)																		
Method:	*Units:m*	-	0.48	-0.46	-1.15	-1.53	-	-0.40	-	1.83	-	-	-	-	-0.01	-0.60	-1.28	-
pH																		
Method:APHA 4500 H B	*Units:pH units*	7.8	6.6	5.7	6.4	6.4	6.9	5.4	7.5	5.7	-	-	-	-	5.6	6.5	4.9	6.3

Notes	Report Number:	W05/2033-1	W05/2033-1	W05/2033-1	W05/2033-1	W05/2033-1	W05/2033-1	W05/2033-1	W05/2033-1	W05/2033-1	W05/2033-1	W05/2033-1	W05/2033-1	W05/2358	W05/2358	W05/2358	W05/2358	W05/2358
Results:	Sample Received:	26/05/05	26/05/05	26/05/05	26/05/05	26/05/05	26/05/05	26/05/05	26/05/05	26/05/05	26/05/05	26/05/05	26/05/05	22/06/05	22/06/05	22/06/05	22/06/05	22/06/05
Client Id		Ex-Works	BH 1	BH 2	BH 4	BH 5	BH 6	BH 7	BH 9	BH 11	3/Angel Cree	BH 12	BH 14	Ex Works	BH 1	BH 2	BH 4	BH 5
Laboratory Id		W12828/001	W12828/002	W12828/003	W12828/004	W12828/005	W12828/006	W12828/007	W12828/008	W12828/009	W12828/010	W12828/011	W12828/012	W13143/001	W13143/002	W13143/003	W13143/004	W13143/005
Conductivity (uS/cm)																		
Method:APHA 2510 B	*Units:uS/cm@25℃*	540	340	NR	NR	NR	NR	190	250	1900	4240	380	NR	560	360	NR	NR	NR
Groundwater level (RL)																		
Method:	*Units:m*	-	+1.73	-	-	-	-	-0.16	-0.75	-1.33	-	-0.05	-	-	1.33	-	-	-
pH																		
Method:APHA 4500 H B	*Units:pH units*	6.8	5.8	-	-	-	-	5.8	6.1	4.6	6.4	5.8	-	6.7	5.8	-	-	-

Notes	Report Number:	W05/3572-2	W05/3572-2	W05/3572-2	W05/3572-2	W05/3572-2	W05/3572-2	W05/3572-2	W05/3572-2	W05/3572-2	W05/3572-2	W05/3572-2	W05/3572-2	W05/3572-2	W05/3963	W05/3963	W05/3963	W05/3963
Results:	Sample Received:	21/09/05	21/09/05	21/09/05	21/09/05	21/09/05	21/09/05	21/09/05	21/09/05	21/09/05	21/09/05	21/09/05	21/09/05	21/09/05	21/10/05	21/10/05	21/10/05	21/10/05
Client Id		Ex.Works	BH 1	BH 1A	BH 4	BH 5	BH 6	BH 7	BH 9	BH 11	3/Angel Cree	BH 12	BH 2A	BH 3A	Ex.Works	BH 1	BH 1A	BH 4
Laboratory Id		W14389/001	W14389/002	W14389/003	W14389/004	W14389/005	W14389/006	W14389/007	W14389/008	W14389/009	W14389/010	W14389/011	W14389/012	W14389/013	W14768/001	W14768/002	W14768/003	W14768/004
Conductivity (uS/cm)																		
Method:APHA 2510 B	*Units:uS/cm@25℃*	580	640	NR	750	NR	NR	160	270	1280	18030	770	NR	NR	600	1010	Dry	Dry
Groundwater level (RL)																		
Method:	*Units:m*	-	1.39	-	-0.33	-	-	-0.29	-0.87	-1.42	-	-0.26	-	-	-	1.05	-	-
pH																		
Method:APHA 4500 H B	*Units:pH units*	6.7	5.8	-	6.9	-	-	5.5	6.0	5.3	6.8	5.3	-	-	6.9	6.0	-	-

YEARLY SAMPLING

	Report Number:	W05/4442	W05/4442	W05/4442	W05/4442	W05/4442	W05/4442	W05/4442	W05/4442	W05/4442	W05/4442	W05/4442	W05/4442	W05/4442
Results:	Sample Received:	21/11/05	21/11/05	21/11/05	21/11/05	21/11/05	21/11/05	21/11/05	21/11/05	21/11/05	21/11/05	21/11/05	21/11/05	21/11/05
Client Id		Ex-Works	BH 1	BH 3A	BH 4	BH 5	BH 6	BH7	BH 9	BH 11	ue Angle Cre	BH 12	BH 2A	BH 1A
Laboratory Id		W15175/001	W15175/002	W15175/003	W15175/004	W15175/005	W15175/006	W15175/007	W15175/008	W15175/009	W15175/010	W15175/011	W15175/012	W15175/013
Cl : SO4 Ratio														
Method:	*Units:-*	0.53	4.4	NR	5.1	NR	NR	3.3	0.88	3.6	7.4	0.56	NR	NR
Conductivity (uS/cm)														
Method:APHA 2510 B	*Units:uS/cm@25℃*	690	590	-	1080	-	-	170	410	1180	>20,000	570	-	-
Groundwater level (RL)														
Method:	*Units:m*	-	1.33	-	0.57	-	-	-0.42	-1.08	-1.30	-	-0.31	-	-
pH														
Method:APHA 4500 H B	*Units:pH units*	7.7	6.9	-	7.9	-	-	6.9	7.3	6.8	7.7	6.5	-	-

Analytical Report - Enviro-Managers	
Client:	**Cleary Bros (Bombo) Pty Ltd**
	Springhill Rd
Contact Name:	**Mr Ron Bryant**
Client Reference:	**Gerroa Bores**

NR = No Result - Dry

Notes	Report Number:	W05/0671	W05/0671	W05/1086-1	W05/1086-1	W05/1086-1	W05/1086-1	W05/1086-1	W05/1086-1	W05/1086-1	W05/1086-1	W05/1086-1	W05/1086-1	W05/1086-1	W05/1086-1	W05/1620	W05/1620	W05/1620
Results:	**Sample Received:**	**24/02/05**	**24/02/05**	**22/03/05**	**22/03/05**	**22/03/05**	**22/03/05**	**22/03/05**	**22/03/05**	**22/03/05**	**22/03/05**	**22/03/05**	**22/03/05**	**22/03/05**	**22/03/05**	**27/04/05**	**27/04/05**	**27/04/05**
Client Id		**Bore Hole 12**	**Bore Hole 14**	**Ex Works**	**BH 1**	**BH 2**	**BH 4**	**BH 5**	**BH 6**	**BH 7**	**BH 9**	**BH 11**	**lue Angle cree**	**BH 12**	**BH 14**	**Ex-Works**	**BH1**	**BH2**
Laboratory Id		W11511/011	W11511/012	W11945/001	W11945/002	W11945/003	W11945/004	W11945/005	W11945/006	W11945/007	W11945/008	W11945/009	W11945/010	W11945/011	W11945/012	W12413/001	W12413/002	W12413/003
Conductivity (uS/cm)																		
Method:APHA 2510 B	***Units:uS/cm@25℃***	350	NR	530	290	NR	NR	NR	NR	160	450	820	9140	330	NR	510	300	NR
Groundwater level (RL)																		
Method:	***Units:m***	-0.15	-	-	1.73	-	-	-	-	-0.16	-0.80	-1.48	-	-0.20	-	-	+1.53	-
pH																		
Method:APHA 4500 H B	***Units:pH units***	5.3	-	6.6	6.0	-	-	-	-	5.9	6.9	5.9	6.7	5.3	-	7.3	6.5	-

Notes	Report Number:	W05/2358	W05/2358	W05/2358	W05/2358	W05/2358	W05/2358	W05/2358	W05/2774	W05/2774	W05/2774	W05/2774	W05/2774	W05/2774	W05/2774	W05/2774	W05/2774	W05/2774
Results:	**Sample Received:**	**22/06/05**	**22/06/05**	**22/06/05**	**22/06/05**	**22/06/05**	**22/06/05**	**22/06/05**	**21/07/05**	**21/07/05**	**21/07/05**	**21/07/05**	**21/07/05**	**21/07/05**	**21/07/05**	**21/07/05**	**21/07/05**	**21/07/05**
Client Id		**BH 6**	**BH 7**	**BH 9**	**BH 11**	**ue Angel Cre**	**BH 12**	**BH 14**	**Ex Works**	**BH 1**	**BH 2**	**BH 4**	**BH 5**	**BH 6**	**BH 7**	**BH 9**	**BH 11**	**ue Angel Cre**
Laboratory Id		W13143/006	W13143/007	W13143/008	W13143/009	W13143/010	W13143/011	W13143/012	W13573/001	W13573/002	W13573/003	W13573/004	W13573/005	W13573/006	W13573/007	W13573/008	W13573/009	W13573/010
Conductivity (uS/cm)																		
Method:APHA 2510 B	***Units:uS/cm@25℃***	NR	210	220	900	>20,000	NR	NR	550	440	NR	740	100	NR	160	220	2150	5200
Groundwater level (RL)																		
Method:	***Units:m***	-	-0.31	-0.95	-0.88	-	-	-	-	1.73	-	0.07	0.23	-	0.09	-0.50	-1.48	-
pH																		
Method:APHA 4500 H B	***Units:pH units***	-	5.6	6.0	5.4	6.5	-	-	7.0	5.7	-	6.4	5.0	-	5.4	5.7	4.9	6.4

Notes	Report Number:	W05/3963	W05/3963	W05/3963	W05/3963	W05/3963	W05/3963	W05/3963	W05/3963	W05/3963	W05/4819	W05/4819	W05/4819	W05/4819	W05/4819	W05/4819	W05/4819	W05/4819
Results:	**Sample Received:**	**21/10/05**	**21/10/05**	**21/10/05**	**21/10/05**	**21/10/05**	**21/10/05**	**21/10/05**	**21/10/05**	**21/10/05**	**20/12/05**	**20/12/05**	**20/12/05**	**20/12/05**	**20/12/05**	**20/12/05**	**20/12/05**	**20/12/05**
Client Id		**BH 5**	**BH 6**	**BH 7**	**BH 9**	**BH 11**	**ue Angle Cre**	**BH 12**	**BH 2A**	**BH 3A**	**Ex-Works**	**BH 1**	**BH 1A**	**BH 4**	**BH 5**	**BH 6**	**BH 7**	**BH 9**
Laboratory Id		W14768/005	W14768/006	W14768/007	W14768/008	W14768/009	W14768/010	W14768/011	W14768/012	W14768/013	W15693/001	W15693/002	W15693/003	W15693/004	W15693/005	W15693/006	W15693/007	W15693/008
Conductivity (uS/cm)																		
Method:APHA 2510 B	***Units:uS/cm@25℃***	Dry	Lost	170	260	1010	>20,000	620	Dry	Dry	670	470	Dry	1110	Dry	NR	140	380
Groundwater level (RL)																		
Method:	***Units:m***	-	-	-0.41	-1.07	-1.33	-	-0.37	-	-	-	1.21	-	-0.43	-	-	-0.40	-0.98
pH																		
Method:APHA 4500 H B	***Units:pH units***	-	-	5.6	5.6	5.2	6.6	5.3	-	-	7.7	6.1	-	7.2	-	-	5.9	6.7

YEARLY SAMPLING

	Report Number:
Results:	**Sample Received:**
Client Id	
Laboratory Id	
Cl : SO4 Ratio	
Method:	***Units:-***
Conductivity (uS/cm)	
Method:APHA 2510 B	***Units:uS/cm@25℃***
Groundwater level (RL)	
Method:	***Units:m***
pH	
Method:APHA 4500 H B	***Units:pH units***

Analytical Report - Enviro-Managers	
Client:	**Cleary Bros (Bombo) Pty Ltd**
	Springhill Rd
Contact Name:	**Mr Ron Bryant**
Client Reference:	**Gerroa Bores**

NR = No Result - Dry

Notes	**Report Number:**	W05/1620	W05/1620	W05/1620	W05/1620	W05/1620	W05/1620	W05/1620	W05/1620	W05/1620
Results:	**Sample Received:**	27/04/05	27/04/05	27/04/05	27/04/05	27/04/05	27/04/05	27/04/05	27/04/05	27/04/05
Client Id		BH4	BH5	BH6	BH7	BH9	BH11	B/Angle Creek	BH12	BH14
Laboratory Id		W12413/004	W12413/005	W12413/006	W12413/007	W12413/008	W12413/009	W12413/010	W12413/011	W12413/012
Conductivity (uS/cm)										
Method:APHA 2510 B	***Units:uS/cm@25℃***	NR	NR	NR	140	400	790	7380	410	NR
Groundwater level (RL)										
Method:	***Units:m***	-	-	-	-0.31	-0.95	-1.53	-	-1.30	-
pH										
Method:APHA 4500 H B	***Units:pH units***	-	-	-	5.6	6.5	5.6	6.9	5.9	-

Notes	**Report Number:**	W05/2774	W05/2774	W05/3172	W05/3172	W05/3172	W05/3172	W05/3172	W05/3172	W05/3172	W05/3172	W05/3172	W05/3172	W05/3172	W05/3172
Results:	**Sample Received:**	21/07/05	21/07/05	22/08/05	22/08/05	22/08/05	22/08/05	22/08/05	22/08/05	22/08/05	22/08/05	22/08/05	22/08/05	22/08/05	22/08/05
Client Id		BH 12	BH 14	WM1A	xisting Work	WM1	WM2A	WM4	WM5	WM3A	WM7	WM9	WM11	ue Angle Cre	WM12
Laboratory Id		W13573/011	W13573/012	W13973/001	W13973/002	W13973/003	W13973/004	W13973/005	W13973/006	W13973/007	W13973/008	W13973/009	W13973/010	W13973/011	W13973/012
Conductivity (uS/cm)															
Method:APHA 2510 B	***Units:uS/cm@25℃***	NR	NR	NR	560	670	NR	780	NR	NR	160	250	1360	8540	760
Groundwater level (RL)															
Method:	***Units:m***	-	-	-	-	1.12	-	0.78	-	-	-0.14	-0.72	-1.29	-	-0.17
pH															
Method:APHA 4500 H B	***Units:pH units***	-	-	-	7.0	6.0	-	6.8	-	-	5.6	5.5	4.5	6.7	5.4

Notes	**Report Number:**	W05/4819	W05/4819	W05/4819	W05/4819	W05/4819
Results:	**Sample Received:**	20/12/05	20/12/05	20/12/05	20/12/05	20/12/05
Client Id		BH 11	ue Angle Cre	BH 12	BH 2A	BH 3A
Laboratory Id		W15693/009	W15693/010	W15693/011	W15693/012	W15693/013
Conductivity (uS/cm)						
Method:APHA 2510 B	***Units:uS/cm@25℃***	1230	17420	590	Dry	Dry
Groundwater level (RL)						
Method:	***Units:m***	-1.44	-	-0.17	-	-
pH						
Method:APHA 4500 H B	***Units:pH units***	5.7	7.0	5.3	-	-

YEARLY SAMPLING

	Report Number:
Results:	**Sample Received:**
Client Id	
Laboratory Id	
Cl : SO4 Ratio	
Method:	***Units:-***
Conductivity (uS/cm)	
Method:APHA 2510 B	***Units:uS/cm@25℃***
Groundwater level (RL)	
Method:	***Units:m***
pH	
Method:APHA 4500 H B	***Units:pH units***

Monthly Water Monitoring Results - GW and SW.xls

ID	Parameter	Units	09/24/2003	10/27/2003	11/19/2003	12/31/2003	01/30/2004	02/26/2004	03/31/2004	04/29/2004	05/27/2004	06/28/2004	07/28/2004	08/27/2004	09/27/2004	10/27/2004	11/26/2004	12/29/2004	01/20/2005
	Cl:SO4 Ratio	mg/l			10						23						5.2		
	Conductivity	uS/cm@25 deg C	898	1113	970	615	534	489	382	460	365	323	278	396	479	430	710	780	1030
	Groundwater Level	m	0.51	0.33	-0.06	-	-	1.93	1.63	1.65	1.69	1.53	1.65	1.73	1.7	1.94	1.48	1.43	0.48
	pH	pH units	6.3	6.6	5.4	8.4	5.9	5.8	6.2	5.4	6.3	6.1	5.7	6.2	5.8	6.5	6.7	6.5	6.6
WM2																			
	Cl:SO4 Ratio	mg/l			3.3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Conductivity	uS/cm@25 deg C	466	530	465														
	Groundwater Level	m	0.29	0.17	-0.03														
	pH	pH units	7	7	7.4														
WM4																			
	Cl:SO4 Ratio	mg/l	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Conductivity	uS/cm@25 deg C																	
	Groundwater Level	m																	
	pH	pH units																	
WM5																			
	Cl:SO4 Ratio	mg/l	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Conductivity	uS/cm@25 deg C																	
	Groundwater Level	m																	
	pH	pH units																	
WM6																			
	Cl:SO4 Ratio	mg/l	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Conductivity	uS/cm@25 deg C																	
	Groundwater Level	m																	
	pH	pH units																	
WM7																			
	Cl:SO4 Ratio	mg/l			4.8						3.8						3		
	Conductivity	uS/cm@25 deg C	325	293	245	257	324	290	285	248	268	292	262	339	336	180	210	190	160
	Groundwater Level	m	-0.39	-0.31	-0.34	-0.23	-0.37	-0.41	-0.51	0.09	-0.29	-0.26	-0.28	-0.41	-0.41	0.09	-0.21	-	-0.46
	pH	pH units	5.5	5.7	5.8	6.1	5.9	5.7	5.6	6	5.8	5.6	5.6	5.4	5.2	5.8	5.4	5.5	5.7
WM9																			
	Cl:SO4 Ratio	mg/l			1.4						0.63						1.1		
	Conductivity	uS/cm@25 deg C	162	178	166	176.9	334	336	725	309	219	188	192	274	276	140	350	370	860
	Groundwater Level	m	-0.74	-0.88	-0.92	-0.75	-0.95	-0.9	-1.1	-0.45	-0.63	-0.79	-0.81	-1	-0.95	-0.79	-0.75	-0.9	-1.15
	pH	pH units	5.7	5.6	6	6.1	6.4	6.2	7	6.5	6.1	6.1	6.2	5.5	5.6	6.2	6.3	6.1	6.4
WM11																			
	Cl:SO4 Ratio	mg/l			5.8						4.4						3.6		
	Conductivity	uS/cm@25 deg C	1358	1178	798	660	561	912	NR	688	1325	804	1231	1202	2110	1540	840	970	1110
	Groundwater Level	m	-1.08	-0.88	-0.87	-1.66	-1.46	-1.38		-1.52	-1.23	-1.48	-1.46	-1.55	-1.46	-1.38	-1.38	-0.98	-1.53
	pH	pH units	5	5.3	5.1	6	5.5	5.4		5.4	5	5	4	5.1	4.9	4.8	5.9	6	6.4
WM12																			
	Cl:SO4 Ratio	mg/l			5.5						3.8						1.3		
	Conductivity	uS/cm@25 deg C	460	464	434	2700	3080	312	347	240	254	373	612	695	961	640	600	620	430
	Groundwater Level	m	-0.17	-0.08	0.03	-0.4	-0.45	-0.45	-0.45	-0.18	-0.13	-0.25	-0.3	-0.29	-0.25	0.14	-0.2	-0.2	-0.4
	pH	pH units	6.2	7	6.2	6	6.4	6.1	6.2	6.1	6.2	4.3	3.4	3.9	3.3	6.2	3.9	5.4	5.4
WM14																			
	Cl:SO4 Ratio	mg/l	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Conductivity	uS/cm@25 deg C																	
	Groundwater Level	m																	
	pH	pH units																	
Ex Works																			
	Cl:SO4 Ratio	mg/l			0.84						NR						0.71		
	Conductivity	uS/cm@25 deg C	1339	615	557	615	654	655	660	603		524	545	779	902	510	530	530	560
	Groundwater Level	m	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
	pH	pH units	8.1	8.1	7.5	8.4	8.4	7.5	7.8	7.5		7.4	7.2	7.3	7.6	7.8	7.5	7.4	7.8
Blue Angle Creek																			
	Cl:SO4 Ratio	mg/l			6.3						6.4						5.8		
	Conductivity	uS/cm@25 deg C	3670	3910	3980	10830	10830	1538	24600	5660	4520	14950	7890	16540	36400	750	10010	20400	20000
	Groundwater Level	m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	pH	pH units	6.8	6.7	7.1	7.1	7.2	6.4	6.7	6.6	5.9	6.8	6.3	6.4	6.6	3.5	7	6.9	6.9
South Reed																			
	Cl:SO4 Ratio	mg/l	NR	NR	0.86	NR	NR	NR	NR	NR	NR								
	Conductivity	uS/cm@25 deg C			558														
	Groundwater Level	m			-														
	pH	pH units			7.5														

Table 1D - Gerroa Monthly Groundwater Results (BH 1-6)

Client Reference: **Gerroa Bores**

NR = No Result - Dry

Notes	**Report Number:**	**W05/0186**	**W05/0671**	**W05/1086-1**	**W05/1620**	**W05/2033-1**	**W05/2358**	**W05/2774**	**W05/3172**	**W05/3572-2**	**W05/3963**	**W05/4442**	**W05/4819**			
Results:	**Sample Receive**	**20/01/2005**	**24/02/2005**	**22/03/2005**	**27/04/2005**	**26/05/2005**	**22/06/2005**	**21/07/2005**	**22/08/2005**	**21/09/2005**	**21/10/2005**	**21/11/2005**	**20/12/2005**			
Client Id		**BH 1**	**BH 1**	**BH 1**	**BH1**	**BH 1**	**BH 1**	**BH 1**	**WM1**	**BH 1**	**BH 1**	**BH 1**	**BH 1**	**Minimum**	**Average**	**Maximim**
Laboratory Id		**W11016/002**	**W11511/002**	**W11945/002**	**W12413/002**	**W12828/002**	**W13143/002**	**W13573/002**	**W13973/003**	**W14389/002**	**W14768/002**	**W15175/002**	**W15693/002**			
Conductivity (uS/cm)																
Method:APHA 2510 B	***Units:uS/cm@25***	1030	370	290	300	340	360	440	670	640	1010	590	470	290	531	1030
Groundwater level (RL)																
Method:	***Units:m***	0.48	1.83	1.73	1.53	1.73	1.33	1.73	1.12	1.39	1.05	1.33	1.21	0.48	1.39	1.83
pH																
Method:APHA 4500 H B	***Units:pH units***	6.60	5.70	6.00	6.50	5.80	5.80	5.70	6.0	5.80	6.00	6.90	6.1	5.70	6.08	6.90

Notes	**Report Number:**	**W05/3172**	**W05/3572-2**	**W05/3963**	**W05/4442**	**W05/4819**	**W05/0671**	**W05/1086-1**	**W05/1620**	**W05/2033-1**	**W05/2358**	**W05/2774**	**W05/3172**	**W05/3572-2**	**W05/3963**	**W05/4442**
Results:	**Sample Receive**	**22/08/2005**	**21/09/2005**	**21/10/2005**	**21/11/2005**	**20/12/2005**	**24/02/2005**	**22/03/2005**	**27/04/2005**	**26/05/2005**	**22/06/2005**	**21/07/2005**	**22/08/2005**	**21/09/2005**	**21/10/2005**	**21/11/2005**
Client Id		**WM3A**	**BH 3A**	**BH 3A**	**BH3A**	**BH 3A**	**BH 4**	**BH 4**	**BH4**	**BH 4**	**BH 4**	**BH 4**	**WM4**	**BH 4**	**BH 4**	**BH4**
Laboratory Id		**W13973/007**	**W14389/013**	**W14768/013**	**W15175/003**	**W15693/013**	**W11511/004**	**W11945/004**	**W12413/004**	**W12828/004**	**W13143/004**	**W13573/004**	**W13973/005**	**W14389/004**	**W14768/004**	**W15175/004**
Conductivity (uS/cm)																
Method:APHA 2510 B	***Units:uS/cm@25***	NR	NR	Dry	NR	Dry	NR	NR	NR	NR	NR	740	780	750	Dry	1080
Groundwater level (RL)																
Method:	***Units:m***	-	-	-	-	-	-	-	-	-	-	0.07	0.78	-0.33	-	0.57
pH																
Method:APHA 4500 H B	***Units:pH units***	-	-	-	-	-	-	-	-	-	-	6.4	6.8	6.9	-	7.90

Notes	**Report Number:**	**W05/0671**	**W05/1086-1**	**W05/1620**	**W05/2033-1**	**W05/2358**	**W05/2774**	**W05/3572-2**	**W05/3963**	**W05/4442**	**W05/4819**
Results:	**Sample Receive**	**24/02/2005**	**22/03/2005**	**27/04/2005**	**26/05/2005**	**22/06/2005**	**21/07/2005**	**21/09/2005**	**21/10/2005**	**21/11/2005**	**20/12/2005**
Client Id		**BH 6**	**BH 6**	**BH6**	**BH 6**	**BH 6**	**BH 6**	**BH 6**	**BH 6**	**BH6**	**BH 6**
Laboratory Id		**W11511/006**	**W11945/006**	**W12413/006**	**W12828/006**	**W13143/006**	**W13573/006**	**W14389/006**	**W14768/006**	**W15175/006**	**W15693/006**
Conductivity (uS/cm)											
Method:APHA 2510 B	***Units:uS/cm@25***	NR	NR	NR	NR	NR	NR	NR	Lost	NR	NR
Groundwater level (RL)											
Method:	***Units:m***	-	-	-	-	-	-	-	-	-	-
pH											
Method:APHA 4500 H B	***Units:pH units***	-	-	-	-	-	-	-	-	-	-

Table 1D - Gerroa Mon

Client Reference: **Gerroa Bor**

NR = No Result - Dry

Notes	**Report Number:**	**W05/3172**	**W05/3572-2**	**W05/3963**	**W05/4442**	**W05/0671**	**W05/1086-1**	**W05/1620**	**W05/2033-1**	**W05/2358**	**W05/2774**	**W05/3572-2**	**W05/3963**	**W05/4442**	**W05/4819**
Results:	**Sample Receive**	**22/08/2005**	**21/09/2005**	**21/10/2005**	**21/11/2005**	**24/02/2005**	**22/03/2005**	**27/04/2005**	**26/05/2005**	**22/06/2005**	**21/07/2005**	**21/09/2005**	**21/10/2005**	**21/11/2005**	**20/12/2005**
Client Id		**WM1A**	**BH 1A**	**BH 1A**	**BH 1A**	**BH 2**	**BH 2**	**BH2**	**BH 2**	**BH 2**	**BH 2**	**BH 2A**	**BH 2A**	**BH 2A**	**BH 2A**
Laboratory Id		W13973/001	W14389/003	W14768/003	W15175/013	W11511/003	W11945/003	W12413/003	W12828/003	W13143/003	W13573/003	W14389/012	W14768/012	W15175/012	W15693/012
Conductivity (uS/cm)															
Method:APHA 2510 B	***Units:uS/cm@25***	NR	NR	Dry	NR	NR	NR	NR	NR	NR	NR	NR	Dry	NR	Dry
Groundwater level (RL)															
Method:	***Units:m***	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH															
Method:APHA 4500 H B	***Units:pH units***	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes	**Report Number:**	**W05/4819**				**W05/0671**	**W05/1086-1**	**W05/1620**	**W05/2033-1**	**W05/2358**	**W05/2774**	**W05/3172**	**W05/3572-2**	**W05/3963**	**W05/4442**	**W05/4819**
Results:	**Sample Receive**	**20/12/2005**				**24/02/2005**	**22/03/2005**	**27/04/2005**	**26/05/2005**	**22/06/2005**	**21/07/2005**	**22/08/2005**	**21/09/2005**	**21/10/2005**	**21/11/2005**	**20/12/2005**
Client Id		**BH 4**	**Minimum**	**Average**	**Maximim**	**BH 5**	**BH 5**	**BH5**	**BH 5**	**BH 5**	**BH 5**	**WM5**	**BH 5**	**BH 5**	**BH5**	**BH 5**
Laboratory Id		W15693/004				W11511/005	W11945/005	W12413/005	W12828/005	W13143/005	W13573/005	W13973/006	W14389/005	W14768/005	W15175/005	W15693/005
Conductivity (uS/cm)																
Method:APHA 2510 B	***Units:uS/cm@25***	1110	740	892	1110	NR	NR	NR	NR	NR	100	NR	NR	Dry	NR	Dry
Groundwater level (RL)																
Method:	***Units:m***	-0.43	-0.43	0.13	0.57	-	-	-	-	-	0.23	-	-	-	-	-
pH																
Method:APHA 4500 H B	***Units:pH units***	7.2	6.4	7.04	7.90	-	-	-	-	-	5.0	-	-	-	-	-

Notes	**Report Number:**
Results:	**Sample Receive**
Client Id	
Laboratory Id	
Conductivity (uS/cm)	
Method:APHA 2510 B	***Units:uS/cm@25***
Groundwater level (RL)	
Method:	***Units:m***
pH	
Method:APHA 4500 H B	***Units:pH units***

TABLE 1: Surface Water Analytical Results

Foys Swamp, Blue Angle Creek and Gerroa Sand Quarry

Cleary Bros (Bombo) Pty Ltd	*Water Monitoring Program*			Sample ID	M.DRAIN-1	M.DRAIN-1	M.DRAIN-1	M.DRAIN-1	M.DRAIN-1	M.DRAIN-1	M.DRAIN-1	M.DRAIN-2	M.DRAIN-2	M.DRAIN-2	M.DRAIN-2	M.DRAIN-2	M.DRAIN-2	M.DRAIN-2	BA Creek	BA Creek	BA Creek
				Sample ID	Main Drain- up stream	Main Drain- up stream	Main Drain- up stream	Main Drain- up stream	Main Drain- up stream	Main Drain- up stream	Main Drain- up stream	Main Drain- dn stream	Main Drain- dn stream	Main Drain- dn stream	Main Drain- dn stream	Main Drain- dn stream	Main Drain- dn stream	Main Drain- dn stream	Blue Angle Creek	Blue Angle Creek	Blue Angle Creek
	Units	LOR	ANZECC 2000 Guidelines		Wet Weather	Dry Weather	Dry Weather	Dry Weather	Dry Weather	Dry Weather	Dry Weather	Wet Weather	Dry Weather	Dry Weather	Dry Weather	Dry Weather	Dry Weather	Dry Weather	Wet Weather	Dry Weather	Dry Weather
Metals (total)			Marine	Fresh	27/01/05	28/04/05	2/06/05	3/08/05	21/09/05	21/10/06	21/11/05	27/01/05	28/04/05	2/06/05	3/08/05	21/09/05	21/10/06	21/11/05	3/02/05	28/04/05	2/06/05
Aluminium (PH>6.5,)	mg/L	0.0001	ID	0.055			**0.99**	**2.7**			**0.26**			**0.56**	**0.4**			**0.12**			**0.59**
Arsenic	mg/L	0.001	ID	0.013	<0.001		<0.001	<0.001			<0.001	0.002		<0.001	<0.001			<0.001	0.002		0.004
Beryllium	mg/L	0.001	ID	ID	<0.001							<0.001							0.001		
Barium	mg/L	0.001	ID	ID	0.016							0.015							0.014		
Cadmium	mg/L	0.0001	0.0007	0.0002	0.0002		<0.0001	<0.0001			<0.001	**0.0003**		<0.0001	<0.0001			<0.001	**0.0004**		<0.0001
Chromium (Total)	mg/L	0.001	0.0274	ID	0.003		<0.001	0.001				0.003		<0.001	<0.001				0.003		<0.001
Cobalt	mg/L	0.001	0.001	ID	0.01							0.009							**0.004**		
Copper	mg/L	0.001	0.0013	0.0014	<0.001		**0.003**	**0.006**			<0.001	<0.001		**0.003**	**0.002**			<0.001	**0.01**		**0.006**
Lead	mg/L	0.001	0.0044	0.0034	<0.001		<0.001	<0.001			<0.001	<0.001		<0.001	<0.001			<0.001	0.01		<0.001
Zinc	mg/L	0.005	0.015	0.008	**0.013**		**0.012**	**0.031**			<0.005	**0.012**		**0.023**	**0.009**			<0.005	**0.023**		**0.022**
Manganese	mg/L	0.001	ID	1.9	0.596							0.543							0.14		
Nickel	mg/L	0.001	0.007	0.011	0.01							0.009							0.006		
Vanadium	mg/L	0.01	0.1	ID	<0.01							<0.01							<0.01		
Total Iron	mg/L	0.005	ID	ID	0.75		0.71	2.48			0.30	0.42		0.49	0.52			0.11	<0.1		2.07
Mercury	mg/L	0.0001	0.0001	0.00006	<0.0001		<0.0001	<0.0001			<0.0005	<0.0001		<0.0001	<0.0001			<0.0005	0.0001		<0.0001
Weak Acid Dissociable Cyanide	mg/L	0.005	0.004	0.007	- - -							<0.0050							- - -		
Nutrients																					
Fluoride	mg/L	0.1			- - -							- - -							0.1	- - -	
Ammonia as N	mg/L	0.01	0.91	0.9	0.052	0.028	0.073	0.084	0.18	<0.02	0.25	0.096	0.031	0.047	0.02	0.17	0.02	0.19	0.048	0.282	0.53
Nitrate as N	mg/L	0.01	ID	0.7	<0.010	<0.010	0.026	0.014	<0.04	0.05	<0.04	<0.010	<0.010	<0.010	0.023	<0.04	0.09	<0.04	<0.010	0.062	<0.010
Nitrite as N	mg/L	0.01			<0.010		<0.010	0.013	<0.002	0.014	0.004	<0.010	<0.010	<0.010	<0.010	<0.002	0.014	0.005	0.014	<0.010	0.026
Total Kjeldahl Nitrogen as N	mg/L	0.10			0.80	0.60	2.40	2.20	0.84	0.53	0.63	0.70	0.50	0.90	0.60	0.86	0.48	0.47	1.80	1.00	2.30
Total Phosphorus as P	mg/L	0.01		0.05	0.04	0.01	**0.25**	**1.02**	<0.005	<0.005	<0.005	0.01	<0.010	0.02	<0.01	<0.005	<0.005	<0.005	**0.18**	**0.06**	**0.28**
Reactive Phosphorus	mg/L	0.01			<0.010	<0.01	<0.010	<0.010	<0.004	<0.004	<0.004	0.912	<0.010	<0.010	<0.010	<0.004	<0.004	<0.004	- - -	<0.010	<0.010
PH (lab)	pH Unit	0.01			- - -	6.17	6.72	6.33	7.20	7.00	6.80	- - -	6.90	6.71	6.68	7.00	7.00	6.90	- - -	6.80	6.87
Total Dissolved Solids (TDS)	mg/L	1			552	2460	646	1230	***4515.8***	***5808.9***	***3577.8***	- - -	1240	644	1730	***3912.8***	***5453.8***	***4127.2***	303	2330	18500
Electrical Conductivity	uS/cm	1							6740	8670	5340					5840	8140	6160			
Suspended Solids (SS)	mg/L	1			11	7		3				6	10		9				23	13	
Total Hardness	mg/L	1			164	- - -						- - -							73		
Major Ions																					
Calcium	mg/L	1			28		37				53	- - -						63	13		225
Magnesium	mg/L	1			20		26				93	- - -						110	10		587
Sodium	mg/L	1			87		134				669	- - -						789	39		4460
Potassium	mg/L	1			10		10				31	- - -						36	6		176
Bicarbonate as CaCO3	mg/L	1			2		31					- - -							10		90
Total Alkalinity	mg/L	1			2		31					- - -							10		90
Sulphate as SO4	mg/L	1			159		182				293	- - -						392	63		1200
Chloride	mg/L	1			130		212				1308	- - -						1684	64.5		8930
SAR																					
Calcium + Magnesium (meq/L)					3.04		3.99				10.29	- - -						12.19	1.47		59.51
Sodium (meq/L)					3.78		5.83				29.10	- - -						34.32	1.70		194.01
SAR= Na / Sqrt (Ca+ Mg) / 2)					1.23		1.41				2.27	- - -						2.47	0.86		5.46
SAR- Sodium Absorption Ratio					**3.07**		**4.13**				**12.83**	**- - -**						**13.90**	**1.98**		**35.57**
SAR Hazard Ranking					**Low**		**Low**				**Med**							**Med**	**Low**		**V High**

Note:

SAR Hazard ranking based on Fetter, 1994.

3 | 3 Exceeds ANZECC 2000 trigger values (marine and/or fresh water)

Low = 2 to 10, Med = 7 to 18, High= 11 to 26, V High= 26+

nr - no recommended NSW guidelines NA - Not Available

TDS= EC*0.67 (approximate) calculation in italics (Data from Sept to Dec05)

TABLE 1: Surface Water Analytical Results

Foys Swamp, Blue Angle Creek and Gerroa Sand Quarry

				Sample ID	BA Creek	BA Creek	BA Creek	BA Creek	SW Drain	SW Drain	SW Drain
Cleary Bros (Bombo) Pty Ltd	***Water Monitoring Program***			Sample ID	Blue Angle Creek	Blue Angle Creek	Blue Angle Creek	Blue Angle Creek	SW Drain	SW Drain	SW Drain
	Units	LOR	ANZECC 2000 Guidelines		Dry Weather	Dry Weather	Dry Weather	Dry Weather	Wet Weather	Dry Weather	Dry Weather
Metals (total)			Marine	Fresh	3/08/05	21/09/05	21/10/06	21/11/05	27/01/05	2/06/05	21/11/2005
Aluminium (PH>6.5,)	mg/L	0.0001	ID	0.055	**1.47**			**0.02**			
Arsenic	mg/L	0.001	ID	0.013	0.003			<0.001	0.004		
Beryllium	mg/L	0.001	ID	ID					<0.001		
Barium	mg/L	0.001	ID	ID					0.019		
Cadmium	mg/L	0.0001	0.0007	0.0002	<0.0001			<0.001	<0.0001		
Chromium (Total)	mg/L	0.001	0.0274	ID	0.001				0.003		
Cobalt	mg/L	0.001	0.001	ID					**0.002**		
Copper	mg/L	0.001	0.0013	0.0014	**0.008**			<0.001	**0.002**		
Lead	mg/L	0.001	0.0044	0.0034	<0.001			<0.001	<0.001		
Zinc	mg/L	0.005	0.015	0.008	**0.016**			<0.005	**0.412**		
Manganese	mg/L	0.001	ID	1.9					0.003		
Nickel	mg/L	0.001	0.007	0.011					<0.01		
Vanadium	mg/L	0.01	0.1	ID					<0.005		
Total Iron	mg/L	0.005	ID	ID	7.12			0.28	2.16		
Mercury	mg/L	0.0001	0.0001	0.00006	<0.0001			<0.0005	<0.0001		
Weak Acid Dissociable Cyanide	mg/L	0.005	0.004	0.007					- - -		
Nutrients											
Fluoride	mg/L	0.1							- - -		
Ammonia as N	mg/L	0.01	0.91	0.9	0.652	0.22	0.12	0.26	0.074	0.096	0.15
Nitrate as N	mg/L	0.01	ID	0.7	0.231	0.05	0.08	<0.04	<0.010	0.016	<0.04
Nitrite as N	mg/L	0.01			0.114	0.005	0.021	0.004	0.012	<0.010	0.11
Total Kjeldahl Nitrogen as N	mg/L	0.10			0.90	0.73	0.58	0.44	- - -	1.50	1.5
Total Phosphorus as P	mg/L	0.01		0.05	0.05	<0.005	<0.005	<0.005	**0.31**	**0.13**	0.05
Reactive Phosphorus	mg/L	0.01			<0.010	<0.004	<0.004	<0.004	- - -	0.123	0.043
PH (lab)	pH Unit	0.01			6.89	7.00	6.90	6.70	- - -	6.87	7.5
Total Dissolved Solids (TDS)	mg/L	1			3620	***3752***	***7624.6***	***4107.1***	203	243	520
Electrical Conductivity	uS/cm	1				5600	11380	6130			
Suspended Solids (SS)	mg/L	1			26				20		
Total Hardness	mg/L	1							52		
Major Ions											
Calcium	mg/L	1						63	10		
Magnesium	mg/L	1						111	7		
Sodium	mg/L	1						808	26		
Potassium	mg/L	1						37	7		
Bicarbonate as CaCO3	mg/L	1							39		
Total Alkalinity	mg/L	1							39		
Sulphate as SO4	mg/L	1						345	8		
Chloride	mg/L	1						1635	49		
SAR											
Calcium + Magnesium (meq/L)								12.27	1.07		
Sodium (meq/L)								35.15	1.13		
SAR= Na / Sqrt (Ca+ Mg) / 2)								2.48	0.73		
SAR- Sodium Absorption Ratio								**14.19**	**1.54**		
SAR Hazard Ranking								**Med**	**Low**		

Note:

SAR Hazard ranking based on Fetter, 1994.

Low = 2 to 10, Med = 7 to 18, High= 11 to 26, V High= 26+

nr - no recommended NSW guidelines NA - Not Available

TDS= EC*0.67 (approximate) calculation in italics (Data from Sept to Dec05)

TABLE 1: Surface Water Analytical Results

Foys Swamp, Blue Angle Creek and Gerroa Sand Quarry

				Sample ID	W Drain	W Drain	W Drain	NW Drain	NW Drain	NW Drain	NW Drain	NW Drain	NW Drain	Dredge Pond	Dredge Pond	Dredge Pond	Dredge Pond	Dredge Pond	Dredge Pond
Cleary Bros (Bombo) Pty Ltd	***Water Monitoring Program***			Sample ID	W Drain	W Drain	W Drain	NW Drain	NW Drain	NW Drain	NW Drain	NW Drain	NW Drain	MD Pond	MD Pond	MD Pond	MD Pond	MD Pond	MD Pond
	Units	LOR	ANZECC 2000 Guidelines		Wet Weather	Dry Weather	Dry Weather	Wet Weather	Dry Weather	Dry Weather	Dry Weather	Dry Weather	Dry Weather	Wet Weather	Dry Weather	Dry Weather	Dry Weather	Dry Weather	Dry Weather
Metals (total)			Marine	Fresh	27/01/2005	2/06/2005	21/11/2005	27/01/2005	2/06/05	3/08/05	21/09/05	21/10/05	21/11/05	27/01/05	2/06/05	3/08/05	21/09/05	21/10/05	21/11/05
Aluminium (PH>6.5,)	mg/L	0.0001	ID	0.055					**3.04**	**2.83**			**18**		**1.42**	**1.28**			**1.9**
Arsenic	mg/L	0.001	ID	0.013	0.003			<0.001	<0.001	<0.001			<0.001	0.004	0.003	0.002			<0.001
Beryllium	mg/L	0.001	ID	ID	<0.001			0.002						<0.001					
Barium	mg/L	0.001	ID	ID	0.03			0.028						0.01					
Cadmium	mg/L	0.0001	0.0007	0.0002	**0.0005**			**0.0003**	<0.0001	<0.0001			<0.001	0.0002	<0.0001	<0.0001			<0.001
Chromium (Total)	mg/L	0.001	0.0274	ID	0.003			0.002	<0.001	<0.001				0.004	0.002	0.001			
Cobalt	mg/L	0.001	0.001	ID	<0.001			**0.038**						<0.001					
Copper	mg/L	0.001	0.0013	0.0014	**0.025**			**0.003**	**0.002**	**0.004**			**0.002**	<0.001	**0.002**	**0.003**			<0.001
Lead	mg/L	0.001	0.0044	0.0034	0.001			<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001			<0.001
Zinc	mg/L	0.005	0.015	0.008	**0.072**			**1.72**	**0.035**	**0.019**			**0.053**	0.015	**0.05**	**0.012**			<0.005
Manganese	mg/L	0.001	ID	1.9	0.004			0.028						0.003					
Nickel	mg/L	0.001	0.007	0.011	<0.01			<0.01						<0.01					
Vanadium	mg/L	0.01	0.1	ID	**0.022**			0.045						<0.005					
Total Iron	mg/L	0.005	ID	ID	0.83			8.64	0.39	1.4			0.58	0.77	1.14	0.78			0.57
Mercury	mg/L	0.0001	0.0001	0.00006	<0.0001			**0.0016**	<0.0001	<0.0001			<0.0005	<0.0001	<0.0001	<0.0001			<0.0005
Weak Acid Dissociable Cyanide	mg/L	0.005	0.004	0.007	- - -			- - -						<0.0050					
Nutrients																			
Fluoride	mg/L	0.1			- - -			- - -						0.2					
Ammonia as N	mg/L	0.01	0.91	0.9	0.055	0.043	0.35	0.066	0.046	0.059	0.23	<0.02	0.31	0.063	0.038	<0.010	0.20	0.03	0.19
Nitrate as N	mg/L	0.01	ID	0.7	0.011	<0.010	<0.04	<0.010	0.301	<0.010	<0.04	<0.04	<0.04	0.023	<0.010	0.025	<0.04	0.04	<0.04
Nitrite as N	mg/L	0.01			<0.010	<0.010	0.022	<0.010	<0.010	<0.010	<0.002	0.014	<0.002	<0.010	<0.010	<0.010	0.034	0.022	0.027
Total Kjeldahl Nitrogen as N	mg/L	0.10			- - -	1.00	5.7	- - -	1.20	2.10	0.62	0.50	0.46	0.60	0.60	0.40	0.57	0.46	0.39
Total Phosphorus as P	mg/L	0.01		0.05	**0.18**	**0.12**	**0.4**	**0.08**	0.03	**0.35**	0.006	<0.005	<0.005	0.02	0.02	<0.01	0.014	0.026	<0.005
Reactive Phosphorus	mg/L	0.01			- - -	0.066	<0.004	- - -	<0.010	<0.010	<0.004	<0.004	<0.004	- - -	0.01	<0.010	<0.004	0.016	<0.004
PH (lab)	pH Unit	0.01			- - -	7.43	8.20	- - -	4.43	5.06	6.40	6.40	3.80	- - -	7.06	7.47	7.60	7.40	7.50
Total Dissolved Solids (TDS)	mg/L	1			306	220	720	914	406	410	***1742***	***2639.8***	***1815.7***	360	324	336	***406.69***	***425.45***	***589.6***
Electrical Conductivity	uS/cm	1									2600	3940	2710				607	635	880
Suspended Solids (SS)	mg/L	1			21			31		50				11		7			
Total Hardness	mg/L	1			103			212						- - -					
Major Ions																			
Calcium	mg/L	1			24			32	18				60	43	42				47
Magnesium	mg/L	1			10			32	17				65	12	11				14
Sodium	mg/L	1			41			123	78				257	46	42				51
Potassium	mg/L	1			7			10	4				12	4	4				5.2
Bicarbonate as CaCO3	mg/L	1			75			<1	<1					48	47				
Total Alkalinity	mg/L	1			75			<1	<1					48	47				
Sulphate as SO4	mg/L	1			32			264	140				533	109	104				134
Chloride	mg/L	1			61.1			166	110				445	65.5	71				82
SAR																			
Calcium + Magnesium (meq/L)					2.02			4.23	2.30				8.34	3.13	3.00				3.50
Sodium (meq/L)					1.78			5.35	3.39				11.18	2.00	1.83				2.22
SAR= Na / Sqrt (Ca+ Mg) / 2)					1.01			1.45	1.07				2.04	1.25	1.22				1.32
SAR- Sodium Absorption Ratio					**1.77**			**3.68**	**3.17**				**5.47**	**1.60**	**1.49**				**1.68**
SAR Hazard Ranking					**Low**			**Low**	**Low**				**Low**	**Low**	**Low**				**Low**

Note:

SAR Hazard ranking based on Fetter, 1994.

Low = 2 to 10, Med = 7 to 18, High= 11 to 26, V High= 26+

nr - no recommended NSW guidelines NA - Not Available

TDS= EC*0.67 (approximate) calculation in italics (Data from Sept to Dec05)

Table 4- Field Chemistry Measurements- Surface Waters

Dredge Pond, Foys Swamp and Blue Angle Creek

Water Body	Lab Sample ID	Field Sample ID	Date	Decription	pH	Redox (mV)	EC (uS/cm)	TDS (mg/L)- #	DO (%)	Temp	Comments
Main Dredge Pond	M.D.Pond	FC-13	24/01/2005	Clear water	6.19	222	503	337	65	27.5	Groundwater
	M.D.Pond	FC-13	27/01/2005	Clear water	6.15	265	562	377	70	24.9	
	M.D.Pond	FC-13	2/06/2005	Clear water	6.35	190	655	439	80	8.3	(EC=1614m at 1.2m, pH 7.47)
	M.D.Pond	FC-13	3/08/2005	Clear water	6.3	185	528	354	65	17.2	dry period, low water level
	M.D.Pond	FC-13	21/10/2005	Clear water	7.73	92	298	200	95	20.92	Enviromanagers
	M.D.Pond	FC-13	21/11/2005	Clear water	7.58	96	617	413	100	23.32	Enviromanagers
	M.D.Pond	FC-13	20/12/2005	Clear water	7.86	82	647	433	99	22.83	Enviromanagers
South Dredge Pond	S.D Pond	FC-14	27/01/2005	Clear, >1m depth, no visible flow, vegetated	6.49	142	237	159	39	24.5	Vegetated, collects runoff?
	S.D Pond	FC-14	31/01/2005	Clear, >1m depth, no visible flow, vegetated	5.58	311	222	149	98	30	Vegetated, collects runoff?
GW Drain-1		FC-23	24/01/2005	clear, no visible flow, >1.5m depth 5m wide,	5.17	233	769	515	20	23.9	water level ~0.5m bgl
		FC-23	27/01/2005	clear, no visible flow, >1.5m depth 5m wide,	5.8	337	747	500	31	26.1	water level ~0.5m bgl
		FC-23	2/06/2005	clear, no visible flow, >1.5m depth 5m wide,	6.38	136	1164	780	47	14.1	water level ~0.5m bgl
		FC-27	3/08/2005	clear, no visible flow, >1.5m depth 5m wide,	6.64	-8	764	512	75	13.6	dry weather, low drain level
		FC-23	21/10/2005		7.95	73	2437	1633	100	21.24	Enviromanagers
		FC-23	21/11/2005		7.5	97	1247	835	100	21.44	Enviromanagers
		FC-23	20/12/2005		7.06	113	900	603	88	21.69	Enviromanagers
GW Drain-2		FC-18	24/01/2005	clear, no visible flow, >1.5m depth 5m wide,	6.31	158	1505	1008	50	25.3	water level ~0.5m bgl
		FC-18	27/01/2005	clear, no visible flow, >1.5m depth 5m wide,	6.3	278	1546	1036	35	26	water level ~0.5m bgl
		FC-18	3/02/2005	clear, no visible flow, >1.5m depth 5m wide,	6.19	103	1104	740	40	25	water level ~0.2m bgl
		FC-18	2/06/2005	clear, no visible flow, >1.5m depth 5m wide,	6.38	134	946	634	55	14.3	water level ~0.5m bgl
		FC-18	3/08/2005	clear, no visible flow, >1.5m depth 5m wide,	5.9	107	4070	2727	60	14.7	dry weather, low drain level
		FC-18	31/01/2005	clear, no visible flow, >1.5m depth 5m wide,	5.23	227	1534	1028	65	28.4	wet weather
	GW Drain-2	FC-19	24/01/2005	clear, no visible flow, >1.5m depth 5m wide,	6.64	162	1579	1058	55	24.1	
	GW Drain-2	FC-19	4/02/2005	clear, no visible flow, >1.5m depth 5m wide,	6.29	155	967	648	37	19.3	clear water
		FC-8	28/01/2005	shallow ditch near trees	3.62	353	3090	2070	60	29	drainage ditch, no flow
		FC-8	3/02/2005	shallow ditch near trees	4.6	14	323	216	32	27	wet weather
		FC-9	28/01/2005	shallow ditch near trees	3.33	453	2590	1735	45	33	Heavy vegetation
		FC-9	31/01/2005	shallow ditch near trees	3.34	227	1776	1190	37	31	Heavy vegetation
		FC-9	3/02/2005	shallow ditch near trees	4.73	117	288	193	47	23	wet weather
		FC-15	3/02/2005	clear, no visible flow, >1.5m depth,5m wide.	5.99	100	865	580	33	22.8	water level ~0.2m bgl
	GW Drain-2	FC-18	21/10/2005		7.85	99	7857	5264	100	20.61	Enviromanagers
	GW Drain-2	FC-18	21/11/2005		6.89	28	6574	4405	100	21.41	Enviromanagers
	GW Drain-2	FC-18	20/12/2005		7.26	118	4821	3230	85	21.69	Enviromanagers
GW Drain-3	GW Drain-3	FC-16	24/01/2005	clear, no visible flow, >1.5m depth,5m wide.	6.14	159	1320	884	60	24.6	water level ~0.5m bgl
	GW Drain-3	FC-16	2/06/2005	clear, no visible flow, >1.5m depth,5m wide.	5.02	125	1137	762	60	14.7	water level ~0.5m bgl
	GW Drain-3	FC-16	3/08/2005	clear, no visible flow, >1.5m depth,5m wide.	3.82	156	4020	2693	70	14.8	dry weather, low drain level
	GW Drain-3	FC-16	21/10/2005		8.3	94	7875	5276	100	21	Enviromanagers
	GW Drain-3	FC-16	21/11/2005		6.46	46	7976	5344	100	22.04	Enviromanagers
	GW Drain-3	FC-16	20/12/2005		7.22	102	5871	3934	90	22.87	Enviromanagers

Table 4- Field Chemistry Measurements- Surface Waters

Dredge Pond, Foys Swamp and Blue Angle Creek

Water Body	Lab Sample ID	Field Sample ID	Date	Decription	pH	Redox (mV)	EC (uS/cm)	TDS (mg/L)- #	DO (%)	Temp	Comments
GW Drain-4		FC-20	24/01/2005	Shallow <0.2m dish drain, stagnant water	3.58	339	1795	1203	50	26.1	acid waters
		FC-20	27/01/2005	Shallow <0.2m dish drain, stagnant water	3.36	475	1131	758	45	30	acid waters, rusty on bank
		FC-20	2/06/2005	Shallow <0.2m dish drain, stagnant water	4.17	310	1438	963	73	17.37	acidic, rusty on bank
	GW Drain-4	FC-10	28/01/2005	shallow drain, no flow	3.03	381	4680	3136	15	35.1	drainage ditch, no flow
		FC-11	28/01/2005	shallow drain, no flow	3.83	390	1227	822	50	34	drainage ditch, no flow
	GW Drain-4	FC-10	21/10/2005		7.7	108	12310	8248	100	21.27	Enviromanagers
	GW Drain-4	FC-10	21/11/2005		3.76	362	923	618	100	23.79	Enviromanagers
	GW Drain-4	FC-10	20/12/2005	dry							
GW Drain-5	GW Drain-5	FC-26	27/01/2005	clear, no visible flow, >1.5m depth,5m wide.	6.79	356	2117	1418	50	28	clear water
	GW Drain-5	FC-26	3/02/2005	clear, no visible flow, >1.5m depth,5m wide.full	6.39	75	1563	1047	46	21.8	clear water, wet weather flow, full drain
	GW Drain-5	FC-26	2/06/2005	clear, no visible flow, >1.5m depth,5m wide.full	7.32	173	1554	1041	51	11.4	clear water
	GW Drain-5	FC-26	3/08/2005	clear, no visible flow, >1.5m depth,5m wide	6.63	192	3250	2178	60	14.6	dry weather, low water level
		FC-7	28/01/2005	south end of drain 5	6.23	99	505	338	100	24	groundwater, deep drain, clear water
		FC-7	31/01/2005	south end of drain 5	5.41	261	863	578	50	26	groundwater, deep drain, clear water
		FC-7	3/02/2005	south end of drain 5	5.85	89	1082	725	36	19.6	groundwater, deep drain, clear water
	GW Drain-5	FC-26	21/10/2005		7.57	129	8242	5522	96	21.33	Enviromanagers
	GW Drain-5	FC-26	21/11/2005		7.54	116	7289	4884	98	22.35	Enviromanagers
	GW Drain-5	FC-26	20/12/2005		7.54	109	5331	3572	76	23.09	Enviromanagers
Drain-6	GWDrain-6		3/08/2005	slight flow (1L/min)	6.93	103	2120	1420	75	14.3	dry weather, low water level
	GWDrain-6		2/06/2005	slight flow (1L/min)	7.11	156	1173	786	60	9.4	slow flow
	GWDrain-6		21/10/2005		7.71	109	2394	1604	100	21.68	Enviromanagers
	GWDrain-6		21/11/2005		7.86	102	1949	1306	100	21.21	Enviromanagers
	GWDrain-6		20/12/2005		7.75	100	2131	1428	72	19.26	Enviromanagers
SW Drain	SW Drain	FC-29	27/01/2005	Shallow drain (<1m), flowing (~1L/sec), heavy vegetation, cow dung	6.48	171	256	172	10	23.3	cow dung, odour, turbid, gw seepage
	SW Drain	FC-29	2/06/2005	Shallow drain (<1m), flowing (~1L/sec), heavy vegetation, cow dung	6.83	127	312	209	47	14.7	cow dung, odour, turbid, gw seepage
	SW Drain	FC-29	3/08/2005	Shallow drain (<1m), flowing No flow, heavy vegetation, cow dung	7.11	5	340	228	70	15.3	dry weather, low drain levels- stagnant
	SW Drain	FC-29	21/10/2005		7.65	87	465	312	92	20.66	Enviromanagers
	SW Drain	FC-29	21/11/2005		7.98	80	389	261	100	20.91	Enviromanagers
	SW Drain	FC-29	20/12/2005		7.6	82	373	250	81	17.36	Enviromanagers
W Drain	W Drain	FC-28	27/01/2005	3m wide, approx 1m deep, still water	7.08	185	417	279	38	22.8	slight turbid, brown, vegetated drain
	W Drain	FC-28	2/06/2005	3m wide, approx 1m deep, still water	7.49	120	448	300	70	17.4	slight turbid, brown, vegetated drain
	W Drain	FC-28	3/08/2005	3m wide, approx 1m deep, still water	7.4	11	440	295	75	15.8	slight turbid, brown, vegetated, stagnant
	W Drain	FC-28	21/10/2005	dry							
	W Drain	FC-28	21/11/2005		8.14	79	689	462	154	19.45	Enviromanagers
	W Drain	FC-28	20/12/2005		7.56	87	539	361	59	15.56	Enviromanagers

Table 4- Field Chemistry Measurements- Surface Waters

Dredge Pond, Foys Swamp and Blue Angle Creek

Water Body	Lab Sample ID	Field Sample ID	Date	Decription	pH	Redox (mV)	EC (uS/cm)	TDS (mg/L)- #	DO (%)	Temp	Comments
NW Drain	NW Drain	FC-3	27/01/2005	3m wide, approx 1m deep, still water, heavy vegetation	4.1	188	1103	739	16	24.2	still water, vegatation in drain, slight turbid
		FC-1	27/01/2005	shallow drain, no flow	3.54	355	1114	746	26	25.3	acid waters
		FC-2	27/01/2005	deep drain, no flow	3.22	462	1642	1100	40	25.8	acid waters
	NW Drain	FC-3	27/01/2005	deep drain, no flow	3.4	463	1390	931	28	26.5	acid waters
		FC-4	27/01/2005	deep drain, no flow	3.16	470	2099	1406	30	27.3	acid waters
		FC-5	27/01/2005	shallow drain, no flow	3.33	406	4810	3223	41	30	acid waters
	NW Drain	FC-3	2/06/2005	deep drain, no flow	4.81	258	720	482	47	12.7	Heavy vegetation
		FC-4	3/08/2005	deep drain, no flow	4.82	74	1918	1285	73	13.6	dry weather, low drain levels
	NW Drain	FC-3	3/08/2005	deep drain, no flow	4.98	81	672	450	65	14.6	dry weather, low drain levels
	NW Drain	FC-3	21/10/2005		6.91	128	3214	2153	67	21.32	Enviromanagers
	NW Drain	FC-3	21/11/2005		4.11	337	2079	1393	100	22.6	Enviromanagers
	NW Drain	FC-3	20/12/2005		6.56	90	1636	1096	79	21.22	Enviromanagers
Main Drain (up stream)	MDrain-1	FC-17	24/01/2005	clear, no visible flow, >1.5m depth,5m wide.	5.73	158	781	523	35	25.3	water level ~0.5m bgl
	MDrain-1	FC-17	27/01/2005	clear, no visible flow, >1.5m depth,5m wide.	5.42	276	805	539	34	26.6	water level ~0.5m bgl
	MDrain-1	FC-17	31/01/2005	clear, no visible flow, >1.5m depth 5m wide,	5.35	130	1034	693	61	28	wet weather
	MDrain-1	FC-17	2/06/2005	clear, no visible flow, >1.5m depth,5m wide.	6.38	136	1164	780	47	12.6	water level ~0.5m bgl
	MDrain-1	FC-17	3/08/2005	clear, no visible flow, >1.5m depth,5m wide.	6.3	26	2101	1408	33	13.2	dry weather, low drain levels
	MDrain-1	FC-17	21/10/2005		7.27	97	7293	4886	62	21.55	Enviromanagers
	MDrain-1	FC-17	21/11/2005		7.28	109	2506	1679	111	21.22	Enviromanagers
	MDrain-1	FC-17	20/12/2005		7.24	115	3192	2139	77	21.41	Enviromanagers
Main Drain (dn stream)	MDrain-2	FC-32	27/01/2005	clear, no visible flow, >1.5m depth,4m wide.	6.52	222	1309	877	24	27.8	water level ~0.5m bgl
	MDrain-2	FC-32	4/02/2005	shallow drain, no flow	5.5	180	960	643	35	19.3	clear water
	MDrain-2	FC-32	2/06/2005	moderately full	7.06	166	1194	800	42	10.9	clear water, drain almost full
	MDrain-2	FC-32	3/08/2005	clear water, no visible flow, >1.5m depth,4m wide.	6.98	112	2330	1561	63	14.1	clear water. Dry weather - low level
	MDrain-2	FC-32	21/10/2005		7.34	130	6827	4574	70	22.97	Enviromanagers
	MDrain-2	FC-32	21/11/2005		6.89	28	6574	4405	125	21.41	Enviromanagers
	MDrain-2	FC-32	20/12/2005		7.43	107	3485	2335	74	23.5	Enviromanagers
Large Dam	LD-2/ M Dam	FC-30	27/01/2005	Full dam next to Beach Rd, 300 MG capacity	7.01	160	154	103	50	24.8	slight turbid, brown.
	M Dam	FC-30	2/06/2005	Full dam next to Beach Rd, 300 MG capacity	8.42	162	177	119	95	17.2	slight turbid, brown.
	LD-2/ M Dam	FC-30	3/08/2005	Full dam next to Beach Rd, 300 MG capacity	6.12	78	170	114	80	14.5	slight turbid, brown.
	M Dam	FC-30	21/10/2005		8.32	62	294	197	100	20.09	Enviromanagers
	M Dam	FC-30	21/11/2005		6.77	95	186	125	100	22.55	Enviromanagers
	M Dam	FC-30	20/12/2005		7.73	80	194	130	100	21.85	Enviromanagers
Small Dams		FC-22	24/01/2005	clear, small, vegetated, <0.7m deep	6.35	199	87	58	50	27	very shallow, no flow.
		FC-21	24/01/2005	Clear water, dam next to Beach Rd, 10 MG capacity	6.4	200	232	155	65	25.8	~0.5 mbg, 50m by 50m, 3.5m deep
		FC-24	24/01/2005	Clear water, dam downhill of large dam	6.95	170	159	107	85	26.1	~0.5 mbg, captures leakage from large dam
		FC-31	24/01/2005	Clear water, small shallow dam next to Beach Rd, vegetated	6.15	216	143	96	55	25.3	Heavy vegetation
Blue Angle Creek (dn)	BA Creek	FC-25	31/01/2005	5-10m wide, next to flood gates	4.79	275	1351	905	26	25.8	slightly turbid, brown, wet weather
	BA Creek	FC-25	3/02/2005	5-10m wide, next to flood gates- moderate flow	6.69	392	392	263	50	26	slight-mod turbid, brown- wet weather flows
	BA Creek	FC-25	2/06/2005	5-10m wide, next to flood gates- moderate flow	6.7	174	21820	14619	43	15.5	high tide
	BA Creek	FC-25	3/08/2005	5-10m wide, next to flood gates- low flow	6.58	109	6320	4234	33	16.2	Low tide, mouth open, slight turbidity

Table 4- Field Chemistry Measurements- Surface Waters

Dredge Pond, Foys Swamp and Blue Angle Creek

Water Body	Lab Sample ID	Field Sample ID	Date	Decription	pH	Redox (mV)	EC (uS/cm)	TDS (mg/L)- #	DO (%)	Temp	Comments
	BA Creek	FC-25	21/10/2005		7.28	138	9981	6687	81	22.69	Enviromanagers
	BA Creek	FC-25	21/11/2005		7.15	85	5229	3503	92	21.35	Enviromanagers
	BA Creek	FC-25	20/12/2005		7.32	85	10460	7008	73	17.48	Enviromanagers
				Min	3.03	5	87	58	10	8	
				Max	8.42	475	21820	14619	154	35	
				Average	6.24	171	2353	1577	65	22	

Notes:

E2W Field Equipment Calibrated: Field Kit 90 FLMVSA (EnviroEquip Pty Ltd)

mbgl= metres below ground level

Enviromanagers conducted sampling from September 2005 onwards

Table 5- Groundwater Field Chemical Parameters

Cleary Bros - Beach Road, Berry.

Well ID	Date	Time	SWL (m bgl)	Stick up (m)	BOH (m bgl)	Volume Purged (L)	pH	Redox (mV)	EC (uS/cm)	TDS (mg/L)- #	DO (%)	Comments
New Wells (Jan 05)												period of wet weather and boggy ground
GW-A	3/02/2005	8.19 am	0.00	0.70	2.20	50	6.02	37	140	94	30	slight turbidity, brown, rapid recovery (high K), some sw ingress
	31/01/2005	1.30pm	0.10	0.70		1	6.82	95	337	226	4	trace H2S odour (field chem only)
	8/02/2005	9.30 am	0.30	0.70								excavation area
	28/04/2005	9.30 am	0.72	0.70	2.30							no field chem (lab analyses)
	2/06/2005	9.15 am	0.24	0.70	2.30							
	3/08/2005	12.15 pm	0.58	0.70	0.92	2						insufficient sample- slow recovery when purged
	21/11/2005	1pm	0.91	0.70			6.66	-29	555	372	67.4	Enviromanagers
	20/12/2005	2pm	0.96	0.70								Enviromanagers
GW-B	3/02/2005	8.19 pm	0.00	0.77	2.20	15	4.21	143	2228	1493	49	clear water, moderate recovery, some sw ingress
	31/01/2005	2.30pm	0.00	0.77		1	4.17	302	3460	2318	15	slight turbidity, brown
	15/02/2005	2.00 pm	0.70	0.77								water level measured during dry period
	2/06/2005	11.30am	0.60	0.77								
	3/08/2005	2.20pm	0.48	0.77	1.98	2	5.31	-36	3310	2218	10	turbid, H2S odour
	21/11/2005	11am	0.63	0.77			4.27	30	2806	1880	65	Enviromanagers
	20/12/2005	2.50pm	0.63	0.77								Enviromanagers
GW-C	4/02/2005	8.30am	0.00	0.73	2.20	8	3.75	200	7540	5052	28	slightly turbid- brown, slow gw recovery
	15/02/2005	2.00 pm	0.71	0.73								water level measured during dry period
	28/04/2005	11.30am	0.49	0.73	2.20							no field chem (lab analyses)
	2/06/2005	11.40am	0.48	0.73								
	3/08/2005	2.30pm	0.58	0.73	2.58	2	5.5	-108	7690	5152	9.5	turbid, H2S odour
	21/11/2005	1.30am	0.58	0.73			4.55	28	6114	4096	56.7	Enviromanagers
	20/12/2005	3pm	0.71	0.73								Enviromanagers
GW-D	4/02/2005	9.00am	0.00	0.50	2.20	10	3.81	232	7510	5032	14	test
	15/02/2005	2.15 pm	0.77	0.50								water level measured during dry period
	2/06/2005	3.20pm	0.49	0.50								
	3/08/2005	1.40pm	0.60	0.50	2.13	2	5.81	-23	3510	2352	8	turbid water, slow recovery
	21/11/2005	11am	0.76	0.50			3.91	103	3267	2189	40.7	Enviromanagers
	20/12/2005	3.30pm	0.93	0.50								Enviromanagers
GW-E	4/02/2005	9.40am	1.40	0.71	2.03	1	4.27	193	2560	1715	30	mod turbid - brown, v slow gw recovery
	15/02/2005	3.00pm	1.41	0.71								higher ground
	2/06/2005	3.30pm	0.58	0.71								
	3/08/2005	2.00pm	0.63	0.71	1.97	2	5.62	-33	3730	2499	10	turbid water, slow recovery
	21/11/2005	11.20am	0.91	0.71			4.67	63	4126	2764	51.4	Enviromanagers
	20/12/2005	4pm	1.04	0.71								Enviromanagers
GW-F	3/08/2005	12.30pm	0.42	1.15	1.77	2	6.14	122	502	336	33.3	turbid water, slow recovery
	28/04/2005	9.30am	0.58	1.15	1.77							dry weather
	2/06/2005	10.10am	0.21	1.15								
	21/11/2005	1.10pm	0.68	1.15			6.4	5	545	365	77.3	Enviromanagers
	20/12/2005	4.30pm	0.81	1.15								Enviromanagers
GW-G	28/04/2005	9.45 am	0.62	1.15	1.32							dry weather
	2/06/2005	10am	0.18	1.15								
	3/08/2005	1.00pm	0.55	1.15	1.32	2	6.86	89	630	422	25	turbid water, slow recovery
	21/11/2005	4:48	0.77	1.15			6.98	-86	400	268	36.9	Enviromanagers
	20/12/2005	1pm	0.88	1.15								Enviromanagers
Existing Wells												
MW-2R	28/04/2005	12.30pm	0.60	0.66	1.22							dry weather
	3/08/2005	11.45am	0.70	0.66	1.22	2	NA					insufficient sample- slow recovery when purged
	21/11/2005		dry	0.66								
	20/12/2005	2pm	dry	0.66								Enviromanagers
MW-1#	3/02/2005	3.00pm	0.61	0.23	3.85	10	6.27	74	452	303	19.9	Very turbid, grey (frogs inside well)

Notes:
E2W - Field parameters (ph, EC etc) noted are at end of purging and start of sampling.
E2W Field Equipment Calibrated: Field Kit 90 FLMVSA (EnviroEquip)
SWL= standing water level
BOH= bottom of bore
mbgl= metres below ground level
TDS = EC*0.67 (approximate)

APPENDIX B
ASSMP

APPENDIX B
ACID SULPHATE MANAGEMENT PLAN
PROPOSED NORTHERN EXTENSION OF GERROA SAND QUARRY
GERROA AND BEACH ROADS, GERROA

1. INTRODUCTION

Coastal, low-lying alluvial soils, lying below about RL 5, generally contain framboidal pyrite or other sulphides. These are rounded, microbially generated microscopic mineral grains, which are stable in soils below the water table, or in dense clay-rich soils that are periodically re-wetted. In such situations[1] where the sulphides are kept out of contact with air, they are relatively stable, and generally in "equilibrium" with the local environment. Soils, which have appreciable pyrite or other sulphides which have not yet reacted significantly with air, are referred to as Potential Acid Sulfate Soils, or PASS.

If such sulphide-bearing or pyritic soils are disturbed by excavation, thereby allowing ready access of oxygen to the sulphides from air, a spontaneous or irreversible natural oxidation reaction takes place. This results in the generation of sulphuric acid or acid sulphates. (Pyritic soils, which have begun to generate acid, are referred to as Actual Acid Sulfate Soils or AASS). The acid is transported by water, and if allowed to build up sufficient concentration, poses a direct environmental threat to organisms that come in contact with such waters.

Additionally, increasingly acidic waters can dissolve many metal ions which would otherwise remain insoluble and hence not available for uptake by organisms. These ions comprise aluminium and iron, plus a suite of heavy metals such as zinc, lead and cadmium, which at elevated levels can be toxic to plants, animals and humans.

The measure of acidity in waters is pH; pure therefore neutral water has a pH of 7; pH values below 7 are acidic, pH values above 7 are basic or alkaline. A decrease of 1 pH unit represents a 10-fold increase in the concentration of dissolved hydrogen ions, which is what produces acidity. Further, the pH scale is not linear; the change in pH of a natural body of water from 5 to 4 is 10 times as undesirable as a change from 6 to 5; the change from 5 to 3 is 100 times as undesirable.

Most organisms can cope with pH in the range 5.5 to 8.5 - pH values in natural waters below 5 are undesirable; below 4, they are unacceptable.

This acid sulfate soil management plan (ASSMP) is aimed at remediating or controlling the generation of acid sulfates during the excavation of (actual and potential) acid sulfate soils.

The key to optimal performance in managing the acid sulfate soil risk, and minimising the impact on the environment, is to comprehensively assess the spatial nature <u>before</u> any excavation is commenced. Only in this way can the ASS risk be best quantified, and the appropriate remediation procedure formulated (and incorporated into the staged ASSMP).

Attention is drawn to the fact that ASS testing generally requires 5 to 10 working days, and therefore should not be left to the last minute. The above does not reduce the need for monitoring during and after construction.

A clear line of communication and command should be set up, so that non-compliances, or performance below defined guidelines, can be immediately reported to the Cleary Bros (Bombo) Pty Ltd (CB) project manager (PM), who in turn can issue relevant directives to rectify the situation. Note however, that this does not preclude the independent monitoring consultants from direct communication with the CB site staff.

It is considered that lengthy, overly complicated and generalised ASSMPs are more difficult to comprehend and carry out, and may leave too many interpretations and decisions to the contractors. This ASSMP template, for implementation of dredging, associated disposal of reject materials and restoration and it is therefore brief and focused, with little left for interpretation.

RESPONSIBILITIES OF THE OPERATOR

2.1 The operator (CB) is responsible for the correct implementation of the ASS management protocols presented in this ASSMP. The CB site staff is not empowered to vary any of the listed specific procedures in Section 5, unless explicit written approval has been given by the PM.

Where ambiguity or conflict exists as to the procedure to be followed, it is the CB site staff's responsibility to seek clarification from the PM, in writing if necessary.

2.2 With respect to ASS management, CB site staff is responsible for a degree of self-monitoring, to a level and schedule agreed to in writing with the PM, or to that stated in the individual protocols of Section 5. Daily logs of such monitoring will be kept by the contractor, and signed copies will be forwarded to the PM weekly, or as requested.

It is the responsibility of CB site staff, independent monitoring consultants (as applicable) to inform the PM immediately on discovery of non-compliances or exceedence and with the latter's approval, to implement immediate remedial measures.

It is expected that independent monitoring consultants will inspect the site on both a regular and random basis, and carry out such sampling and/or in-situ measurements as are necessary to check compliance with the ASSMP.

The requirements of ASS management are in addition to, but do not override any other standard procedures such as safety considerations. Where conflict results, or may result from, the implementation of ASS management as against other performance criteria, it is the CB site staff's responsibility to obtain directives from the PM.

3. WATER AND LEACHATE MONITORING AND DISCHARGE

If left unmanaged, the acidity and heavy metal contamination of pyritic ASS and PASS materials is generated in, and transported by water. Such waters can contaminate both groundwater and surface waters, eventually entering rivers and estuaries.

The aim of the ASSMP is to minimise the impact on the environment and to ensure that ASS leachate, which enter and mix with natural waters, meet acceptable guidelines. In addition, one of the measures of the performance of the management procedures lies in the water quality of leachate and surface runoff from processed sand stockpiles, and the quality of local groundwater into which leachate have mixed. Monitoring of the water mass up-gradient, within and downstream of the dredge pond will be required to demonstrate that target criteria are met.

Although the volume of the dredge pond and bunded nature of the quarry area is expected to be sufficient to contain runoff from processed sand stockpiles and direct rainfall to the pond surface during even heavy or sustained rainfall, there is very limited potential for discharge during flooding events (infrequent) of Foys Swamp. While such discharges will enter natural waterways and they will be diluted, it is still a requirement of the ASSMP that water quality be as good as possible prior to discharge. Management by natural dilution is not acceptable.

It is for the above reasons that water quality in the dredge pond be kept as good as practicable at all times. In this way, even unexpected heavy rainfall presents no immediate problem for leachate overflows.

3.1 Target water quality of dredge pond

pH between 6.5 and 9
Dissolved oxygen (DO) > 6 mg/L (> 80 – 90% saturation)
Total dissolved solids (TDS) < 1500 mg/L
Total suspended solids < 50 mg/L
Fe (total) < 0.5 mg/L and Al (total) < 0.055 mg/L for pH > 6.5.

(Note: natural concentrations of Fe in the surface water in adjacent drains, canal and groundwater are expected to be in excess of the target range; however operations should be managed to maintain values are within natural ranges).

3.2 Target main canal and Blue Angle Creek water quality

pH <0.2 unit change
Total dissolved solids (TDS) >1 500 mgL
Dissolved oxygen (DO) >6 mg/L.

3.3 Monitoring frequency

Unless otherwise indicated in the specific protocols of Section 5, the general rule here is to monitor daily all those temporary processed sand stockpiles from which leachate is weeping. This monitoring is continued until a time trend is built up demonstrating targeted performance of the sand processing methodology (at which time monitoring frequency can be progressively decreased) or until leachate flow has ceased.

After all but the lightest rainfall, all stockpiles should be inspected and the leachate tested. As well, all stockpiles should be inspected on Mondays to record the results of any rain events that occurred over the weekends. Weekly measurements of water quality in the dredge pond should also be carried out.

Monitoring of water quality within the dredge pond should be carried out on a weekly basis while monitoring of downstream water bodies and groundwater monitoring bores should be carried out monthly, with a progressive reduction in monitoring frequency once time trends are established. Monitoring of the downstream waters should continue for a period of two years after completion of quarrying.

A written log of results should be kept, and passed weekly to the PM.

3.4 Discharges from dredge pond

Discharges (considered unlikely) of water, complying with quality criteria, from the dredge pond should be controlled. Water quality should be checked several days before projected discharge, to allow for any additional remediation if required. The pH and DO should also be checked just prior to discharge.

4. NEUTRALISING MATERIALS

4.1 Medium-fine aglime will be used for lining of processing/stockpile areas and potential for co-interment or as a layer of neutralising agent at the fines-water interface in the reject material disposal areas within the base of the dredge pond. Dolomitic aglime, or magnesium-blend aglime, should not be used. The aglime grind should have at least 85% by weight passing 1 mm, and 100% passing 2.5 mm; in general a finer grind is better.

The aglime purity should preferably be 90% or better, (that is, NV>90), unless there is a significant savings to be made by use of less pure aglime. In the latter case, however, the individual lime dosing rates as listed in the next sections will need to be increased by a factor of 90/NV.

The requirement for greater amounts of aglime of lower purity should be borne in mind when assessing the supplies of this material, as the cost savings from less pure material may be offset by the need for more, and correspondingly higher total transport costs.

It is recommended that an aglime dump is set up at the site. Aglime is non-corrosive, and requires no special handling - it may be necessary to cover the stockpile with a tarpaulin to prevent it blowing away by strong winds, and from wetting, since it is then more difficult to spread.

4.2 in general, ponded leachate from excavated and processed (PASS) sands should not be appreciably acidic, since the management protocols have been formulated to prevent buildup of acidity. However, unforeseen events such as intersection of high sulphide content feed materials may result in the stockpiling of sand with unacceptable for use as a concrete aggregate. If left to oxidise, especially over weekends, there may be production of leachate which have unacceptable acidity; i.e. a pH less than 5.

In the above instance, and in cases where ponded leachate needs ‘finishing’ before discharge to the dredge pond, a calcium hydroxide solution may be used for rapid neutralisation. This may be made from slaked lime, or from quicklime, by stirring about 0.3 kilogram of either into water, in a container of sufficient volume such as a used plastic 200 litre drum. The slurry should be allowed to settle, and the clear solution (which will be caustic, with a pH of around 12.2) can be pumped or sprayed into the standing water in small amounts, with some agitation and monitoring, until the pH is brought to acceptable levels. <u>Do not overdose</u>.

It is recommended that the operator always have several bags of quicklime or slaked lime on hand, with necessary equipment to make, transport and apply the hydroxide solution as required.

Quicklime is very reactive and quite corrosive (caustic) - special handling and safety procedures are required. When mixed with water, reaction generates much heat, so that the 0.3 kg amount should be added slowly to a large amount of water.

5. MANAGEMENT OF EXCAVATION AND PROCESSING/STOCKPILE AREAS

5.1 The discharge point at the southwestern section of the existing dredge pond should be maintained at current levels which have resulted in no previous requirement for discharge.

5.2 Select a processing/stockpile site adjacent to a deeper (preferably > 4 m) section of the dredge pond suitable for reburial of reject materials.

5.3 Prepare a processing/stockpile site (one of more area of sufficient size to treat sandy materials at the proposed excavation rate and to store sufficient for aggregate for the period required to carry out verification testing). The area should be on gently sloping ground with a natural or engineered fall to a drain for return of dredge water and any leachates to the dredge pond. <u>Do not excavate the processing/stockpile site</u> as the underlying sandy profile is expected to be permeable and as such, the preparation of the area will require the placement of a select clayey layer (minimum 300 mm thick) or a plastic liner to prevent infiltration of any leachate. Lime the base of the pad (a guard layer) 5 kg/m^2 per metre height of the expected processed sand stockpile.

5.4 Bund off the processing/stockpile area to prevent runoff to areas other than the dredge pond using clayey, non-ASS material.

5.5 Monitor leachate from stockpile areas daily, testing for pH (should not fall below 5.5). If there are weeping points for any acidic leachate which has washed away the aglime, add extra lime aggregate to flow path.

5.6 Continue to monitor leachate weeping points and ponded leachate daily, until no more leachate is generated. If ponded leachate pH falls slightly below 5.5, add aglime directly over the surface of the leachate drain. In the unlikely event that pH falls significantly, neutralisation with calcium hydroxide solution may be required. The intent of this treatment is to minimise changes to the dredge pond water quality.

5.7 Following any rain, recommence the monitoring cycle, and treat accordingly.

5.8 Progressively test (SPOCAS method) in a NATA registered laboratory the processed sand at an initial rate of 1 sample per 1000 m^3 or additionally if required for verification of suitability for use as concrete aggregate.

5.9 If testing indicates unacceptable sulphide content in processed sand, re-process (potentially requiring variation in the processing methodology) and verify acceptable values have been obtained.

6. REBURIAL OF TREATED REJECT MATERIAL

6.1 Select and record locations of areas (water depth preferably > 4 m over emplaced material) for reburial of sulphidic fines and PASS clay from Unit 3.

6.2 Sluice or pump processing fines to emplacement area.

6.3 If clay from Unit 3 cannot be reburied below water within 2 days, retain the material on prepared liming/treatment pads for classification of the material and treatment prior to final reburial.

6.4 Monitor water quality (vertical profile) over emplacement site within the dredge pond.

6.5 If oxidation of reburied material is indicated and posing a risk to water quality within the dredge pond, investigate and institute appropriate remedial measure (e.g. spreading of fine ground aglime or capping with sand layer).

6.6 Continue current monitoring of dredge pond water quality to verify that the burial has not environmental effects. Monitoring should be continued for at least two years following completion of quarrying and remedial works instituted if appropriate.

6.7 All records applicable to acid sulphate testing and treatment shall be collated to substantiate treatment.

7. CONTINGENCY PLANNING

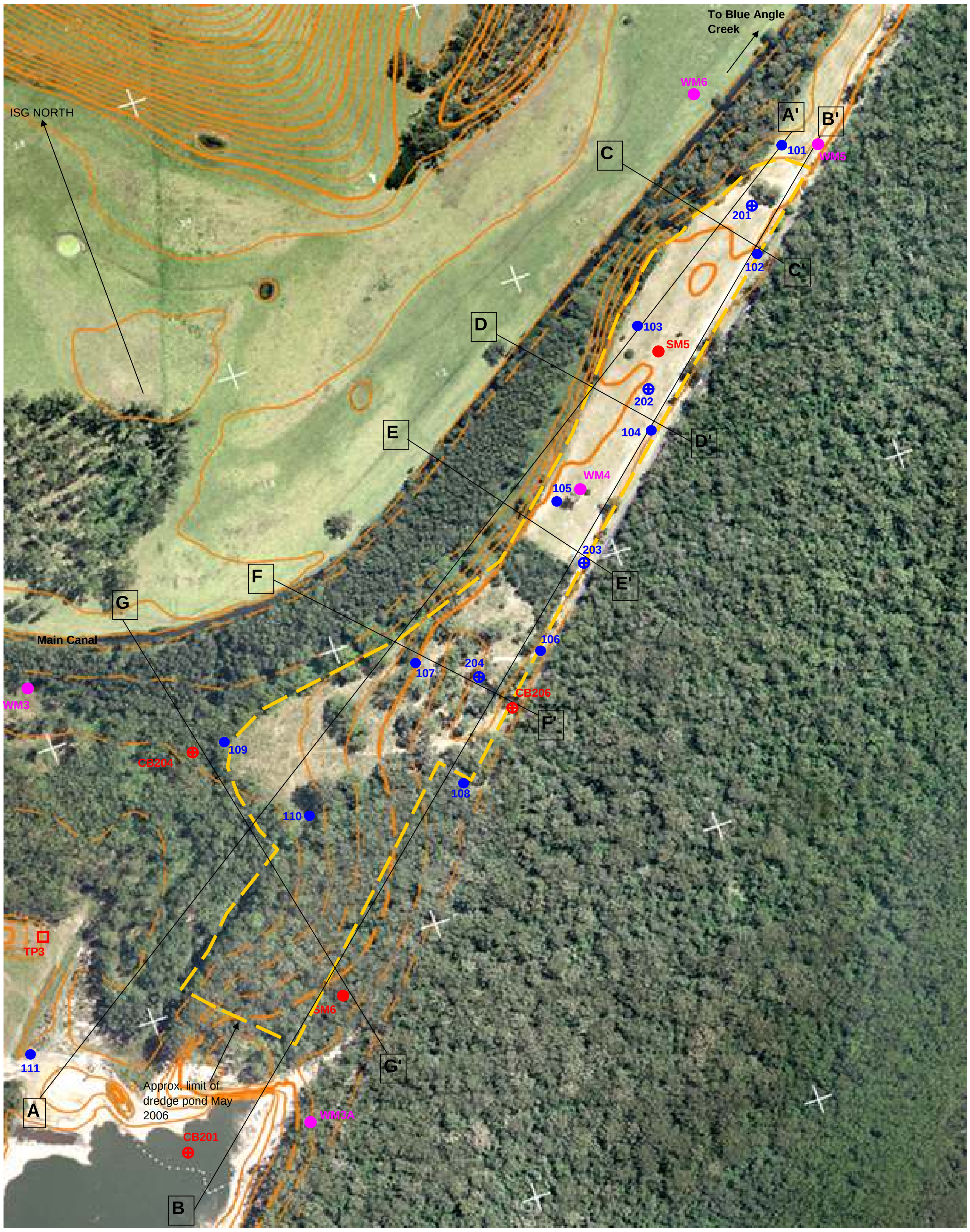
Contingency measures are included within the quarrying, monitoring, processing, treatment, restoration and reporting protocols detailed above. These protocol are designed to provide an early detection of a non-conformance and a consequent corrective action.

Any modification of the protocols required to meet unexpected conditions shall be agreed to by the PM. Monitoring shall be used to confirm the effectiveness of any changes.

The principal contingency during the operational and restoration phases of quarrying is by control of water quality of the dredge pond and timing of any discharge from the site. The discharge of water/leachate will be halted where a non-conformance is identified, the source investigated and corrective actions implemented.

The preparation of processing and stockpile areas, including the placement of lime layers below these areas, will provide a contingency against leachate passing through the subgrade without having been monitored and treated if required.

DRAWINGS



0m 250m
SCALE

LEGEND

- TEST PIT (CLEARY BROS)
- BORE (CLEARY BROS)
- BORE (DEPARTMENT OF MINERAL RESOURCES)
- CONE PENETRATION TEST (DOUGLAS PARTNERS)
- BORE (DOUGLAS PARTNERS)
- SURFACE CONTOUR (1m INTERVAL)
- APPROXIMATE OUTLINE OF PROPOSED SAND QUARRY APPLICATION
- GROUNDWATER MONITORING BORE (APPROX. LOCATION ONLY)

NOTE: FOR DETAILS OF SECTIONS A-A' & B-B' SEE DRAWING 3
FOR DETAILS OF SECTIONS C-C' TO G-G' SEE DRAWING 4

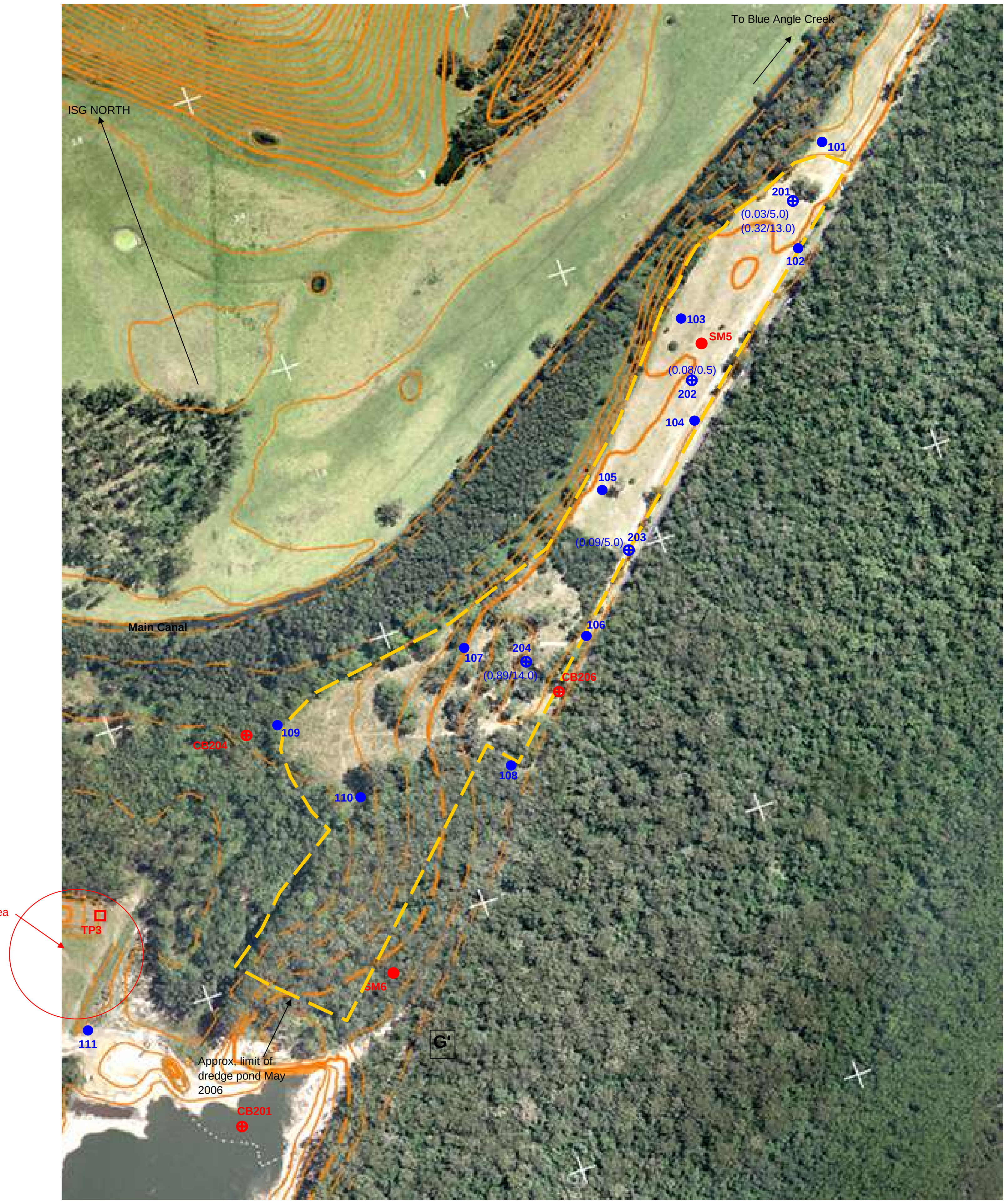
Douglas Partners
Geotechnics - Environment - Groundwater

Sydney, Newcastle, Brisbane Melbourne, Perth, Wollongong Campbelltown, Cairns, Darwin Townsville

Title

LOCATION OF INVESTIGATION
PROPOSED NORTHERN EXTENSION
ACID SULPHATE SOIL MANAGEMENT PLAN
GERROA SAND QUARRY
GERROA

Client:	CLEARY BROS (BOMBO) PTY LTD				
Drawn By: GRW	Scale: As shown	Project No.	37673B	Office:	Sydney
Approved By:	GRW	Date 5/05/2006	Drawing No.	1	



D1 - D16 this area
D8 (0.31/1.7)
D10 (0.71/1.9)
D13 (0.60/1.4)
D16 (1.98/3.8)

0m ← SCALE → 250m

LEGEND

(0.02/0.1)	Scr% / depth at top of test interval
(0.21/1.4)	Spos% / depth at top of test interval
AASS	Actual acid sulphate soil
□	TEST PIT (CLEARY BROS)
⊕ (red)	BORE (CLEARY BROS)
● (red)	BORE (DEPARTMENT OF MINERAL RESOURCES)
● (blue)	CONE PENETRATION TEST (DOUGLAS PARTNERS)
⊕ (blue)	BORE (DOUGLAS PARTNERS)
— — (orange)	SURFACE CONTOUR (1m INTERVAL)
— — (yellow)	APPROXIMATE OUTLINE OF PROPOSED SAND QUARRY APPLICATION

NOTE: FOR DETAILS OF SECTIONS A-A' & B-B' SEE DRAWING 3
FOR DETAILS OF SECTIONS C-C' TO G-G' SEE DRAWING 4

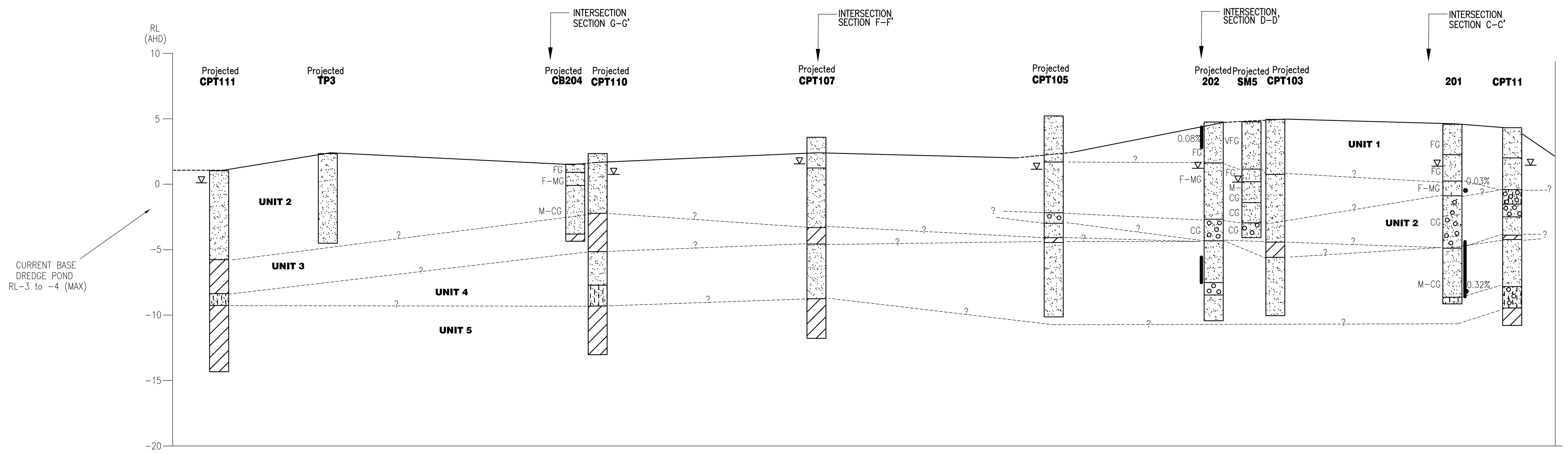
Douglas Partners
Geotechnics · Environment · Groundwater

Sydney, Newcastle, Brisbane
Melbourne,Perth, Wollongong
Campbelltown, Cairns, Darwin
Townsville

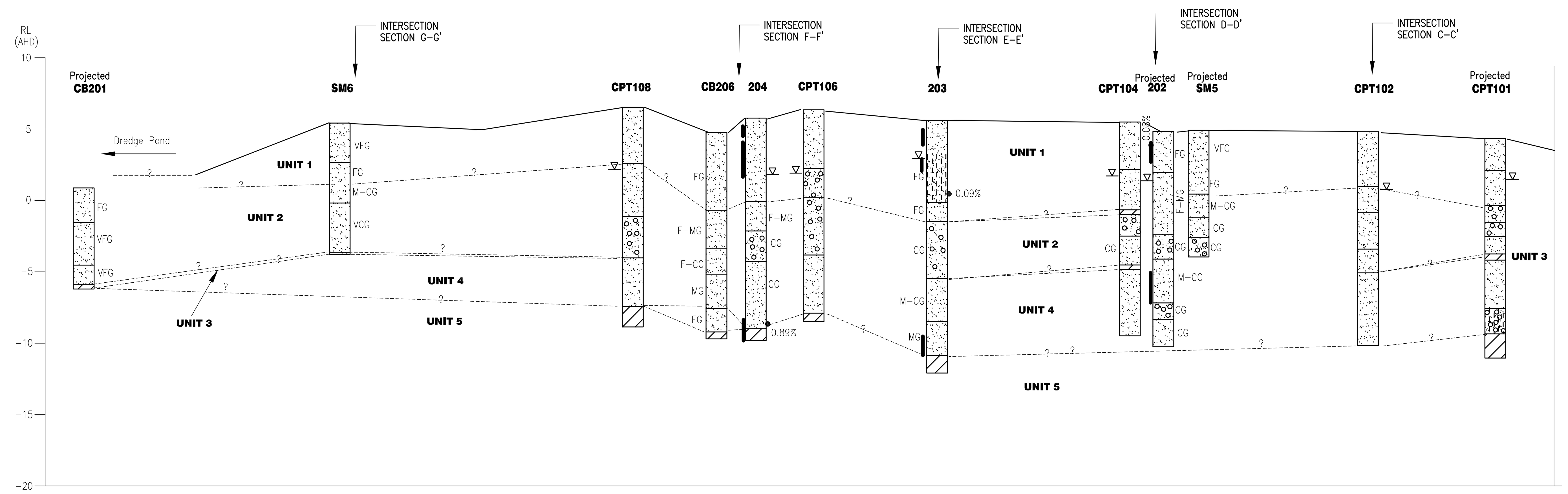
Title
SUMMARY OF ACID SULPHATE LABORATORY TESTING
PROPOSED NORTHERN EXTENSION
ACID SULPHATE SOIL MANAGEMENT PLAN
GERROA SAND QUARRY
GERROA

Client:	CLEARY BROS (BOMBO) PTY LTD						
Drawn By:	GRW	Scale:	As shown	Project No.	37673B	Office:	Sydney
Approved By:	GRW			Date	5/05/2006	Drawing No.	2

P:\37673B GERROA, Acid Sulphate Management Plan Gerroa Quarry GRW\Drawings\37673B-3.dwg, 5/25/2006 10:16:38 AM



SECTION A-A'



SECTION B-B'

LEGEND

- SAND
- SILTY SAND
- SANDY CLAY
- CLAY
- SANDY GRAVEL/GRAVELLY SAND
- SILTY SAND GRAVEL
- POSITIVE FIELD SCREENING RESULTS
- ●0.09%=%Spos

VFG VERY FINE GRAINED
FG FINE GRAINED
MG MEDIUM GRAINED
CG COARSE GRAINED

WATER LEVEL
INTERPRETED BOUNDARY

SCALE 0 5 10 15m
1:250 Vertical
10x Vertical Ex.

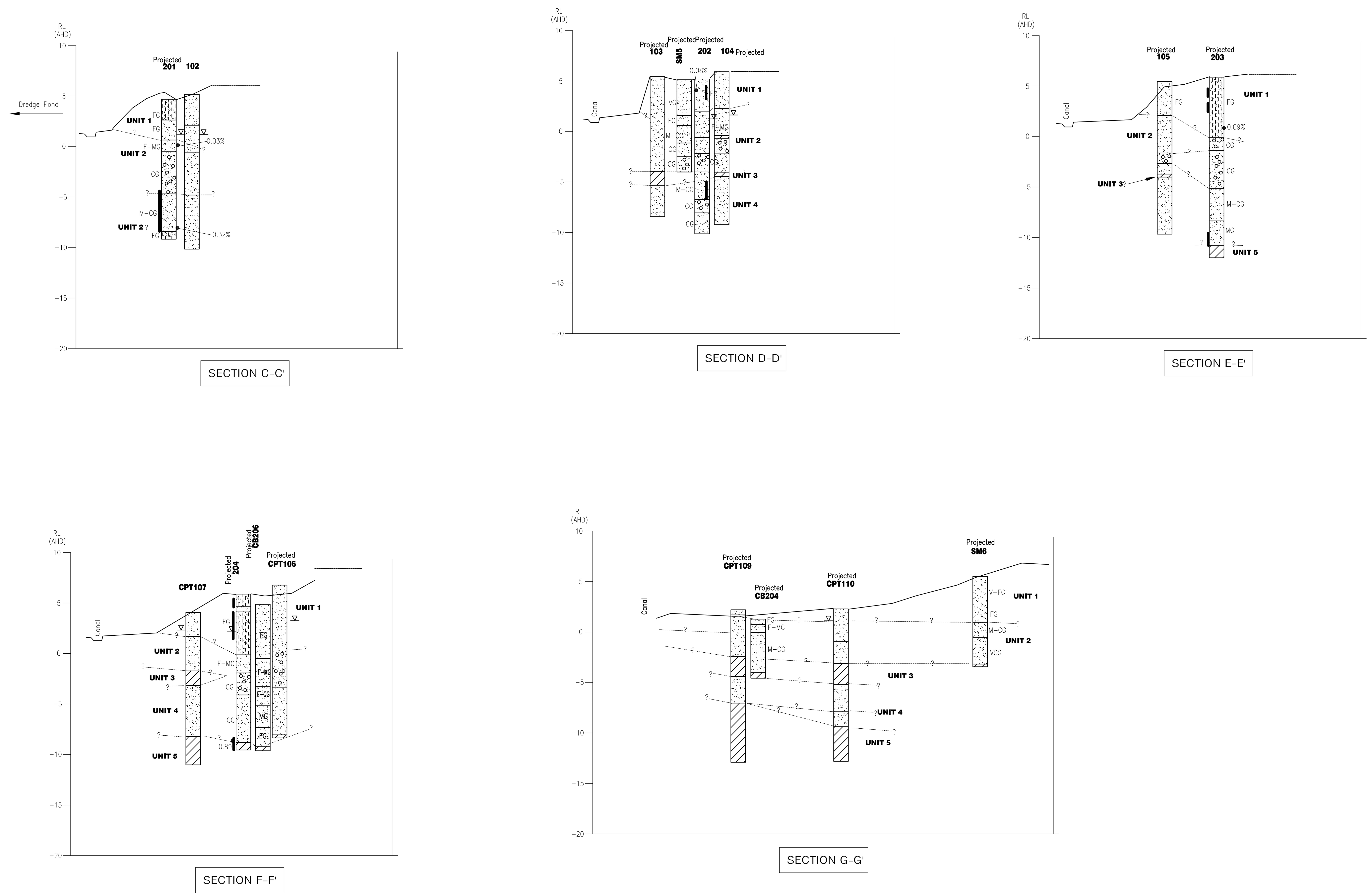
SCALE 0 50 100m
1:1250 Horizontal

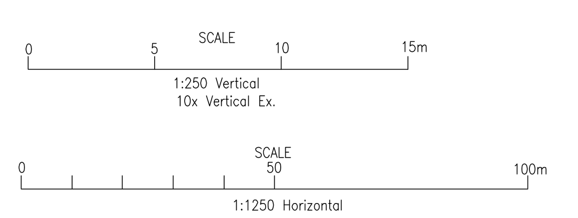
NOTE: FOR LOCATIONS OF SECTIONS A-A' & B-B' SEE DRAWING 1

Douglas Partners
Geotechnics, Environment, Groundwater
Sydney, Newcastle, Brisbane, Melbourne, Perth, Darwin, Wyong, Campbelltown, Townsville, Cairns, Wollongong

TITLE: Geological Sections A-A' & B-B'
Proposed Northern Extension
Acid Sulphate Management Plan
Gerroa Sand Quarry
GERROA

CLIENT: Cleary Bros (Bombo) Pty Ltd			
DRAWN BY: PSCH	SCALE: As shown	PROJECT No: 37673B	OFFICE: SYDNEY
APPROVED BY:		DATE: 8.5.2006	DRAWING No: 3





LEGEND

- SAND
- SILTY SAND
- SANDY CLAY
- CLAY
- SANDY GRAVEL/GRAVELLY SAND
- SILTY SAND GRAVEL
- POSITIVE FIELD SCREENING RESULTS
- ●0.09%=%Spos

VFG VERY FINE GRAINED
FG FINE GRAINED
MG MEDIUM GRAINED
CG COARSE GRAINED

WATER LEVEL
– – –?– – – INTERPRETED BOUNDARY

NOTE: FOR LOCATIONS OF SECTIONS C-C' TO G-G' SEE DRAWING 1

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Geotechnics, Environment, Groundwater
Sydney, Newcastle, Brisbane, Melbourne, Perth, Darwin, Wyong, Campbelltown, Townsville, Cairns, Wollongong

TITLE:
Geological Sections C-C' TO G-G'
Proposed Northern Extension
Acid Sulphate Management Plan
Gerroa Sand Quarry
GERROA

CLIENT: Cleary Bros (Bombo) Pty Ltd			
DRAWN BY: PSCH	SCALE: As shown	PROJECT No: 37673B	OFFICE: SYDNEY
APPROVED BY:		DATE: 8.5.2006	DRAWING No: 4