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Goulburn Murray Water
Report for Lake Moodemere
Water Savings Impact
Assessment
Acid Sulphate Soil
Assessment
January 2010



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1. Introduction

Goulburn-Murray Water (G-MW) commissioned GHD Pty Ltd (GHD) to undertake an acid sulphate soil assessment at the site of the proposed pipeline and regulating structure associated with The Lake Moodemere water savings upgrades in accordance with the Draft Coastal Acid Sulphate Soil Strategy (DSE 2008).

This report documents the works undertaken and the outcomes of the investigation.

1.1 Proposed Development

The project area includes the assessment of three sections of infrastructure;

1. Pipeline: a pipeline to divert water from the Murray River to Sunday Creek;
2. Regulator: a proposed regulator situated on Lake Moodemere; and
3. Track: an access track in private and public land to the Lake Moodemere regulator site.

The pipeline alignment is located between the Murray River and Sunday Creek and is predominantly located within an existing power line easement. Sections of the pipeline are located outside this easement within the land surrounding the Murray River. The pipeline is 400 metres in length using 400-450mm diameter pipe and will be laid at a depth of 1 meter (approx. 600mm of cover).

Also associated with this project is the construction of a regulator located between Sunday Creek and Lake Moodemere at a site known as Hell's Gate. The current designed regulator is based on an earthen embankment type structure, with a series of box culverts (6 No. 1200 mm wide x 600 mm high). Disturbance depths are likely to extend to 300mm

In addition, there is an 850 m long access track located within private and public land. This access track is regularly used by standard sized vehicles (approximately 1.5 m in width) to access the Hell's Gate site (including local farmers) and is to be upgraded to allow for future use by trucks accessing the regulator site during construction phase of the project. The upgrade of the track is unlikely to disturb soil at depth, therefore it will not be considered as part of the ASS investigation.

The proposed site of the pipeline and regulating structure is shown in Figure 1 and 2.

1.2 Objectives

This assessment aims to identify and delineate acid sulphate soils (ASS) in the areas that will be disturbed during the construction phase of work. The scope of work is summarised as follows:

- ▶ Undertake a site investigation to determine the potential for the presence of ASS on-site; and
- ▶ Assess the results in accordance with the Draft Strategy for Coastal Acid Sulphate Soils in Victoria 2008.

1.3 Scope of work

The ASS investigation involved the following scope of work, which was undertaken in accordance with the Draft CASS Strategy (DSE 2008):



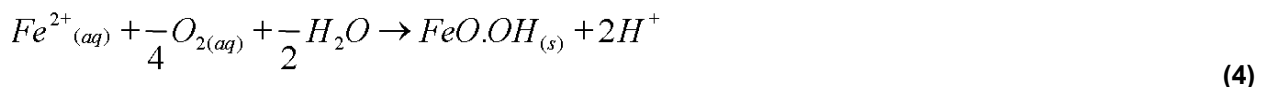
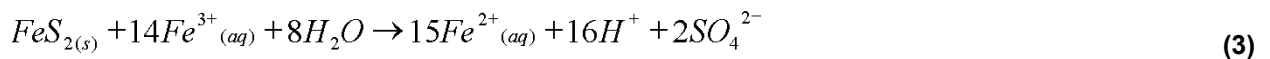
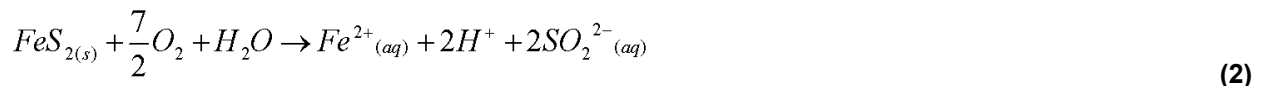
- ▶ Phase 1 - Desktop Assessment of site conditions and assessment of the potential for acid sulphate soils;
- ▶ Phase 2 – ASS Assessment including:
 - Hand auger selected locations to investigate the subsurface conditions;
 - Logging of materials encountered during intrusive investigations;
 - Collection of representative soil samples for laboratory testing;
 - Undertake laboratory testing on the soil samples recovered from the boreholes;
- ▶ Prepare a report presenting the results of the investigation and assessment in accordance with relevant guidelines.



2. Information on Acid Sulphate Soils

2.1 Background

Acid sulphate soils (ASS) include both actual acid sulphate soils (AASS) and potential acid sulphate soils (PASS). These soils generally occur below the water table in Quaternary-aged (1.8 Ma¹ – Present) marine or estuarine sediments, which are predominantly confined to coastal lowlands with elevations generally below 5 mAHD. Within these sediments, the majority of soils that present an environmental risk are generally confined to Holocene-aged (<10 000 years) material. When these lowland areas are disturbed, either by excavation or draining, which lowers the watertable, oxygen may get mixed into or enter the soil/sediment profile. Oxygen in the soil/sediment profile can oxidise sulphide minerals, typically mono-sulphide metals and pyrite, resulting in the formation of sulphate and iron oxyhydroxide minerals. In the presence of water, the sulphates hydrolyse to form sulfuric acid (H₂SO₄) and the iron ions combine with oxygen to form iron oxide (FeO₂), releasing hydrogen ions into solution causing further acidification. The formation of sulfuric acid causes the pH to fall below neutral (pH 7), with extremely low pH levels possible (pH < 4). The four equations below illustrate the acidification process associated with the oxidation of pyrite (FeS₂) and ferrous iron that is commonly associated with ASS. As shown the critical acid generation step is not in the oxidation of pyrite to ferric iron (Fe³⁺) shown in equation (1), but rather the formation of ferrous iron (Fe²⁺). The process is further accelerated when considering that the ferric iron produces (equation 1), while not generating acid then participates in the formation of ferrous iron (equation 3) which results in eight times greater acid generation than the direct oxidation of pyrite to ferrous iron (equation 2). The final step in acid generation can then occur in surface waters with the formation of Ochre (FeO.OH) (equation 4)



Under acidic conditions, metals such as aluminium and iron, as well as trace heavy metals (including arsenic) become more soluble and therefore are more easily mobilised by infiltrating waters. Subsequently, the surrounding land (soil) and nearby waterways may become contaminated with acids and/or metals leached from the sediments by the acid. In addition Ochre formation in surface water (equation 4) results in depletion of dissolved oxygen further increasing impacts to the surface water ecosystem. This may result in the significant degradation or destruction of the surrounding ecosystem. Acidic conditions generated by ASS can also cause significant damage to infrastructure through the

¹ Ma – million years



corrosion of concrete (e.g. bridge piers, stormwater drains and underground services), steel (e.g. pipes) and can result in the rapid deterioration of asphalt surfaces.

Under natural conditions, PASS are usually located below the watertable. A decrease in the watertable beyond its natural seasonal fluctuation can expose these soils to oxygen, oxidising the pyritic sediment and producing sulphuric acid. PASS are not usually present above the natural watertable because these materials have been exposed to oxygen long enough to convert all the sulfide (i.e. pyrite) to acid and AASS. The AASS materials commonly have a mottled appearance (e.g. orange and yellow discolouration).

2.2 Applicable Legislation

The following state legislation and policies applies to ASS assessment and management in Victoria.

2.2.1 Environmental Protection Act - Industrial Waste Management Policy (Waste ASS)

The *Environment Protection Act 1970* was established to regulate pollution and set up the ability to develop state environment protection policies and industrial waste management policies.

The *State environment protection policy (Prevention and management of contamination of land) S95, 4 June 2002* and the *Industrial waste policy (Waste acid sulphate soils 1999)* provide a framework to prevent and regulate pollution from ASS in Victoria.

The *Industrial waste management policy* sets out the management regime for disposal and reuse of waste acid sulphate soils and specifies the responsibilities of those involved.

EPA Publication 655 *Acid Sulphate Soil and Rock (August 1999)* is a guideline for assessment and provides definitions as well as an outline of identification, assessment, classification and management requirements and methodologies.

2.2.2 Draft Strategy for Coastal Acid Sulphate Soils in Victoria 2008

It was recognised that the above EPA policies and guidelines provided a hierarchy for management of acid sulphate soils, but focused largely on safe disposal and reuse. As such a statewide coastal mapping program was undertaken in by DPI (2003) to provide guidance on the potential occurrence of coastal acid sulphate soils (CASS).

Since this pilot mapping study, a draft strategy for the management of coastal acid sulphate soils has been developed and was released in June 2008.

The draft strategy for coastal acid sulphate soils in Victoria builds on a number of policies and legislative initiatives. It relies on a risk-based assessment that follows four phases through from desktop reviews to best practise management plans.

As this draft management strategy considers previous policies and guidelines, it has been adopted as the assessment guideline for this investigation.

2.2.3 The Planning and Environment Act 1987

The planning system is the primary means for regulating land use and approving development and is an important mechanism for triggering the consideration of CASS. The *Planning and Environment Act 1987* requires planning authorities when preparing a planning scheme to 'take into account any significant



effects which it considers the scheme or amendment might have on the environment or which it considers the environment might have on the use and development envisaged in the scheme or amendment' (Section 12).

State Planning Policy Framework (SPPF) 15.08-2 2006 stresses the need to avoid disturbing acid sulphate soils. It is used as a trigger for the implementation of CASS risk management process.



3. Acid Sulphate Management in Victoria

3.1 Background

The presence of coastal acid sulphate soils (CASS) should be assessed in accordance with the Draft Strategy for CASS in Victoria (2008). The objective of this strategy is to protect the environment, humans and infrastructure from the potential harmful impacts of disturbing CASS. This involves the protection of environment, social and economic, values of the coast and the avoidance of pollution and other activities that negatively impact on these values.

The draft strategy provides decision-making principles and a series of actions to achieve this objective. A risk management approach (Risk Management Process) to CASS is proposed in order that through greater awareness and understanding, decisions can be made around known risk. The implementation of best practise assessment and management techniques can ensure the consequences of activities in CASS areas can be reduced or nullified.

3.2 Risk Management Process

The CASS risk management process should be followed when a high-risk activity is proposed in a high-risk area. This is defined as:

- ▶ CASS high-risk area – area <10 m AHD; or areas sampled and mapped and displayed as risk areas; and
- ▶ High risk activities include:
 - Excavating soil/sediment (>100 m³)
 - Extracting or lowering groundwater
 - Filling land (>100 m³ or >100 m² area)

The CASS risk management process is divided into four phases. Each phase of the process should be approved by the relevant decision-maker and remains the responsibility of the project proponent. These phases are summarised in Figure 3.

Phase 1 – determines whether CASS is present

Phase 2 – determines the extent of acid production if CASS is disturbed

Phase 3 – risk assessment matrix tool for risk identification

Phase 4 – requires development of a management plan to ensure best practise environmental management guidelines are implemented to mitigate the risks identified in Phase 3.

3.2.1 Phase 1 – Preliminary Risk Assessment for CASS

A preliminary risk assessment aims to determine the potential for the occurrence and severity of CASS (if present) at a given site.

Desktop Review

This involves a desktop review of available information such as ASS maps, geological maps, topographic maps, groundwater regimes, vegetation maps etc and any other site-specific information from any previous investigations.



Preliminary Field Investigation

If the desktop assessment indicates a potential for the presence of CASS, a preliminary field assessment will be required. The assessment should aim to confirm the findings of the desktop study. If soils and/or groundwater sample analysis indicates any potential CASS occurrence, a full site assessment is required, which is encompassed in Phase 2.

3.2.2 Phase 2 – Full Site Assessment

Sampling and Analysis Plan (SAP)

Sampling frequency for a given project is outline in the CASS Draft Strategy. A sampling and analysis plan should follow the guidelines for the aerial extent of the site and depth of disturbance.

Analytical Schedule

An analytical schedule and the testing frequency are given in the CASS Draft Strategy, which also includes handling and storage of samples. A NATA registered laboratory should be used to conduct all laboratory testing and reporting of results.

Interpretation of Results

Results should be summarised in a worksheet that details the net acidity of the samples reported in kg H₂SO₄/tonne sediment. These can then be compared with the Soil Sulfide Hazard (CASS Draft Strategy) criteria to determine if the soils pose an environmental risk. If samples exceed the values in the CASS Draft Strategy, Phase 4 is triggered.

3.2.3 Phase 3 – Risk Assessment Matrix

The use of the risk assessment matrix is intended as a tool for risk identification and to assist in the development of an appropriate CASS management plan. Further assessment may be required to determine risk to the environment in greater detail (e.g. groundwater investigation) and determine the parameters that must be met in order to demonstrate acceptable risk to the environment.

3.2.4 Phase 4 – Best Practice Management Guidelines

Phase 4 provides a best practice management guidelines (BPMG) for producing a CASS management plan (CASSMP) where this is required by Phase 2 and Phase 3.



4. Phase 1 - Desktop Assessment of Site Conditions and Assessment of the Potential for Acid Sulphate Soils

4.1 Site Conditions

The site is Lake Moodemere and Sunday Creek, which is adjacent to the Murray River, 8 km west of Rutherglen and 10 km south of Wahgunyah in Victoria. Sunday Creek runs along the east side of Lake Moodemere. Sunday Creek services several farms for stock / domestic and irrigation purposes and is also used for recreational purposes (water skiing). Sunday Creek is currently serviced by Lake Moodemere via a gravity feed pipe and pumping station from the Murray River. The proposed scope of works for Sunday Creek is to bypass Lake Moodemere by installing a pumping station and pipeline from the Murray River to Sunday Creek and a regulating structure between Lake Moodemere and Sunday Creek to hold water within Sunday Creek.

4.2 Regional Geology

A review of published geological information was undertaken, which included review of the Wangaratta 1:250 000 geological map (GSV 1997) (see Figure 4 for details). The geology of the area includes:

- ▶ Quaternary (Holocene) fluvial, lacustrine deposits, clay, sand and sandy clay, believed to occur across the entire site area; overlying
- ▶ Quaternary (Pleistocene) Shepparton Formation fluvial deposits silt, sand and minor gravels and
- ▶ The Pinnak Sandstone of the Adaminaby Group Sediments (of early Ordovician age), which consists of marine, sandstone, mudstone, siltstone and minor chert.

Quaternary sediments, in particular those of Holocene and Pleistocene age of which the sediments were deposited are identified in the CASS Draft Strategy as a source of acid sulphate soils.

4.3 Review of Regional Acid Sulphate Soil Maps

A review of the Australia Soil Resource Information System (ASRIS) National Acid Sulphate Soil Hazard Map indicates that Lake Moodemere and the southern portion of Sunday Creek are located within a high risk area of probable acid sulphate soils (see Figure 5 for details) surrounded by areas of extremely low probability. These areas are likely to relate to inundated areas, such as main river or creek lines or any areas that are likely to have baseline flow (i.e. intersect the watertable) where sediment has not been exposed or has had limited exposure to atmosphere. Any reductions in water levels in these areas may expose these sediments and lead to acidification of soils.

4.4 Potential for Coastal Acid Sulphate Soils

The desktop review has confirmed that parts of the site are within mapped areas of probable acid sulphate soils. As such further investigation such as soil sampling, laboratory testing and assessment of risk may be required. The presence of acid sulphate soils and their potential impact may need to be considered during the proposed development works in particular where:



- ▶ Any changes to water levels are proposed, in particular lowering of water levels or dewatering either temporarily during the construction phase or as part of the longer term plan for the site;
- ▶ If excavation of soils is proposed as part of the redevelopment works, acid sulphate soils may be encountered and may require management/ treatment; and
- ▶ Potential impact of acid sulphate soils on any proposed structures during the design and construction phases (i.e. potential to change design to avoid disturbance, liming of exposed surfaces and use of materials that are more resistant in acidic conditions).



5. Phase 2 Acid Sulphate Soil Assessment

The Phase 2 assessment included the following:

- ▶ Visual inspection of the site conditions;
- ▶ Determination of appropriate sampling density and locations;
- ▶ Hand auger to a maximum depth of 2.0 m to investigate the subsurface conditions (based on an expected depth of disturbance of 1.0 m);
- ▶ Logging of materials encountered within the hand augered locations;
- ▶ Collection of representative soil samples for laboratory testing;
- ▶ Laboratory testing of the soil samples recovered from the test pits; and
- ▶ Assessment and classification of soils based on the analytical results.

5.1 Inspection of Site Conditions

The proposed site for the pump station was on the eastern bank of the Murray River approximately 2-3m above the water level. The historic pump structure and intake pipe were still intact at the time of investigation. The proposed pipeline alignment was intersected by various access tracks and crossed a minor gully at ~200m chainage. The site surrounding Hell's gate was relatively low lying and well vegetated with reeds and trees.

5.2 Sampling Density, Location and Analysis Plan

For a linear pipeline of 400m and excavation depth of 1.0m, a minimum of 4 locations is recommended in Table 1 of Attachment 2 of the CASS Draft Strategy (DSE 2008). The positioning of the samples locations were evenly spaced along the length of the proposed pipeline alignment (BH01 to BH04). Three hand auger locations were established at the site of Hell's Gate (BH05 to BH07) and an additional location (BH08) was established on the bank of Lake Moodemere approximately 100m east of the boat ramp.

A preliminary analytical program testing all samples pH and pH_{fox} was utilised to screen the samples prior to selecting samples for SPOCAS (Suspension Peroxide Oxidation Combined Acidity and Sulphate) analysis. This analytical method is an acid base accounting test that includes measurement of the maximum oxidisable sulphur, Titratable Actual Acidity (TAA) and Titratable Peroxide Acidity (TPA) and the potential Acid Neutralising Capacity (ANC) present in the soil sample. The TPA result of SPOCAS represents a measure of the net acidity, effectively equivalent to the sum of the soils potential sulphidic acidity and actual acidity. The calculated Titratable Sulphidic Acidity (TSA) is the difference between TPA and TAA. The peroxide oxidisable sulphur content (S_{POS}) provides a measure of the maximum amount of potentially oxidisable sulphur in the soil sample and represents the sulphur trail.

Table 7 of Appendix 3b of the CASS Draft Strategy (DSE 2008) provides soil sulphide hazard classes, which are determined by the sulphur concentrations and net acidity, reported in the SPOCAS analysis. Results from this investigation have been classified by this system. The Soil Sulphide Hazard Classes are presented in Table 1 of this report.



Table 1 Soil Sulphide Hazard Classes

Risk Class	No Risk Class				Risk Class			
	"No Sulphur"		Non-Reactive		Moderate Risk		High Risk	
Hazard class	Sulphur	Net Acidity	Sulphur	Net Acidity	Sulphur	Net Acidity	Sulphur	Net Acidity
1 (Coarse)	1	N/A	>1 (<10)	<3	>1	>3	>10	>5
2 (Medium)	2	N/A	>2 (<20)	<6	>2	>6	>20	>10
3 (Fine)	3	N/A	>3 (<30)	<9	>3	>9	>30	>15

Table obtained from: Draft Strategy for Coastal Acid Sulphate Soils in Victoria, Victorian Steering Committee for Coastal Acid Sulphate Soils, Victorian Government Department of Sustainability and Environment, Melbourne, June 2008. All units in kg H₂SO₄/t

5.3 Sampling and Soils Encountered

Pipeline:

The sample locations were dug using a hand auger of 60mm diameter. With samples collected at depth intervals of 0.1 m, 0.5m, 1.0m, 1.5m and 2.0 m depth.

The soils encountered were relatively consistent across the site with the depth to the clayey materials decreasing as distance from the Murray River increased:

Soils encountered in BH01 and BH02 (closer to the Murray River) included:

- ▶ 0.0 m to ~1.7 m Sand, light brown, fine grained, mica flecks present, dry and loose; and
- ▶ 1.7 m to 2.0 m Clayey sand, light brown, fine grained, trace mica, moist and loose.

Soils encountered in BH03 and BH04 (further from the Murray River) included:

- ▶ 0.0 m to 0.3 m Clayey Sand, moderate brown, fine grained, mica present, slightly moist and moderately dense;
- ▶ 0.3m to 1.0 m Sand, light brown, medium to coarse grained, mica present, slightly moist and loose; and
- ▶ 1.0 m to 2.0 m Clay, sandier at depth, light grey to grey, firm, low to moderate plasticity depending on sand content.

Hell's Gate:

Samples were collect from two locations beneath the water level using the piston sampler. Samples were collected at depth intervals of 0.1m, 0.5m and 0.8m. The softer sediments (0.0m to 0.2m) were collected with a shovel due to poor recovery using the piston sampler method.

A hand auger hole was established on the bank of the Hell's Gate to a depth of 1.3m. Samples were collected at depth intervals of 0.1m, 0.5m and 1.2m.

Soils encountered at Hell's Gate included:

- ▶ 0.0 m to 0.2 m Silt, dark brown brown, very soft; and
- ▶ 0.2 m to 0.8 m Clay, moderate plasticity, firm to stiff, wet (submerged).



Soil conditions in the hand auger location (BH07) were similar to the clays encountered in the piston sample locations, with exception of the water content. No water seepage was noted despite the close proximity of the waters edge.

No distinct hydrogen sulfide (H₂S) odours were noted during the investigation.

The bore logs are presented in Appendix A.

5.4 Laboratory Analysis

Collected samples were submitted under a chain of custody to MGT Environmental (MGT) for SPOCAS analysis. Eight (8) samples were selected for analysis, which included two quality control (QC) samples. One quality control sample remained in the MGT batch while the second was sent to ALS. Both MGT and ALS are NATA-registered for all tests conducted. Tabulated analytical results are presented in Appendix B. Chain of custody and laboratory certificate of analysis is included in Appendix C.

5.5 Field and Laboratory Results

This section of the report provides a discussion of the laboratory test results for the samples collected and analysed from the boreholes installed on the site.

The pH of the soils measured in the field ranged from 4.8 to 6.9, with field peroxide oxidised pH changes ranging from 0 to 4.0 pH units. The field pH and peroxide oxidised pH data for each well is briefly discussed below.

- ▶ BH1 (New Pipeline): Soils at this location largely comprised sand over the full depth of investigation (2m). A total of 4 samples from this borehole were tested, with pH ranging from 5.1 (1m depth) to 6.5 (0.1m depth). Field peroxide testing indicated changes in pH of between 1.3 and 4 pH units. In all cases the pH after peroxide oxidation dropped below 4, with the highest changes of 4 pH units recorded in the shallowest sample (0.1m depth). Based on the moisture content in the soil and other field observations the water table does not appear to have been encountered within the 2m investigation depth of this borehole;
- ▶ BH2 (New Pipeline): Soils at this location largely comprised of sand over the full depth of investigation (2m). A total of 5 samples from this borehole were tested, with pH ranging from 5.4 (0.1m depth) to 6.9 (2m depth). Field peroxide testing indicated changes in pH of between 1.0 and 2.8 pH units. Only one sample (0.1m depth) had a pH after peroxide oxidation dropped below 4. Based on the moisture content in the soil and other field observations the water table does not appear to have been encountered within the 2m investigation depth of this borehole;
- ▶ BH3 (New Pipeline): Soils at this location largely comprised of sand over the upper 0.7m and clay over the remainder of depth of investigation (2m). A total of 5 samples from this borehole were, with pH ranging from 4.8 (1m depth) to 6.4 (2m depth). Field peroxide testing indicated changes in pH of between 1.7 and 2.4 pH units. Three samples (0.1m, 1m and 1.5m depth) had a pH after peroxide oxidation dropped below 4. Based on the moisture content in the soil and other field observations the water table does not appear to have been encountered within the 2m investigation depth of this borehole;
- ▶ BH4 (New Pipeline): Soils at this location largely comprised sand over the upper 1.4m and sandy clay over the remainder of depth of investigation (2m). A total of 5 samples from this borehole were, with pH ranging from 4.9 (1.5m and 2m depth) to 5.7 (1m depth). Field peroxide testing indicated changes in



pH of between 2.2 and 2.7 pH units. In all cases the pH after peroxide oxidation dropped below 4, with the highest changes of 2.7 pH units recorded in the 1.5m depth sample. Based on the moisture content in the soil and other field observations the water table does not appear to have been encountered within the 2m investigation depth of this borehole;

- ▶ BH5 (Hells Gate Area): Soils at this location largely comprised silt and clay over the entire depth of investigation (0.8m). A total of 3 samples from this borehole were tested, with pH ranging from 6.1 (0.1m and 0.3m depth) to 6.4 (0.8m depth). Field peroxide testing indicated changes in pH of between 1.7 and 3.6 pH units. Two samples (0.1m, and 0.3m depth) had a pH after peroxide oxidation dropped below 4. Moisture content in the soil was saturated, since the borehole was established below the waters surface at Hells Gate;
- ▶ BH6 (Hells Gate Area): Soils at this location largely comprised silt and clay over the entire depth of investigation (0.8m). A total of 3 samples from this borehole were tested, with pH ranging from 5.8 (0.8m depth) to 6 (0.1m and 0.3m depth). Field peroxide testing indicated changes in pH of between 3.1 and 3.6 pH units. In all cases the pH after peroxide oxidation dropped below 4, with the highest changes of 2.7 pH units recorded in the 1.5m depth sample. Moisture content in the soil was saturated, since the borehole was established below the waters surface at Hells Gate;
- ▶ BH7 (Hells Gate Area): Soils at this location comprised clay over the entire depth of investigation (1.3m). A total of 3 samples from this borehole were tested, with pH ranging from 5.1 (0.1m depth) to 6.9 (1.3m depth). Field peroxide testing indicated changes in pH of between 0 and 2.7 pH units. One sample (0.1m depth) had a pH after peroxide oxidation dropped below 4. The moisture content in the soil was noted as moist to wet, despite close proximity of the lakes edge no in-flowing water was observed.
- ▶ BH8 (Lakes Edge): Soils at this location largely comprised sand to a depth of 0.2m, overlying clay over the remainder of the depth of investigation (1.5m). A total of 4 samples from this borehole were tested, with pH ranging from 5.1 (1m depth) to 6.5 (0.1m depth). Field peroxide testing indicated changes in pH of between 1.3 and 4.0 pH units. In all cases the pH after peroxide oxidation dropped below 4, with the highest changes of 4 pH units recorded in the 0.1m depth sample. The moisture content in the soil was noted as moist to wet, despite close proximity of the lakes edge no in-flowing water was observed.

Based on the laboratory testing of 8 samples using the SPOCAS method the following comments can be made with respect to the results set out in Table 2.

- ▶ A total of 4 samples analysed fell within texture group 1 (Sand), 2 samples fell within texture group 2 (Clayey Sand) and 2 samples fell within texture group 3 (Sandy Clay);
- ▶ SPOCAS testing estimated the net sulphuric acid generation potential for the samples analysed between 0.49 to 73.5 kg/t, indicating variable conditions;
- ▶ Net sulphuric acid generation potential varied within texture groups with no discernable difference between texture groups; and
- ▶ Acid generation risk classification ranged from No Risk in 1 sample (BH03 2.0m depth, texture group 3) to 4 samples with Moderate Risk (BH02 0.5m depth, texture group 1, BH03 0.1m depth, texture group 2, BH04 0.1m depth, texture group 2, BH08 0.1m depth, texture group 1) and 3 samples in the High Risk Group (BH01 0.1m depth, texture group 1, BH05 0.1m depth, texture group 1, BH06 0.8m depth, texture group 3); and



- Based on the limited number of samples tested the area along the new pipeline varies in risk from No Risk to High Risk, while the Hells Gate area samples tested all fell in the high risk group.

Table 2 Summary of Results and Classification of Soils.

Sample ID	Lithology	Texture Group	Sulfur (Peroxide Acidity Sulfur)			Risk Class
			Criteria		Lab Result	
			kg H ₂ SO ₄ /t	mole H ⁺ /t		
BH01-0.1	Sand	1	1	210	10.29	High Risk
BH02-0.5	Sand	1	1	41	2.009	Moderate Risk
BH03-0.1	Clayey Sand	2	2	350	17.15	Moderate Risk
BH03-2.0	Sandy Clay	3	3	10	0.49	No sulphur/ No Risk
BH04-0.1	Clayey Sand	2	2	83	4.067	Moderate Risk
BH05-0.1	Silt	1	1	1500	73.5	High Risk
BH06-0.8	Clay	3	3	1400	68.6	High Risk
BH08-0.1	Sand	1	1	48	2.352	Moderate Risk



6. Quality Assurance/ Quality Control (QA/QC)

Established quality assurance/quality control (QA/QC) procedures to assess data quality were maintained throughout the project. The QA/QC program undertaken as part of the assessment included the following:

- ▶ Use of appropriately qualified and trained staff;
- ▶ Preservation of samples with ice during transport from the field to the laboratory;
- ▶ Transportation of samples with accompanying chain-of-custody documentation;
- ▶ Compliance with sample holding times;
- ▶ Review of results of blind duplicate and split duplicate samples;
- ▶ Review of results of rinsate blank and trip blank samples; and
- ▶ Review of internal analysis of laboratory duplicates, spikes and blanks.

The QC program employed during this investigation was in accordance with the general requirements set out in the Australian Standard AS4482.1 (2005). QC samples provide information that discounts or potentially identifies errors due to possible sources of cross contamination, inconsistencies in sampling techniques and analytical methods/procedures employed.

Summary of QA/QC Compliance

Table 3 provides a summary of the Quality Assurance and Quality Control (QAQC) Data Quality Indicators (DQIs) used in the Soil Assessment, and an assessment of the compliance of the data set with these QA/QC DQIs.

Table 3 Summary of QA/QC Compliance for Soil Sampling

Item	Objective	Reference	Summary of Results	Compliance
Comparison of field and analytical data	Agreement between visual and olfactory evidence with laboratory results.		Soils on the waste transfer site did not visually represent typical coastal acid sulphate soils.	Yes
Calibration of field instruments	Meet calibration specifications.	AS4482.1-2005	No field equipment with calibration requirements was used for this project	N/A
Chain of Custody documentation	Completed.		Completed in full.	Yes
Sample analysis and extraction holding times	Comply with holding times.	AS4482.1-2005	Refer to ALS QCI report in Appendix B.	Yes
Analysis of inter-laboratory duplicate samples	1 for every 20 samples	AS4482.1-2005/US EPA	Good correlation with the exception of the RPD for sulfidic - Titratable Sulfidic	Yes



Item	Objective	Reference	Summary of Results	Compliance
			Acidity (s-23H) for ETP07-0.1 and QC03 reporting an RPD of 52.6%	
Analysis of intra-laboratory duplicate samples	1 for every 20 samples	AS4482.1-2005/US EPA	2 intra-laboratory samples were analysed for 12 primary samples. The percentage was increased to allow for no inter-laboratory analysis. Good correlation with the exception of the RPD for sulfidic - Titratable Sulfidic Acidity (s-23H) for ETP07-0.1 and QC03 reporting an RPD of 52.6%	No, there were some minor exceedences of acceptance criteria where both analysis had concentrations of more than order of magnitude above the acceptance criteria. Assessment of the laboratory QA/QC data for both laboratories showed compliance with acceptance criteria and hence both analysis appear valid. Therefore the main reason for the difference may relate to heterogeneity within the sample and given that the primary analysis produced the more conservative result this was not considered to indicate a significant breach of DQI indicator criteria.
Analysis of laboratory method blanks	No contamination of blanks.	Laboratory Quality Control Reports.	No method blank outliers reported. Refer to ALS QCI report in Appendix B	Yes
Analysis of spike recoveries	Recoveries within the laboratory specified recovery limits.	Laboratory Quality Control Reports.	No method blank outliers reported. Refer to ALS QCI report in Appendix B	Yes
Analysis of laboratory duplicates	Frequencies and RPDs within guideline and internal laboratory limits	NEPM (1999)	No method blank outliers reported. Refer to ALS QCI report in Appendix B	Yes
Analysis of rinsate and trip blanks	Frequencies within guideline limits, and reported concentrations below the laboratory LOR	NEPM (1999) and MGT certificates on analysis	No sampling equipment used that required decontaminating. No requirement for trip blanks as not analysing for volatile organic compounds	Yes



Although there were some non-conformances with the intra-laboratory RPD result for magnesium values and sulphur trail, the majority of the GHD QAQC DQIs were within the specified requirements and therefore, overall, the data was considered to be valid and of sufficient quality to meet the data quality objectives for the assessment.



7. Discussion of Results

This section provides a brief discussion of the investigation results. Acid sulphate soils generally relate to saturated soils where considerable sulphide mineral build up occurred as a consequence of prolonged reducing conditions. These soils generally generate acid when drained, allowing oxygen to diffuse into the sulphide mineral zone, causing oxidation. Setting of the processes outlined in Section 2.1. The degree and extent of acid generation then depends on the sulphur mineral species present. The more unstable and readily oxidisable minerals degrade first causing rapid acidification. More stable sulphur mineral species may degrade slowly producing smaller amounts of acid over long term. This latter process can lead to residual acid generation in soils above the saturated zone or soils that were drained in the past.

Field and laboratory testing for acid generation potential rely on relatively aggressive methods in order to obtain investigation results within a reasonable timeframe. The drawback is that potential and net acid generation potential is overestimated, particularly for soils from the unsaturated zone or oxidised groundwater regions, where the main acid generation potential is associated with more stable sulphide mineral species.

The investigation results are discussed with respect to the two investigation areas.

7.1 New Pipeline

A total of 4 boreholes were drilled along the proposed new pipeline alignment. All samples from the boreholes were tested for pH and peroxide oxidised pH. These results indicates that the majority of the samples had acid generation potential. The laboratory SPOCAS tests confirmed acid generation potential, classifying the majority of samples tested as Moderate Risk. The maximum acid generation potential was estimated at 17.15 kg H₂SO₄/t. These results indicated that soils are slightly acidic to neutral and in such conditions, metals such as aluminium and iron, as well as trace heavy metals (including arsenic) have low to slight mobility. However, the soils did indicate acid generation potential which could enhance the mobility of the more soluble and therefore are more easily mobilised inorganic elements by infiltrating waters. Subsequently, the surrounding land (soil), underlying groundwater and nearby waterways may become contaminated with metals leached from the sediments by the acid. This may result in the significant degradation or destruction of the surrounding ecosystem. Acidic soils may also cause damage to construction materials through corrosion (such as concrete, steel and asphalt).

Based on the results of the intrusive investigation the water table does not appear to have been encountered with the investigation depth of the 4 boreholes. Further the highest acid generation potential was associated with the shallowest soil samples where oxygen would be readily present in the soil profile. Therefore the risk of acid generation, while generally considered moderate based on the laboratory results, GHD consider that the actual risk when considering the geological and hydrogeological factors described is low. The acid generation potential noted in the laboratory results is considered to result from the presence of more stable sulphide minerals or other stable acid generating minerals and that while these may represent a low volume generator in the long term they are not considered to pose an unacceptable risk of significant acid generation in the short term.



7.2 Hells Gate Area

A total of 3 boreholes were drilled in the vicinity of the proposed regulating structure. All samples from the boreholes were tested in the field for pH and peroxide oxidised pH. These results indicate that all samples had acid generation potential. The laboratory SPOCAS tests confirmed acid generation potential, classifying the majority of samples tested as High Risk. The maximum acid generation potential was estimated at 73.5 kg H₂SO₄/t. These results indicated that soils are generally slightly acidic and in such conditions, metals such as aluminium and iron, as well as trace heavy metals (including arsenic) have slight mobility. However, the soils did indicate high risk for acid generation potential which could enhance the mobility of the more soluble and therefore are more easily mobilised inorganic elements by infiltrating waters. Subsequently, the surrounding land (soil), underlying groundwater and nearby waterways may become contaminated with metals leached from the sediments by the acid. This may result in the significant degradation or destruction of the surrounding ecosystem. Acidic soils may also cause damage to construction materials through corrosion (such as concrete, steel and asphalt).

Soils present during intrusive investigations at Hells Gate were saturated. Therefore there is a risk of acid generation for any soils excavated from the area and this is reflected in the high risk for acid generation potential. GHD consider that the soils in this area may represent an actual risk when considering the geological and hydrogeological factors and consider that management and possibly mitigation may be required for any soils excavated from this area or any in-situ soils subject to dewatering. The acid generation potential for soils in this area noted in the laboratory results is considered to possibly result from the presence of some unstable and more stable sulphide minerals or other stable acid generating minerals and that these may represent generators of acid in the short and long term. The presence of these potential acid sulphate soils in this area is related to the landscape position and sediments accumulated in this depositional environment (waterlogged, high organic matter soils).



8. Conclusions and Recommendations

8.1 Conclusions

The acid sulphate soil investigation involved a preliminary Phase 1 desktop assessment and Phase 2 site investigation, which included excavation and sampling of soils at 8 sample locations to a maximum depth of 2.0 m.

The results of the acid sulphate soil investigation indicate that:

- ▶ Soils encountered were observed to be sands, silty to sandy clays of medium to high plasticity which appeared to be characteristic of an alluvial profile.;
- ▶ Soils investigated along the proposed new pipeline alignment appeared to occur above the watertable, while those in the Hells Gate area were submerged or subject to a shallow water table;
- ▶ The results of SPOCAS testing indicated that soils at the proposed new pipeline and Hells Gate area were not coastal acid sulphate soils, however, they reported slightly acidic to neutral pH with potential for moderate to high net acidity, which indicated these soils, were potential acid soils in the saturated zones of the soils in the Hells Gate area.

Based on the results of this acid sulphate soil investigation, and the presence of potential acidic soils, construction works on the Hells Gate area would need to consider the potential impact of acidic soils on building materials or spoil excavated from the area. As such the building structures would need to be designed accordingly and an appropriate soil management and mitigation plan implemented..

8.2 Recommendations

Based on the results of the investigation and the conclusions made above the following works is recommended:

- ▶ Analysis of collected samples for water-leachable metals to understand the potential for mobilisation of metals due to acidic soil conditions; and
- ▶ Development of an environmental management plan to manage acidic soils in the event that results indicate a potential for mobilisation of metals due to acidic soil conditions.



9. Limitations

This report presents the results of an investigation and assessment program to determine the presence of coastal acid sulphate soils, and was produced specifically for Goulburn Murray Water and for the purposes of this commission. No warranties, expressed or implied, are offered to any third parties and no liability will be accepted for use of this report by any third party.

This report presents the results of an acid sulphate soil investigation conducted specifically for the purposes of this commission. The data and advice provided herein relate only to the project and structures described herein and must be reviewed by a competent Environmental Scientist, experienced in contaminated site investigations, before being used for any other purposes. GHD accepts no responsibility for other use of the data.

Where drill hole or test pit logs, laboratory tests, geophysical tests and similar work have been performed and recorded by others the data is included and used in the form provided by others. The responsibility for the accuracy of such data remains with the issuing authority, not with GHD.

The advice tendered in this report is based on information obtained from the investigation locations, test points and sample points and is not warranted in respect to the conditions that may be encountered across the site at other than these locations. It is emphasised that the actual characteristics of the subsurface and surface materials may vary significantly between adjacent test points and sample intervals and at locations other than where observations, explorations and investigations have been made. Sub-surface conditions, including groundwater levels and contaminant concentrations can change in a limited time. This should be borne in mind when assessing the data.

It should be noted that because of the inherent uncertainties in the sub-surface evaluations, changed or unanticipated sub-surface conditions may occur that could affect total project costs and/or execution. GHD does not accept responsibility for the consequences of significant variations in the conditions.

An understanding of the site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure-specific and some experienced based. Hence this report must be read in full and should not be altered, amended or abbreviated, issued in part or issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances that arise from the issue of the report that has been modified other than by GHD.

The scope of works undertaken does not include soil sampling and analysis at sufficient density (i.e. number of analysis results per metric tonne of soil) as would be required by EPA should site soils be proposed for excavation and transport from the site.



10. References

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DPI 2003. Acid sulphate soil hazard maps – guidelines for coastal Victoria. Victorian Department of Primary Industries - Centre for Land Protection Research, Report No. 12, March 2003.

DSE 2008. Draft Strategy for Coastal Acid Sulphate Soils in Victoria, Victorian Steering Committee for Coastal Acid Sulphate Soils, Victorian Government Department of Sustainability and Environment, Melbourne, June 2008.

GSV 1996. Colac 1:250 000 geological map (Second Edition). Geological Survey of Victoria, Department of Manufacturing & Industry Development, Victoria.

Victorian Government Gazette (1999) – *Industrial Waste Management Policy (Waste Acid Sulphate Soils)*. No. S 125 Wednesday 18 August 1999.



444,000 445,000 446,000 447,000

6,011,000

6,010,000

6,009,000

Murray River

Existing Lake Moodemere Pump Station and Regulator

Lake Moodemere

Sunday Creek

Pump Offtake (2 off) (McDonalds Lane)

Hells Gate Regulator

FEDERATION WAY

LAKE ROAD

MOODEMERE ROAD

MURRAY VALLEY HIGHWAY

6,011,000

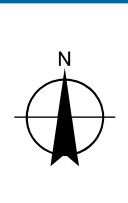
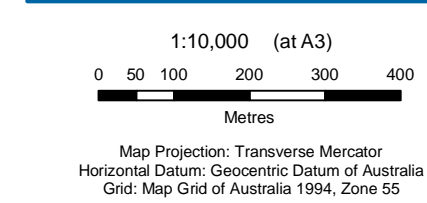
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UNNAMED

MURRAY VALLEY HIGHWAY



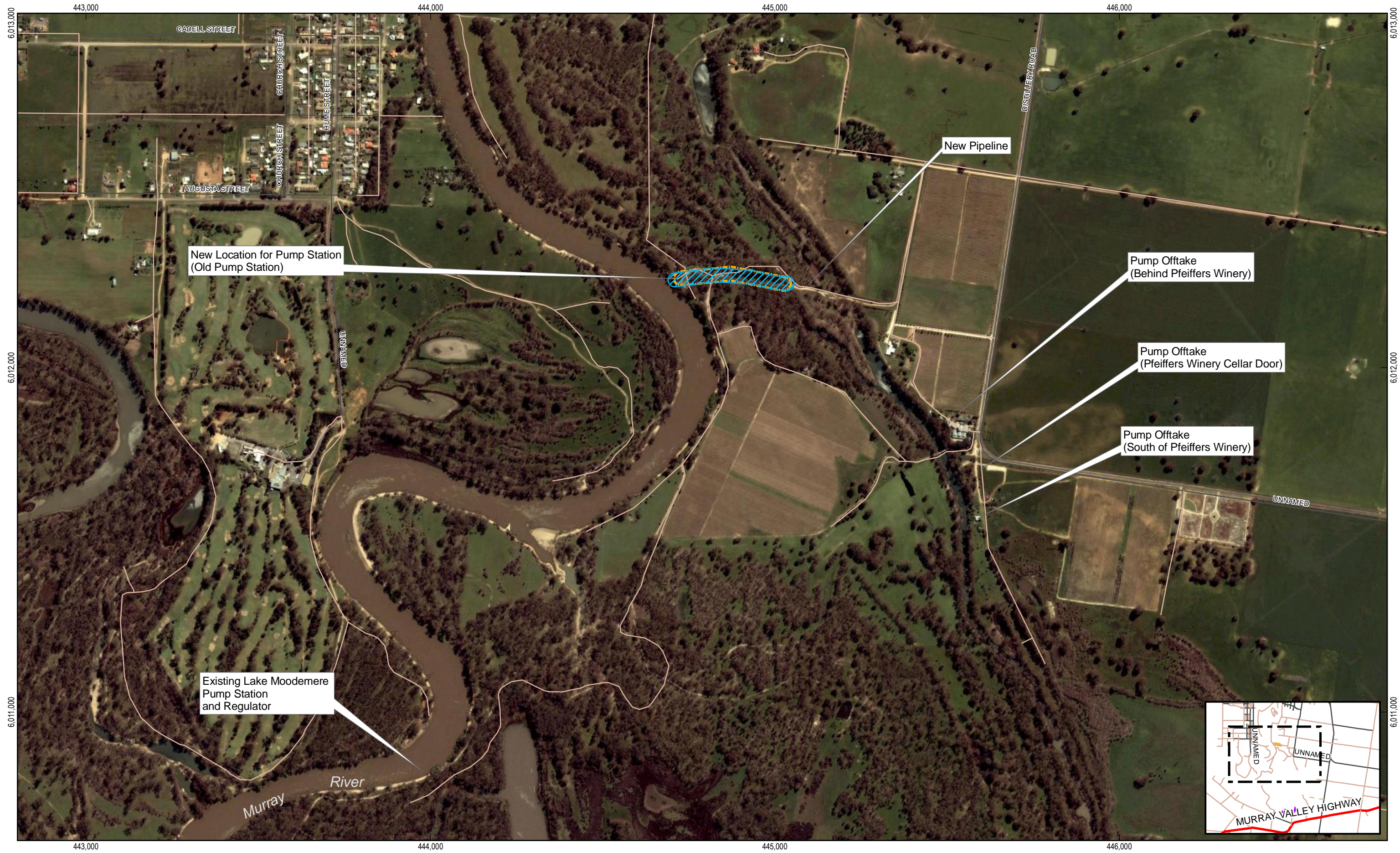
Legend

Highway	Access Track
Sealed Road (Arterial & Local)	New Pipeline
Unsealed Road	Activity Areas
Unsealed Track	



Goulburn Murray Water	Job Number	31-24122
Lake Moodemere Water Savings	Revision	A
Impact Assessment	Date	09 Sep 2009

General Arrangement Plan Figure 1

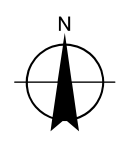
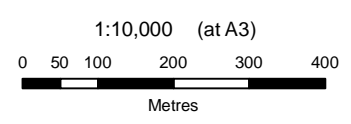


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Legend

- Highway
- Sealed Road (Arterial & Local)
- Unsealed Road
- Unsealed Track
- Access Track
- New Pipeline
- Activity Areas



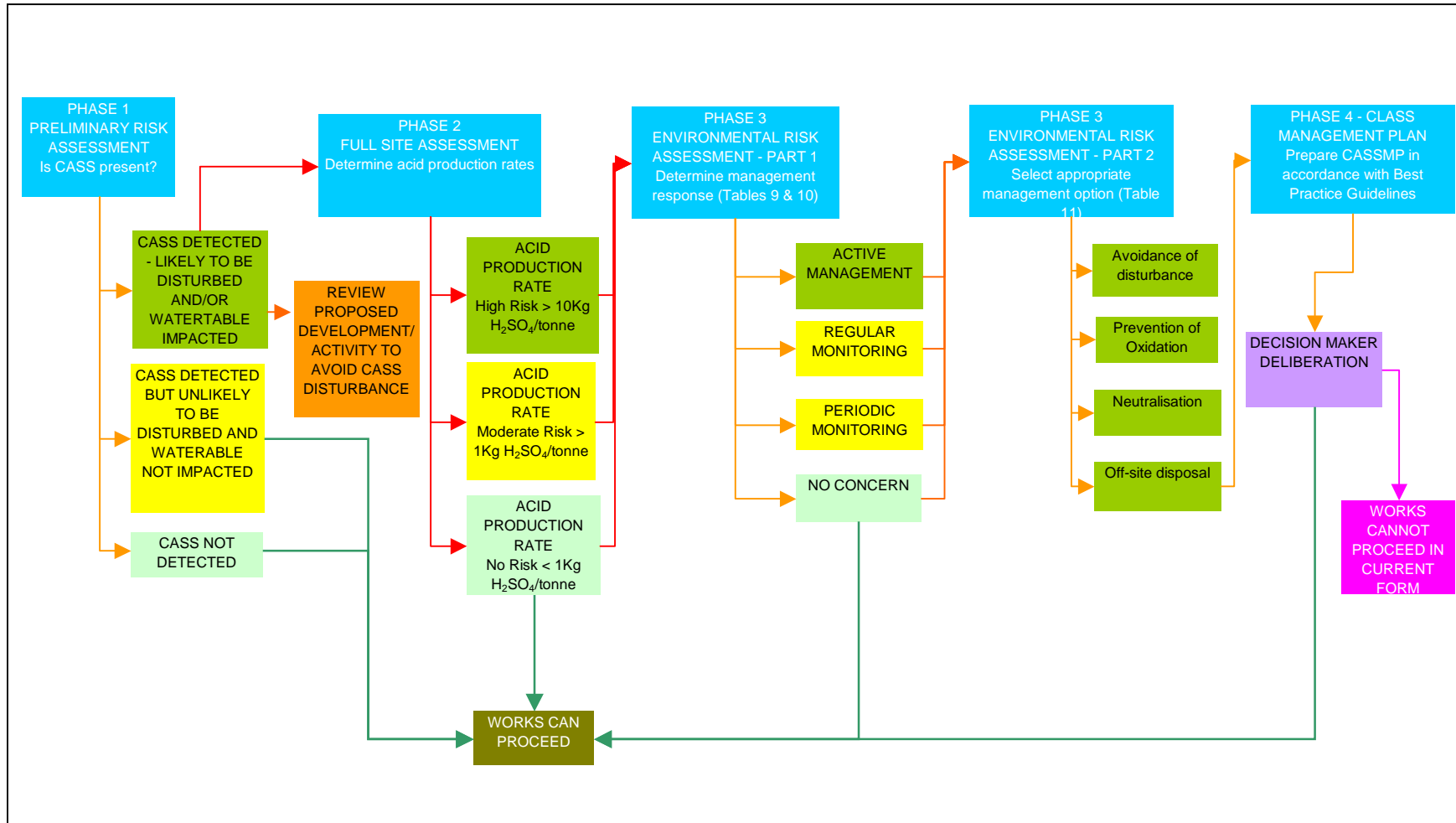
CLIENTS | PEOPLE | PERFORMANCE

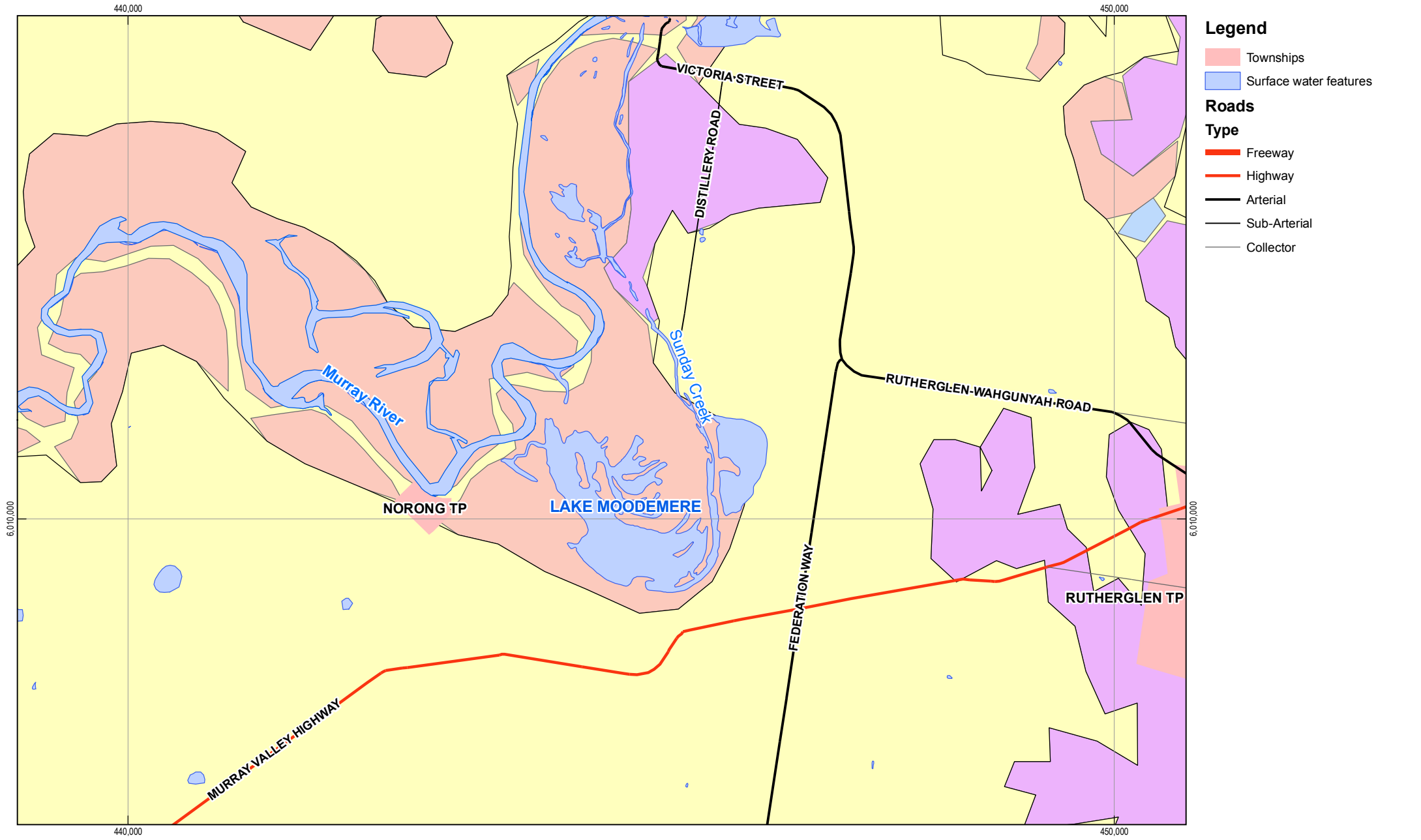
Goulburn Murray Water
Lake Moodemere Water Savings
Impact Assessment

Job Number	31-24122
Revision	A
Date	09 Sep 2009

General Arrangement Plan Figure 2

Victoria Coastal Acid Sulfate Soils (CASS) Risk Management Process





- Legend**
- Townships
 - Surface water features
- Roads**
- Type**
- Freeway
 - Highway
 - Arterial
 - Sub-Arterial
 - Collector

1:50,000

0 0.2 0.4 0.8 1.2 1.6

Kilometers (at A4)

Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia 1994
 Grid: Map Grid of Australia, Zone 55



- Geology (1:250,000)**
- Cu - Fluvio-glacial, glaciomarine: tillite, diamictite, sandstone, mudstone, conglomerate
 - Oa - Marine: sandstone, mudstone, siltstone, minor chert
 - Qc - Fluvial, lacustrine: clay, sand, sandy clay
 - Qs - Fluvial: silt, sand, minor gravel
 - Tp - Fluvial: silt, sand and gravel

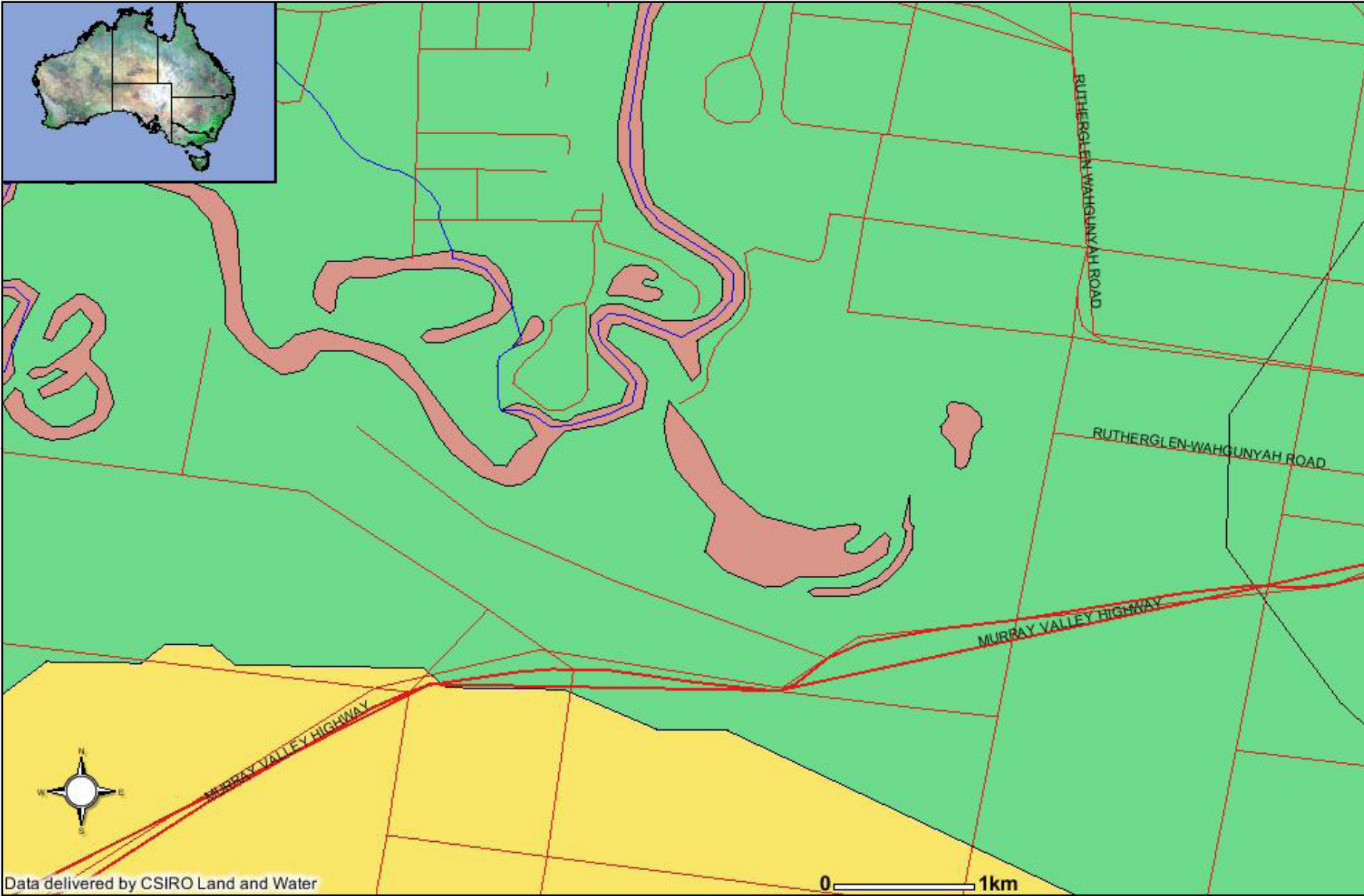


Goulburn Murray Water
 Lake Moodemere Water Savings
 Impact Assessment

Job Number	31-24122-03
Revision	0
Date	19 Jan 2010

Regional Geology Map

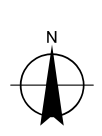
Figure 4



- Legend**
- Locations
 - Roads (1:250K)
 - ⚡ Highway
 - ⚡ Other Roads
 - ⚡ Streams
 - ▣ Builtup Areas
 - ▣ Inland Water Bodies
 - National Acid Sulfate Soils (NatASS)**
 - ▣ A High Probability
 - ▣ B Low Probability
 - ▣ C Extremely Low Probability
 - ▣ Base-Map

Map Source: Australian Soil Resource Information System (ASRIS), National Acid Sulfate Soil Map

Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia 1994
 Grid: Map Grid of Australia, Zone 55



Goulburn Murray Water
 Lake Moodemere Water Savings
 Impact Assessment

Job Number	31-24122-03
Revision	0
Date	19 Jan 2010

National Acid Sulfate Soil Risk Map **Figure 5**



Appendix A

Bore Logs



BOREHOLE LOG

Environmental

Bore No.: BH01

Page: 1 of 1

Client: Goulburn Murray Water
 Project: Lake Moodemere
 Job No.: 312412203
 Location: Proposed Pipeline
 Date Drilled: 29/09/09 to: 29/09/09

Drilling Co.: N/A
 Driller: N/A
 Rig Type: Hand Auger
 Total Depth (m): 2.0
 Diameter (mm): 60

Easting: 0444727
 Northing: 6012258
 Grid Ref: MGA 94 Zone 55
 Collar RL:
 Logged by: AB Checked by:

DRILLING						SOIL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture Condition	Consistency	CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Depth/ Elevation (m)
Depth (m)	Field Rank	Sample Method	PID (ppm)	Sample ID	Water					
0.0						Ground Surface				
				BH01-0.1		NATURAL SAND Light brown, fine grained, with silt, with clay, mica present, rootlets.	D-M	L		0.00
						As above, lighter in colour (tan).	D	L		0.20
				BH01-0.5						
						As above, silt and clay content decreasing (trace silt + clay), rootlets no longer present.	D	L		0.60
1.0				BH01-1.0						
				BH01-1.2		As above				1.20
				BH01-1.5						
				BH01-2.0						
2.0						EOH at 2.0m				2.00
3.0										

NOTES: Borehole initially to 1.2m, returned to extend to 2.0m



BOREHOLE LOG

Environmental

Bore No.: BH02

Page: 1 of 1

Client: Goulburn Murray Water
 Project: Lake Moodemere
 Job No.: 312412203
 Location: Proposed Pipeline
 Date Drilled: 29/09/09 to: 29/09/09

Drilling Co.: N/A
 Driller: N/A
 Rig Type: Hand Auger
 Total Depth (m): 2.0
 Diameter (mm): 60

Easting: 0444872
 Northing: 6012272
 Grid Ref: MGA 94 Zone 55
 Collar RL:
 Logged by: AB Checked by:

DRILLING						Soil Description Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture Condition	Consistency	CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Depth/ Elevation (m)
Depth (m)	Field Rank	Sample Method	PID (ppm)	Sample ID	Water					
0.0						Ground Surface				0.00
				BH02-0.1 DUP01		NATURAL SAND Light brown / tan, fine grained, poorly graded, mica present, trace clay.	D	L		
				BH02-0.5 DUP02						
				BH02-1.0 DUP03						
1.0				BH02-1.2 DUP04		As above.				1.20
				BH02-1.5 DUP15		Clayey SAND Light brown (slightly darker than above, trace mica.	M	L		1.70
				BH02-2.0 DUP16						
2.0						EOH at 2.0m				2.00
3.0										

NOTES: Borehole initially to 1.2m, returned to extend to 2.0m. Duplicates taken at all depths to ensure one will be available for SPOCAS



BOREHOLE LOG

Environmental

Bore No.: BH03

Page: 1 of 1

Client: Goulburn Murray Water
 Project: Lake Moodemere
 Job No.: 312412203
 Location: Proposed Pipeline
 Date Drilled: 29/09/09 to: 29/09/09

Drilling Co.: N/A
 Driller: N/A
 Rig Type: Hand Auger
 Total Depth (m): 2.0
 Diameter (mm): 60

Easting: 0444956
 Northing: 6012256
 Grid Ref: MGA 94 Zone 55
 Collar RL:
 Logged by: AB Checked by:

DRILLING						Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture Condition	Consistency	CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Depth/ Elevation (m)
Depth (m)	Field Rank	Sample Method	PID (ppm)	Sample ID	Water					
0.0						Ground Surface				0.00
				BH03-0.1		NATURAL Clayey SAND - Sandy CLAY Moderate brown / grey, fine grained, mica present.	D-M	L-D		
				BH03-0.5		SAND Light grey / light brown, med-coarse grained, mica present.	D-M	L		0.30
				BH03-1.0		CLAY Light-moderate grey, moderate plasticity, crumbles, with fine sand, some mica, with silt.	D-M	F		0.70
				BH03-1.2		As above				1.20
				BH03-1.5						
				BH03-2.0		Sandy CLAY Light grey, low plasticity, crumbles, sand is fine to medium grained, trace mica.	D	F		1.80
2.0						EOH at 2.0m				2.00
3.0										

NOTES: Borehole initially to 1.2m, returned to extend to 2.0m.



BOREHOLE LOG

Environmental

Bore No.: BH04

Page: 1 of 1

Client: Goulburn Murray Water
Project: Lake Moodemere
Job No.: 312412203
Location: Proposed Pipeline
Date Drilled: 29/09/09 to: 29/09/09

Drilling Co.: N/A
Driller: N/A
Rig Type: Hand Auger
Total Depth (m): 2.0
Diameter (mm): 60

Easting: 0445010
Northing: 6012246
Grid Ref: MGA 94 Zone 55
Collar RL:
Logged by: AB **Checked by:**

DRILLING						SOIL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture Condition	Consistency	CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Depth/ Elevation (m)
Depth (m)	Field Rank	Sample Method	PID (ppm)	Sample ID	Water					
0.0						Ground Surface				
				BH03-0.1 DUP05 DUP06		NATURAL Clayey SAND Moderate brown / grey / orangey brown, medium to coarse grained, mica present, rootlets	D-M	L		0.00
						Clayey layer 0.3m to 0.4m.				0.30
				BH03-0.5 DUP07 DUP08		SAND Pale brown, medium to coarse grained (river sand), mica present.	D	L		0.60
1.0				BH03-1.0 DUP09 DUP10		As above, clay content increasing.				1.20
				BH03-1.5 DUP11 DUP12		Sandy CLAY Moderate grey / brown, some orange / red / black mottling, possible iron oxide, low plasticity, crumbles, sand is fine to medium grained, mica present.	D	F		1.40
2.0				BH03-2.0 DUP13 DUP14		EOH at 2.0m				2.00
3.0										

NOTES: Duplicates taken at all depths to ensure QA sample exists for sample selected for SPOCAS



BOREHOLE LOG

Environmental

Bore No.: BH05
Page: 1 of 1

Client: Goulburn Murray Water Project: Lake Moodemere Job No.: 312412203 Location: Hells Gate Date Drilled: 29/09/09 to: 29/09/09	Drilling Co.: N/A Driller: N/A Rig Type: Piston Sampler Total Depth (m): 0.8 Diameter (mm): 40	Easting: 0445694 Northing: 6009463 Grid Ref: MGA 94 Zone 55 Collar RL: Logged by: AB Checked by:
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DRILLING						Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture Condition	Consistency	CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Depth/ Elevation (m)
Depth (m)	Field Rank	Sample Method	PID (ppm)	Sample ID	Water					
0.0						Ground Surface				
				BH05-0.1 DUP17		NATURAL SILT Dark brown, very soft.	W	S		0.00
				BH05-0.3 DUP18		CLAY Grey to dark grey, moderate plasticity, mica present.		F-St		0.20
				BH05-0.8 DUP19		CLAY Greenish grey, stiff, moderate to high plasticity, mica present, no odour.		St		0.60
						EOH at 0.8m				0.80
1.0										
2.0										
3.0										

NOTES: Duplicates taken at all depths to ensure sample selected for SPOCAS has a QA sample.

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993.



BOREHOLE LOG

Environmental

Bore No.: BH06

Page: 1 of 1

Client: Goulburn Murray Water
 Project: Lake Moodemere
 Job No.: 312412203
 Location: Hells Gate
 Date Drilled: 29/09/09 to: 29/09/09

Drilling Co.: N/A
 Driller: N/A
 Rig Type: Piston Sampler
 Total Depth (m): 0.8
 Diameter (mm): 40

Easting: 0445698
 Northing: 6009465
 Grid Ref: MGA 94 Zone 55
 Collar RL: 129
 Logged by: AB Checked by:

DRILLING						Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture Condition	Consistency	CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Depth/ Elevation (m)
Depth (m)	Field Rank	Sample Method	PID (ppm)	Sample ID	Water					
0.0						Ground Surface				
				BH06-0.1		NATURAL SILT Moderate to dark brown, soft.	W	S		0.00
				BH06-0.3						
						Transition to clay.				0.40
				BH06-0.8		CLAY Moderate to dark grey, moderate to high plasticity, trace mica, no odour.	W	F		0.50
						EOH at 0.8m				0.80
1.0										
2.0										
3.0										

NOTES:



BOREHOLE LOG

Environmental

Bore No.: BH07
Page: 1 of 1

Client: Goulburn Murray Water	Drilling Co.: N/A	Easting: 0445694
Project: Lake Moodemere	Driller: N/A	Northing: 6009460
Job No.: 312412203	Rig Type: Hand Auger	Grid Ref: MGA 94 Zone 55
Location: Hells Gate - Edge of Bank	Total Depth (m): 1.3	Collar RL:
Date Drilled: 29/09/09 to: 29/09/09	Diameter (mm): 60	Logged by: AB Checked by:

DRILLING						Soil Description Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture Condition	Consistency	CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Depth/ Elevation (m)
Depth (m)	Field Rank	Sample Method	PID (ppm)	Sample ID	Water					
0.0						Ground Surface				0.00
				BH07-0.1		NATURAL CLAY Light grey, orange mottling, moderate to high plasticity, mica present, some sandy sections.	M	F-St		
				BH07-0.5						
1.0				BH07-1.2		As above, sand content increasing (sandy clay / clayey sand).	M	F-St		1.00
						EOH at 1.3m				1.30
2.0										
3.0										

NOTES: Borehole located 0.5m from waters edge and 0.1m higher than waters surface. Hole not producing water (i.e. low transmissivity)

GHD Soil Classifications: The GHD Soil Classification is based on Australian Standards AS 1726-1993.



BOREHOLE LOG

Environmental

Bore No.: BH08

Page: 1 of 1

Client: Goulburn Murray Water
 Project: Lake Moodemere
 Job No.: 312412203
 Location: Lakes edge
 Date Drilled: 29/09/09 to: 29/09/09

Drilling Co.: N/A
 Driller: N/A
 Rig Type: Hand Auger
 Total Depth (m): 1.5
 Diameter (mm): 60

Easting: 0444271
 Northing: 6010483
 Grid Ref: MGA 94 Zone 55
 Collar RL:
 Logged by: AB Checked by:

DRILLING						SOIL DESCRIPTION Soil Type (Classification Group Symbol); Particle Size; Colour; Secondary / Minor Components.	Moisture Condition	Consistency	CONTAMINANT INDICATORS Odours, staining, waste materials, separate phase liquids, imported fill, ash.	Depth/ Elevation (m)
Depth (m)	Field Rank	Sample Method	PID (ppm)	Sample ID	Water					
0.0						Ground Surface				
				BH08-0.1		NATURAL SAND Moderate grey, fine to medium grained, orange patches.	M	L		0.00
				BH08-0.5		Sandy CLAY Grey with orange mottling, moderate plasticity.				0.20
1.0				BH08-1.0		As above, orangey section.				1.00
				BH08-1.5		Gravelly SAND Grey, coarse, gravel up to 1cm, river deposits.	M			1.40
						EOH at 1.5m				1.50
2.0										
3.0										

NOTES: Borehole located near boat shed on waters edge.



Appendix B
Tabulated Acid Sulphate Soil Analytical
Results

**312412203 - Moodemere Phase 2 ASS Investigations
 Preliminary Analysis and Results**

Sample_ID	BH1-0.1	BH1-0.5	BH1-1.0	BH1-1.5	BH1-2.0	BH2-0.1	BH2-0.5
Sample_Depth							
Sampled_Date	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009
Lab Report No.	252970	252970	252970	252970	252970	252970	252970
Action Criteria (Based on Draft Strategy for Coastal Acid Sulfate Soils)	Preliminary	None	None	None	None	Preliminary	Preliminary
Texture							
Coarse ¹	Coarse	Coarse	Coarse	Coarse	Coarse	Coarse	Coarse
Medium ²							
Fine ³							
Clay (%)							
≤5							
5 to 40							
≥40							
Analyte	Units	LOR					
EA029-A: pH Measurements							
pH (Field pH)	pH Unit	0.1					
pH (Field pH = Hydrogen peroxide)	pH Unit	0.1					
Δ pH	pH Unit	0.1					
			5.2	6.3	6.4	6.3	6.6
			2.9	5.8	5.1	4.8	4.6
			2.3	0.5	1.3	1.5	2.0
							5.4
							3.3
							2.1
							6.4
							3.6
							2.8

* Soil type - Taken from borelog description
 1 Coarse = Sands;
 2. Medium = Sandy loams/silts to light clays/silts;
 3. Fine = Medium to heavy clays, silty clays

**312412203 - Moodemere Phase 2 ASS Investigations
 Preliminary Analysis and Results**

Sample_ID	BH2-1.0	BH2-1.5	BH2-2.0	BH3-0.1	BH3-0.5	BH3-1.0	BH3-1.5					
Sample_Depth												
Sampled_Date	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009					
Lab Report No.	252970	252970	252970	252970	252970	252970	252970					
Action Criteria (Based on Draft Strategy for Coastal Acid Sulfate Soils)	None	None	None	Preliminary	None / Preliminary	Preliminary	Preliminary					
Texture												
Coarse ¹	Medium ²	Fine ³	Coarse	Coarse	Medium	Medium	Coarse	Fine	Fine			
Clay (%)												
Analyte	Units	LOR	≤5	5 to 40	≥40							
EA029-A: pH Measurements												
pH (Field pH)	pH Unit	0.1				6.3	6.5	6.9	5.1	6.1	4.8	5.1
pH (Field pH = Hydrogen peroxide)	pH Unit	0.1				4.9	5	5.9	2.7	4.4	2.6	2.9
Δ pH	pH Unit	0.1				1.4	1.5	1.0	2.4	1.7	2.2	2.2

* Soil type - Taken from borelog description
 1 Coarse = Sands;
 2. Medium = Sandy loams/silts to light clays/silts;
 3. Fine = Medium to heavy clays, silty clays

**312412203 - Moodemere Phase 2 ASS Investigations
 Preliminary Analysis and Results**

Sample_ID	BH3-2.0	BH4-0.1	BH4-0.5	BH4-1.0	BH4-1.5	BH4-2.0	BH5-0.1
Sample_Depth							
Sampled_Date	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009
Lab Report No.	252970	252970	252970	252970	252970	252970	252970
Action Criteria <small>(Based on Draft Strategy for Coastal Acid Sulfate Soils)</small>	Preliminary	Preliminary	Preliminary	Preliminary	Detailed	Preliminary	Preliminary / Detailed
Texture							
Coarse ¹	Medium ²	Fine ³	Fine	Medium	Medium	Coarse	Fine
Clay (%)							
≤5	5 to 40	≥40					
Analyte	Units	LOR					
EA029-A: pH Measurements							
pH (Field pH)	pH Unit	0.1					
pH (Field pH = Hydrogen peroxide)	pH Unit	0.1					
Δ pH	pH Unit	0.1					
			6.4	5.1	6.1	5.7	4.9
			4.3	2.8	3.8	3.2	2.2
			2.1	2.3	2.3	2.5	2.7
							2.2
							6.1
							2.5
							3.6

* Soil type - Taken from borelog description
 1 Coarse = Sands;
 2. Medium = Sandy loams/silts to light clays/silts;
 3. Fine = Medium to heavy clays, silty clays

Field_ID	BH1-0.1	BH2-0.5	BH3-0.1	BH3-2.0	BH4-0.1	BH5-0.1	BH6-0.8	BH8-0.1
Sampled_Date-Time	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009	29/09/2009

Chem_Group	ChemName	Units	EQL								
Inorganics	Moisture Content (dried @ 103°C)	%	0.1	12	3.6	19	12	16	52	35	14
SPOCAS	Acid Reacted Calcium	%	0.02	0.29	0.05	<0.02	0.73	<0.02	<0.02	0.48	<0.02
	Acid Reacted Magnesium	pH Unit	0.02	0.07	0.13	0.07	0.73	<0.02	0.35	0.27	<0.02
	acidity - Acid Reacted Calcium	mole H+/t	10	140	26	<10	370	<10	<10	240	<10
	acidity - Acid Reacted Magnesium	mole H+/t	10	60	110	58	600	<10	280	220	<10
	acidity - Peroxide Oxidisable Sulfur	mole H+/t	10	210	41	350	<10	83	1500	1400	48
	ANC Fineness Factor	-	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Calcium in Peroxide	%	0.02	5	1.3	3.4	5.3	2.5	6.9	7.1	0.71
	KCl Extractable Calcium	%	0.02	4.7	1.3	3.4	4.5	2.5	6.9	6.6	0.7
	KCl Extractable Magnesium	%	0.02	1.1	1.2	1.6	3.6	1.3	2.4	2.2	0.25
	KCl Extractable Sulfur	%	0.02	0.33	0.1	0.36	0.4	0.35	0.26	0.46	0.27
	Liming Rate	kg CaCO3/t	1	11	2.3	20	<1	6.2	77	73	3.5
	Magnesium in Peroxide	%	0.02	1.2	1.3	1.6	4.3	1.3	2.7	2.4	0.25
	Net Acidity (acidity units)	mole H+/t	10	230	45	390	<10	130	1500	1500	69
	Net Acidity (sulfur units)	%S	0.02	0.36	0.07	0.63	<0.02	0.2	2.5	2.3	0.11
	Peroxide Oxidisable Sulfur	%	0.02	0.33	0.07	0.56	<0.02	0.13	2.4	2.3	0.08
	pH (KCl)	pH Unit	0.1	4.8	4.7	4.5	4.7	4.5	4.9	5	4.6
	pH (Ox)	pH Unit	0.1	6.3	6.6	5.8	7.5	5.9	5.6	5.2	5.7
	sulfidic - Acid Reacted Calcium	mole H+/t	0.02	0.23	0.04	<0.02	0.59	<0.02	<0.02	0.38	<0.02
	sulfidic - Acid Reacted Magnesium	%S	0.02	0.1	0.18	0.09	0.96	<0.02	0.46	0.35	<0.02
	sulfidic - Titratable Actual Acidity	%S	0.02	0.03	<0.02	0.07	<0.02	0.07	0.05	0.08	0.03
	sulfidic - Titratable Peroxide Acidity	%S	0.02	0.04	0.08	0.08	0.08	0.07	0.08	0.14	0.05
	sulfidic - Titratable Sulfidic Acidity	%S	0.02	<0.02	0.07	<0.02	0.08	<0.02	0.02	0.06	<0.02
	Sulfur in Peroxide	%	0.02	0.66	0.17	0.92	0.4	0.48	2.7	2.7	0.34
	Titrateable Actual Acidity	mole H+/t	2	21	3.8	44	<2	41	34	51	21
	Titrateable Peroxide Acidity	pH Unit	2	27	49	48	51	46	49	90	29
	Titrateable Sulfidic Acidity	pH Unit	2	5.6	45	4.3	50	5	15	39	7.5



Appendix C

Laboratory Analysis Documentation

Chain of Custody and Laboratory Certificates of Analysis

CERTIFICATE OF ANALYSIS

GHD Melbourne
Level 8, 180 Lonsdale St
Melbourne
Victoria 3000
Site: LAKE MOODEMERE 312412203

Report Number: 253953-V1 Page 1 of 9
Order Number:
Date Received: Oct 19, 2009
Date Sampled: Sep 29, 2009
Date Reported: Nov 17, 2009
Contact: Ashley Barber

Methods

- Method 102 - ANZECC - % Moisture

Comments

Notes

Authorised

Report Number: 253953-V1



Michael Wright
Senior Principal Chemist
NATA Signatory



Glenn Jackson
Client Manager



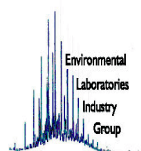
Orlando Scalzo
Chief Organic Chemist
NATA Signatory



Andrew Cook
Chief Inorganic Chemist



NATA Corporate Accreditation Number 1261
The tests, calibrations or measurements covered by this document have been performed in accordance with NATA requirements which include the requirements of ISO/IEC 17025 and are traceable to national standards of measurement. This document shall not be reproduced except in full



GLOSSARY OF TERMS

UNITS

mg/kg	milligrams per Kilogram	mg/l	milligrams per litre
ug/l	micrograms per litre	ppm	Parts per million
ppb	Parts per billion	%	Percentage
org/100ml	Organisms per 100 millilitres	NTU	Units

TERMS

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery
CRM	Certified Reference Material - reported as percent recovery
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands. In the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
Batch Duplicate	A second piece of analysis from a sample outside of the clients batch of samples but run within the laboratory batch of analysis.
Batch SPIKE	Spike recovery reported on a sample from outside of the clients batch of samples but run within the laboratory batch of analysis.
USEPA	United States Environment Protection Authority
APHA	American Public Health Association
ASLP	Australian Standard Leaching Procedure (AS4439.3)
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice

QC - ACCEPTANCE CRITERIA

RPD Duplicates	Results <10 times the LOR : No Limit Results between 10-20 times LOR : RPD must lie between 0-50% Results >20 times LOR : RPD must lie between 0-20%
LCS Recoveries	Recoveries must lie between 70-130% - Phenols 30-130%
CRM Recoveries	Recoveries must lie between 70-130% - Phenols 30-130%
Method Blanks	Not to exceed LOR
SPIKE Recoveries	Recoveries must lie between 70-130% - Phenols 30-130%
Surrogate Recoveries	Recoveries must lie between 50-150% - Phenols 20-130%

GENERAL COMMENTS

- All results in this report supersede any previously corresponded results.
- All soil results are reported on a dry basis.
- Samples are analysed on an as received basis.

QC DATA GENERAL COMMENTS

- Where a result is reported as a less than (<), higher than the nominated LOR this is due to either Matrix Interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
- Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
- Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
- Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
- Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
- Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
- Polychlorinated Biphenyls are spiked only using Arochlor 1260 in Matrix Spikes and LCS's.
- For Matrix Spikes and LCS results a dash "-" in the report means that the specific analyte was not added to the QC sample.
- Duplicate RPD's are calculated from raw analytical data thus it is possible to have two two sets of data below the LOR with a positive RPD - eg: LOR 0.1, Result A = <0.1 (raw data is 0.02) & Result B = <0.1 (raw data is 0.03) resulting in a RPD of 40% calculated from the raw data.

REPORT SPECIFIC NOTES

Company Name: GHD Pty Ltd VIC Address: Level 8, 180 Lonsdale St Melbourne Victoria 3000	Order No.: Report #: 253953 Phone: 8687 8000 Fax: 8687 8111	Received: Oct 19, 2009 12:00 Due: Oct 26, 2009 06:59 Priority: 5 Day Contact name: - GHD INVOICES
Client Job No.: LAKE MOODEMERE 312412203	mgt Client Manager: Glenn Jackson	

Sample Detail						% Moisture	SPOCAS (Acid Sulphate Soils)
Laboratory where analysis is conducted							
Melbourne Laboratory - NATA Site #1254						X	X
Sydney Laboratory - NATA Site #18217							
Sample ID	Sample Date	Sampling Time	Matrix	LAB ID	Comment		
BH1-0.1	Sep 29, 2009		Soil	M09-Oc06862	ADDITIONAL ANALYSIS	X	X
BH2-0.5	Sep 29, 2009		Soil	M09-Oc06863	ADDITIONAL ANALYSIS	X	X
BH3-0.1	Sep 29, 2009		Soil	M09-Oc06864	ADDITIONAL ANALYSIS	X	X
BH3-2.0	Sep 29, 2009		Soil	M09-Oc06865	ADDITIONAL ANALYSIS	X	X
BH4-0.1	Sep 29, 2009		Soil	M09-Oc06866	ADDITIONAL ANALYSIS	X	X
BH5-0.1	Sep 29, 2009		Soil	M09-Oc06867	ADDITIONAL ANALYSIS	X	X
BH6-0.8	Sep 29, 2009		Soil	M09-Oc06868	ADDITIONAL ANALYSIS	X	X
BH8-0.1	Sep 29, 2009		Soil	M09-Oc06869	ADDITIONAL ANALYSIS	X	X
DUP17	Sep 29, 2009		Soil	M09-Oc06870	ADDITIONAL ANALYSIS	X	X

GHD Melbourne	Client Sample ID		BH1-0.1	BH2-0.5	BH3-0.1	BH3-2.0
Level 8, 180 Lonsdale St	Lab Number		M09-Oc06862	M09-Oc06863	M09-Oc06864	M09-Oc06865
Melbourne	Matrix		Soil	Soil	Soil	Soil
Victoria 3000	Sample Date		Sep 29, 2009	Sep 29, 2009	Sep 29, 2009	Sep 29, 2009
Analysis Type	LOR	Units				
% Moisture	0.1	%	12	3.6	19	12
Acidity Trail						
Acid trail - Titratable Actual Acidity	2	mol H+/t	21	3.8	44	< 2
Acid trail - Titratable Peroxide Acidity	2	mol H+/t	27	49	48	51
Acid trail - Titratable Sulfidic Acidity	2	mol H+/t	5.6	45	4.3	50
sulfidic - Titratable Actual Acidity	0.02	% pyrite S	0.03	< 0.02	0.07	< 0.02
sulfidic - Titratable Peroxide Acidity	0.02	% pyrite S	0.04	0.08	0.08	0.08
sulfidic - Titratable Sulfidic Acidity	0.02	% pyrite S	< 0.02	0.07	< 0.02	0.08
Sulfur trail						
acidity - Peroxide Oxidisable Sulfur	10	mol H+/t	210	41	350	< 10
Sulfur - KCl Extractable	0.02	% S	0.33	0.10	0.36	0.40
Sulfur - Peroxide	0.02	% S	0.66	0.17	0.92	0.40
Sulfur - Peroxide Oxidisable Sulfur	0.02	% S	0.33	0.07	0.56	< 0.02
pH Measurements						
pH-KCL	0.1	units	4.8	4.7	4.5	4.7
pH-OX	0.1	units	6.3	6.6	5.8	7.5
Calcium Values						
Acid Reacted Calcium	0.02	% Ca	0.29	0.05	< 0.02	0.73
acidity - Acid Reacted Calcium	10	mol H+/t	140	26	< 10	370
Calcium - KCl Extractable	0.02	% Ca	4.7	1.3	3.4	4.5
Calcium - Peroxide	0.02	% Ca	5.0	1.3	3.4	5.3
sulfidic - Acid Reacted Calcium	0.02	% S	0.23	0.04	< 0.02	0.59
Magnesium Values						
Acid Reacted Magnesium	0.02	% Mg	0.07	0.13	0.07	0.73
acidity - Acid Reacted Magnesium	10	mol H+/t	60	110	58	600
Magnesium - KCl Extractable	0.02	% Mg	1.1	1.2	1.6	3.6
Magnesium- Peroxide	0.02	% Mg	1.2	1.3	1.6	4.3
sulfidic - Acid Reacted Magnesium	0.02	% S	0.10	0.18	0.09	0.96
Acid Base Accounting						
ANC Fineness Factor	0.5		1.5	1.5	1.5	1.5
Liming rate	1	kg CaCO3/t	11	2.3	20	< 1

GHD Melbourne	Client Sample ID		BH1-0.1	BH2-0.5	BH3-0.1	BH3-2.0
Level 8, 180 Lonsdale St	Lab Number		M09-Oc06862	M09-Oc06863	M09-Oc06864	M09-Oc06865
Melbourne	Matrix		Soil	Soil	Soil	Soil
Victoria 3000	Sample Date		Sep 29, 2009	Sep 29, 2009	Sep 29, 2009	Sep 29, 2009
Analysis Type	LOR	Units				
Net Acidity (acidity units)	10	mol H+/t	230	45	390	< 10
Net Acidity (sulfur units)	0.02	% S	0.36	0.07	0.63	< 0.02

GHD Melbourne	Client Sample ID		BH4-0.1	BH5-0.1	BH6-0.8	BH8-0.1
Level 8, 180 Lonsdale St	Lab Number		M09-Oc06866	M09-Oc06867	M09-Oc06868	M09-Oc06869
Melbourne	Matrix		Soil	Soil	Soil	Soil
Victoria 3000	Sample Date		Sep 29, 2009	Sep 29, 2009	Sep 29, 2009	Sep 29, 2009
Analysis Type	LOR	Units				
% Moisture	0.1	%	16	52	35	14
Acidity Trail						
Acid trail - Titratable Actual Acidity	2	mol H+/t	41	34	51	21
Acid trail - Titratable Peroxide Acidity	2	mol H+/t	46	49	90	29
Acid trail - Titratable Sulfidic Acidity	2	mol H+/t	5.0	15	39	7.5
sulfidic - Titratable Actual Acidity	0.02	% pyrite S	0.07	0.05	0.08	0.03
sulfidic - Titratable Peroxide Acidity	0.02	% pyrite S	0.07	0.08	0.14	0.05
sulfidic - Titratable Sulfidic Acidity	0.02	% pyrite S	< 0.02	0.02	0.06	< 0.02
Sulfur trail						
acidity - Peroxide Oxidisable Sulfur	10	mol H+/t	83	1500	1400	48
Sulfur - KCl Extractable	0.02	% S	0.35	0.26	0.46	0.27
Sulfur - Peroxide	0.02	% S	0.48	2.7	2.7	0.34
Sulfur - Peroxide Oxidisable Sulfur	0.02	% S	0.13	2.4	2.3	0.08
pH Measurements						
pH-KCL	0.1	units	4.5	4.9	5.0	4.6
pH-OX	0.1	units	5.9	5.6	5.2	5.7
Calcium Values						
Acid Reacted Calcium	0.02	% Ca	< 0.02	< 0.02	0.48	< 0.02
acidity - Acid Reacted Calcium	10	mol H+/t	< 10	< 10	240	< 10
Calcium - KCl Extractable	0.02	% Ca	2.5	6.9	6.6	0.70
Calcium - Peroxide	0.02	% Ca	2.5	6.9	7.1	0.71
sulfidic - Acid Reacted Calcium	0.02	% S	< 0.02	< 0.02	0.38	< 0.02
Magnesium Values						
Acid Reacted Magnesium	0.02	% Mg	< 0.02	0.35	0.27	< 0.02
acidity - Acid Reacted Magnesium	10	mol H+/t	< 10	280	220	< 10
Magnesium - KCl Extractable	0.02	% Mg	1.3	2.4	2.2	0.25
Magnesium- Peroxide	0.02	% Mg	1.3	2.7	2.4	0.25
sulfidic - Acid Reacted Magnesium	0.02	% S	< 0.02	0.46	0.35	< 0.02
Acid Base Accounting						
ANC Fineness Factor	0.5		1.5	1.5	1.5	1.5
Liming rate	1	kg CaCO3/t	6.2	77	73	3.5

GHD Melbourne	Client Sample ID		BH4-0.1	BH5-0.1	BH6-0.8	BH8-0.1
Level 8, 180 Lonsdale St	Lab Number		M09-Oc06866	M09-Oc06867	M09-Oc06868	M09-Oc06869
Melbourne	Matrix		Soil	Soil	Soil	Soil
Victoria 3000	Sample Date		Sep 29, 2009	Sep 29, 2009	Sep 29, 2009	Sep 29, 2009
Analysis Type	LOR	Units				
Net Acidity (acidity units)	10	mol H+/t	130	1500	1500	69
Net Acidity (sulfur units)	0.02	% S	0.20	2.5	2.3	0.11

GHD Melbourne

	Client Sample ID		DUP17
Level 8, 180 Lonsdale St	Lab Number		M09-Oc06870
Melbourne	Matrix		Soil
Victoria 3000	Sample Date		Sep 29, 2009
Analysis Type	LOR	Units	
% Moisture	0.1	%	51
Acidity Trail			
Acid trail - Titratable Actual Acidity	2	mol H+/t	34
Acid trail - Titratable Peroxide Acidity	2	mol H+/t	44
Acid trail - Titratable Sulfidic Acidity	2	mol H+/t	10
sulfidic - Titratable Actual Acidity	0.02	% pyrite S	0.05
sulfidic - Titratable Peroxide Acidity	0.02	% pyrite S	0.07
sulfidic - Titratable Sulfidic Acidity	0.02	% pyrite S	0.02
Sulfur trail			
acidity - Peroxide Oxidisable Sulfur	10	mol H+/t	1300
Sulfur - KCl Extractable	0.02	% S	0.51
Sulfur - Peroxide	0.02	% S	2.6
Sulfur - Peroxide Oxidisable Sulfur	0.02	% S	2.1
pH Measurements			
pH-KCL	0.1	units	5.0
pH-OX	0.1	units	5.5
Calcium Values			
Acid Reacted Calcium	0.02	% Ca	< 0.02
acidity - Acid Reacted Calcium	10	mol H+/t	< 10
Calcium - KCl Extractable	0.02	% Ca	6.6
Calcium - Peroxide	0.02	% Ca	6.6
sulfidic - Acid Reacted Calcium	0.02	% S	< 0.02
Magnesium Values			
Acid Reacted Magnesium	0.02	% Mg	0.24
acidity - Acid Reacted Magnesium	10	mol H+/t	200
Magnesium - KCl Extractable	0.02	% Mg	2.6
Magnesium- Peroxide	0.02	% Mg	2.8
sulfidic - Acid Reacted Magnesium	0.02	% S	0.32
Acid Base Accounting			
ANC Fineness Factor	0.5		1.5
Liming rate	1	kg CaCO3/t	67

GHD Melbourne Level 8, 180 Lonsdale St Melbourne Victoria 3000	Client Sample ID		DUP17
	Lab Number		M09-Oc06870
	Matrix		Soil
	Sample Date		Sep 29, 2009
Analysis Type	LOR	Units	
Net Acidity (acidity units)	10	mol H+/t	1300
Net Acidity (sulfur units)	0.02	% S	2.2



Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB0915865	Page	: 1 of 4
Client	: GHD SERVICES PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ASHLEY BARBER	Contact	: Tim Kilmister
Address	: LEVEL 8, 180 LONSDALE ST MELBOURNE VIC, AUSTRALIA 3001	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: ashley.barber@ghd.com.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 08 8235 6650	Telephone	: +61-7-3243 7222
Facsimile	: +61 08 8235 6694	Facsimile	: +61-7-3243 7218
Project	: 312412203 Lake Moodemere	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 06-OCT-2009
C-O-C number	: ----	Issue Date	: 29-OCT-2009
Sampler	: Ashley Barber	No. of samples received	: 11
Site	: ----	No. of samples analysed	: 1
Quote number	: EN/005/09		

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Inorganics

Environmental Division Brisbane

Part of the **ALS Laboratory Group**

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General Comments

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

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

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

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

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

- **Excess ANC not required because pH OX less than 6.5.**
- **Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO₃) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m³ in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m³'.**
- **pH FOX Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Vigorous; 4 - Very Vigorous**
- **Retained Acidity not required because pH KCl greater than or equal to 4.5**



Analytical Results

Sub-Matrix: SOIL

Client sample ID

Client sampling date / time

				DUP02	----	----	----	----
				29-SEP-2009 09:35	----	----	----	----
Compound	CAS Number	LOR	Unit	EB0915865-002	----	----	----	----
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	6.3	----	----	----	----
pH (Fox)	----	0.1	pH Unit	4.2	----	----	----	----
Reaction Rate	----	1	Reaction Uni	2	----	----	----	----
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	5.3	----	----	----	----
pH OX (23B)	----	0.1	pH Unit	4.8	----	----	----	----
EA029-B: Acidity Trail								
Titrate Actual Acidity (23F)	----	2	mole H+ / t	6	----	----	----	----
Titrate Peroxide Acidity (23G)	----	2	mole H+ / t	<2	----	----	----	----
Titrate Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	----	----	----	----
sulfidic - Titrate Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
sulfidic - Titrate Peroxide Acidity (s-23G)	----	0.02	% pyrite S	<0.02	----	----	----	----
sulfidic - Titrate Sulfidic Acidity (s-23H)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.02	% S	<0.02	----	----	----	----
Peroxide Sulfur (23De)	----	0.02	% S	<0.02	----	----	----	----
Peroxide Oxidisable Sulfur (23E)	----	0.02	% S	<0.02	----	----	----	----
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<10	----	----	----	----
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.02	% Ca	0.02	----	----	----	----
Peroxide Calcium (23Wh)	----	0.02	% Ca	0.02	----	----	----	----
Acid Reacted Calcium (23X)	----	0.02	% Ca	<0.02	----	----	----	----
acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<10	----	----	----	----
sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S	<0.02	----	----	----	----
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.02	% Mg	0.02	----	----	----	----
Peroxide Magnesium (23Tm)	----	0.02	% Mg	<0.02	----	----	----	----
Acid Reacted Magnesium (23U)	----	0.02	% Mg	<0.02	----	----	----	----
Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<10	----	----	----	----
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S	<0.02	----	----	----	----
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	----	----	----	----
Net Acidity (sulfur units)	----	0.02	% S	<0.02	----	----	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	<10	----	----	----	----



Analytical Results

Sub-Matrix: **SOIL**

Client sample ID

Client sampling date / time

Compound	CAS Number	LOR	Unit	DUP02	---	---	---	---
				29-SEP-2009 09:35	---	---	---	---
				EB0915865-002	---	---	---	---
EA029-H: Acid Base Accounting - Continued								
Liming Rate	----	1	kg CaCO3/t	<1	---	---	---	---





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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	A. Barber P. Beck	G. Jones P. Beck		G. Jones		19/1/2010