APPENDIX D: SOILS AND GROUNDWATER REPORTS (RCA, 1998, 2001)

REPORT ON GEOTECHNICAL AND ACID SULFATE CONDITIONS

HEXHAM SWAMP

EIS

Prepared for

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REPORT ON
GEOTECHNICAL AND ACID SULFATE CONDITIONS
HEXHAM SWAMP EIS

1 INTRODUCTION

Robert Carr & Associates were requested by WBM Oceanics to undertake a study of Hexham Swamp. The objective of the study was to assess the distribution and properties of the site soil profiles, the presence of acid-sulfate soils and the impact of tidal inundation in terms of hydro-geology, acid generation and soil erosion. This involved a review of available data, field studies and laboratory analysis. The study will be integrated into an Environmental Impact Statement (EIS) being prepared by WBM.

The work involved the following:

- compilation of background data
- limited soil and groundwater sampling
- laboratory analysis of selected samples

2 PROPOSED DEVELOPMENT

Hexham Swamp is located approximately 5 km northeast of Newcastle. It is part of the Ironbark Creek Catchment, which feeds into the Hunter River. Hexham Swamp comprises an area of about 3800ha of freshwater and estuarine wetlands. The area is drained by Ironbark Creek and a dendritic network of channels including Fishery and Shelley Creeks.

The swamp is covered by State Environmental Planning Policy No 14 - Coastal Wetlands (SEPP 14) which states that any draining, filling, clearing or levee construction within the area is deemed a designated development and therefore requires an EIS. The study area is bounded by the New England Highway to the North, Minmi Road and residential development at Wallsend and Maryland to the South and the disused Richmond Vale rail line to the West (see drawing 1).

The swamp is closed off to the tidal influence of the river by means of 8 floodgates constructed in 1970 to 1971 and situated at the mouth of Ironbark Creek. These gates allow one way flow of water from the swamp to the river. Under these low inflow conditions, the average water level in the swamp is closer to the low tide level in the Hunter River rather than the mean tidal level. One of the gates has been left open about 0.15m to allow some tidal interchange. Some of the effects of the current floodgate regime have been:

- A lowering of the ground water table behind the gates
- A large reduction in the extent of saline waters entering the swamp
- Stagnation of water behind the floodgates

It is proposed that some or all of these floodgates may be reopened to allow tidal exchange in the swamp. The objectives of this action would be to:

- Enhance fishery habitats
- Improve habitat for birds, frogs and aquatic invertebrates
- Increase the diversity of habitats within Hexham Swamp
- Reduce nutrient levels in the water
- Reduce water weeds such as alligator weed
- Normalise dissolved oxygen levels
- Increase salinity and tidal flooding over acid sulfate soils, reversing any acid mobilisation in swamp drainage
- Increase the flushing of small tributaries which have become stagnant under the present floodgate regime
- Restore scouring of the creek bed

Options proposed by WBM for the proposed operation of the floodgates are:

1. "Do Nothing" - Maintain the current situation (ie one gate opened to a height of 0.15m)
2. One gate open, used to assess the impact of the initial stage of the gradual opening of all 8 gates, resulting in an inundation area of 0.45km^2
3. Full opening of the floodgates at all times except when the river is in flood, resulting in the inundation of 11.6km^2
4. Same as option 3 but with gate closure to exclude the highest tides, resulting in the minimisation of ponded water at the upper tidal limit
5. Same as option 3 but also including the bunding of an area at Shortland to prevent flooding across the rear of residential properties

The location of the proposed bunding in option 5 is shown in Drawing 2.

There are concerns that the excavation of on site materials used in the construction of the bund would result in acid sulfate soil conditions and generation of acid. This issue is addressed in the report together with geotechnical considerations.

3 BACKGROUND REVIEW

3.1 Acid Sulfate Soils

Acid Sulfate Soils (ASS) contain pyrite which, on exposure to oxygen and water, leads to the generation of sulphuric acid. Acidic leachate can lead to the release of toxic concentrations of aluminium and iron into water bodies which can affect water quality and cause significant ecological damage.

ASS can therefore be a major constraint on land use and development, however successful management of areas of ASS is possible.

There are two types of ASS, actual ASS and potential ASS. Actual ASS are those presently producing acid by the oxidation of pyrite in the soil. Potential ASS are soils containing pyrite which have not yet oxidised and these are generally located below the water table.

ASS can occur in the following geomorphic settings:

- Sediments of recent geological age
- Soil horizons not more than 5m above high tide level
- Marine and estuarine settings

There are a number of ways of assessing the presence or absence of acid sulfate soils. These methods are discussed below as most of them have been used during previous investigation of the subject site.

Field Testing:
Soils are tested using a calibrated pH meter before and after oxidation in peroxide. Soils with in-situ pH of less than 2.5 after oxidisation are potential ASS and soils with an in-situ pH less than 4 are actual ASS. This test does not differentiate between sulphur based and organic based acidity.

Visual observations:
Potential ASS are typically

- Waterlogged
- pH neutral
- Dark grey, estuarine, clays, silts or sands

The presence of actual ASS is indicated by the following:

- Acid surface or groundwater
- Iron stains on any drain surfaces or iron stained drain water
- Jarosite present in soil (indicated by pale yellow precipitates and coatings)
- Unusually clear or milky green drain water

Laboratory testing: The following laboratory tests are available for assessing the acid potential of a soil -

Peroxide Oxidisable Sulphur Analysis (POSA) - the POSA test measures the acidity potentially produced from pyrite oxidation only and does not include acidification from other sources (such as carbon). This test may be conservative because it does not take into account the natural acid buffering capacity of the soil.

EPA guidelines state that samples with more than 0.05% oxidisable sulphur may constitute a significant risk in the absence of buffering sources.

For clayey soils, levels of POSA greater than 1.54 kg H_2SO_4/tonne of dry soil may constitute a significant risk while for sandy soils 0.31 kg H_2SO_4/tonne of dry soil is the threshold value.

Acid Neutralising Capacity (ANC) – some soils have a natural acid buffering or neutralising capacity which can be assessed by determining the soil lime (calcium carbonate) content. The ANC is used in conjunction with the POSA results to determine the Net Acid Generating Potential (NAGP) of the soil.

Net Acid Generating Potential (NAGP) – NAGP is the amount of acidity by pyrite oxidation less the buffering capacity of the soil. If the acid produced is greater than the buffering capacity of the soil, acid will be produced. NAGP can be used to assess the amount of neutralising agent required to treat the net acid generated.

A NAGP greater than zero indicates that acid may be produced during the oxidation of pyrite.

Total Carbon - the oxidation of organic carbon in soils can also produce low pH results due to the production of organic acids. However, in the field, this oxidation process is slow and any acid produced is assimilated by the surrounding environment. It is therefore important to determine if a high acid result is due to the sulphur content or the total carbon content. This can be achieved by determining the total carbon level in the soil.

Total actual acidity (TAA) and Total potential acidity (TPA) - the total actual acidity (TAA) is the total amount of acidity in the soil at the time of testing. The total potential acidity (TPA) is the maximum amount of acidity which a soil may contain after complete oxidation and takes into account the neutralising capacity of the soil. The difference between the TAA and TPA result gives a potential for the future oxidation that may occur.

TAA and TPA analyses enable an assessment of the neutralisation required to bring the soil material pH to 5.5. There are no criteria for acceptable concentrations of TPA or TAA although a TPA of zero indicates that no significant levels of acid are expected to be produced on oxidation.

3.2 Previous Acid Sulfate Studies

The Beresfield 1:25,000 Acid Sulfate Risk map by the Department of Land and Water Conservation (DLWC) shows the probability of encountering acid-sulfate soils in the study area. Hexham Swamp to lies almost entirely within an area described as having "high probability of occurrence of acid-sulfate soil materials within the soil profile". This map is shown in Drawing 3 together with locations where samples have been tested for acid sulfate soil conditions. The locations where test results indicate actual or potential acid sulfate soils are noted.

Previous studies and soil profile testing carried out in the study area in relation to acid sulfate soils includes:

- EIS by CH2M Hill in 1997 for the proposed Maryland to Shortland Rising Main,
- DLWC sampling and testing in August and September 1996 along Ironbark Creek, and
- DWLC Newcastle Acid Sulfate Soil Survey in 1998.

The EIS prepared by CH2M Hill in 1997 for the proposed Maryland to Shortland Rising Main involved drilling and sampling of 6 boreholes along the length of the rising main. The location of the boreholes is shown in Drawings 2 and 3. Samples were collected at depth intervals of 0.5m from 4 of the boreholes. Bores HA5 and HA6 were located in fill material and no samples were collected. The borelogs indicated two distinct layers in the soil profile. The top layer was clay and found to be generally 1-1.5m deep with the water table at a depth of around 1m. Below this layer was a Shelley clay of high plasticity. The samples were tested for oxidisable sulphur and acid neutralising capacity (ANC). From this the net acid generating capacity (NAGP) of the soil was determined. Results from the study are presented in Table 1.

Table 1 Acid Sulfate Laboratory Test Results
Maryland to Shortland Rising Main

Bore	**Depth (m)**	**Oxidisable Sulphur %**	**ANC %**	**NAGP Kg H_2SO_4/ tonne**
HA1	0.5	0.027	0.76	-6.8
	1.0	1.62	0.84	**+42.3**
	1.5	2.38	2.6	**+48.4**
	2.0	1.71	7.5	-21.4
HA2	0.5	0.14	0.26	**+1.8**
	1.0	3.36	0.43	**+101**
	1.5	2.15	10.4	-36.7
HA3	0.5	0.064	0.93	-7.3
	1.0	2.28	10.2	-306
	1.5	0.68	10.7	-85.7
	2.0	1.73	9	-35.9
HA4	0.5	0.036	0.93	-8.2
	1.0	1.85	9.4	-36.1
	1.5	1.57	9.0	-40.8
	2.0	1.26	7.9	-39.6

ANC = acid neutralising capacity
NAGP = net acid generating potential

The samples indicate the presence of high oxidisable sulphur levels below the water table with most of the soil samples containing greater than the EPA threshold of 0.05% oxidisable sulphur and up to 3% in some samples. The amount of buffering capacity available in the soil is derived from the soil calcium carbonate content. In most of the soil samples the acid neutralising capacity was sufficient to neutralise any acid that would be produced resulting in a negative NAGP value. This buffering is limited by the size of the carbonate particles, which in this case, particularly in the lower soil horizon, is in the form of larger particles such as shells. The buffering or acid neutralising capacity of similar soils appears to be variable between locations and with depth at a specific location. This may be associated with a variable carbonate content distribution within the clay soils. The lower oxidisable sulphur content in the samples from 0.5m depth suggests that the sulphur content above the water table has been significantly reduced through oxidation.

The Department of Land and Water Conservation sampled 4 locations at depths of 0m to 0.6m along Ironbark Creek in August 1996 and tested for acid sulfate potential. A second set of samples was collected during September 1996 from the same locations along the length of the creek and approximately 6 metres from the bank of the creek. The 4 sample locations used during the DLWC study are shown on Drawings 2 and 3 and the results of the tests conducted by the DLWC are presented in Table 2.

Table 2. DLWC Laboratory Acid Sulfate Results

Sample	EC (dS/m)	pH	TPA (moles/ kg)	Iron Present	pH after Oxidation	Texture
Ironbark Ck 1	2.93	8.6	0.16	yes	3.2	Light Med Clay
Ironbark Ck 2A	0.91	7.3	0.113	yes	3.9	Silty Clay
Ironbark Ck 2B	2.73	8	0.078	no	4.1	Silty Clay
Ironbark Ck 3	1.97	8.4	0.023	no	4.5	Clay Loam
Ironbark Ck 4	6.76	8.2	0.225	no	4.3	Silty Clay
No.1	0.32	7.4	nd	no	5.6	Medium Clay
No.2	0.29	7.3	nd	no	5.5	Light Med Clay
No.3	0.23	5.1	<0.001	no	5.2	Clay Loam
No.4	0.23	5.3	0.006	no	5.1	Clay Loam

nd = not detected
TPA = total potential acidity
EC = electrical conductivity

The results indicate that there are no actual or potential acid sulfate soils based on pH before and after oxidation. The soils sampled in from the creek bank (No 1 to No 4) do not appear to contain sulphidic materials. It is difficult to assess a relationship between the sample location proximity to the creek bank and acid sulfate soil potential as samples were taken from varying depths. However results suggest that the occurrence of sulphidic materials in the soil profile may be variable and localised and that some neutralising of the soils may be required should they become oxidised.

Data on acid sulfate soil conditions acidity was obtained from the two soil profiles drilled and tested in Hexham Swamp as part of the Newcastle Acid Sulfate Soil Survey. This data is summarised in Table 3.

Table 3 Newcastle Acid Sulfate Soil Survey, Hexham Swamp Test Data

Profile	EC dS/m	pH (water)	pH after oxidation	TAA (moles/kg)	TPA (moles/kg)
5 0.2 – 0.6m	1.2	5	4.5	0.006	0.006
5 0.6 – 1.4m	1.3	5.6	4.2	0	0.008
4 0.3 – 0.6m	0.9	6.7	5.5	0	0
4 0.6 – 1.0m	0.9	6.7	5.8	0	0.009

EC = electrical conductivity
TAA = total actual acidity
TPA = total potential acidity

The results indicate very limited production of acid would occur on oxidation.

3.3 Soil Properties

A study of the properties of the soil in Hexham swamp was undertaken by the Ironbark Creek Erosion Task Group in a study commissioned by the Hunter Valley Conservation Trust. This study examined the soil properties of different regions in the Ironbark Creek catchment and included the comprehensive analysis of two samples taken from Hexham Swamp - one sample from each of the dominant soil horizons. A soil landscape map undertaken for the catchment is shown on Drawing 4 and indicates that the swamp occurs within the Hexham Swamp soil landscape.

Soil profiles undertaken by the DLWC in the study area and incorporated into the NSW soil data system are attached in Appendix 1 and are summarised in Table 4.

Table 4 DLWC Soil Data Profiles

Profile	Layer depth (m)	Texture	Structure	Erosion Hazard
165	0 – 0.6 0.6 – 1.2	Silty clay loam Silty light clay	Massive massive	Slight
167	0 – 0.35 0.35 – 0.9 0.9 – 2.0	Clay loam, sandy Light-medium clay Silty light clay	Weak pedality Moderate pedality Weak pedality	Moderate
168	0 – 0.25 0.25 – 0.8	Clay loam Medium-heavy clay	Weak pedality Smooth peds	Slight
169	0 – 0.12 0.12 – 0.25 0.25 – 0.6	Loam Fine sandy clay loam Light clay	Weak pedality Weak pedality Moderate pedality	Slight
170	0 – 0.28 0.28 – 0.65	Heavy clay loam Silty clay loam (jarosite)	Moderate pedality Massive	Slight
171		No data		Slight
173	0 – 0.23 0.23 – 0.42 0.42 – 1.1	Clay loam Light clay Fine sandy loam	Moderate pedality Massive massive	Slight
175	0 – 0.25 0.25 – 0.47 0.47 – 0.57	Clay loam Medium clay Sandy clay loam	Moderate pedality	Slight
4	0 – 0.3 0.3 – 0.6 0.6 – 1.0	Silty clay Light-medium clay Light-medium clay	Moderate pedality Massive Massive	Slight
5	0 – 0.2 0.2 – 0.6 0.6 – 1.4	Fibric peat Silty clay Clay loam, sandy	Moderate pedality Massive Massive	Slight

The profiles in Table 4 indicate the soil profiles within the swamp range from loam to clay with typically a clayey loam topsoil to about 0.2m to 0.3m over a light to medium clay that becomes sandier (sandy clay loam to sandy loam) at depths of about 1m.

Other soil materials noted in the swamp area include brown fibrous peat comprising a surface layer of organic material and loose pale sand which often contains shell fragments and may underlie the surficial clay layers.

Soil data from the 6 bores undertaken by CH2M Hill in 1997 for the proposed Maryland to Shortland Rising Main can be summarised as:

- Topsoil comprising low to medium plasticity clay about 0.2m thick, over
- Clay, high plasticity, variable strength ranging from stiff to soft, strength decreasing with depth, to 0.8m to 1.4m, with a groundwater table at about 1m depth, over
- Shelley clay, high plasticity, soft to depths in excess of 2m.
- Fill was encountered in two of the bores.

The physical characteristics of the two dominant soil horizons in Hexham swamp as tested by the DLWC are shown in Table 5. Also included in the table is a summary of information obtained from the NSW soil data system.

Table 5 Hexham Swamp physical soil properties

Profile		**hs1**	**hs2**	**173**	**173**	**175**	**175**
Layer				1	2	1	2
Particle size analysis (%)	clay	20	50	25	51	52	45
	silt	23	21	22	32	28	29
	very fine sand	24	14	-	-	-	-
	fine sand	12	6	26	12	17	20
	coarse sand	20	8	8	5	3	6
	gravel	1	1	19	-	-	-
Dispersion Percentage	(%)	16	31	24	62	56	15
Emmerson Aggregate Test	(class)	3(1)	5	3-2	2-1	2-1	5
USCS Classification	(class)		CH	OL	CH	OL	CL
pH		6.1	7.2	4.6	4.4	6.2	6.8
Electrical Conductivity	(dS/m)	0.06	0.06	0.21	0.35	4	4.5
Liquid Limit	(%)		79				
Plastic Limit	(%)		24				
Linear Shrinkage	(%)		15				

Results indicate that the soils sampled range from silty clays (clays) with a variable sand content through to silty clayey sands (loams). The results indicate that two of the clay samples are partially dispersive with the remaining 4 samples being non–dispersive. A linear shrinkage value of 15% for one of the clay samples indicates that clay soils are likely to undergo shrinkage and fissuring on drying.

3.4 Groundwater Properties

The position of the groundwater table relative to the ground surface has been noted on some DLWC soil profiles as well as the borelogs along the proposed route of the Marylands to Shortland rising main. In general the ground water table is noted to occur between 0.5 and 1.5m below ground level.

Fluctuations in the ground water level can be expected depending on climate.

3.5 Soil Erosion

The Ironbark Creek Catchment Erosion Task Group Study identified sources of sediment that enters Hexham swamp and concluded that no significant erosion was occurring in Hexham swamp and that the area was in a period of siltation. The sediment load entering the swamp greatly exceeds the sediment discharge into the Hunter River.

Soil profile mapping by the DLWC indicates that the surface soils within the swamp area generally have only a slight erosion hazard.

The incidence of scour erosion has been noted in the west of the swamp and this has been attributed to high run-on from the surrounding cleared slopes and the effects of lowered water tables due to drainage of the swamp. The paths taken by catchment run-on causes the localised formation of scour channels resulting in redistribution of sediments to lower gradient areas of the swamp away from the margins.

3.6 Geotechnical Data

A number of geotechnical investigations have been undertaken for road, industrial and communication projects around the perimeter areas of Hexham Swamp. A summary of subsurface conditions for the projects is presented in Table 6 with approximate locations shown on Drawing 2.

Table 6 Geotechnical Data

Site	Project / Location	Profile	Depth (m) to	
			Rock	GWT
A	Sandgate Road Industrial	Clay alluvium	6	1
B	Radio Tower Hexham Swamp	Soft estuarine clay	8	0.1
C	Creek Road Industrial	Fill to 3m over interbedded clays and sands	9	2.5
D	State Highway 23	Soft estuarine clay	5	0.1
E	State Highway 23	Sand to 6m over clay	35	1
F	State Highway 23 Ironbark Creek Bridge	Clay to 2.5m over sand to 25m over clay	>34	1
G	Hexham Coal Preparation Plant	Coal chitter and tailing fill up to 6-7m over low strength alluvial soils	-	-
H	Maryland and Windy Hill residential subdivisions	Residual clay soils over siltstone rock	1-3	-

GWT = ground water table depth below the surface

The soils encountered in the Hexham Swamp are characterised by the presence of saturated low strength clays typically of soft to firm consistency with a surface crust of variable thickness. These clay soils are prone to consolidation settlement on loading. Observation of the fill pads for the transmission easement along Ironbark Creek indicates settlements of in the order of 0.3m to 0.5m for 1m to 1.5m high fill embankments. The settlement is relative to the pile supported concrete foundations.

This has implications for the design and construction of bund walls and levees. Bunds or levees constructed on these soils will undergo consolidation settlement with the rate and magnitude dependent on the depth and geotechnical properties of the soil and the applied load (ie bank height). Where bunds or levees are proposed, this issue will need to be assessed as the implications of a bund/levee crest level that reduces with time will need to be considered.

4 FIELDWORK

Fieldwork undertaken by Robert Carr & Associates Pty Ltd involved:

- Drilling of 9 hand auger bores (up to 1.7m depth) for soil profile identification and to provide samples for physical and acid sulfate testing and groundwater quality assessment.
- Installation of three 50mm PVC standpipe piezometers for groundwater sampling and quality assessment.
- Field measurement of groundwater and surface water pH and electrical conductivity (E.C.)
- Mapping of soil profiles, creek bank erosion and site features.

Laboratory testing was undertaken to characterise site conditions and supplement existing data. Laboratory testing involved:

- Acid sulfate testing on 8 samples to assess oxidisable sulphur levels, total actual acidity, total potential acidity, soil buffering capacity and net acid generating potential.
- Emerson crumb dispersion testing on 2 samples using saline site water
- Particle size distribution analysis on 2 samples for erosion susceptibility analysis
- Water quality testing of 3 groundwater samples recovered from the piezometers.

The locations of the bores are shown on Drawing 2 with standpipe piezometers installed in bores 1, 2 and 7. Engineering logs of the bores are presented in Appendix 1.

5 FIELD AND LABORATORY TEST RESULTS

5.1 Groundwater Quality

Groundwater samples were taken from the three piezometers on 30th August 1998. The samples were tested for general water quality indicators. The results are shown below in Table 8. Samples GW1, GW2 and GW7 were taken from bores BH1, BH2 and BH7 respectively.

All the waters tested were Na-Cl type waters and were found to be slightly acidic. Nutrient (nitrate) levels were low. GW1 (upstream) and GW2 (downstream) were highly saline as would be expected given they were taken from bores situated near the floodgates. Water taken from GW7 in the northern corner of the swamp was found to be fresh.

Table 7 Groundwater quality data

Analyte		Sample ID		
		GW1	GW2	GW7
Cations in mg/l	Calcium as Ca	367	153	35.4
	Magnesuim as Mg	624	389	15
	Sodium as Na	5430	3640	85.3
	Potassium as K	91.3	108	2.5
Cations in me/l	Calcium as Ca	18.3	7.6	1.8
	Magnesuim as Mg	51.4	32	1.2
	Sodium as Na	236	158	3.7
	Potassium as K	2.3	2.8	0.063
	pH	5.3	6.3	5.8
	E.C @25°C (uS/cm)	26100	19900	724
	Resistivity @ 25°C (Ohm.m)	0.4	0.5	14
	Hydroxide as OH	nd	nd	nd
	Carbonate as CO_3	nd	nd	nd
Anions as mg/l	Bicarbonate as HCO_3	21.8	212	47.9
	Sulphate as SO_4	5510	1160	128
	Chloride as Cl	6890	6410	106
	Nitrate as NO_3	0.13	nd	nd
	Hydroxide as OH	nd	nd	nd
	Carbonate as CO_3	nd	nd	nd
Anions as me/l	Bicarbonate as HCO_3	0.36	3.5	0.78
	Sulphate as SO_4	115	24.3	2.7
	Chloride as Cl	194	180	3
	Nitrate as NO_3	0.002	nd	nd
	TDS - Based on E.C	16700	12700	463
Derived Data (mg/l)	TDS - Calculated (HCO_3=CO_3)	18900	12000	396
	Total Hardness	3480	1980	150
	Carbonate Hardness	17.9	174	39.2
	Total Alkalinity as $CaCO_3$	17.9	174	39.2
	Cation Total (me/l)	308	201	6.8
Totals and Balance	Anion Total (me/l)	309	208	6.4
	Ion Difference	1	7.5	0.3
	Ion Balance (%)	0.20%	1.80%	2.50%
	Sodium/Total Cation Ratio (%)	77%	79%	55%
	Cl/SO_4 Ratio	1.3	5.5	0.8

The Cl/SO_4 ratio was determined for all three samples. In GW1 and GW7 this ratio was found to be around 1 and the pH to be around 6. This indicates the presence of pyritic material plus the presence of a buffering agent in the soil such as calcium carbonate.

Measurement of groundwater electrical conductivity and pH was undertaken in the bores during drilling. Results are presented on the logs and are summarised in Table 8.

Table 8 Field Groundwater Quality Data

Bore	**Depth to groundwater (m)**	**EC µS/m**	**pH**
1	1.1	19500	5.3
2	0.3	15900	6.1
3	0.7	32000	5.5
4	0.25	900	7.2
5	0.6	3000	5.8
6	0.7	19000	6.7
7	0.25	700	6.9

EC = electrical conductivity

Results indicate the presence of highly saline ground water over most of the swamp area with fresh water recharge over the higher areas at the northern corner (bore 4) and along Ironbark Creek from the Wallsend area.

A confined aquifer in sandy soils appears to occur across the eastern part of the swamp at a shallow depth (about 1m) beneath surface clay layers. The aquifer appears to be saline indicating marine deposition. Fresh water recharge appears to be occurring around the margins of the aquifer, however the confined nature of the aquifer and the clayey nature of the surface layers suggest that the rate of fresh water recharge is slow. The lowering of ground water levels associated with the tidal gates and cessation of tidal flushing is likely to have increased the rate of fresh water recharge into the saline aquifer, however the aquifer still maintains a strong saline signature.

5.2 Acid Sulfate Test Results

The methodology adopted for the acid sulfate soils investigation was based on acid sulfate guidelines established by the EPA and more recent guidelines developed by the EPA, Department of Urban Affairs and Planning and the Acid Sulfate Soils Management Advisory Committee.

Samples were stored in airtight plastic bags at below 4°C and sent to the Centre for Coastal Management at Southern Cross University for analysis. Sample analysis involved a combination of the following tests:

- pH (1:5) in water

- Oxidisable sulphur, %Sox
- POSA, peroxide oxidisable sulphuric acidity, kg H_2SO_4/tonne
- Total Sulphur , %S
- Total Carbon, %C
- Total actual acidity (TAA)
- Total potential acidity (TPA)

Laboratory report sheets for acid sulfate testing are attached and summarised in Table 9.

Table 9 Acid Sulfate Test Results, Total Actual and Potential Acidity

Bore	Depth (m)	PH (water)	TAA pH	TPA pH
1	0.05	6.1	4.6	5.0
1	0.45	6.7	6.0	6.3
1	1.6	6.0	5.4	
2	0.05	6.5	5.6	6.2
2	0.25	6.2	4.9	6.1
3	1.2	7.1	6.4	5.9
4	0.5	7.5	6.3	6.0
6	0.23	7.0	6.2	6.2
7	0.05	6.2	5.6	
7	0.8	5.0	4.0	5.5
9	0.05	4.6		
9	0.4-0.5	3.6		
9	1.0		3.7	1.5

Results indicate that, apart from Bore 9, none of the samples tested would be classified as actual or potential acid sulfate soils. The soil profile at bore 9 had well developed jarrosite nodules between 0.3m and 0.6m depth and a pH of 3.6, indicative of actual acid sulfate soil conditions. Estuarine clay from 1.0m depth had a total potential acidity of 1.5, indicating potential acid sulfate soils.

Table 10 Total Potential Acidity and Neutralising Requirements

Bore	Depth (m)	Oxidisable Sulphur %	POSA Kg H_2SO_4/ tonne	TPA Kg H_2SO_4/ tonne	Neutralising Requirements Kg lime/ m^3
1	0.05	0.029	0.9	0.1	0.1
1	0.45	0.023	0.7	0	0
1	1.6	(0.52) *			NT
2	0.05	0.013	0.4	0	0
2	0.25	0.023	0.7	0	0
3	1.2	<0.005	<0.2	0	0
4	0.5	<0.005	<0.2	0	0
6	0.23	<0.005	<0.2	0	0
7	0.05	(0.08) *			NT
7	0.8	0.011	0.3	0	0
9	0.05	(0.22)*			
9	0.4-0.5	(2.12)*			
9	1.0	5.7	178	178	129

* Neutralising requirements based on TPA results

(0.52)* = total sulphur NT= not tested

POSA = peroxide oxidisable sulphur analysis

TPA = total potential acidity

The levels of oxidisable sulphur from all samples tested, except location 9, were less than 0.03% which is less than the action criteria threshold of 0.05% outlined by the EPA, Department of Urban Affairs and Planning and the Acid Sulfate Soils Management Advisory Committee (1997) for sandy loams and light clays. The tested POSA values are less than the threshold of 1.54 Kg H_2SO_4/ tonne of soil used by the NSWEPA (1995) for soils having a high risk of acid generation. The TPA values are less than 0.1 H_2SO_4/ tonne indicating limited potential for acid production.

The high sulphur content encountered in bore 1 at 1.6m depth indicates the presence of potential acid sulfate soils at depth at this location.

Very high sulphur and oxidisable sulphur levels were encountered in bore 9 with a total potential acidity of 178kg $H_2 SO_4$ /tonne of soil. A neutralising requirement of in excess of 100kg of lime per cubic metre of soil would be required if the soil were oxidised at this location.

5.3 Soil Profiles

Soil profiles drilled to supplement the existing DLWC data confirmed the general subsurface profiles noted in Section 3.3.

The soil profiles encountered appear to have been derived from either alluvial sedimentation associated with fresh water overbank deposits from the Hunter River and Ironbark Creek or estuarine sedimentation associated with saline waters. Table 12 shows the depth to which clay and sand layers were encountered in the bores and delineates between clays on the basis of inferred depositional origin.

Table 11 Bore Profiles and Inferred Depositional Origin

Bore	Estuarine clays	Alluvial clays/silts	Sands	Comment
1	-	0 – 0.5m	0.5m - >1.7m	
2	> 1.7m			
3	-	0 – 0.9m	0.9m - >1.7m	
4	-	0.2 – 1.0m	1.0m - >1.7m	
5	-	0 – 0.85m	-	
6	-	0 - >1.5m	-	
7	-	0 - .1.25m	-	
8	-	-	-	fill
9	>1.6m			

\- not present

The surface soils over most of the swamp appear to have derived through alluvial soil deposition associated with the Hunter River and the catchment creeks entering the swamp. The terrestrially derived alluvial soils are usually not associated with acid sulfate soil conditions and this has been confirmed by test results in these areas. Estuarine soils may occur in these areas below the surface alluvial soils.

The occurrence of estuarine mud (clay and silt) deposits at shallow depth appears to be localised around the Ironbark Creek area. The marine deposition of these mud deposits is conducive to the formation of acid sulfate soil conditions as noted on Drawing 3 which shows the distribution of potential or actual acid sulfate soils based on laboratory test results.

5.4 Physical Soil Test Results and Properties

Physical testing on soil samples recovered from the bores involved:

- Emerson crumb testing carried out in saline water to assess potential soil dispersion. Results on clay samples from bores 1 and 4 indicated that the soils are non-dispersive.
- Particle size distribution testing from bores 1 and 7 indicated a silt and fines content of 21% and 54% respectively in the sandy / loamy soils.

The presence of some partially dispersive clay soils was noted in Section 3.3. In general the clay soils encountered in the swamp appear to be non-dispersive with the localised occurrence of some partially dispersive soils. Clays exposed in the creek banks along the waterways do not exhibit erosion characteristics that would be associated with dispersive soils.

The moisture content of the clay soils increases with depth and will fluctuate depending on climatic conditions and the ground water level. During the summer months a thin surface crust of higher strength soil will develop over the low strength saturated clays. Depending on the clay type, surface fissuring or cracking of the clays may occur on desiccation. The clay soils within the swamp are generally saturated with moisture contents well in excess of that required to achieve compaction specification for earthworks such as bunds and levees. Significant drying of these soils would be required before they could be utilised for engineered structures.

6 EROSION AND SEDIMENTATION

The Ironbark Creek Total Catchment Strategy Study has noted that Hexham Swamp acts as an excellent trap for the catchment area with little of the sediment transported through the swamp to the Hunter River. The swamp acts as an efficient sediment basin due to a low gradient and mass of filtering vegetation. The study estimated an annual sediment load of about 8,500 tonnes of delivered sediment with an output of about 400 tonnes into the Hunter River. The sediment load is noted to be variable, depending on climate and development.

Whilst the Hexham Swamp area acts as a sediment trap, erosion and soil loss is occurring in the residual soil landscapes around the swamp. The areas surrounding the swamp comprise residual clay soils and weathered rock associated with the Tomago Coal Measures. These clay soils are highly susceptible to sheet and rill erosion particularly where the topsoil has been removed or disturbed.

Creek bank erosion within the study area was noted at the following locations:

- Ironbark Creek at the HWC pipeline crossing where scour erosion of the western bank has exposed the piles and concrete foundations and resulted in cracking of the wingwall.
- Fishery Creek where localised scour has resulted in past failure of wingwall foundations for the HWC pipeline. Removal of support from beneath and behind the walls has required replacement with concrete piled foundations. Localised high scour flows may occur at this location as the embankment along the HWC easement appears to direct surface flows to this location.

- Along the western banks of Ironbark Creek which have been cleared for grazing. The bank is typically steep and up to 1m in height with localised slumping and toppling failures occurring due to erosional undercutting. The presence of small terraces of limited width running parallel to and below the level of the general bank may be indicative of past slump failure along the bank or alternatively have been formed by cattle. The occurrence of rock fill along parts of the bank suggests some measure of past stabilisation work has been undertaken in some areas.

- Fill estimated up to about 1m in height has been placed in the past along the eastern bank of Ironbark Creek between the tidal gates and the HWC pipeline to form a bund. The eastern bank exhibits a lesser degree of bank erosion than the western bank due to the presence of vegetation. At some locations erosion at the fill and soil interface is undercutting the bank and causing localised toppling of soil blocks.

Evidence of creek bank erosion associated with cattle and stock was noted along Ironbark, Fishery and Shelley Creeks. Creek bank erosion appears to be predominantly occurring in areas where vegetation has been removed for grass pasture.

The fill embankments and tracks along the HWC pipeline and transmission line easements act as bunds locally impounding surface waters and resulting in localised areas of concentrated flow. The concentration of flows by these structures increases the risk of localised sheet and scour erosion.

The susceptibility to erosion of the surface soils in Hexham Swamp is considered to be low on the basis of soil properties, vegetative cover and very low surface gradients. The swamp is periodically inundated with significant run off of surface waters occurring to the drainage paths. Under these general sheet flow conditions the erosion hazard appears to be slight, however under concentrated flows the risk of erosion is high.

Some localised sheet and rill erosion is occurring along the margins of the swamp where urbanisation has resulted in increased and concentrated run off. The erosion appears to be predominantly occurring along the foot slopes of the surrounding residual soil hillside areas at the transition with the swamp. The boundary between the hillside areas and the low gradient swamp areas is generally marked by a sharp break of slope.

7 IMPACT OF TIDAL INUNDATION

7.1 Acid Sulfate Soils

The issue has been raised that with regular tidal inundation, poor quality water (ie low pH and iron and aluminium rich) may be flushed from these areas into Ironbark Creek and the Hunter River. The potential occurrence of a pulse of high acid water discharge during the initial stages of tidal inundation has been assessed.

Tidal inundation will significantly reduce the potential of acid sulfate soils to generate acid by raising the groundwater table and providing a more static groundwater level. This will limit the depth of potential pyrite oxidation and restrict fluctuations in groundwater levels associated with climate. The other beneficial effect of tidal inundation is the buffering component of saline soils associated with carbon dioxide and bicarbonate ions which tends to maintain a pH within the slightly alkaline range (7.5 – 8.5). The re-introduction of a tidal regime will help to stabilise the current oscillating pH and salinity levels that occur at the tidal gates.

McGregor (1979) noted that with the installation of the tidal gates there was no drop in pH of discharge waters as was expected given the potential lowering of the groundwater levels.

Water quality monitoring has been undertaken by the NSW Department of Public Works both upstream and downstream of the tidal gates at Ironbark Creek. Results for May and June of 1998 are attached in Appendix 2 and indicate:

- Downstream from the gates under tidal influence pH fluctuates between 6.5 and 8.5 on a tidal basis with higher pH values under the influence of mildly alkaline saline water at high tide and lower pH values under the influence of swamp drainage at low tide.

- Upstream from the gate pH is relatively stable at 6.5 to 7.5 with no noticeable increase after rainfall events.

- Electrical conductivity levels downstream range from <1 to 50 mS/m depending on tide and the amount of fresh water discharge from the gates. Upstream the salinity levels range from <1 to about 40 mS/m depending on the rate of saline inflow through the one tidal gate relative to fresh water discharge from the catchment.

- Between 17th and 20th of May, approximately 130 mm of rainfall fell in the catchment area. Water levels at the tidal gates rose to about 1m to 1.5m above tidal level on the 20th of May. Under discharge from the catchment, pH levels both upstream and downstream of the gates remained static at about 6.5 until tidal influence of saline waters started occurring about 3 days later downstream and about 10 days later upstream. A minimum pH level of

6 occurred during and subsequent to the catchment discharge with no noticeable low pH levels associated with acidic discharge after catchment flushing.

- An extended dry period occurred in the region during the summer months of 1998 and extending through to the last week in May. At this point it is envisaged that groundwater levels in the swamp would have been at a low point and the depth of potential acid sulfate soil oxidation at a maximum. Subsequent inundation and flushing usually represents a worst case scenario in terms of generating acid run of. Monitoring results at the tidal gates after this event do not the presence of acidic discharge.

The above data indicates that under the current hydrological / hydro-geological regime, there does not appear to be episodes during which pulses of acidic water (ie pH <4) are discharged from the tidal gates. The swamp is subject to periodic inundation and flooding with the surface soils subject to flushing from freshwater run off into the creeks with discharge through the gates. During two periods of flooding and inundation in May 1998 (after an extended dry period) and August 1998, no evidence of acidic discharge was recorded at the tidal gates.

The distribution of acid sulfate soils appears to be limited to the area around Ironbark Creek. The absence of noticeable acidic discharge is likely to be associated with the limited distribution of actual acid sulfate soils and an inherent buffering capacity associated with the presence of carbonate within the soils and saline groundwater.

The risk of an initial acid discharge into the Hunter River following the onset of tidal flushing is considered to be low. Some minor localised acid discharge may occur associated with spatial variation in acid generating potential and buffering capacity of the surface soils, however this is highly likely to be buffered by the saline waters and diluted by non acidic discharge. Once a tidal strategy is decided on, it is recommended that a more detailed acid sulfate assessment be undertaken in areas proposed for inundation and an acid sulfate management plan be prepared.

In relation to the flood gate operation options proposed by WBM and outlined in Section 1.0, the 'no nothing' option carries the highest risk associated with potential discharge of acid water into Ironbark Creek due to the continued depression of the groundwater table.

The area inundated with 8 gates open as compared with one gate, occurs mainly in the area to the north-west of Ironbark, Fishery and Shelley Creeks where acid sulfate soils do not appear to be present.

As the distribution of acid sulfate soils appears to be limited to the area around Ironbark Creek, an increase in groundwater levels and the area of inundation will reduce the risk of acid generation.

The area of the proposed bund wall at Shortland has been identified as containing acid sulfate soils with high sulphur levels. Construction of the bund wall would help to maintain depressed groundwater levels and oxidising conditions in these soils. Inundation of this area would reduce the risk of acid generation.

7.2 Groundwater

Tidal inundation will result in gradual infiltration of saline water into the sandy aquifer that underlies large areas of the site. As the aquifer exhibits saline properties, the opening of the floodgates is not likely to have any major impact on the ground water apart from raising and maintaining a more static ground water level.

The rise in groundwater level will have a beneficial effect in reducing the depth of soil subject to oxidising conditions and hence limiting the potential of acid sulfate soils to generate acid. The rise in groundwater level will have a detrimental effect in terms of establishing and maintaining access tracks and easements as soil strength will tend to decrease with saturation resulting in very poor subgrade conditions.

The aerial extent over which arise in groundwater levels will occur will depend on the flood gate option. Opening of one gate only will have a restricted impact on groundwater levels and recharge, being mainly confined to Ironbark and Fishery Creeks. Opening of 8 gates would result in elevation of groundwater levels over a significant area resulting in recharge of the existing saline aquifer and a reduction in the potential for acid production from acid sulfate soils.

An additional beneficial effect will be to reduce the hydraulic gradient for any leachate contained within the Astra Street Landfill at Shortland. This will reduce flow rates from the landfill to the surrounding environment.

7.3 Creek Bank Erosion

The banks along Ironbark Creek and to a lesser extent Fishery and Shelley Creeks are undergoing localised erosion and regression. This appears to primarily occur in areas where:

- Native vegetation has been cleared to grass pasture
- Cattle have accessed the creek banks
- Fill has been placed along the banks to form bunds

- Concentration of run off has occurred through low fill embankments associated with tracks and easements or drains

Tidal inundation will result in increased ebb tidal velocities along the channel areas with the extent of the influence depending on the number of tidal gates opened. In the short term this is likely to result in an increase in the rate of bank erosion due to:

- Increased groundwater seepage from creek banks associated with raising of the groundwater table
- Minor scour effects associated with tidal flows
- Concentration of tidal over-bank flows at low points along the creeks
- Gradual death of salt intolerant vegetation such as grasses

In the long term the re-establishment of native vegetation such as mangroves will have a beneficial effect on creek bank stability and once established, the rate of erosion is likely to be significantly less than that presently occurring. In terms of creek bank stability, re-vegetation should be undertaken along the banks of areas proposed for tidal inundation.

The Ironbark Creek Total Catchment Strategy Study has noted that the swamp acts as an efficient sediment trap with the annual volume of sediment input greatly in excess of output into the Hunter River. Sedimentation of the drainage paths and creeks is being promoted by the sediment surplus and the low flow conditions induced by current flood gate operation. The continuance will result in gradual sedimentation of the waterways. The option of opening the flood gates will promote tidal flushing of suspended sediments and reduce the risk of sedimentation along the waterways. Tidal inundation is unlikely to significantly increase the volume of sediment discharge into the Hunter River as the bulk of the sediment load entering the swamp is derived from surrounding urban areas which are generally located about 0.5km or more from the area of maximum tidal inundation (8 gates open).

7.4 Bund Wall Construction

The construction of a bund wall to protect properties in the Shortland area as shown on Drawing 2 is an option to limit tidal inundation of private properties. Based on the soil profile encountered at bore 9, the subsurface profile comprises soft to firm estuarine clays to depths in excess of 1.6m with shallow groundwater levels and acid sulfate soil conditions. The site conditions impose the following constraints on bund construction:

- Excavation of site soils for use in bund construction would need to be undertaken in accordance with an acid sulfate management plan which will require the application of lime at high dosage rates.
- The clay soils are saturated and will require significant drying back prior to being suitable for compaction.
- Bunds will undergo settlement associated with consolidation of the soft to firm clays with the rate and amount of settlement dependant on the height of the wall and the depth and geotechnical properties of the underlying clays.
- Poor access and trafficability for construction plant.

Considering the above it is likely that construction of an earth embankment bund wall will require importation of fill materials. Geotechnical investigation will need to be undertaken for bund wall construction to assess the above issues.

8 REFERENCES

ANZECC (1992). Australian Water Quality Guidelines for Fresh and Marine Waters.

CH2M HILL Australia Pty Ltd (1997) Maryland to Shortland Rising Main Environmental Impact Statement Final Report

Department of Land and Water Conservation, Soil Data Base

Hunter Catchment Management Trust and the Department of Conservation and Land Management (1993) Soil Landscapes of the Ironbark Creek Catchment Soil Survey Unit Miscellaneous Report No. 3

Ironbark Creek TCM Committee (1996) Ironbark Creek TCM Strategy. Vol 2. Technical Report. Hunter Catchment Management Trust.

McGregor, W.N. (1979) The Environmental Effects of Flood Mitigation Works with Particular Reference to Estuarine Situation

NSWEPA (1995). Assessing and Managing Acid Sulfate Soils. Guidelines For Land Management in NSW Coastal Areas. June 1995.

NSWEPA, DUAP, ASSMAC, 'Acids Sulfate Soils, Assessment and Management Guidelines', Draft, Nov 1997.

NSW Department of Public Works and Services, Ironbark Creek Water Quality Monitoring, May and June 1998.

Mark Delaney

ATTACHMENTS

Appendix 1	Soil Profiles
Appendix 2	Ironbark Creek water quality monitoring (PWD)
Appendix 3	Laboratory Test Results
Drawing 1	Study Area
Drawing 2	Data Locations
Drawing 3	Acid Sulfate Risk Map
Drawing 4	Soil Landscapes of the Ironbark Creek Catchment Area

APPENDIX 1

SOIL PROFILES

LAND & WATER
CONSERVATION

Andrew Goodwin
Robert Carr and Associates Pty Ltd
92 Hill Street
Carrington NSW 2294

Contact: Andrew Rawson
Phone: (02)98956203
Fax: (02)98956205
e-mail:
arawson@dlwc.nsw.gov.au

Our Ref:
[G:\SOILDATA\ARAWSON\GOODWIN.DOC]
Your Ref:

31 July, 1998

Dear Andrew,

Re: Soil Profile Data for the Hexham Swamp Study

Enclosed are the Plain English Reports for the profiles 165, 167, 168, 169, 170, 171, 173 and 175 from the Newcastle Soil Landscapes, and profiles 4 and 5 from the survey Acid Sulphate Soils - Newcastle as requested.

I hope this meets your requirements. If you require any more detail do not hesitate to contact us.

Yours sincerely,

A Rawson

Andrew Rawson
Manager, Soil Data System
NSW Department of Land and Water Conservation

NEWCASTLE SOIL LANDSCAPES Profile No. 165

MAP REFERENCES:
1:100 000 sheet no:9232 NEWCASTLE
AMG Eastings:376500
AMG Northings:6359800
Scale of Mapping:1:100 000
AMG Zone:56

SURVEY DETAILS:
Described by:L Henderson
Site Location:BACK OF 2NX
Date:30/04/91
No of layers described: 2

Methods of exposure:core sample

SOIL and MAP CODES:
Great Soil Group:HG, Humic Gley
Factual Key:Gn2.83
Geology Map Code:Qe

TOPOGRAPHY:
Slope:0%, estimated
Elevation (m):20
Aspect:NE

LANDFORM:
Site Process:alluvial
Local Relief:extremely low(< 9m)
Landform Pattern:alluvial plain
Site Morphology:flat
Microrelief:none
Landform Element:plain

VEGETATION:
Vegetation Community:swamp complex
Vegetation Form:tree, shrub, sedge

SITE CONDITION:
Expected Dry Condition:hardsetting
Current Condition:soft
Site Disturbance:extensive clearing

LITHOLOGY:
Rock Outcrop:nil
Upper Solum PM:alluvium
Substrate:alluvium

LAND USE:
Site:Volun./native pasture
General Area:Volun./native pasture

HYDROLOGY:
Run Off:none
Permeability:very slowly permeable
Free Water Presence:none
Run On:none
Profile Drainage:very poorly drained

EROSION:
none

EROSION HAZARD: slight

SALINITY: salting evident

FIELD NOTES:
Potential Acid Sulphate soil.

<u>LAYER:</u> 1 A
Depth (m): .00 to .60

COLOUR: moist:10YR 2/2 (brownish black)
value/chroma:1
type:mechanical

MOTTLES: <u>Dominant</u>:
colour:orange
contrast:distinct
abundance:2% - 10%

TEXTURE: silty clay loam

CONSISTENCE:
plasticity:moderately plastic
soil water status:dry

STRUCTURE:
grade:massive

SOIL FAUNA ACTIVITY:
degree:none

```
CRACKS:
        fine (<5 mm):none
COARSE FRAGMENTS:
                type:not evident
ROOTS:
   very fine (<1 mm):many(25-100/10x10cm)              fine (1-2 mm):common(10-25/10x10cm)
CHEMICAL TESTS:
                  pH:  6.0 ()
ERODIBILITY TESTS:
               crumb:no change
SAMPLE(S) TAKEN:    undisturbed
FIELD NOTES:
                    Spongy surface.
BOUNDARY:
     distinctiveness:gradual (50-100 mm)                      shape:smooth

LAYER:         2  B                                  Depth (m):   .60 to   1.20
COLOUR:          moist:10YR 4/1 (brownish gray)    value/chroma:2a
MOTTLES:      Dominant:                                    type:mechanical
                colour:orange
              contrast:distinct                      abundance:2% - 10%
TEXTURE:            silty light clay
CONSISTENCE:
          plasticity:very plastic                   stickiness:very sticky
   soil water status:moderately moist
STRUCTURE:
               grade:massive
SOIL FAUNA ACTIVITY:
              degree:none
CRACKS:
        fine (<5 mm):none
COARSE FRAGMENTS:
                type:not evident
ROOTS:
   very fine (<1 mm):common(10-25/10x10cm)             fine (1-2 mm):few(1-10/10x10cm)
CHEMICAL TESTS:
                  pH:  8.5 ()
ERODIBILITY TESTS:
               crumb:aggregates slake
SAMPLE(S) TAKEN:    undisturbed
FIELD NOTES:
                    Layer continues.
```

MAP REFERENCES:
1:100 000 sheet no:9232 NEWCASTLE
AMG Eastings:376500
AMG Northings:6361000
Scale of Mapping:1:25 000
AMG Zone:56

SURVEY DETAILS:
Described by:L Henderson
Site Location:BELOW SEWAGE PLANT- LATERITE
Date:30/04/91
No of layers described: 3

Methods of exposure:batter

SOIL and MAP CODES:
Great Soil Group:YE, Yellow Earth
Geology Map Code: Pa

TOPOGRAPHY:
Slope:estimated

LANDFORM:
Site Process:residual
Local Relief:extremely low(< 9m)
Landform Pattern:low hills
Site Morphology:lower slope
Microrelief:none
Landform Element:footslope

VEGETATION:
Vegetation Community:dry sclerophyll forest
Vegetation Form:tree
Angophora floribunda (rough-barked apple)
Eucalyptus tereticornis (forest red gum)

SITE CONDITION:
Expected Dry Condition:hardsetting
Current Condition:hard set
Site Disturbance:highly disturbed

LITHOLOGY:
Rock Outcrop:nil
Upper Solum PM:gravel, clay
Substrate:gravel, clay

LAND USE:
Site: Volun./native pasture
General Area: Volun./native pasture

HYDROLOGY:
Run Off:moderate
Permeability:moderately permeable
Free Water Presence:none
Run On:low
Profile Drainage:well drained

EROSION HAZARD: moderate

LAYER: 0 Surface
COARSE FRAGMENTS:
type:as parent material
size:cobbles(60-200 mm)
amount:common(10-20%)

LAYER: 1 A
Depth (m): .00 to .35
COLOUR: **moist:**10YR 2/3 (brownish black)
value/chroma:5a
TEXTURE: clay loam,sandy
CONSISTENCE:
disruptive test:moderately weak force
soil water status:dry
STRUCTURE:
grade:weak pedality
dominant peds:5-10 mm, polyhedral
fabric:rough-faced peds
ped coatings:none
CRACKS:
fine (<5 mm):none
COARSE FRAGMENTS:

```
                type:not identified                       amount:very few(< 2%)
        distribution:dispersed
          weathering:non-weathered
               shape:sub-rounded
                size:cobbles(60-200 mm)
                type:as parent material                   amount:common(10-20%)
        distribution:dispersed
          weathering:weakly weathered
               shape:sub-rounded, angular, angular platy
                size:gravel(6-20 mm)
                type:ironstone                            amount:few(2-10%)
        distribution:dispersed
          weathering:weakly weathered
               shape:sub-rounded
                size:fine gravel(2-6 mm)
PANS:
                type:not evident
SEGREGATIONS:
                type:not evident
ROOTS:
   very fine (<1 mm):none
ERODIBILITY:         moderate
CHEMICAL TESTS:
                  pH:  5.5 ()
ERODIBILITY TESTS:
               crumb:no change
SAMPLE(S) TAKEN:     none
BOUNDARY:
     distinctiveness:gradual (50-100 mm)                    shape:smooth

LAYER:        2  B                                       Depth (m):   .35 to    .90
COLOUR:        moist:10YR 5/6 (yellowish brown)      value/chroma:4
MOTTLES:   Dominant:                                         type:not evident
TEXTURE:             light-medium clay
CONSISTENCE:
     disruptive test:very firm force
   soil water status:dry
STRUCTURE:
               grade:moderate pedality
       dominant peds:20-50 mm, angular blocky
    subdominant peds:5-10 mm, angular blocky
              fabric:smooth-faced peds
        ped coatings:none
CRACKS:
        fine (<5 mm):none
COARSE FRAGMENTS:
                type:not identified                       amount:few(2-10%)
        distribution:dispersed
          weathering:non-weathered
               shape:sub-rounded
                size:cobbles(60-200 mm)
                type:as parent material                   amount:common(10-20%)
        distribution:dispersed
          weathering:weakly weathered
               shape:sub-rounded, angular, angular platy
                size:gravel(6-20 mm)
                type:ironstone                            amount:common(10-20%)
        distribution:dispersed
          weathering:weakly weathered
               shape:sub-rounded
```

```
MAP REFERENCES:
  1:100 000 sheet no:9232  NEWCASTLE                Scale of Mapping:1:100 000
        AMG Eastings:376050                                 AMG Zone:56
       AMG Northings:6361100
SURVEY DETAILS:
        Described by:L Henderson                                Date:30/04/91
       Site Location:NEAR IRONBARK CREEK
                                                     No of layers described:  2
 Methods of exposure:auger, core sample
SOIL and MAP CODES:
    Great Soil Group:HG, Humic Gley
         Factual Key:Gn3.63
    Geology Map Code:Qe
TOPOGRAPHY:
               Slope:0%, estimated
       Elevation (m):1
LANDFORM:
        Site Process:depositional                    Site Morphology:flat
        Local Relief:extremely low(< 9m)                 Microrelief:none
    Landform Pattern:plain                          Landform Element:plain
VEGETATION:
Vegetation Community:swamp complex
     Vegetation Form:tree, shrub, sedge
SITE CONDITION:
Expected Dry Condition:loose
   Current Condition:loose
    Site Disturbance:extensive clearing
LITHOLOGY:
      Upper Solum PM:clay, organic material
           Substrate:clay, organic material
LAND USE:
                Site:Volun./native pasture
        General Area:Volun./native pasture
HYDROLOGY:
             Run Off:low                                      Run On:none
        Permeability:very slowly permeable          Profile Drainage:very poorly drained
 Free Water Presence:none
EROSION:
                     none
EROSION HAZARD:     slight
SALINITY:           salting evident

LAYER:        1  A                                      Depth (m):   .00 to     .25
COLOUR:        moist:10YR 1.7/1 (black)              value/chroma:1
MOTTLES:    Dominant:                                        type:mechanical
              colour:orange
            contrast:distinct                           abundance:< 2%
TEXTURE:            clay loam
CONSISTENCE:
   soil water status:dry
STRUCTURE:
               grade:weak pedality
       dominant peds:2-5 mm, crumb
    subdominant peds:5-10 mm, angular blocky
              fabric:rough-faced peds
CRACKS:
   coarse (10-20 mm):evident                very coarse (20-50 mm):evident
COARSE FRAGMENTS:
                type:not evident
```

```
ROOTS:
   very fine (<1 mm):common(10-25/10x10cm)
ERODIBILITY:        low
CHEMICAL TESTS:
                  pH:  6.0 ()
ERODIBILITY TESTS:
               crumb:no change
SAMPLE(S) TAKEN:    none
BOUNDARY:
     distinctiveness:clear (20-50 mm)                        shape:smooth

LAYER:        2  B                                       Depth (m):   .25 to    .80
COLOUR:        moist:10YR 5/1 (brownish grey)         value/chroma:2a
MOTTLES:     Dominant:                                         type:mechanical
              colour:orange
            contrast:distinct                            abundance:10% - 20%
TEXTURE:            medium-heavy clay
CONSISTENCE:
   soil water status:dry
STRUCTURE:
              fabric:smooth-faced peds
CRACKS:
   coarse (10-20 mm):evident                very coarse (20-50 mm):evident
COARSE FRAGMENTS:
                type:not evident
ERODIBILITY:        low
CHEMICAL TESTS:
                  pH:  8.5 ()
ERODIBILITY TESTS:
               crumb:no change
SAMPLE(S) TAKEN:    none
FIELD NOTES:
                     Layer continues.
```

```
MAP REFERENCES:
  1:100 000 sheet no:9232  NEWCASTLE              Scale of Mapping:1:100 000
        AMG Eastings:376900                                AMG Zone:56
       AMG Northings:6360950
SURVEY DETAILS:
        Described by:L Henderson                              Date:30/04/91
                                                   No of layers described:  3
 Methods of exposure:pit
SOIL and MAP CODES:
    Great Soil Group:BP, Brown Podzolic Soil
         Factual Key:Db3.2
TOPOGRAPHY:
               Slope:8%, estimated                          Aspect:NW
       Elevation (m):20
LANDFORM:
        Site Process:residual                      Site Morphology:crest
    Slope Morphology:maximal                          Local Relief:extremely low(< 9m)
         Microrelief:none                        Landform Pattern:low hills
   Landform Element:hillcrest
VEGETATION:
Vegetation Community:unknown
SITE CONDITION:
        Ground Cover:100%                Expected Dry Condition:hardsetting
   Current Condition:hard set
    Site Disturbance:cleared,no cultivation
LITHOLOGY:
        Rock Outcrop:nil
      Upper Solum PM:not identified
           Substrate:not identified
LAND USE:
                Site:Improved pasture
        General Area:Improved pasture
HYDROLOGY:
        Permeability:moderately permeable      Profile Drainage:well drained
EROSION:
                     none
EROSION HAZARD:     moderate
SALINITY:           no salting evident

LAYER:        1  A1                                   Depth (m):   .00 to    .12
COLOUR:        moist:10YR 2/3 (brownish black)     value/chroma:5a
TEXTURE:            loam
CONSISTENCE:
   soil water status:dry
STRUCTURE:
               grade:weak pedality
       dominant peds:10-20 mm, sub-ang. blocky
              fabric:rough-faced peds
SOIL FAUNA ACTIVITY:
              degree:none
CRACKS:
       fine (<5 mm):none
COARSE FRAGMENTS:
                type:as parent material                     amount:few(2-10%)
        distribution:dispersed
          weathering:weakly weathered
               shape:sub-angular, angular
                size:fine gravel(2-6 mm)
ROOTS:
```

```
   very fine (<1 mm):few(1-10/10x10cm)
ERODIBILITY:            moderate
ERODIBILITY TESTS:
                  crumb:no change
SAMPLE(S) TAKEN:        none
BOUNDARY:
     distinctiveness:abrupt (5-20 mm)                        shape:wavy

LAYER:         2   A2                                Depth (m):   .12 to    .25
COLOUR:          moist:10YR 3/2 (brownish black)   value/chroma:1
                   dry:10YR 6/2 (greyish yellow brown)
MOTTLES:     Dominant:                                        type:unspecified
                colour:red
             contrast:distinct                         abundance:10% - 20%
TEXTURE:                fine sandy clay loam
CONSISTENCE:
   soil water status:dry
STRUCTURE:
                  grade:weak pedality
       dominant peds:10-20 mm, sub-ang. blocky
                fabric:rough-faced peds
SOIL FAUNA ACTIVITY:
                degree:none
CRACKS:
        fine (<5 mm):none
COARSE FRAGMENTS:
                  type:as parent material                   amount:few(2-10%)
          distribution:dispersed
            weathering:weakly weathered
                 shape:sub-angular, angular
                  size:fine gravel(2-6 mm)
ROOTS:
   very fine (<1 mm):few(1-10/10x10cm)
ERODIBILITY:            moderate
ERODIBILITY TESTS:
                  crumb:no change
SAMPLE(S) TAKEN:        none

LAYER:         3   B                                 Depth (m):   .25 to    .60
COLOUR:          moist:7.5YR 4/6 (brown)           value/chroma:5b
TEXTURE:                light clay
CONSISTENCE:
   soil water status:dry
STRUCTURE:
                  grade:moderate pedality
       dominant peds:10-20 mm, angular blocky
    subdominant peds:5-10 mm, angular blocky
                fabric:smooth-faced peds
SOIL FAUNA ACTIVITY:
                degree:none
CRACKS:
        fine (<5 mm):none
ERODIBILITY:            moderate
ERODIBILITY TESTS:
                  crumb:aggregates slake
SAMPLE(S) TAKEN:        none
FIELD NOTES:
                         Layer continues.
```

LAYER: 99 Substrate **Depth (m):** .60 to

```
MAP REFERENCES:
  1:100 000 sheet no:9232  NEWCASTLE                   Scale of Mapping:1:100 000
        AMG Eastings:376550                                     AMG Zone:56
       AMG Northings:6362600
SURVEY DETAILS:
        Described by:L Henderson                                 Date:01/05/91
       Site Location:NORTH SIDE FISHERIES CREEK
                                                      No of layers described:  2
 Methods of exposure:core sample
SOIL and MAP CODES:
    Great Soil Group:HG, Humic Gley
         Factual Key:Gn3.93
    Geology Map Code:Qe
TOPOGRAPHY:
               Slope:0%, estimated
       Elevation (m):1
LANDFORM:
        Site Process:depositional                   Site Morphology:flat
    Landform Pattern:plain                         Landform Element:swamp
VEGETATION:
SITE CONDITION:
Expected Dry Condition:seasonal cracking
   Current Condition:cracked, poached
    Site Disturbance:extensive clearing
LITHOLOGY:
      Upper Solum PM:sand, silt, clay
LAND USE:
                Site:Volun./native pasture
        General Area:Volun./native pasture
HYDROLOGY:
            Run Off:none                                   Run On:none
        Permeability:very slowly permeable       Profile Drainage:very poorly drained
 Free Water Presence:below soil surface       Free Water Depth(m):   0.80
EROSION:
                      none
EROSION HAZARD:       slight
SALINITY:             salting evident
FIELD NOTES:
                       Potential Acid Sulphate Soil.

LAYER:          1  A                                  Depth (m):   .00 to    .28
COLOUR:           moist:10YR 2/1 (black)           value/chroma:1
MOTTLES:    Dominant:                                      type:unspecified
                 colour:orange
               contrast:prominent                     abundance:2% - 10%
TEXTURE:              heavy clay loam
CONSISTENCE:
   soil water status:dry
STRUCTURE:
                  grade:moderate pedality
       dominant peds:50-100 mm, prismatic
                 fabric:earthy
        ped coatings:few (< 10%) distinct clay
SOIL FAUNA ACTIVITY:
                 degree:none
CRACKS:
                 CRACKS:                   very coarse (20-50 mm):evident
COARSE FRAGMENTS:
                   type:not evident
```

```
ROOTS:
   very fine (<1 mm):common(10-25/10x10cm)
     medium (2-5 mm):few(1-2/10x10 cm)
ERODIBILITY:        low
CHEMICAL TESTS:
                  pH:  6.0 ()
SAMPLE(S) TAKEN:    undisturbed
BOUNDARY:
     distinctiveness:gradual (50-100 mm)                        shape:smooth

LAYER:        2  B                                      Depth (m):    .28 to    .65
COLOUR:        moist:10YR 4/1 (brownish gray)        value/chroma:2a
MOTTLES:    Dominant:                                            type:unspecified
              colour:yellow
            contrast:distinct                           abundance:10% - 20%
TEXTURE:            silty clay loam
CONSISTENCE:
   soil water status:wet
STRUCTURE:
               grade:massive
              fabric:earthy
SOIL FAUNA ACTIVITY:
              degree:none
CRACKS:
              CRACKS:                             very coarse (20-50 mm):evident
COARSE FRAGMENTS:
                type:not evident
ROOTS:
     medium (2-5 mm):common(2-5/10x10cm)
ERODIBILITY:        low
CHEMICAL TESTS:
                  pH:  3.5 ()
SAMPLE(S) TAKEN:    undisturbed
FIELD NOTES:
                     Layer continues.
                     Jarosite down root traces.
```

NEWCASTLE SOIL LANDSCAPES Profile No. 171

MAP REFERENCES:

1:100 000 sheet no:9232 NEWCASTLE
Scale of Mapping:1:100 000
AMG Eastings:375700
AMG Zone:56
AMG Northings:6362900

SURVEY DETAILS:

Described by:L Henderson
Date:01/04/91
Site Location:ON BEND OF FISHERIES CREEK
No of layers described: 2
Methods of exposure:core sample

SOIL and MAP CODES:

Great Soil Group:HG, Humic Gley
Factual Key: Gn3.93
Geology Map Code: Qe

TOPOGRAPHY:

Slope:5%, estimated
Aspect:NE
Elevation (m):1

LANDFORM:

Site Process:depositional
Site Morphology:flat
Microrelief:none
Landform Pattern:plain
Landform Element:swamp

VEGETATION:

SITE CONDITION:

Expected Dry Condition:seasonal cracking
Current Condition:cracked, poached
Site Disturbance:extensive clearing

LITHOLOGY:

Upper Solum PM:sand, silt, clay

LAND USE:

Site: Volun./native pasture
General Area: Volun./native pasture

HYDROLOGY:

Run Off:none
Run On:none
Permeability:very slowly permeable
Profile Drainage:very poorly drained
Free Water Presence:below soil surface
Free Water Depth(m): 0.80

EROSION:

none

EROSION HAZARD: slight
SALINITY: salting evident

LAYER: 1 A **Depth (m):** .00 to .30

ROOTS:

very fine (<1 mm):abundant(>200/10x10cm)
SAMPLE(S) TAKEN: undisturbed
FIELD NOTES:

Firm, spongy, very fine peds on surface.

LAYER: 2 B **Depth (m):** .30 to 1.05

SAMPLE(S) TAKEN: undisturbed
FIELD NOTES:

Layer continues.

NEWCASTLE SOIL LANDSCAPES Profile No. 173

MAP REFERENCES:
1:100 000 sheet no:9232 NEWCASTLE
Scale of Mapping:1:25 000
AMG Eastings:377000
AMG Zone:56
AMG Northings:6364200

SURVEY DETAILS:
Described by:L Henderson
Date:01/05/91
No of layers described: 3

SOIL and MAP CODES:
Great Soil Group:HG, Humic Gley
Factual Key:Gn3.91

TOPOGRAPHY:
Slope:0%, estimated
Elevation (m):1

LANDFORM:
Site Process:alluvial
Site Morphology:flat
Microrelief:none
Landform Pattern:alluvial plain
Landform Element:backplain

VEGETATION:
Vegetation Community:grassland/herbland

SITE CONDITION:
Ground Cover:100%
Expected Dry Condition:hardsetting
Current Condition:hard set, poached
Site Disturbance:cleared,no cultivation

LITHOLOGY:
Rock Outcrop:nil
Upper Solum PM:alluvium

LAND USE:
Site:Improved pasture
General Area:Improved pasture

HYDROLOGY:
Run Off:none
Run On:none
Permeability:very slowly permeable
Profile Drainage:very poorly drained

EROSION HAZARD: slight

LAYER: 1 A
Depth (m): .00 to .23

COLOUR: moist:7.5YR 3/2 (brownish black)
value/chroma:1

TEXTURE: clay loam

CONSISTENCE:
disruptive test:moderately weak force
shearing test:crumbly
soil water status:dry

STRUCTURE:
grade:moderate pedality
dominant peds:5-10 mm, granular
fabric:rough-faced peds

CHEMICAL TESTS:
pH: 5.5 ()

SAMPLE(S) TAKEN: none

BOUNDARY:
distinctiveness:gradual (50-100 mm)

LABORATORY:
Sample no:92/53/14
Depth: .00 to .23

Volume Expansion.:(P5A/1VE) 18.0 %
PSA - Clay:(P7B/3-1) 25 %
PSA - Silt:(P7B/3-2) 22 %
PSA - Fine sand:(P7B/3-3) 26 %
PSA - Coarse sand:(P7B/3-4) 8 %
PSA - Gravel:(P7B/3-5) 19 %
Dispersion %:(P8A/2DP) 24 %
Emerson Aggregate test (SCS):(P9B/2EAT) 3-2

```
Unified Soil Class. Syst:(P13B/2) OL
                    :(P18A/2-1) 55.6 %
Permanent Wilting Point:(P18A/2-2) 34.0 %
   Wind - erodible %:(P21A/1) 94 %
EC of a Soil Suspension:(C1A/3EC) 0.21 dS/m
pH - 1:5 soil:0.01M CaCl2,ge:(C2B/2PH) 4.6 1:5 0.01M
     CEC -Agthiourea:(C5A/3-1) 24.4 meq/100g
 Exch Ca -Agthiourea:(C5A/3-2) 5.8 meq/100g
 Exch Mg -Agthiourea:(C5A/3-3) 9.0 meq/100g
 Exch Na -Agthiourea:(C5A/3-4) 2.3 meq/100g
  Exch K -Agthiourea:(C5A/3-5) 2.0 meq/100g
 Exch Al -Agthiourea:(C5A/3-6) .4 meq/100g
Organic Carbon of a Soil:(C6A/2OC) 5.74 %
Avail P Bray No.1 & Bray No.2:(C8A/3P) 1 ppm P
Soil Phosphorus Sorption:(C8B/2) 854 ppm

LAYER:         2  B2                                 Depth (m):   .23 to    .42
COLOUR:          moist:10YR 5/2 (greyish yellow brown)  value/chroma:2a
MOTTLES:     Dominant:                                          type:weathered
                colour:orange
              contrast:distinct                      abundance:2% - 10%
          Sub-dominant:                                         type:weathered
                colour:dark
              contrast:distinct                      abundance:2% - 10%
TEXTURE:                light clay
CONSISTENCE:
            plasticity:moderately plastic
   soil water status:dry
STRUCTURE:
                 grade:massive
                fabric:earthy
COARSE FRAGMENTS:
                  type:charcoal                         amount:few(2-10%)
CHEMICAL TESTS:
                   pH:  5.5 ()
SAMPLE(S) TAKEN:     none
BOUNDARY:
     distinctiveness:gradual (50-100 mm)
LABORATORY:                                          Sample no:92/53/15
                                                        Depth:  .23 to   .42

   Volume Expansion.:(P5A/1VE) 29.0 %
    Linear shrinkage:(P6A/1LS) 19.0 %
          PSA - Clay:(P7B/3-1) 51 %
          PSA - Silt:(P7B/3-2) 32 %
     PSA - Fine sand:(P7B/3-3) 12 %
   PSA - Coarse sand:(P7B/3-4) 5 %
        Dispersion %:(P8A/2DP) 62 %
Emerson Aggregate test (SCS):(P9B/2EAT) 2-1
Unified Soil Class. Syst:(P13B/2) CH
                    :(P18A/2-1) 52.7 %
Permanent Wilting Point:(P18A/2-2) 30.5 %
EC of a Soil Suspension:(C1A/3EC) 0.35 dS/m
pH - 1:5 soil:0.01M CaCl2,ge:(C2B/2PH) 4.4 1:5 0.01M
     CEC -Agthiourea:(C5A/3-1) 29.1 meq/100g
 Exch Ca -Agthiourea:(C5A/3-2) 4.6 meq/100g
 Exch Mg -Agthiourea:(C5A/3-3) 14.0 meq/100g
 Exch Na -Agthiourea:(C5A/3-4) 4.4 meq/100g
  Exch K -Agthiourea:(C5A/3-5) 2.0 meq/100g
 Exch Al -Agthiourea:(C5A/3-6) .6 meq/100g
Organic Carbon of a Soil:(C6A/2OC) 1.25 %
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```
Avail P Bray No.1 & Bray No.2:(C8A/3P) 3 ppm P
Soil Phosphorus Sorption:(C8B/2) 752 ppm

LAYER:          3  B3                                  Depth (m):   .42 to    1.10
COLOUR:           moist:10YR 4/3 (dull yellowish brown)  value/chroma:5a
MOTTLES:     Dominant:                                          type:weathered
                colour:orange
             contrast:distinct                         abundance:2% - 10%
TEXTURE:                fine sandy loam
CONSISTENCE:
   soil water status:moderately moist
STRUCTURE:
                  grade:massive
                 fabric:earthy
CHEMICAL TESTS:
                     pH:  6.5 ()
SAMPLE(S) TAKEN:        none
```

```
MAP REFERENCES:
  1:100 000 sheet no:9232  NEWCASTLE              Scale of Mapping:1:25 000
        AMG Eastings:376200                               AMG Zone:56
       AMG Northings:6364400
SURVEY DETAILS:
        Described by:L Henderson                             Date:30/04/91
                                                     No of layers described:  3

 Methods of exposure:core sample
SOIL and MAP CODES:
    Great Soil Group:HG, Humic Gley
         Factual Key:Gn3.91
TOPOGRAPHY:
               Slope:0%, estimated
       Elevation (m):2
LANDFORM:
        Site Process:alluvial                      Site Morphology:flat
        Local Relief:extremely low(< 9m)               Microrelief:none
    Landform Pattern:plain                        Landform Element:swamp
VEGETATION:
Vegetation Community:swamp complex
     Vegetation Form:tree, tussock grass
SITE CONDITION:
Expected Dry Condition:seasonal cracking
   Current Condition:cracked, firm
LITHOLOGY:
      Upper Solum PM:alluvium
           Substrate:alluvium
LAND USE:
                Site:Improved pasture
        General Area:Improved pasture
HYDROLOGY:
             Run Off:none                                      Run On:none
        Permeability:very slowly permeable        Profile Drainage:very poorly drained
EROSION:
                     none
EROSION HAZARD:     slight
SALINITY:           salting evident

LAYER:        1  A                                      Depth (m):   .00 to    .25
COLOUR:        moist:7.5YR 3/2 (brownish black)      value/chroma:1
TEXTURE:            clay loam
CONSISTENCE:
          plasticity:moderately plastic
   soil water status:moderately moist
STRUCTURE:
               grade:moderate pedality
       dominant peds:50-100 mm, sub-ang. blocky
    subdominant peds:100-200 mm, prismatic
              fabric:smooth-faced peds
ERODIBILITY:        low
CHEMICAL TESTS:
                  pH:  5.5 ()
SAMPLE(S) TAKEN:    undisturbed
BOUNDARY:
     distinctiveness:gradual (50-100 mm)                        shape:smooth
LABORATORY:                                             Sample no:92/53/16
                                                            Depth:  .00 to   .25

   Volume Expansion.:(P5A/1VE) 18.0 %
    Linear shrinkage:(P6A/1LS) 17.0 %
```

```
          PSA - Clay:(P7B/3-1) 52 %
          PSA - Silt:(P7B/3-2) 28 %
     PSA - Fine sand:(P7B/3-3) 17 %
   PSA - Coarse sand:(P7B/3-4) 3 %
        Dispersion %:(P8A/2DP) 56 %
Emerson Aggregate test (SCS):(P9B/2EAT) 2-1
Unified Soil Class. Syst:(P13B/2) OL
                    :(P18A/2-1) 61.5 %
Permanent Wilting Point:(P18A/2-2) 33.7 %
EC of a Soil Suspension:(C1A/3EC) 4 dS/m
pH - 1:5 soil:0.01M CaCl2,ge:(C2B/2PH) 6.2 1:5 0.01M
     CEC -Agthiourea:(C5A/3-1) 46.8 meq/100g
 Exch Ca -Agthiourea:(C5A/3-2) 7.8 meq/100g
 Exch Mg -Agthiourea:(C5A/3-3) 24.6 meq/100g
 Exch Na -Agthiourea:(C5A/3-4) 13.3 meq/100g
  Exch K -Agthiourea:(C5A/3-5) 3.6 meq/100g
 Exch Al -Agthiourea:(C5A/3-6) .3 meq/100g
Organic Carbon of a Soil:(C6A/20C) 5.97 %
Avail P Bray No.1 & Bray No.2:(C8A/3P) 8 ppm P
Soil Phosphorus Sorption:(C8B/2) 707 ppm

LAYER:        2  B2                                     Depth (m):   .25 to    .47
COLOUR:        moist:10YR 5/2 (greyish yellow brown)  value/chroma:2a
MOTTLES:    Dominant:                                           type:mechanical
              colour:yellow
            contrast:distinct                           abundance:10% - 20%
TEXTURE:            medium clay
CONSISTENCE:
          plasticity:very plastic
   soil water status:moist
STRUCTURE:
              fabric:earthy
ERODIBILITY:        low
CHEMICAL TESTS:
                  pH:  6.5 ()
SAMPLE(S) TAKEN:    undisturbed
BOUNDARY:
     distinctiveness:gradual (50-100 mm)                    shape:smooth
LABORATORY:                                             Sample no:92/53/17
                                                            Depth:  .25 to   .47
   Volume Expansion.:(P5A/1VE) 14.0 %
          PSA - Clay:(P7B/3-1) 45 %
          PSA - Silt:(P7B/3-2) 29 %
     PSA - Fine sand:(P7B/3-3) 20 %
   PSA - Coarse sand:(P7B/3-4) 6 %
        Dispersion %:(P8A/2DP) 15 %
Emerson Aggregate test (SCS):(P9B/2EAT) 5
Unified Soil Class. Syst:(P13B/2) CL
                    :(P18A/2-1) 53.7 %
Permanent Wilting Point:(P18A/2-2) 26.0 %
EC of a Soil Suspension:(C1A/3EC) 4.5 dS/m
pH - 1:5 soil:0.01M CaCl2,ge:(C2B/2PH) 6.8 1:5 0.01M
     CEC -Agthiourea:(C5A/3-1) 33.1 meq/100g
 Exch Ca -Agthiourea:(C5A/3-2) 7.7 meq/100g
 Exch Mg -Agthiourea:(C5A/3-3) 18.8 meq/100g
 Exch Na -Agthiourea:(C5A/3-4) 9.8 meq/100g
  Exch K -Agthiourea:(C5A/3-5) 2.8 meq/100g
 Exch Al -Agthiourea:(C5A/3-6) .3 meq/100g
Organic Carbon of a Soil:(C6A/20C) .81 %
Avail P Bray No.1 & Bray No.2:(C8A/3P) 8 ppm P
```

Soil Phosphorus Sorption:(C8B/2) 425 ppm

```
LAYER:          3  B3                               Depth (m):   .47 to    .57
COLOUR:          moist:10YR 4/3 (dull yellowish brown)  value/chroma:5a
TEXTURE:              sandy clay loam
CONSISTENCE:
   soil water status:wet
STRUCTURE:
              fabric:earthy
ERODIBILITY:          low
CHEMICAL TESTS:
                  pH:  8.0 ()
```

```
NSW SOIL DATA SYSTEM      Soil Profile Report      Printed  24 Jul 1998 (09:04:13)
                  ACID SULPHATE SOILS - NEWCASTLE Profile No. 5        Page 1


MAP REFERENCES:
  1:100 000 sheet no:9232  NEWCASTLE                 Scale of Mapping:1:25 000
        AMG Eastings:376875                                  AMG Zone:56
       AMG Northings:6364225
SURVEY DETAILS:
        Described by:C Murphy                                   Date:28/07/94
       Site Location:HEXAM SWAMP
                                                      No of layers described:  3
 Methods of exposure:auger
SOIL and MAP CODES:
       Soil Map Code:Ek1
    Great Soil Group:HG, Humic Gley
    Geology Map Code:Qa
AUST. SOIL CLASS.:
Sulphidic, Extratidal, Hydrosol;Medium, Non Gravelly, Peaty, Clayey, Very Deep.
Confidence level: 3
TOPOGRAPHY:
               Slope:0%, measured
       Elevation (m):2
LANDFORM:
        Site Process:depositional                    Site Morphology:flat
        Local Relief:extremely low(< 9m)            Landform Pattern:plain
    Landform Element:plain
VEGETATION:
Vegetation Community:swamp complex
Casuarina glauca (swamp she oak)
Juncus spp. (rushes)
SITE CONDITION:
        Ground Cover:100%
   Current Condition:soft
LITHOLOGY:

  Substrate Material:lower solum parent mat.   Substrate Strength:weak
      Upper Solum PM:organic material, alluvium, marine
           Substrate:marine
LAND USE:
                Site:Volun./native pasture
        General Area:Volun./native pasture
HYDROLOGY:
            Run Off:low                                    Run On:very high
        Permeability:slowly permeable          Profile Drainage:very poorly drained
 Free Water Presence:below soil surface       Free Water Depth(m):   0.50
EROSION:
                     none
EROSION HAZARD:     slight
SALINITY:           salting evident
FIELD NOTES:
                     Holocene estuarine deposit capped with
                     fluvial sediments.
                     Owner said shell layer can occur from
                     1.5m to 3m depth therefore expect PAS
                     below lower material.

LAYER:        0  Surface

LAYER:        1  O                               Depth (m):   .00 to    .20
COLOUR:        moist:10YR 2/1 (black)          value/chroma:1
MOTTLES:     Dominant:                                 type:unspecified
              colour:red
```

```
            contrast:distinct                                abundance:2% - 10%
TEXTURE:                fibric peat
CONSISTENCE:
          plasticity:slightly plastic                       stickiness:slightly sticky
    texture modifier:no change
       shearing test:crumbly
   soil water status:moderately moist
STRUCTURE:
               grade:moderate pedality
       dominant peds:< 2   mm, crumb
              fabric:rough-faced peds
ROOTS:
   very fine (<1 mm):common(10-25/10x10cm)          fine (1-2 mm):common(10-25/10x10cm)
     medium (2-5 mm):none                         coarse (>5 mm):none
ERODIBILITY:            low
CHEMICAL TESTS:
                  pH:  5.5 ()
BOUNDARY:
     distinctiveness:sharp (<5 mm)

LAYER:        2  B                                   Depth (m):   .20 to    .60
COLOUR:          moist:10YR 5/1 (brownish grey)    value/chroma:2a
MOTTLES:    Dominant:                                      type:unspecified
              colour:orange
            contrast:distinct                          abundance:10% - 20%
        Sub-dominant:                                      type:unspecified
              colour:yellow
            contrast:distinct                          abundance:2% - 10%
TEXTURE:                silty clay
CONSISTENCE:
          plasticity:very plastic                     stickiness:very sticky
    texture modifier:no change
       shearing test:plastic
   soil water status:moist
STRUCTURE:
               grade:massive
ROOTS:
   very fine (<1 mm):few(1-10/10x10cm)            fine (1-2 mm):few(1-10/10x10cm)
     medium (2-5 mm):none                       coarse (>5 mm):none
ERODIBILITY:            low
CHEMICAL TESTS:
                  pH:  5.5 ()
SAMPLE(S) TAKEN:        disturbed
FIELD NOTES:
                         Alluvial origin ?? pH H2O2 4.5 TPA 0.006
BOUNDARY:
     distinctiveness:sharp (<5 mm)
LABORATORY:                                          Sample no:94/80/6
                                                         Depth:      to    .60

 EC - 1:5 soil:water:(C1A1/1) 1.20 dS m-1
pH of a Soil:Water Suspension:(C2A/2PH) 5
pH 1:20 Soil:H2O2 Suspension:(C2C/1PH) 4.5
Total Actual Acidity:(C16A/1) 0.006
Total Potential Acidity:(C17A/1) 0.006

LAYER:        3  2Dg                                 Depth (m):   .60 to   1.40
COLOUR:          moist:10YR 5/1 (brownish grey)    value/chroma:2a
MOTTLES:    Dominant:                                      type:not evident
TEXTURE:                clay loam sandy, fine sandy
CONSISTENCE:
```

plasticity:moderately plastic
stickiness:moderately sticky
texture modifier:no change
shearing test:plastic
soil water status:wet

STRUCTURE:
grade:massive

ROOTS:
very fine (<1 mm):none
fine (1-2 mm):none
medium (2-5 mm):none
coarse (>5 mm):none

ERODIBILITY: moderate

CHEMICAL TESTS:
pH: 7.5 ()

SAMPLE(S) TAKEN: disturbed

FIELD NOTES:
Estuarine origin ??, continues, could not core further material is super saturated and sandy.

LABORATORY:
Sample no:94/80/7
Depth: to 1.40

EC - 1:5 soil:water:(C1A1/1) 1.34 dS m-1
pH of a Soil:Water Suspension:(C2A/2PH) 5.6
pH 1:20 Soil:H2O2 Suspension:(C2C/1PH) 4.2
Total Actual Acidity:(C16A/1) 0
Total Potential Acidity:(C17A/1) 0.008

ACID SULPHATE SOILS - NEWCASTLE Profile No. 4

```
MAP REFERENCES:
  1:100 000 sheet no:9232  NEWCASTLE                Scale of Mapping:1:25 000
        AMG Eastings:378425                                  AMG Zone:56
       AMG Northings:6361650
SURVEY DETAILS:
        Described by:C Murphy                                  Date:28/07/94
       Site Location:DRAIN SANDGATE ROAD 30M SOUTH ASTON ST
                                                   No of layers described:  3
 Methods of exposure:auger
SOIL and MAP CODES:
       Soil Map Code:Ek1
    Great Soil Group:HG, Humic Gley
    Geology Map Code:Qa
AUST. SOIL CLASS.:
Sulphidic, Extratidal, Hydrosol;Thick, Non Gravelly, Clayey, Clayey, Very Deep.
Confidence level: 3
TOPOGRAPHY:
               Slope:0%, measured
       Elevation (m):2
LANDFORM:
        Site Process:lacustrine                  Site Morphology:flat
        Local Relief:extremely low(< 9m)        Landform Pattern:plain
    Landform Element:swamp
VEGETATION:
Vegetation Community:swamp complex
     Vegetation Form:tree, rush
     Casuarina glauca (swamp she oak)
SITE CONDITION:
        Ground Cover:100%               Expected Dry Condition:hardsetting
   Current Condition:soft
LITHOLOGY:

  Substrate Material:lower solum parent mat.    Substrate Strength:weak
      Upper Solum PM:organic material, alluvium, marine
           Substrate:marine
LAND USE:
                Site:Timber/scrub/unused
        General Area:Urban
HYDROLOGY:
            Run Off:low                                    Run On:moderate
       Permeability:very slowly permeable    Profile Drainage:very poorly drained
EROSION:
                    none
EROSION HAZARD:     slight
SALINITY:           salting evident
FIELD NOTES:
                    Holocene estuarine backswamp.

LAYER:        1  A                                Depth (m):   .00 to    .30
COLOUR:        moist:10YR 1.7/1 (black)        value/chroma:1
TEXTURE:            silty clay
CONSISTENCE:
          plasticity:moderately plastic         stickiness:moderately sticky
    texture modifier:no change
       shearing test:crumbly
   soil water status:moderately moist
STRUCTURE:
               grade:moderate pedality
```

```
       dominant peds:2-5 mm, polyhedral
              fabric:rough-faced peds
ROOTS:
   very fine (<1 mm):many(25-100/10x10cm)          fine (1-2 mm):common(10-25/10x10cm)
     medium (2-5 mm):few(1-2/10x10 cm)            coarse (>5 mm):none
CHEMICAL TESTS:
                  pH:  6.5 ()
FIELD NOTES:
                      Non ASS, organic rich.
BOUNDARY:
     distinctiveness:sharp (<5 mm)

LAYER:          2  B                                 Depth (m):   .30 to    .60
COLOUR:           moist:7.5Y 5/1 (grey)            value/chroma:2a
MOTTLES:      Dominant:                                    type:unspecified
                colour:yellow
              contrast:distinct                       abundance:10% - 20%
          Sub-dominant:                                    type:unspecified
                colour:orange
              contrast:distinct                       abundance:10% - 20%
TEXTURE:               light-medium clay
CONSISTENCE:
          plasticity:very plastic                    stickiness:very sticky
    texture modifier:no change
       shearing test:labile
   soil water status:moist
STRUCTURE:
               grade:massive
ROOTS:
   very fine (<1 mm):few(1-10/10x10cm)            fine (1-2 mm):few(1-10/10x10cm)
     medium (2-5 mm):few(1-2/10x10 cm)           coarse (>5 mm):none
CHEMICAL TESTS:
                  pH:  7.5 ()
SAMPLE(S) TAKEN:     disturbed
FIELD NOTES:
                     pH H2O2 5.5 TPA <0.003 non PAS indicated
                     Expect PAS below.
BOUNDARY:
     distinctiveness:clear (20-50 mm)
LABORATORY:                                          Sample no:94/80/4
                                                         Depth:      to   .60

 EC - 1:5 soil:water:(C1A1/1) .92 dS m-1
pH of a Soil:Water Suspension:(C2A/2PH) 6.7
pH 1:20 Soil:H2O2 Suspension:(C2C/1PH) 5.5
Total Actual Acidity:(C16A/1) 0
Total Potential Acidity:(C17A/1) 0

LAYER:          3  B                                 Depth (m):   .60 to   1.00
COLOUR:           moist:N 5/0 (grey)               value/chroma:2a
TEXTURE:               light-medium clay
CONSISTENCE:
          plasticity:very plastic                    stickiness:very sticky
    texture modifier:no change
       shearing test:plastic
   soil water status:wet
STRUCTURE:
               grade:massive
ROOTS:
   very fine (<1 mm):none                         fine (1-2 mm):none
     medium (2-5 mm):none                       coarse (>5 mm):none
```

CHEMICAL TESTS:
pH: 8.0 ()

SAMPLE(S) TAKEN: disturbed

FIELD NOTES:

Continues, butter consistance, saturated
Expect PAS below.
TPA 0.009 Ph H2O2 5.8.

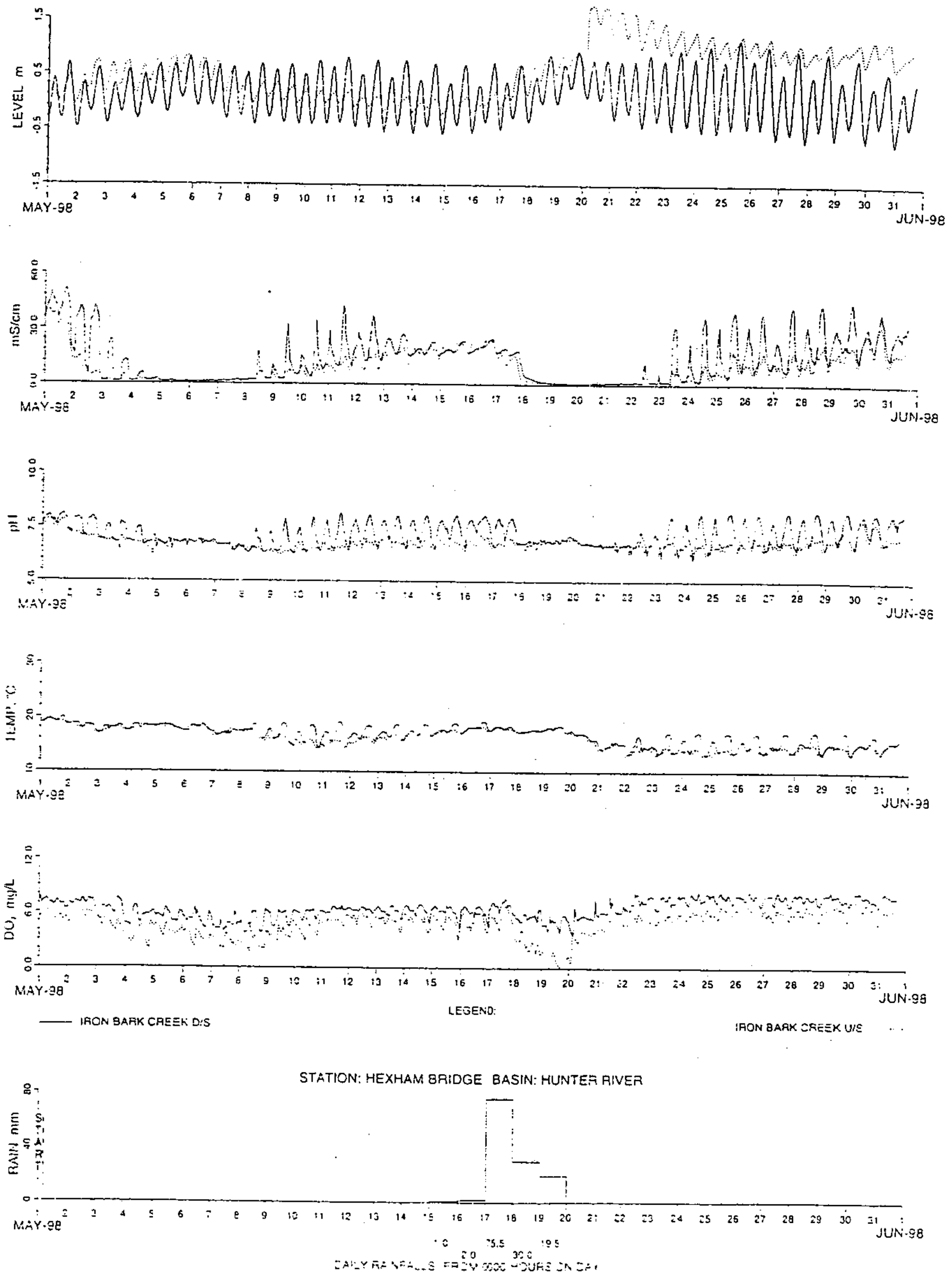
LABORATORY:

Sample no:94/80/5
Depth: to 1.00

EC - 1:5 soil:water:(C1A1/1) .91 dS m-1
pH of a Soil:Water Suspension:(C2A/2PH) 6.7
pH 1:20 Soil:H2O2 Suspension:(C2C/1PH) 5.8
Total Actual Acidity:(C16A/1) 0
Total Potential Acidity:(C17A/1) 0.009

APPENDIX 2

IRONBARK CREEK
WATER QUALITY MONITORING



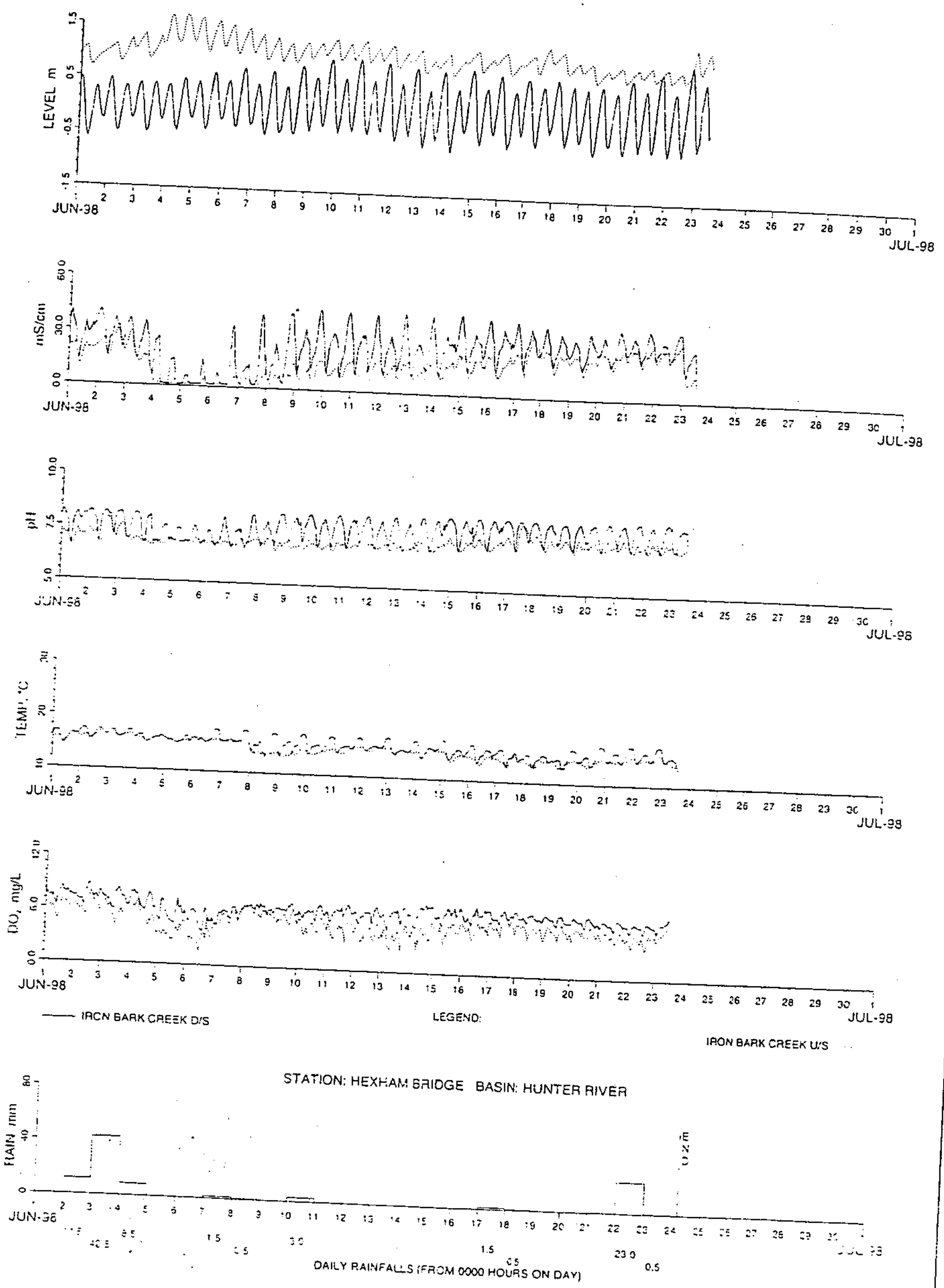
NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

MANLY HYDRAULICS LABORATORY

IRON BARK CREEK WATER QUAITY
MAY 1998

MHL
Report XXX

Figure



NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES
MANLY HYDRAULICS LABORATORY

IRON BARK CREEK WATER QUAITY
JUNE 1998

MHL
Report XXX

Figure

APPENDIX 3

LABORATORY TEST RESULTS

Environmental Analysis Laboratory
Centre for Coastal Management

PO BOX 5125, EAST LISMORE NSW 2480 AUSTRALIA
TELEPHONE: (02) 6620 3678
FACSIMILE: (02) 6620 3957

Job Number	J3241
Sample Accession No.	Samples 1 - 10
Sample Type	SOIL
No. of samples	10
Date supplied	5th August, 1998
Invoice Number	21414

Laboratory
Certified
Laboratory
Practice
REG. NO.: CLP0052

28th August, 1998

Attn/ Mark Delaney
Robert Carr & Associates
PO Box 175
CARRINGTON NSW 2294

Dear Mark,

Herewith are the results of the analysis of the 10 soil samples supplied on 5th August, 1998.

From the tests conducted most of the samples do not appear to be actual or potential acid sulphate soils: sample BH1 1.60m depth may be potential acid sulphate but further tests would be required to confirm this. All samples tested for TPA showed no potential acidity.

Please contact the laboratory if you have any queries.

Yours faithfully,

Graham Lancaster,
Laboratory Manager

Analysis performed according to "Standard Methods for the Examination of Water & Wastewater", 19th Edition 1995, APHA, except where stated otherwise.

Southern Cross University

RESULTS OF ACID SULPHATE SOIL ANALYSIS (Page 1 of 2)

Samples supplied by Robert Carr & Associates on 5th August, 1998 - Lab. Job No. J3241

Analysis requested by Mark Delaney - Your Job. No. 928

Sample Site	Depth (m)	our lab code	Description	pH (1:5 water)	Conductivity (1:5 water) dS/m	Extractable Sulphate Sulphur %Skcl	Oxidisable Sulphur %Sox (as %Sp - %Skcl)	POSA Kg H2SO4/ Tonne soil	Total Sulphur % S	Total Carbon % C	% ANC %CaCO3	NAGP Kg H2SO4/ Tonne soil
BH1	0.05	1	clay	6.11	0.103	0.003	0.029	0.9	0.05	4.72	..	..
BH1	0.45	2	clay	6.68	2.790	0.041	0.023	0.7	0.12	1.84	0.33	-2.5
BH1	1.60	3	sand/clay	6.05	2.079	..	..	..	0.52	2.95	..	..
BH2	0.05	4	clay	6.50	1.431	0.027	0.013	0.4	0.08	2.46	..	..
BH2	0.25	5	clay	6.20	0.648	0.011	0.023	0.7	0.10	3.69	0.10	-0.3
BH3	1.20	6	sand/clay	7.06	2.920	0.037	<0.005	<0.2	0.05	0.18	..	..
BH4	0.50	7	clay	7.53	0.739	0.049	<0.005	<0.2	0.07	0.91	0.60	-6.0
BH6	0.20	8	clay	7.00	2.333	0.069	<0.005	<0.2	0.12	2.47	..	..
BH7	0.05	9	clay	6.22	0.100	..	..	..	0.08	4.98	..	..
BH7	0.80	10	clay	5.00	0.148	0.015	0.011	0.3	0.05	2.08	0.00	0.3

Note:

1- All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)

2- Methods as per EPA, Acid Sulphate Soils Analytical Methods, June 1996

3- Total carbon and total sulphur determined using a LECO sulphur/carbon analyser

4- Bulk density was determined immediately on arrival to laboratory (insitu bulk density is preferred)

5- Neutralising Requirement (based on POSA, NAGP or TPA) = Kg H_2SO_4/tonne x bulk density

6- The neutralising requirement does not include a safety margin for complete neutralisation (a factor of 1.5 is often recommended)

7- ANC= Acid Neutralising Capacity of the Soil (Detection limit of 0.05% $CaCO_3$ Equivalent)

8- NAGP= Net Acid Generating Potential= (31.3*%Sox)-(10*%ANC) (From Mulvey, 1993)

9- Oxidisable Sulphur was determined using peroxide oxidation and analysis of sulphate = Total Oxidisable sulphur - extractable sulphate sulphur

10- POSA (Kg H_2SO_4/tonne soil) = oxidisable sulphur * 31.25

11- TPA and TAA are using the modified double oxidation technique to reduce the interferrence of organic matter

12- for conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm

checked: ....

RESULTS OF ACID SULPHATE SOIL ANALYSIS (Page 2 of 2)

Samples supplied by Robert Carr & Associates on 5th August, 1998 - Lab. Job No. J3241

Analysis requested by Mark Delaney - Your Job. No. 928

Sample Site	Depth (m)	our lab code	TAA pH	Total Actual Acidity (TAA) mole / Kg	TPA pH	Total Potential Acidity (TPA) mole / Kg	Total Potential Acidity (TPA) Kg H2SO4/tonne	Total Sulphidic Acidity (TSA) Kg H2SO4/tonne	Lab. Bulk Density tonne DW/m3	Neutralising Requirement Kg Lime/m3 (based on %S)	Neutralising Requirement Kg Lime/m3 (based on POSA)	Neutralising Requirement Kg Lime/m3 (based on NAGP)	Neutralising Requirement Kg Lime/m3 (based on TPA)
BH1	0.05	1	4.64	0.008	4.97	0.002	0.1	-0.3	1.11	1.8	1.0	..	0.1
BH1	0.45	2	6.00	0.000	6.27	0.000	0.0	0.0	1.12	4.2	0.8	0.0	0.0
BH1	1.60	3	5.36	0.004	..	..	..	..	1.37	21.9	..	..	..
BH2	0.05	4	5.65	0.000	6.25	0.000	0.0	0.0	1.09	2.5	0.5	..	0.0
BH2	0.25	5	4.91	0.002	6.15	0.000	0.0	-0.1	1.22	3.9	0.9	0.0	0.0
BH3	1.20	6	6.36	0.000	5.94	0.000	0.0	0.0	1.34	1.9	0.0	..	0.0
BH4	0.50	7	6.33	0.000	6.02	0.000	0.0	0.0	1.02	2.1	0.0	0.0	0.0
BH6	0.20	8	6.17	0.000	6.16	0.000	0.0	0.0	1.03	3.9	0.0	..	0.0
BH7	0.05	9	5.61	0.000	5.53	0.000	0.0	0.0	1.04	2.6	..	..	0.0
BH7	0.80	10	4.01	0.035	5.47	0.000	0.0	-1.7	1.11	1.7	0.4	0.4	0.0
										Refer Note 6	Refer Note 6	Refer Note 6	Refer Note 6

Note:

1- All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)

2- Methods as per EPA, Acid Sulphate Soils Analytical Methods, June 1996

3- Total carbon and total sulphur determined using a LECO sulphur/carbon analyser

4- Bulk density was determined immediately on arrival to laboratory (insitu bulk density is preferred)

5- Neutralising Requirement (based on POSA, NAGP or TPA) = Kg H2SO4/tonne x bulk density

6- The neutralising requirement does not include a safety margin for complete neutralisation (a factor of 1.5 is often recommended)

7- ANC= Acid Neutralising Capacity of the Soil (Detection limit of 0.05% CaCO3 Equivalent)

8- NAGP= Net Acid Generating Potential= (31.3*%Sox)-(10*%ANC) (From Mulvey, 1993)

9- Oxidisable Sulphur was determined using peroxide oxidation and analysis of sulphate = Total Oxidisable sulphur - extractable sulphate sulphur

10- POSA (Kg H2SO4/tonne soil) = oxidisable sulphur * 31.25

11- TPA and TAA are using the modified double oxidation technique to reduce the interferrence of organic matter

12- for conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm

checked: ....

Environmental Analysis Laboratory
Centre for Coastal Management

PO BOX 5125, EAST LISMORE NSW 2480 AUSTRALIA
TELEPHONE: (02) 6620 3678
FACSIMILE: (02) 6620 3957

Job Number	J3315
Sample Accession No.	Samples 1 - 3
Sample Type	SOIL
No. of samples	3
Date supplied	26th August, 1998
Invoice Number	21449

Laboratory
Certified
Laboratory
Practice

REG. NO.: CLP0052

10th September, 1998

Attn/ Mark Delaney
Robert Carr & Associates
PO Box 175
CARRINGTON NSW 2294

Dear Mark,

Herewith are the results of the analysis of the 3 soil samples supplied on 26th August, 1998.

All three samples are likely to be potential acid sulphate soils. The further POCAS testing was conducted on the 1.0 m depth sample and the indication was that all the sulphur is oxidisable. It has actually occurred that the total sulphur is lower than the oxidisable sulphur which is theoretically impossible. We have checked the POCAS technique and have excellent correlation between TPA and oxidisable sulphur; we have also double checked the LECO total sulphur. We are now communicating with the LECO company to determine why the new unit is underestimating the high range sulphur results.

Please contact the laboratory if you have any queries.

Yours faithfully,

G. Lancaster

Graham Lancaster,
Laboratory Manager

Results refer to samples as received at the laboratory. This report is not to be reproduced except in full.

Analysis performed according to "Standard Methods for the Examination of Water & Wastewater", 19th Edition 1995, APHA, except where stated otherwise.

Southern Cross University

RESULTS OF ACID SULPHATE SOIL ANALYSIS (Page 1 of 2)

Samples supplied by Robert Carr & Associates on 26th August, 1998 - Lab. Job No. J3315
Analysis requested by Mark Delaney - Your Job No. 928

Sample Site	Depth (m)	Description	pH (1:5 water)	Conductivity (1:5 water) dS/m	Extractable Sulphate Sulphur %Skcl	Oxidisable Sulphur %Sox (as %Sp - %Skcl)	POSA Kg H2SO4/ Tonne soil	Total Sulphur % S	Total Carbon % C
BORE 9	**0 - 0.05**	clay/loam	4.55	0.235	..	..	..	0.22	7.79
BORE 9	**0.4 - 0.5**	clay	3.59	1.111	..	..	..	2.12	5.80
BORE 9	**1.0**	clay	3.74	3.200	0.039	5.703	178.2	5.38	3.36

Note:

1- All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)
2- Methods as per EPA, Acid Sulphate Soils Analytical Methods, June 1996
3- Total carbon and total sulphur determined using a LECO sulphur/carbon analyser
4- Bulk density was determined immediately on arrival to laboratory (insitu bulk density is preferred)
5- Neutralising Requirement (based on POSA, NAGP or TPA) = Kg H2SO4/tonne x bulk density
6- The neutralising requirement does not include a safety margin for complete neutralisation (a factor of 1.5 is often recommended)
7- ANC= Acid Neutralising Capacity of the Soil (Detection limit of 0.05% CaCO3 Equivalent)
8- NAGP= Net Acid Generating Potential= (31.3*%Sox)-(10*%ANC) (From Mulvey, 1993)
9- Oxidisable Sulphur was determined using peroxide oxidation and analysis of sulphate = Total Oxidisable sulphur - extractable sulphate sulphur
10- POSA (Kg H2SO4/tonne soil) = oxidisable sulphur * 31.25
11- TPA and TAA are using the modified double oxidation technique to reduce the interferrence of organic matter
12- for conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
.. - Analysis not requested

checked: ....

RESULTS OF ACID SULPHATE SOIL ANALYSIS (Page 2 of 2)

Samples supplied by Robert Carr & Associates on 26th August, 1998 - Lab. Job No. J3315
Analysis requested by Mark Delaney - Your Job No. 928

Sample Site	Depth (m)	TAA pH	Total Actual Acidity (TAA) mole / Kg	TPA pH	Total Potential Acidity (TPA) mole / Kg	Total Potential Acidity (TPA) Kg H2SO4/tonne	Total Sulphidic Acidity (TSA) Kg H2SO4/tonne	Lab. Bulk Density tonne DW/m3	Neutralising Requirement Kg Lime/m3 (based on %S)	Neutralising Requirement Kg Lime/m3 (based on POSA)	Neutralising Requirement Kg Lime/m3 (based on TPA)
BORE 9	0 - 0.05	..	..	..	..	..	..	0.71	4.7	..	..
BORE 9	0.4 - 0.5	..	..	..	..	..	..	0.60	38.9	..	..
BORE 9	1.0	3.69	0.092	1.48	3.625	177.8	173.3	0.73	119.5 Refer Note 6	129.4 Refer Note 6	129.1 Refer Note 6

Note:

1- All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)
2- Methods as per EPA, Acid Sulphate Soils Analytical Methods, June 1996
3- Total carbon and total sulphur determined using a LECO sulphur/carbon analyser
4- Bulk density was determined immediately on arrival to laboratory (insitu bulk density is preferred)
5- Neutralising Requirement (based on POSA, NAGP or TPA) = Kg H2SO4/tonne x bulk density
6- The neutralising requirement does not include a safety margin for complete neutralisation (a factor of 1.5 is often recommended)
7- ANC= Acid Neutralising Capacity of the Soil (Detection limit of 0.05% CaCO3 Equivalent)
8- NAGP= Net Acid Generating Potential= (31.3*%Sox)-(10*%ANC) (From Mulvey, 1993)
9- Oxidisable Sulphur was determined using peroxide oxidation and analysis of sulphate = Total Oxidisable sulphur - extractable sulphate sulphur
10- POSA (Kg H2SO4/tonne soil) = oxidisable sulphur * 31.25
11- TPA and TAA are using the modified double oxidation technique to reduce the interferrence of organic matter
12- for conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
.. - Analysis not requested

checked: ....

amdel

NATA

This Laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of accreditation. This document shall not be reproduced except in full.

Accreditation No. 1464

ENVIRONMENTAL AND INDUSTRIAL SERVICES DIVISION
Trading as Australian Analytical Laboratories Pty Ltd
ACN 001 491 667

Correspondence to:
PO BOX 514
HORNSBY NSW 1630

5 Kelray Place
ASQUITH NSW 1630
Telephone: (02) 9482 1922
Facsimile: (02) 9482 1734

CERTIFICATE OF ANALYSIS

Contents :
1) Cover Page
2) Analysis Report Pages
3) QA/QC Appendix

REPORT No : 8E01371

ATTENTION : Mr Mark Delaney

CLIENT : Robert Carr & Associates

SAMPLES : 3

REFERENCE : 928

DATE RECEIVED : 31/07/98

DATE REPORTED : 07/08/98

Method	Description
WAT2	Std Water Analysis

RESULTS

All samples were analysed as received. This report relates specifically to the samples received. Results relate to the source material only to the extent that the samples as supplied are truly representative of the sample source. This report replaces any preliminary results issued. Note that for schemes indicated with * NATA registration does not cover the performance of this service.

PLEASE SEE ATTACHED PAGES FOR RESULTS

per G.W. ANDERSON
Manager Environmental Sydney

amdel

Job Number : 8E01371
Client : Robert Carr & Associates
Reference : 928

Page 1 of 2
plus Cover Page

	Lab No	E59010	E59011	E59012		
	Sample Id	GW1	GW2	GW7		
Analyte	PQL					
WAT2 Standard Water Analysis						
Chemical Composition						
Cations in mg/L						
Calcium as Ca	**0.1**	367	153	35.4		
Magnesium as Mg	**0.1**	624	389	15.0		
Sodium as Na	**0.1**	5430	3640	85.3		
Potassium as K	**0.1**	91.3	108	2.5		
Cations in me/L						
Calcium as Ca	**0.01**	18.3	7.6	1.8		
Magnesium as Mg	**0.002**	51.4	32.0	1.2		
Sodium as Na	**0.004**	236	158	3.7		
Potassium as K	**0.003**	2.3	2.8	0.063		
pH		5.3	6.3	5.8		
E.C. at 25 C (uS/cm)	**1**	26100	19900	724		
Resistivity at 25·C (Ohm.M)	**0.01**	0.4	0.5	14		
Anions in mg/L						
Hydroxide as OH	**1**	nd	nd	nd		
Carbonate as CO3	**1**	nd	nd	nd		
Bicarbonate as HCO3	**1**	21.8	212	47.9		
Sulphate as SO4	**1**	5510	1160	128		
Chloride as Cl	**1**	6890	6410	106		
Nitrate as NO3	**0.1**	0.13	nd	nd		

PQL = Practical Quantitation Limit
LNR = Samples Listed not Received
nd = Not Detected (<PQL)
-- = Not Applicable

Soils : mg/kg (ppm) dry weight unless otherwise specified
Waters : mg/L (ppm) unless otherwise specified
Leachates : mg/L (ppm) in leachate

Job Number : 8E01371
Client : Robert Carr & Associates
Reference : 928

Page 2 of 2
plus Cover Page

	Lab No	E59010	E59011	E59012		
	Sample Id	GW1	GW2	GW7		
Analyte	PQL					
Anions in me/L						
Hydroxide as OH	**0.06**	nd	nd	nd		
Carbonate as CO3	**0.01**	nd	nd	nd		
Bicarbonate as HCO3	**0.01**	0.36	3.5	0.78		
Sulphate as SO4	**0.01**	115	24.3	2.7		
Chloride as Cl	**0.03**	194	180	3.0		
Nitrate as NO3	**0.002**	0.002	nd	nd		
Derived Data (mg/L)						
TDS - Based on E.C.	**1**	16700	12700	463		
TDS - Calculated (HCO3=CO3)	**1**	18900	12000	396		
Total Hardness	**1**	3480	1980	150		
Carbonate Hardness	**1**	17.9	174	39.2		
Total Alkalinity as CaCO3	**1**	17.9	174	39.2		
Totals and Balance						
Cation Total (me/L)	**0.1**	308	201	6.8		
Anion Total (me/L)	**0.1**	309	208	6.4		
Ion Difference	**0.1**	1.0	7.5	0.3		
Ion Balance (%)	**0.1**	0.2%	1.8%	2.5%		
Sodium/Total Cation Ratio (%)		77%	79%	55%		

PQL = Practical Quantitation Limit
LNR = Samples Listed not Received
nd = Not Detected (<PQL)
-- = Not Applicable

Soils : mg/kg (ppm) dry weight unless otherwise specified
Waters : mg/L (ppm) unless otherwise specified
Leachates : mg/L (ppm) in leachate

QA/QC APPENDIX NO. 8E01371

Method	Description
WAT2	Std Water Analysis

Chromatography QA/QC

	Yes	No	N/A
Retention Time Window Within Acceptance Criteria(±2%)			√
Check Standard Within Acceptance Criteria(±10%)			√
Recalibration Within Acceptance Criteria(±15%)			√
Other QA/QC			
Holding time conforming With Method Specification	√		
Chain of Custody Attached	√		

N/A = Not Applicable

Comments

1. Laboratory QA/QC including Duplicates, Matrix Spike Duplicates, and check/reference samples are included in this QA/QC appendix. (Where applicable)
2. Inter-Laboratory proficiency trial results available on request. (Where applicable)
3. Surrogate description and recoveries are recorded in the Report. (Where applicable)
4. Acceptance criteria for specific analytes are listed on each QA/QC page.
5. Practical Quantitation Limit (PQL is typically 2-10 x method detection limit (MDL)).
6. PQL's are matrix dependent and are increased accordingly where sample extracts are diluted.
7. Results are uncorrected for matrix spike or surrogate recoveries.

per G.W. ANDERSON
Manager Environmental Sydney

Job Number : 8E01371

QAQC : Matrix Spike / Check Solution

Analyte	Level (ppm)	Level Detected		Recovery Details			
		Result1 (ppm)	Result2 (ppm)	Rec 1 (%)	Rec 2 (%)	Average (%)	RPD (%)
WAT2 Standard Water Analysis							
Calcium as Ca	50	47.4		95%			
Magnesium as Mg	50	51.6		103%			
Sodium as Na	50	54.3		109%			
Potassium as K	50	55.4		111%			
pH	7.4	7.3		99%			
E.C. at 25 C (uS/cm)	303	310		102%			
Sulphate as SO4	20	20.6		103%			
Chloride as Cl	50	48.4		97%			
Nitrate as NO3	4.4	4.1		93%			
Total Alkalinity as CaCO3	59.5	58.6		98%			

PQL = Practical Quantitation Limit

(S) Soils : mg/kg (ppm) dry weight
(W) Waters : mg/l (ppm)

nd = < PQL
-- = Not Applicable

All results are within the acceptance criteria:

Refer to Amdel-Sydney Quality Control Manual SPM-01 5th Edition 1/6/98

ob Number : 8E01371

QAQC : Control Blank

	SAMPLE ID	Blank				
ANALYTE	PQL					
WAT2 Standard Water Analysis						
Chemical Composition						
Cations in mg/L						
Calcium as Ca	**0.1**	nd				
Magnesium as Mg	**0.1**	nd				
Sodium as Na	**0.1**	nd				
Potassium as K	**0.1**	nd				
Cations in me/L						
Calcium as Ca	**0.01**	nd				
Magnesium as Mg	**0.002**	nd				
Sodium as Na	**0.004**	nd				
Potassium as K	**0.003**	nd				
pH		7.2				
E.C. at 25 C (uS/cm)	**1**	nd				
Resistivity at 25·C (Ohm.M)	**0.01**	--				
Anions in mg/L						
Hydroxide as OH	**1**	nd				
Carbonate as CO3	**1**	nd				
Bicarbonate as HCO3	**1**	nd				
Sulphate as SO4	**1**	nd				
Chloride as Cl	**1**	nd				
Nitrate as NO3	**0.1**	nd				

PQL = Practical Quantitation Limit

(S) Soils : mg/kg (ppm) dry weight
(W) Waters : mg/l (ppm)

nd = < PQL
-- = Not Applicable

All results are within the acceptance criteria:

Refer to Amdel-Sydney Quality Control Manual SPM-01 5th Edition 1/6/98

QAQC : Control Blank

	SAMPLE ID	Blank				
ANALYTE	PQL					
Anions in me/L						
Hydroxide as OH	**0.06**	nd				
Carbonate as CO3	**0.01**	nd				
Bicarbonate as HCO3	**0.01**	nd				
Sulphate as SO4	**0.01**	nd				
Chloride as Cl	**0.03**	nd				
Nitrate as NO3	**0.002**	nd				
Derived Data (mg/L)						
TDS - Based on E.C.	**1**	nd				
TDS - Calculated (HCO3=CO3)	**1**	nd				
Total Hardness	**1**	nd				
Carbonate Hardness	**1**	nd				
Total Alkalinity as CaCO3	**1**	nd				
Totals and Balance						
Cation Total (me/L)	**0.1**	nd				
Anion Total (me/L)	**0.1**	nd				

PQL = Practical Quantitation Limit

(S) Soils : mg/kg (ppm) dry weight
(W) Waters : mg/l (ppm)

nd = < PQL
-- = Not Applicable

All results are within the acceptance criteria:

Refer to Amdel-Sydney Quality Control Manual SPM-01 5th Edition 1/6/98

SUMMARY OF LABORATORY TEST RESULTS

CLIENT: WBM Oceanics **DATE: 11/8/98**
PROJECT: Hexham Swamp EIS **PROJECT No: 928**

Sample No:		C578	C582	
Location:		BH1 - 0.95m	BH7 - 0.25m	
Description:		SAND; with some clay	Clayey silty SAND	
Nominal Size:.		-	-	
Particle Size Distribution: % Passing		RESULT	RESULT	
AS1289 3.6.1	75.0 mm	-	-	
	53.0 mm	-	-	
	37.5 mm	-	-	
	26.5 mm	-	-	
	19.0 mm	-	-	
	13.2 mm	-	-	
	9.5 mm	-	-	
	6.7 mm	-	-	
	4.75 mm	-	-	
	2.36 mm	-	-	
	1.18 mm	-	-	
	0.600 mm	-	-	
	0.425 mm	-	-	
	0.300 mm	-	-	
	0.150 mm	-	-	
	0.075 mm	21	54	
	0.0135 mm	N/A	N/A	

Remarks: Samples tested over 0.75mm sieve only.

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NEWCASTLE LABORATORY N°:[illegible]811
Tested by:DB Checked By:CW
REPORT N°:928 4
DATE:11/8/98
SIGNED:

F-MR-003

RESULTS OF EMERSON CLASS NUMBER DETERMINATION OF A SOIL

CLIENT: WBM Oceanics
PROJECT N°: 928
PROJECT: Hexham Swamp EIS
DATE: 11/8/98
LOCATION: Hexham

SAMPLE N°: C577

DEPTH: 0.45m

MATERIAL DESCRIPTION: Grey mottled orange CLAY

SOURCE OF MATERIAL: BH1

DATE OF SAMPLING: 30/7/98

TYPE OF WATER USED FOR TEST: Sea water
TEMP OF WATER USED FOR TEST (°C): 17

EMERSON CLASS N°: 6

Test Method:AS1289.3.8.1
REMARKS:

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NEWCASTLE LABORATORY N°: 9811
TESTED BY:PB
CHECKED BY CW
REPORT N°:928/1
DATE:10/8/98
SIGNED:

RESULTS OF EMERSON CLASS NUMBER DETERMINATION OF A SOIL

CLIENT: WBM Oceanics

PROJECT N°: 928

PROJECT: Hexham Swamp EIS

DATE: 11/8/98

LOCATION: Hexham

SAMPLE N°: C580

DEPTH: 0.5m

MATERIAL DESCRIPTION: Dark grey/brown CLAY

SOURCE OF MATERIAL: BH4

DATE OF SAMPLING: 30/7/98

TYPE OF WATER USED FOR TEST: Sea water

TEMP OF WATER USED FOR TEST (°C): 17

EMERSON CLASS N°: 6

Test Method:AS1289.3.8.1

REMARKS:

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NEWCASTLE LABORATORY N°: 9811
TESTED BY:PB
CHECKED BY:CW
REPORT N°:928/2
DATE:11/8/98
SIGNED:

RESULTS OF EMERSON CLASS NUMBER DETERMINATION OF A SOIL

CLIENT: WBM Oceanics
PROJECT: Hexham Swamp EIS
LOCATION: Hexham

PROJECT N°: 928
DATE: 11/8/98

SAMPLE N°: C581

DEPTH: 0.5m

MATERIAL DESCRIPTION: Grey & orange/brown sandy CLAY

SOURCE OF MATERIAL: BH5

DATE OF SAMPLING: 30/7/98

TYPE OF WATER USED FOR TEST: Sea water
TEMP OF WATER USED FOR TEST (°C): 17

EMERSON CLASS N°: 6

Test Method:AS1289.3.8.1
REMARKS:

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NEWCASTLE LABORATORY N°: 9817
TESTED BY:PB CHECKED BY:CW
REPORT N°:928/3
DATE:11/8/98
SIGNED:

L-EM-001

TEST BORE REPORT LOG

HOLE No: 1

CLIENT: WBM Oceanics P/L
PROJECT: EIS
LOCATION: Hexham Swamp

DATE: 29/7/98
PROJECT No: 928
SURFACE LEVEL: Existing

SHEET 1 of 1
Method of hole advance: Hand Auger

GROUND WATER	SAMPLES TESTS DEPTHS	DEPTH (M)	RL (M)	STRATA	DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
0.25	D @ 0.1	0.3			TOPSOIL, Sandy Silty CLAY, medium plasticity, moist to wet, numerous rootlets and organic matter, dark grey/black, blocky structure
0.5	D @ 0.45	0.5			CLAY, high plasticity, stiff to very stiff, moist, grey mottled orange
0.75 1.0 1.1 ▽ 1.25 1.5	D @ 0.95 D @ 1.6				SAND, fine to medium grained, with some clay fines, light grey mottled orange some Clayey SAND layers SAND, fine to medium grained, wet, dark grey, with some clay fines, slight organic odour
1.75 2.0 2.25					End Bore Hole 1 at 1.7m 50mm Piezometer installed 29/7/98 to 1.7m depth Slotted 1.2m–1.7m Groundwater sampled 30/7/98 E.C. 19.5mS, pH 5.3 Ironbark Creek 30/7/98 E.C. 1.9mS, pH 6.2

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PO Box 175, Carrington, 2294
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LOGGED: MD
CHECKED: MD
DATE: 30/7/98

F-LOG-002

TEST BORE REPORT LOG

HOLE No: 2

CLIENT:	WBM Oceanics P/L	DATE:	29/7/98	SHEET	1 of 1
PROJECT:	EIS	PROJECT No:	928	Method of hole advance:	Hand Auger
LOCATION:	Hexham Swamp	SURFACE LEVEL:	Existing		

GROUND WATER	SAMPLES TESTS DEPTHS	DEPTH (M)	RL (M)	STRATA	DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		0.05			HUMUS, decomposed vegetation
		0.1			Silty CLAY, moist to wet, dark grey and brown, organic, numerous roots, recent ALLUVIUM
		0.2			FILL, ripped sandstone rock fragments, orange/brown
0.25 0.3 ▽ 0.5 0.75 1.0 1.25 1.5	D @ 0.25 D @ 0.45 D @ 1.2				Silty CLAY, moist to wet, firm, dark brown and grey, organic, numerous roots, blocky structure, some Clayey SILT lenses becoming dark grey/black, soft consistency, high organic content, ESTUARINE SEDIMENT
1.75 2.0 2.25					End Bore Hole 2 at 1.7m 50mm piezometer installed 29/7/98 to 1.7m depth Slotted 1.2m–1.7m Groundwater sampled 30/7/98 E.C. 15.9mS, pH 6.1 Ironbark Creek 30/7/98 E.C. 0.6mS, pH 7.1 (recent floodwaters in Hunter River)

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F-LOG-002

TEST BORE REPORT LOG

HOLE No: 3

CLIENT: WBM Oceanics P/L
PROJECT: EIS
LOCATION: Hexham Swamp

DATE: 29/7/98
PROJECT No: 928
SURFACE LEVEL: Existing

SHEET 1 of 1
Method of hole advance: Hand Auger

GROUND WATER	SAMPLES TESTS DEPTHS	DEPTH (M)	RL (M)	STRATA	DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
0.25		0.4			TOPSOIL, Clayey SILT, moist to wet, dark grey, organic, becoming Silty CLAY with depth
0.5 0.7 0.75	D @ 0.5	0.9			CLAY, medium to high plasticity, stiff, moist, grey mottled orange, trace of fine sand becoming grey
1.0 1.25 1.5	D @ 1.2				Clayey SAND, fine to medium grained, wet, grey, estimated 15% clay content
1.75 2.0 2.25					End Bore Hole 3 at 1.7m Bore groundwater at time of drilling pH 5.5 E.C. 32mS

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DATE:	30/7/98

F-LOG-002

TEST BORE REPORT LOG

HOLE No: 4

CLIENT: WBM Oceanics P/L
PROJECT: EIS
LOCATION: Hexham Swamp

DATE: 29/7/98
PROJECT No: 928
SURFACE LEVEL: Existing

SHEET 1 of 1
Method of hole advance: Hand Auger

GROUND WATER	SAMPLES TESTS DEPTHS	DEPTH (M)	RL (M)	STRATA	DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		0.2		▩	FILL, COAL CHITTER and TAILINGS (slopewash off stockpiles), dark grey/black, wet
0.25 ▽ 0.25 0.5 0.75	D @ 0.5	1.0		▨	CLAY, medium to high plasticity, stiff, moist to wet, dark grey/brown, blocky structure
1.0		1.1		░	SAND, fine to medium grained, wet, grey
1.25 1.5	D @ 1.3			▨	Clayey SAND/Sandy CLAY, fine sand, clay of low to medium plasticity, grey and orange, wet
1.75 2.0 2.25					End Bore Hole 4 at 1.7m Bore Groundwater at time of drilling pH 7.2 E.C. 0.9mS NOTE: Rapid rise in groundwater level to 0.05m once penetrating sand layer at 1.0m to 1.1m

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CHECKED:	MD
DATE:	30/7/98

TEST BORE REPORT LOG

HOLE No: 5

CLIENT: WBM Oceanics P/L
PROJECT: EIS
LOCATION: Hexham Swamp

DATE: 29/7/98
PROJECT No: 928
SURFACE LEVEL: Existing

SHEET 1 of 1
Method of hole advance: Hand Auger

GROUND WATER	SAMPLES TESTS DEPTHS	DEPTH (M)	RL (M)	STRATA	DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
0.25		0.3		≋	TOPSOIL, Sandy SILT, moist to wet, dark grey, with some clay, numerous roots
0.5 0.6 ▽ 0.75	D @ 0.5	0.85		▨	Sandy CLAY, low to medium plasticity, moist/wet becoming wet, grey and orange/brown, some clayey sand layers
1.0				▨	Silty CLAY, moist, grey, relict rock structure, RESIDUAL
1.25 1.5 1.75 2.0 2.25					End Bore Hole 5 at 1.0m Bore Groundwater at time of drilling pH 5.8 E.C. 3mS

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DATE: 30/7/98

F-LOG-002

TEST BORE REPORT LOG

HOLE No: 6

CLIENT: WBM Oceanics P/L
PROJECT: EIS
LOCATION: Hexham Swamp

DATE: 29/7/98
PROJECT No: 928
SURFACE LEVEL: Existing

SHEET 1 of 1
Method of hole advance: Hand Auger

GROUND WATER	SAMPLES TESTS DEPTHS	DEPTH (M)	RL (M)	STRATA	DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		0.15		≀≀≀	TOPSOIL, Clayey SILT, moist to wet, dark grey, organic, with some fine sand
0.25	D @ 0.2	0.3 3.0		▨	Silty CLAY, medium to high plasticity stiff, moist to wet, dark grey, some organic matter
0.5 0.7 ▽ 0.75 1.0 1.25	D @ 0.5			▨	CLAY, medium plasticity, stiff, moist to wet, orange/brown and grey, with some sand, some Sandy CLAY layers
1.5 1.75 2.0 2.25					End Bore Hole 6 at 1.5m Ponding surface water (after recent rains) 2m from bore pH 8.1 E.C. 0.4mS Bore Groundwater at time of drilling pH 6.7 E.C. 19mS

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LOGGED: MD
CHECKED: MD
DATE: 30/7/98

TEST BORE REPORT LOG

HOLE No: 7

CLIENT: WBM Oceanics P/L
PROJECT: EIS
LOCATION: Hexham Swamp

DATE: 29/7/98
PROJECT No: 928
SURFACE LEVEL: Existing

SHEET 1 of 1
Method of hole advance: Hand Auger

	GROUND WATER	SAMPLES TESTS DEPTHS	DEPTH (M)	RL (M)	STRATA	DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
			0.1			TOPSOIL, Clayey Sandy SILT, moist to wet, dark grey
0.25	0.25 ▽	D @ 0.25	0.35			Clayey Silty SAND/Clayey Sandy SILT, fine grained, dark grey, becoming mottled orange brown, moist to wet becoming wet
0.5 0.75 1.0 1.25		D @ 0.8				Silty CLAY, medium–high plasticity, firm, dark grey, mottled orange becoming dark grey with depth, numerous root fibres, moist to wet, some thin sand layers
1.5 1.75 2.0 2.25						End Bore Hole 7 at 1.25m 50mm piezometer installed 29/7/98 to 1.25m depth Slotted 0.75m–1.25m Groundwater sampled 30/7/98 E.C. 0.7mS, pH 6.9 Ironbark Creek 30/7/98 E.C. 0.8mS, pH 6.9

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LOGGED: MD
CHECKED: MD
DATE: 30/7/98

F-LOG-002

TEST BORE REPORT LOG

HOLE No: 8

CLIENT: WBM Oceanics P/L
PROJECT: EIS
LOCATION: Hexham Swamp

DATE: 30/7/98
PROJECT No: 928
SURFACE LEVEL: Existing

SHEET 1 of 1
Method of hole advance: Hand Auger

GROUND WATER	SAMPLES TESTS DEPTHS	DEPTH (M)	RL (M)	STRATA	DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		0.1		≀≀≀	TOPSOIL, organic, black, moist
		0.4		▨	FILL, Clayey SILT, coal chitter, moist, black
	D @ 0.5			▨	FILL, Silty CLAY, moist, black with some white and orange mottling, some coal chitter and brick fragments
					End Bore 8 at 0.6m at refusal on coal chitter

- 0.25
- 0.5
- 0.75
- 1.0
- 1.25
- 1.5
- 1.75
- 2.0
- 2.25

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LOGGED: AG
CHECKED: MD
DATE: 30/7/98

TEST BORE REPORT LOG

HOLE No: 9

CLIENT: WBM Oceanics P/L
PROJECT: EIS
LOCATION: Hexham Swamp

DATE: 21/7/98
PROJECT No: 928
SURFACE LEVEL: Existing

SHEET 1 of 1
Method of hole advance: Hand Auger

GROUND WATER	SAMPLES TESTS DEPTHS	DEPTH (M)	RL (M)	STRATA	DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
0.25 0.3 ▽	D @ 0.0–0.5	0.3		▨	Silty CLAY, stiff to very stiff, medium to high plasticity, moist becoming moist/wet, dark grey and brown, numerous decomposed and partly decomposed roots and fibres
0.5 0.75 1.0 1.25	D @ 0.4–0.5 D @ 1.0	1.3		▨	Silty CLAY, soft/firm, medium to high plasticity, wet, dark grey mottled yellow, well developed jarrosite mottling and nodules from 0.35m to 0.6m
1.5				▨	Organic Sandy CLAY, soft to firm, low to medium plasticity, brown, organic odour
1.75 2.0 2.25					End Bore Hole 9 at 1.6m

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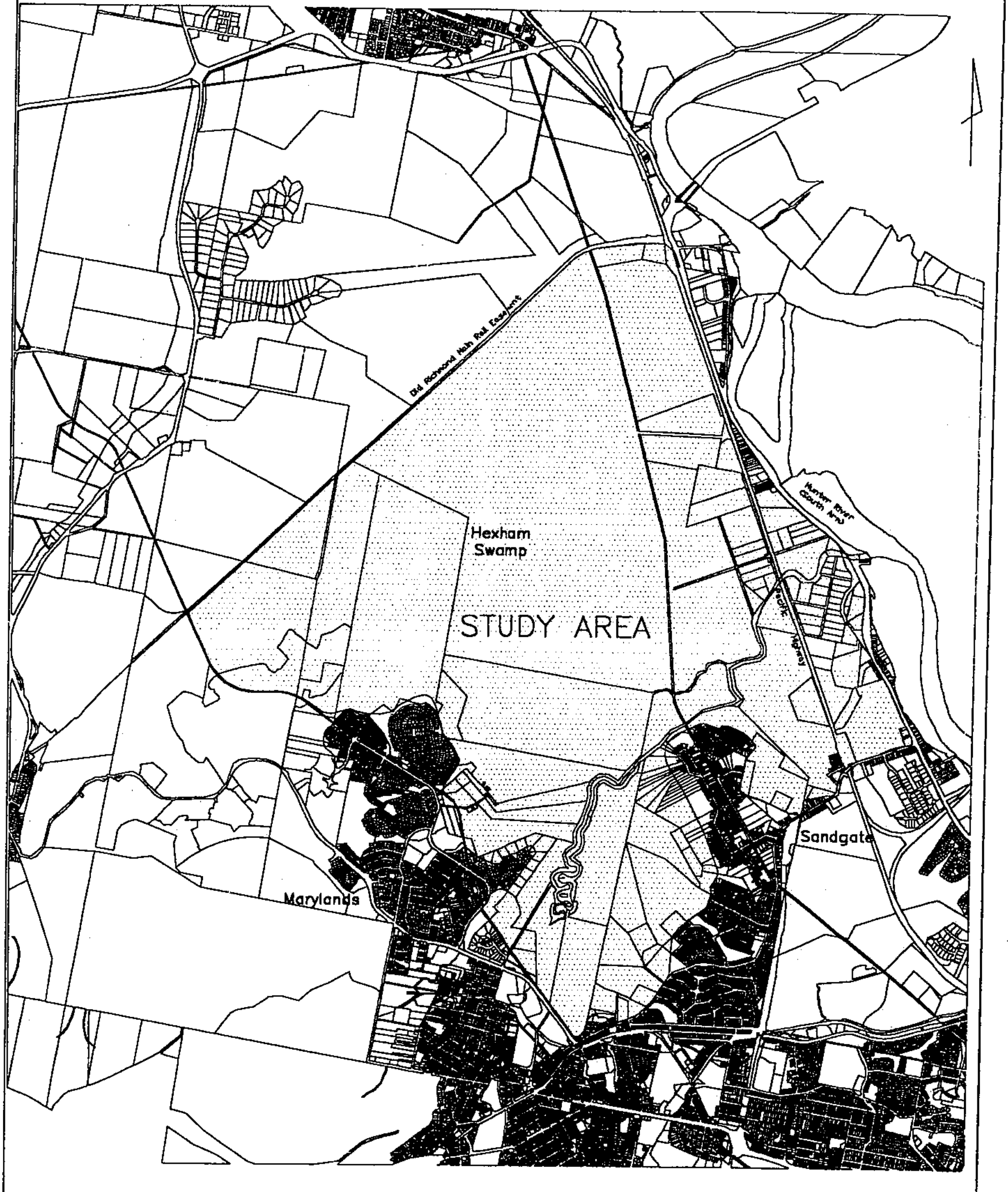
LOGGED: MD
CHECKED: MD
DATE: 30/7/98



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TITLE

STUDY AREA
HEXHAM SWAMP EIS

CLIENT WBM Oceanics Australia

DRAWN BY	AG	SCALE	N.T.S.	PROJECT No	928			OFFICE
APPROVED BY	MD	DATE	24/8/98	DRAWING No	1	Rev	0	NEWCASTLE

E-A4-001

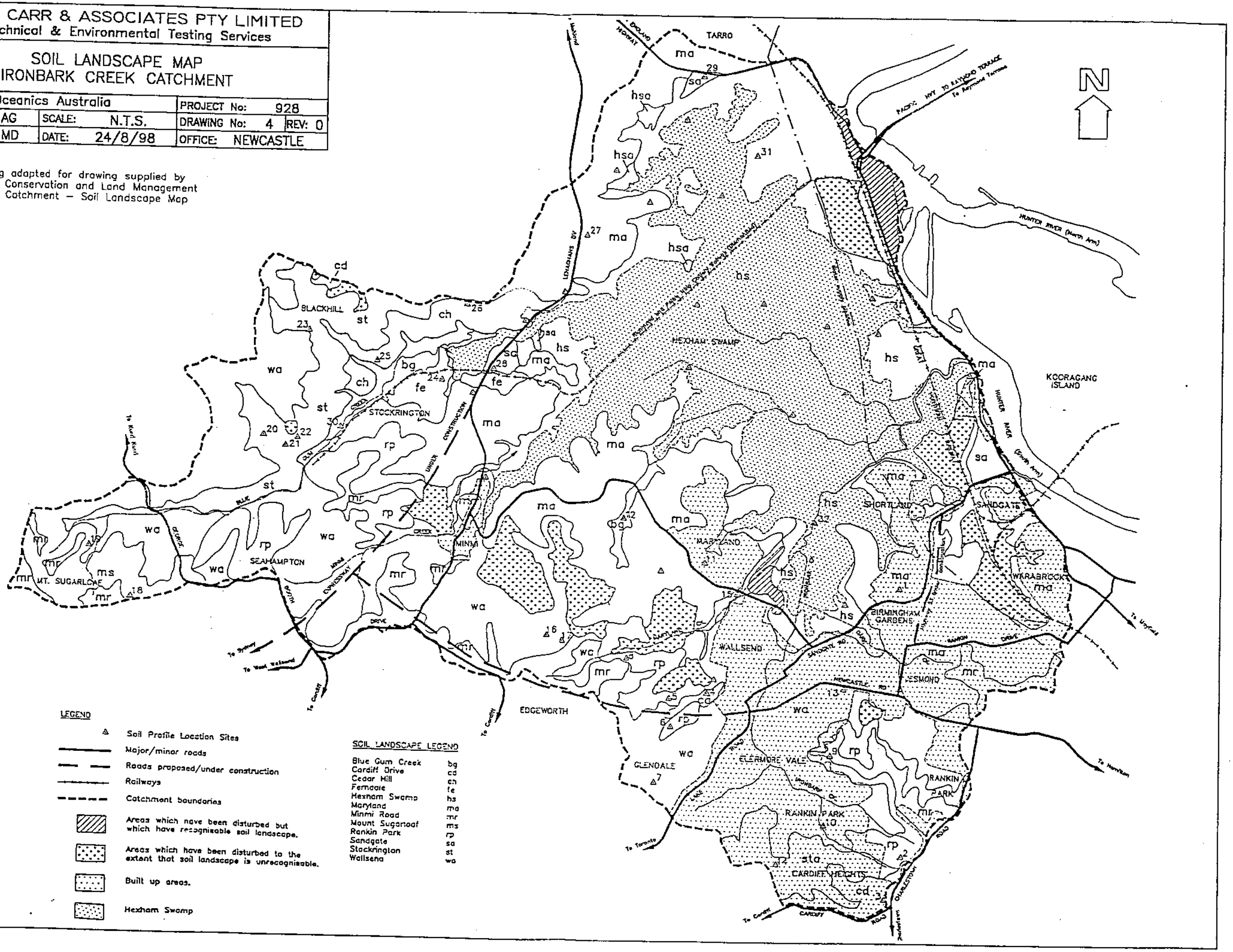
ROBERT CARR & ASSOCIATES PTY LIMITED
Geotechnical & Environmental Testing Services

TITLE:

SOIL LANDSCAPE MAP
IRONBARK CREEK CATCHMENT

CLIENT: WMB Oceanics Australia		PROJECT No: 928	
DRAWN BY: AG	SCALE: N.T.S.	DRAWING No: 4	REV: 0
APPROVED BY: MD	DATE: 24/8/98	OFFICE: NEWCASTLE	

NOTE: Drawing adapted for drawing supplied by Department of Conservation and Land Management Ironbark Creek Catchment – Soil Landscape Map



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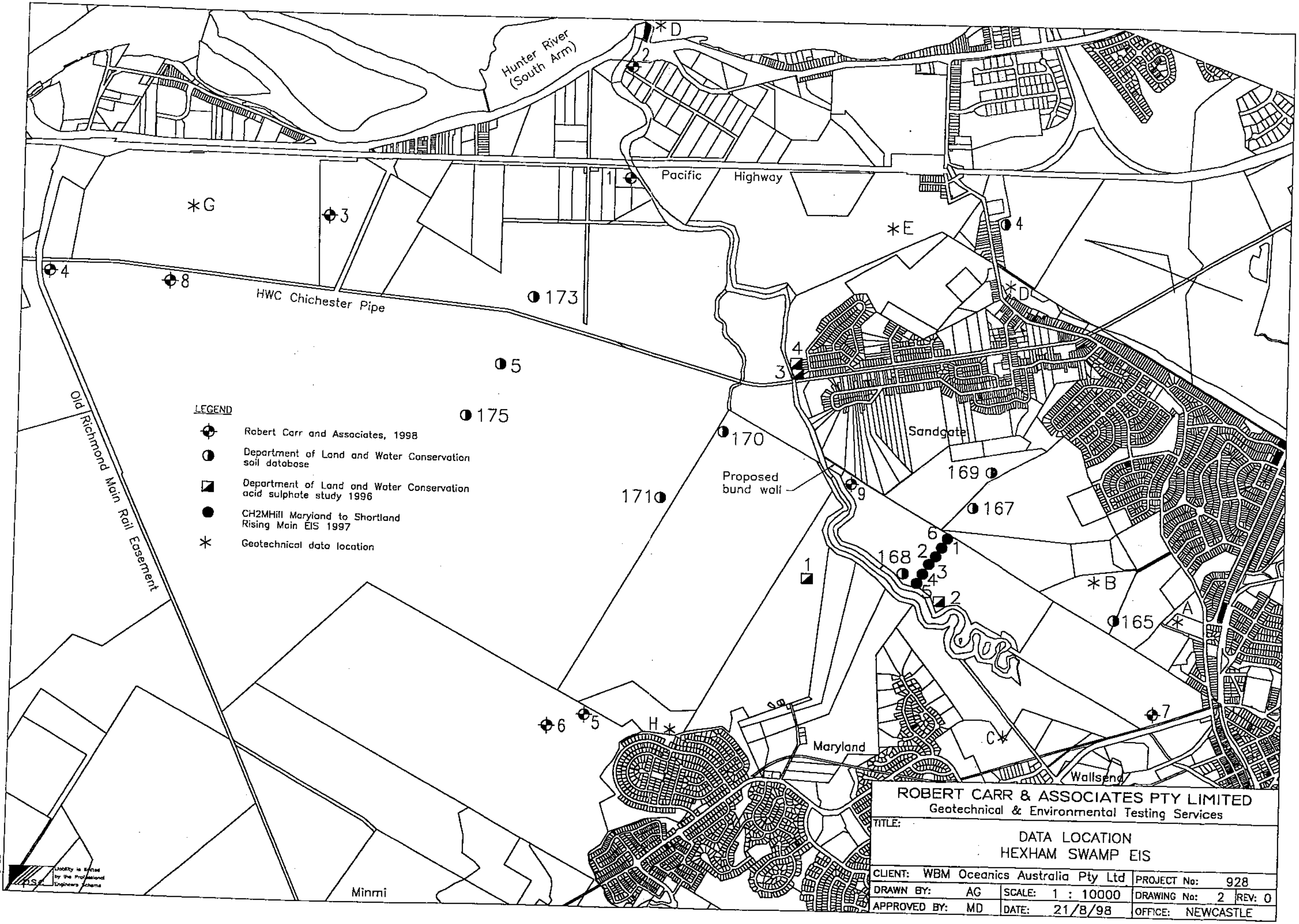
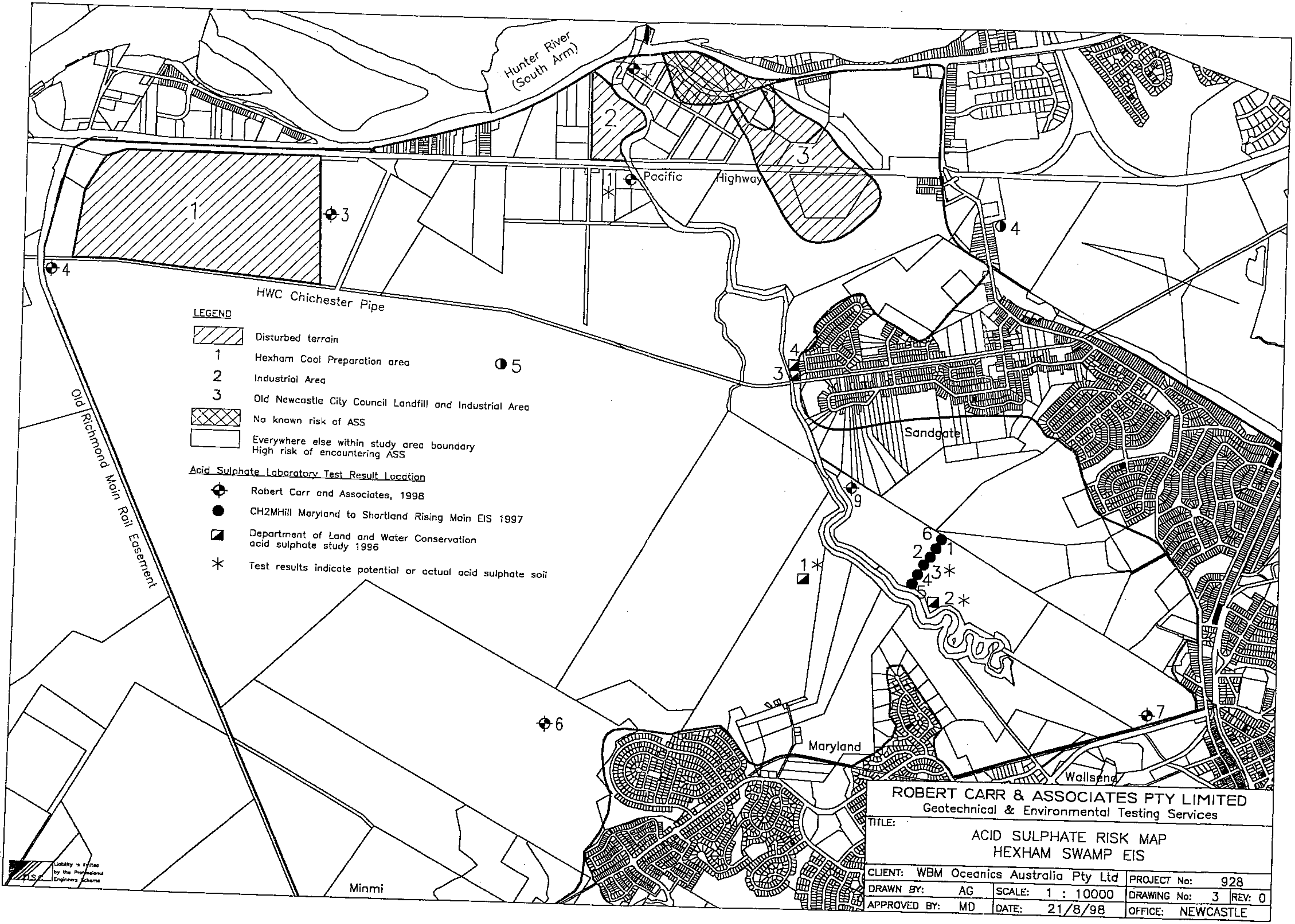


ROBERT CARR & ASSOCIATES PTY LIMITED
Geotechnical & Environmental Testing Services

TITLE:
DATA LOCATION
HEXHAM SWAMP EIS

CLIENT: WBM Oceanics Australia Pty Ltd		PROJECT No: 928	
DRAWN BY: AG	SCALE: 1 : 10000	DRAWING No: 2	REV: 0
APPROVED BY: MD	DATE: 21/8/98	OFFICE: NEWCASTLE	



ROBERT CARR & ASSOCIATES PTY LIMITED
Geotechnical & Environmental Testing Services

TITLE:
ACID SULPHATE RISK MAP
HEXHAM SWAMP EIS

CLIENT:	WBM Oceanics Australia Pty Ltd			PROJECT No:	928
DRAWN BY:	AG	SCALE:	1 : 10000	DRAWING No:	3 REV: 0
APPROVED BY:	MD	DATE:	21/8/98	OFFICE:	NEWCASTLE

GEOTECHNICAL ASSESSMENT OF FLOOD GATE OPENING

IRONBARK CREEK HEXHAM

Prepared for

WBM OCEANICS
AUSTRALIA PTY. LTD.

Prepared by

ROBERT CARR
& ASSOCIATES
PTY. LTD.

Job No. 928A

July 2001

Robert Carr
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GEOTECHNICAL
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Job No. 928A
27 July 2001

The Manager
WBM Oceanics Australia,
126 Belford Street
BROADMEADOW NSW 2292

Attention: Mick Lovely

GEOTECHNICAL ASSESSMENT OF FLOOD GATE OPENING ON RAIL BRIDGE FOUNDATIONS/ABUTMENTS, IRONBARK CREEK

1.0 INTRODUCTION

This report presents the results of a geotechnical appraisal of the rail bridge foundations at Ironbark Creek, Hexham Swamp, to assess likely impact on the foundations and abutments associated with the proposed opening of the tidal gates at the mouth of Ironbark Creek.

Work was commissioned by WBM Oceanics Australia.

Hexham swamp is closed off to the tidal influence of the river by means of 8 floodgates constructed in 1970 to 1971 and situated at the mouth of Ironbark Creek . These gates allow one way flow of water from the swamp to the river. Under these low inflow conditions, the average water level in the swamp is closer to the low tide level in the Hunter River rather than the mean tidal level. One of the gates has been left open about 0.15m to allow some tidal interchange. Some of the effects of the current floodgate regime have been:

- A lowering of the ground water table behind the gates
- A large reduction in the extent of saline waters entering the swamp
- Stagnation of water behind the floodgates

It is proposed that some or all of these floodgates may be reopened to allow tidal exchange in the swamp. One of the objectives of this action would be to restore scouring of the creek bed and increase the flushing of small tributaries which have become stagnant under the present floodgate regime.

An initial site meeting with WBM Oceanics was undertaken on Friday 22 June 2001 to discuss issues associated with the opening of the Ironbark Creek tidal gates and the rail bridge foundations/abutments.

Geotechnical fieldwork was undertaken by a senior engineering geologist on the 20th July 2001 and involved:

- Mapping of site conditions including assessment of the creek bed profile.
- Drilling of two shallow hand auger bores at the abutments. Engineering logs are attached with approximate locations shown on Drawing 1.
- Two dynamic penetrometer tests at the bore locations to assess the strength properties of the near surface soils. Results are shown on the bore logs.
- Digital photography of the rail bridges and abutments. Photographs 1 to 5 are attached.

Results of the mapping are presented on the following attached drawings:

- Drawing 1 – Sketch Plan showing the approximate layout of the rail bridges and foundations together with the inferred current shoreline and the shoreline as indicated on a 1913 plan from NSW Railways.
- Drawing 2 – Sketch Section showing an approximate cross sectional profile of the coal line bridge and Ironbark Creek.

2.0 AVAILABLE DATA

Data for the report has been acquired from the sources noted below.

WMB Oceanics Australia involving 2D flow modelling in Ironbark Creek. The following results were supplied:

Mean high water sprint to mean low water neap

Water level range (-0.2 to 0.45m AHD)

Flow range (11.5 cumecs (positive downstream) to –9.9 cumecs)

Velocity 0.2m/s

King tide

Water level range (-0.15 to 0.77m AHD)

Flow range (31.1 cumecs (positive downstream) to –21 cumecs)

Velocity 0.34m/s

Rail Network Infrastructure comprising the plan "Ironbark Creek, New Abutments for Bridges" prepared by NSW Railways and dated 14/1/1913. The plan shows the layout of the existing coal line bridge (southern, upstream bridge) with details of proposed new abutments and the proposed new main line rail bridge (northern, downstream bridge). A temporary downstream bridge is shown. The plans note the presence of piled foundations without any information on pile depth. It is understood that the above plan is the only information available in relation to foundation conditions for the rail bridges.

Robert Carr and Associates report 928 (September 1998) titled "Geotechnical And Acid Sulfate Conditions Hexham Swamp EIS". The report assessed the distribution and properties of soil profiles, the presence of acid-sulfate soils and the impact of tidal inundation in terms of hydro-geology, acid generation and soil erosion. The study was integrated into the Environmental Impact Statement (EIS) prepared by WBM.

Robert Carr and Associates report 1277a (June 2000) titled "Geotechnical, Acid Sulphate and Contamination Investigation Report for the CTGM Replacement, Tarro To Sandgate" prepared for Hunter Water Engineering. The report involved subsurface investigation along a proposed pipeline route that crossed the Main Northern rail-line at Sparke street.

3.0 SITE CONDITIONS

3.1 SUBSURFACE CONDITIONS

General Subsurface Conditions

The soils encountered in Hexham Swamp are generally characterised by the presence of saturated low strength clays typically of soft to firm consistency with a surface crust of variable thickness. These clay soils are prone to time dependent consolidation settlement on loading. Groundwater levels typically occur close to the ground surface.

Subsurface conditions encountered in geotechnical investigations along Sparke Street and in the vicinity of the road bridge across Ironbark Creek are presented in Table 1.

Table 1 – Summary of Available Geotechnical Information.

Location	Subsurface Conditions
State Highway 23 Ironbark Creek Bridge	• Clay to 2.5m over • Sand to 25m over • Clay • Rock greater than 34m depth
Rail Crossing at Sparke Street	• Sandy clay and clayey sand, very loose / soft, wet, to 3.5m, over • Silty clay, soft, to 9.7m, over • Sand, dense, to depth in excess of 10m.
Ironbark Creek Upstream of Pacific Highway	• Silty clay, soft, to 2.5m depth, over • Sand and silty/ clayey sand, very loose, wet, to 6.5m, over • Sand, medium dense to dense, to depth in excess of 12.2m.

Subsurface Conditions at Bridge Foundations

Bore 1 drilled along the creek line adjacent to the Maitland side of the coal line rail bridge encountered fill (rail ballast, coal chitter and clay) over soft to firm silty clay to depths in the order of 2.4. Dynamic penetrometer testing indicated the presence of a more competent soil strata (stiff clay or dense sand) below about 2.4m depth.

Bore 2 drilled along the creek line adjacent to the Newcastle side of the coal line rail bridge encountered fill (rail ballast and coal chitter) to a depth of about 0.9m overlying very low strength soil to a depth in excess of 2.55m (presumably soft silty clay as encountered in bore 1).

Based on the profiles encountered in the bores and surface observation, the profile along the creek banks adjacent to the bridge foundations comprises gravelly fill over soft compressible clay soils.

Fill estimated up to 2.5m to 3m in depth occurs along the rail lines behind the bridge abutments.

3.2 BRIDGE FOUNDATIONS AND ABUTMENTS

The inferred subsurface conditions at the bridge sites is based on the results of the shallow bores noted above together with available subsurface data from near by projects as noted in Table 1. It is understood that no specific bore data is available at the bridge sites.

The scope of the investigation does not warrant the drilling of deep bores at this stage, however this will need to be undertaken where bridge upgrade/ replacement works are proposed.

Original construction drawings (1913) note that foundations for both bridges are fully supported on piled foundations. No information on pile depth is available with pile diameter shown on the drawings at about 450mm.

The presence of soft (low shear strength) clay soils beneath the bridge foundation area imposes geotechnical constraints on bridge construction. The constraints are:

- Low bearing capacity requires all foundations to be piled to a suitable bearing strata (dense sand, very stiff clay or rock).

- The soft soils are compressible and will be subject to consolidation settlement under loading. As such rail embankments and bridge abutments would be expected to undergo time dependent consolidation settlement. The magnitude of settlement would depend on the applied load (embankment height) and the thickness of soft clay and the rate would depend on the thickness of the soft clay and the drainage conditions (presence of sand layers).
- Stability issues that can limit the height to which embankments can be constructed to within an acceptable factor of safety.
- Differential settlement between pile supported foundations and abutment embankments that are undergoing time dependant consolidation settlement can lead to the development of significant lateral soil movements and pressures on the piled foundations which can lead to damage.

Considering the age of the bridges, primary consolidation settlement of the abutment fill is likely to be complete. Ongoing secondary or creep consolidation settlement is however likely to be ongoing, however the magnitude of this is likely to be significantly less than the magnitude of primary settlement.

Assessment of piling depths, embankment stability and estimation of settlements will require specific geotechnical investigation and is outside the scope of this report.

Comments in relation to the rail bridge foundations are noted in Table 2.

Table 2 – *Summary of Bridge Foundation Observations.*

Bridge	**Side**	**Foundations**
Coal line	Maitland	• Brick foundations supported on 5' thick concrete pile cap as shown in photograph 3. • Concrete pile cap exposed with cracking at the upstream corner as shown on photograph 4. No erosional loss of soil from beneath pile cap noted. • The foundation is located at the edge of the creek.
	Newcastle	• Brick foundations supported on 5' thick concrete pile cap. • No exposure of concrete pile cap. • Foundations located 1.5m to 6m back from creek bank.
Main line	Maitland	• No foundation exposure. • Foundations set back up to 12m from the edge of the creek. Refer to photograph 5.
	Newcastle	• No foundation exposure. • Foundations set back up to 7m to 10m from the edge of the creek.

3.3 CREEK BANK EROSION

Rail Bridge Abutments

No evidence of scour or bank erosion was noted in the creek area along the bridge abutments. The creek bank at the main line bridge is protected by old concrete footings and rock riprap associated with an old bridge (refer to photograph 5).

At the location of the rail bridges Ironbark Creek is in the order of 15m to 20m in width. The creek widens both upstream and downstream from the bridge.

Drawing 1 shows the inferred present creek line (near low tide) and the approximate creek line shown on the 1913 NSW Railways plan. The inferred creek lines suggest that since 1913:

- The width of the creek has narrowed beneath the bridge foundations and this is most likely associated with filling during construction.
- Creek bank erosion and regression has occurred on the upstream Maitland side of the coal line rail bridge. This has resulted in the formation of a bend in the creek bank at the location of the corner of the concrete pile cap footing as shown in photograph 3. As noted in Table 2, the cracking of the footing at this location does not appear to be associated with erosional undercutting of the footing, which has an estimated 0.5m of soil cover above the footing base at the corner.

General

Creek bank erosion along Ironbark Creek has been noted at the following locations:

- The HWC pipeline crossing where scour erosion of the western bank has exposed the piles and concrete foundations and resulted in cracking of a wing-wall that is not pile supported.
- Along the western banks which have been cleared for grazing. The bank is typically steep and up to 1m in height with localised slumping and toppling failures occurring due to erosional undercutting. The occurrence of rock fill along parts of the bank suggests some measure of past stabilisation work has been undertaken in some areas.

The banks along Ironbark Creek are undergoing localised erosion and regression. This appears to primarily occur in areas where:

- Native vegetation has been cleared to grass pasture
- Cattle have accessed the creek banks
- Fill has been placed along the banks to form bunds
- Concentration of run off has occurred through low fill embankments associated with tracks and easements or drains

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 BRIDGE FOUNDATIONS

Based on available construction drawings and the presence of soft compressible soils, it is concluded that the rail bridge foundations are fully pile supported. As such the creek bank soils adjacent to the bridge foundations do not provide structural support for the foundations.

As the bridge structures are pile supported with a concrete pile cap, the erosional loss of soil adjacent to the pile cap footings is likely to have no impact on the structural capacity of the bridge foundations. The soils located adjacent to the footings comprise fill and soft clays and as such no allowance for lateral resistance would be made for these soils in foundation design.

Reconstruction of the coal line bridge abutments was undertaken in 1913. It is not known wether the existing piles at that time were re-used in the reconstruction. It is assumed that the piles are timber. Some deterioration of the footings has occurred (refer to photograph 4) and it is expected that further deterioration of the foundations and abutment structures will continue with time due to material aging effects, ongoing lateral soil movements/ pressures associated with creep settlements and high usage by heavily loaded modern trains.

It is recommended that a dilapidation survey of the bridge structures be undertaken by a structural engineer prior to the opening of the tidal gates.

4.2 CREEK BANK EROSION

Tidal inundation will result in increased tidal velocities along the channel areas with flow velocities up to 0.34m/s under king tide conditions having been modelled by WBM.

The gravelly rail ballast and coal chitter soils exposed along the banks beneath the bridge foundations are considered to have a low erodibility under water flows and the natural clay soils exposed in the banks along the creek are considered to have a low to moderate erodibility.

The Department of Conservation and Land Management Urban Erosion and Sediment Control Manual (1992) notes maximum permissible flow velocities of 0.6m/s to 0.7m/s for low to moderate erodibility soils in bare earth channels. The peak flow velocity of 0.34m/s estimated by WBM for king tide conditions is less than the above values and is less than the maximum permissible flow velocity of 0.4m/s for very high erodibility soils in bare earth channels.

In the short term opening the tidal gates is likely to result in a minor increase in the rate of bank erosion due to:

- Increased groundwater seepage from creek banks associated with raising of the groundwater table.
- Minor scour effects associated with increased tidal flows.
- Concentration of tidal over-bank flows at low points along the creeks.
- Gradual death of salt intolerant vegetation such as grasses.

In the long term the re-establishment of native vegetation such as mangroves will have a beneficial effect on creek bank stability and once established, the rate of erosion is likely to be significantly less than that presently occurring. In terms of creek bank stability, re-vegetation should be undertaken along the banks of areas proposed for tidal inundation.

The Ironbark Creek Total Catchment Strategy Study has noted that the swamp acts as an efficient sediment trap with the annual volume of sediment input greatly in excess of output into the Hunter River. Sedimentation of the drainage paths and creeks is being promoted by the sediment surplus and the low flow conditions induced by current flood gate operation. The approximate creek bed level in 1913 as shown on the NSW Railways plan is noticeably lower than the inferred creek bed profile shown on Drawing 2. This suggests that gradual sedimentation of the creek bed is occurring under the low flow conditions.

An increase in flow conditions along Ironbark Creek is likely to result in scour erosion of recent creek bed sediments, which would result in an increased creek flow capacity. The option of opening the flood gates will promote tidal flushing of suspended sediments and reduce the risk of sedimentation along the waterways.

4.3 SUMMARY

The existing rail bridge foundations are fully pile supported and as such the creek bank soils adjacent to the foundations do not provide structural support for the foundations.

The bridge foundations are showing evidence of deterioration and as such it is recommended that a dilapidation survey of the bridge structures be undertaken prior to the opening of the tidal gates.

The maximum flow velocity estimated by 2D modelling is less than 0.4m/s and as such scour erosion effects adjacent to the bridge foundations are likely to be minimal.

Localised creek bank erosion upstream of the bridge has resulted in exposure of the concrete pile cap along the upstream Maitland side of the coal line rail bridge. Localised cracking of the concrete pile cap has occurred. Whilst the cracking is not associated with creek bank erosion, it is suggested that protection of the pile cap at the exposed corner be provided by rock armour stone or similar.

Yours faithfully
ROBERT CARR AND ASSOCIATES PTY. LTD.

Mark Delaney
Senior Engineering Geologist

Attachments:

- Bore logs
- Drawings
- Photographs

Appendix A

Bore Logs

TEST BORE REPORT LOG

HOLE No: 1

CLIENT: WBM Oceanics Pty Ltd
PROJECT: Ironbark Creek Rail Bridges
LOCATION: Hexham

DATE: 20/7/01
PROJECT No: 928A
SURFACE LEVEL: Existing

SHEET 1 of 1
Method of hole advance: Hand Auger

GROUND WATER	SAMPLES TESTS DEPTHS	DEPTH (M)	RL (M)	STRATA	DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
0.2 ▽		0.1		▩	FILL, rail ballast
				▩	FILL, mixture of coal chitter (Clayey Sandy GRAVEL) and rail ballast, wet, dark grey
0.5		0.35		▩	FILL, mixture of Silty CLAY, dark grey, wet, soft, and Silty Sandy CLAY/Silty Clayey SAND, grey mottled brown, wet with some gravel
1.0 1.5		1.0		▨	Silty CLAY, soft, wet, grey/dark grey
2.0		2.0		▨	CLAY, firm, moist, mottled grey and brown
2.5 3.0 3.5 4.0 4.5					End Bore Hole 1 at 2.4m

Dynamic Penetrometer Test Results (cone tip)

0 – 0.3m Auger Hole
0.3 – 2.1m Penetrometer fell under own weight
2.1 – 2.25m 4 blows
2.25 – 2.4m 5 blows
2.4 – 2.55m 6 blows
2.55 – 2.7m 12 blows

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PO Box 175, Carrington, 2294
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LOGGED: MD
CHECKED: MD
DATE: 24/7/01

F-LOG-002

TEST BORE REPORT LOG

HOLE No: 2

CLIENT: WBM Oceanics Pty Ltd
PROJECT: Ironbark Creek Rail Bridges
LOCATION: Hexham

DATE: 20/7/01
PROJECT No: 928A
SURFACE LEVEL: Existing

SHEET 1 of 1
Method of hole advance: Hand Auger

GROUND WATER	SAMPLES TESTS DEPTHS	DEPTH (M)	RL (M)	STRATA	DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
0.1 ▽				▨	FILL, rail ballast
		0.2		▨	FILL, mixture coal chitter, rail ballast and clay
0.5				▨	
					End Bore Hole 2 at 0.7m at hand auger refusal on rock fragments
1.0					
1.5					<u>Dynamic Penetrometer Test Results (cone tip)</u> 0 – 0.7m Auger hole 0.7 – 0.9 Worked penetrometer through gravelly fill 0.9 – 2.55m Penetrometer fell under own weight.
2.0					
2.5					
3.0					
3.5					
4.0					
4.5					

F-LOG-002

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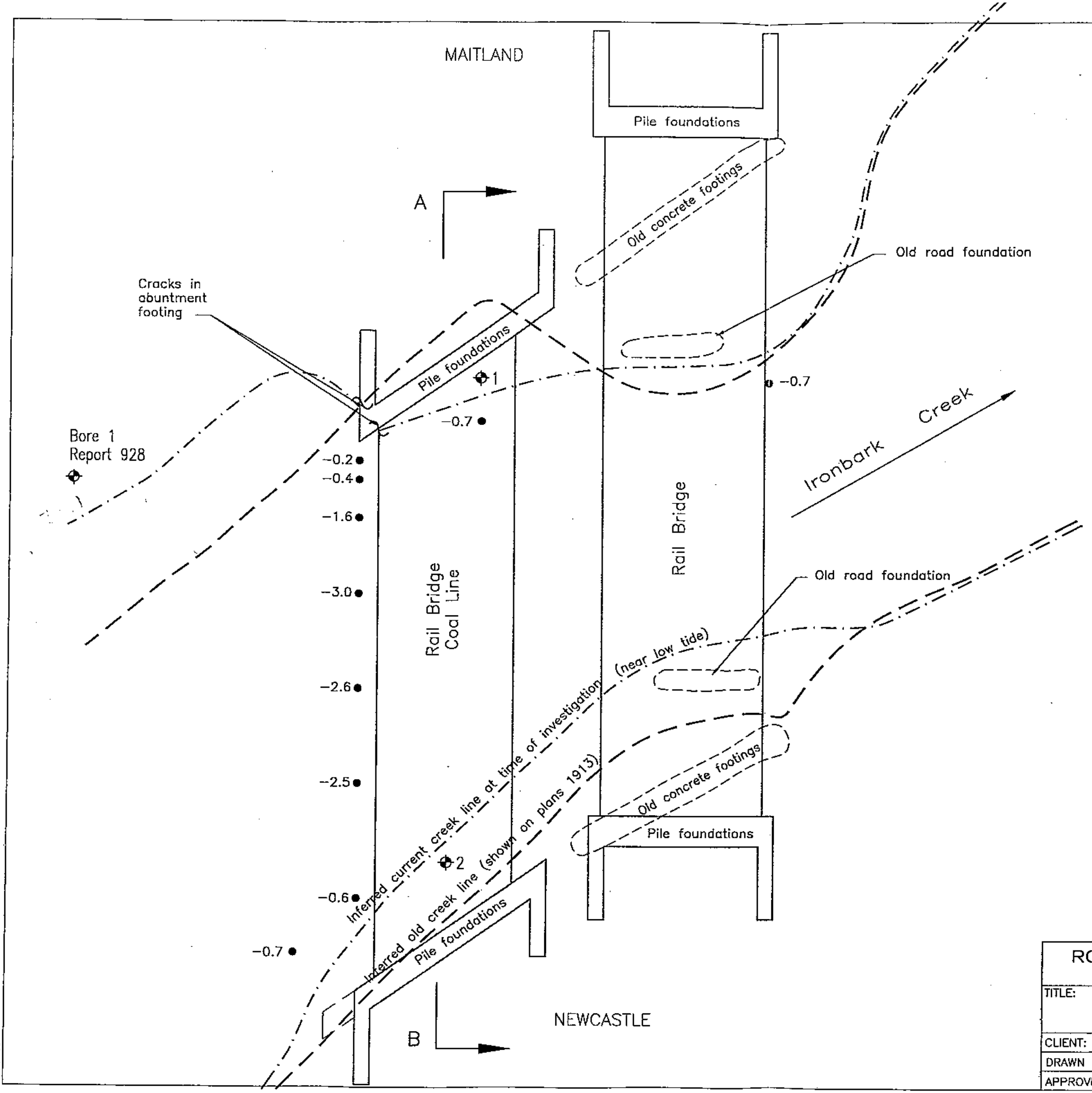
LOGGED: MD
CHECKED: MD
DATE: 24/7/01

Appendix B

Drawing 1 – Site Sketch

Drawing 2 – Sketch Section



LEGEND

⊕ Approximate location of bore hole/dynamic penetrometer

● −0.7 Approximate water depth (m) at 11am−1pm 20/7/01

A B Section A−B

NOTE:
Bridge foundations and creek line adapted from drawing "Ironbark Creek, New Abutments For Bridges", by NSWR, 14/1/1913

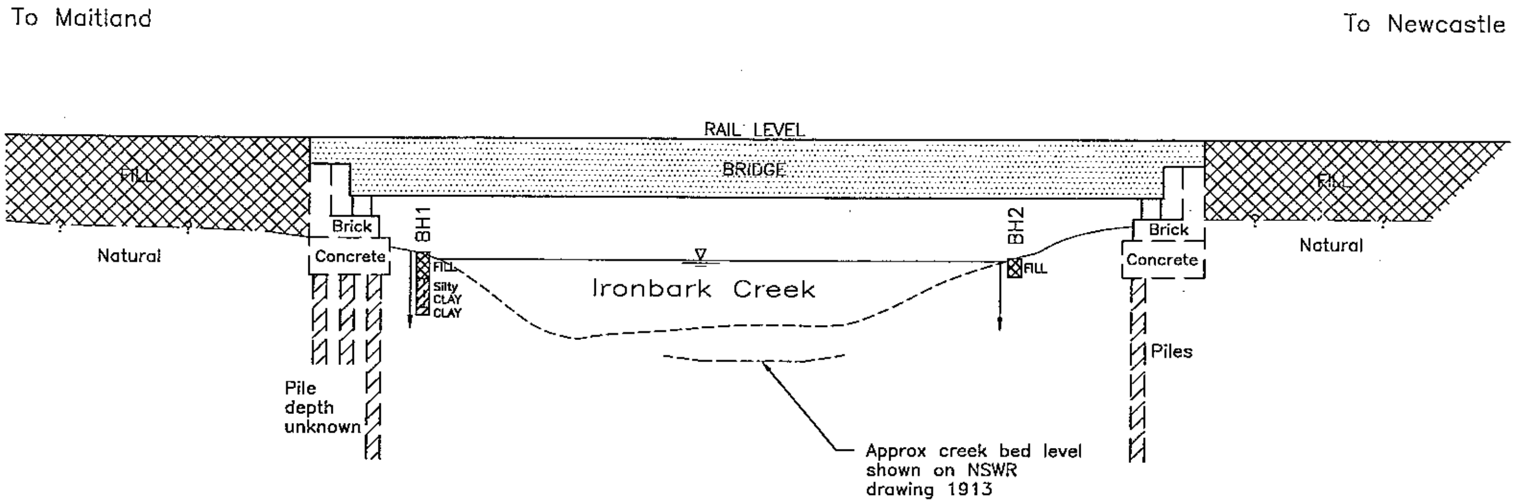
Do not scale, drawing is a sketch plan only

ROBERT CARR & ASSOCIATES PTY LIMITED
Consulting Geotechnical & Environmental Engineers

TITLE:
SKETCH PLAN
IRONBARK CREEK RAIL BRIDGES, HEXHAM

CLIENT: WBM Oceanics Pty Ltd		PROJECT No: 928a	
DRAWN BY: MD	SCALE: ~1 : 200	DRAWING No: 1	REV: 0
APPROVED BY: MD	DATE: 25/7/01	OFFICE: NEWCASTLE	

E-A3-00



NOTE:
Foundation information taken from drawing "Ironbark Creek, New Abutments for Bridges", by NSWR, 14/1/1913

Do not scale, drawing is a sketch section only

ROBERT CARR & ASSOCIATES PTY LIMITED
Consulting Geotechnical & Environmental Engineers

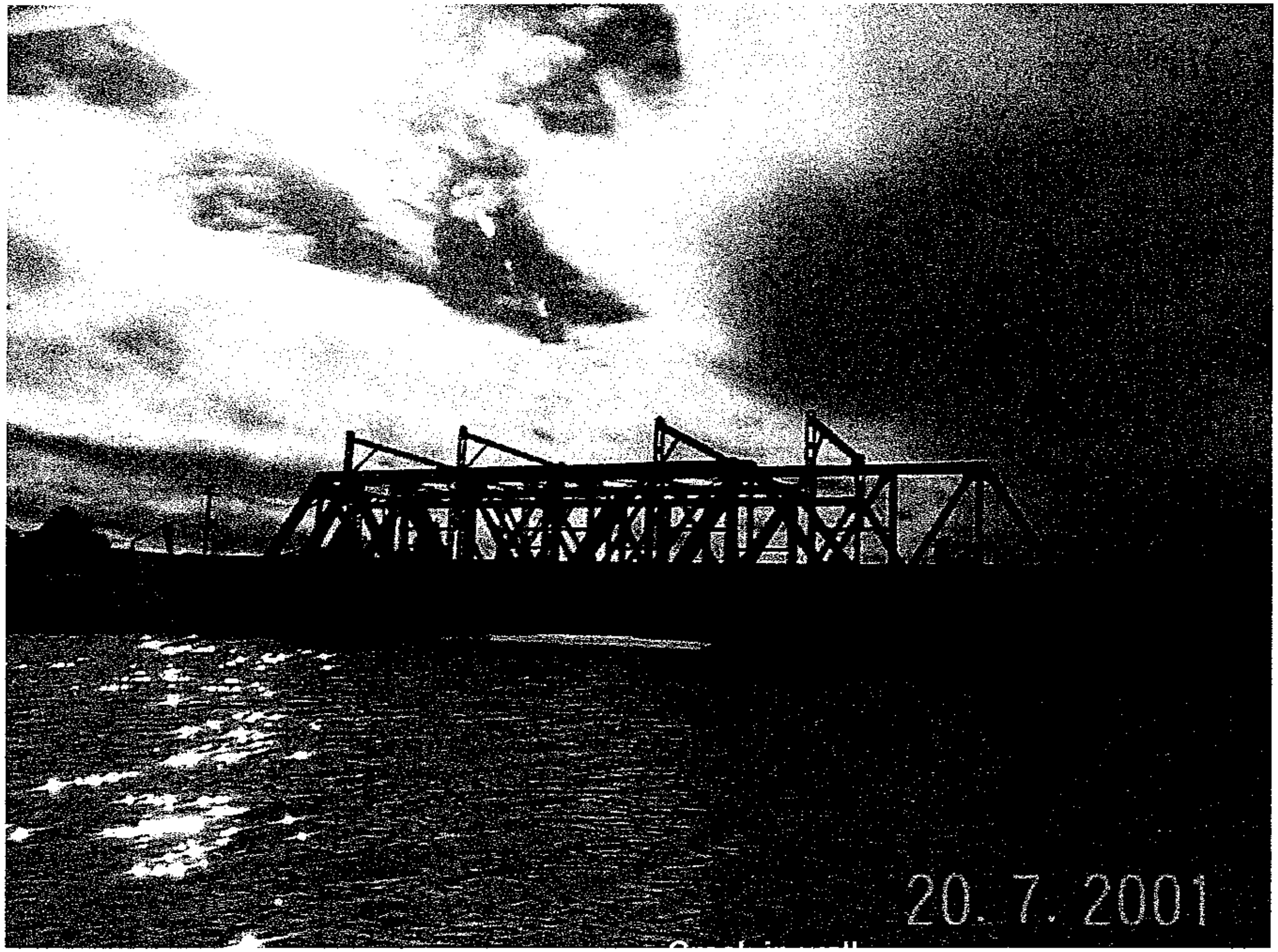
TITLE:
SKETCH SECTION A–B
IRONBARK CREEK RAIL BRIDGES, HEXHAM

CLIENT: WBM Oceanics Pty Ltd		PROJECT No: 928a	
DRAWN BY: MD	SCALE: ~1 : 200	DRAWING No: 2	REV: 0
APPROVED BY: MD	DATE: 23/7/01	OFFICE: NEWCASTLE	

E-A3-00

Appendix C

Photographs



PHOTOGRAPH – No. 1. Upstream view of coal line rail bridge.

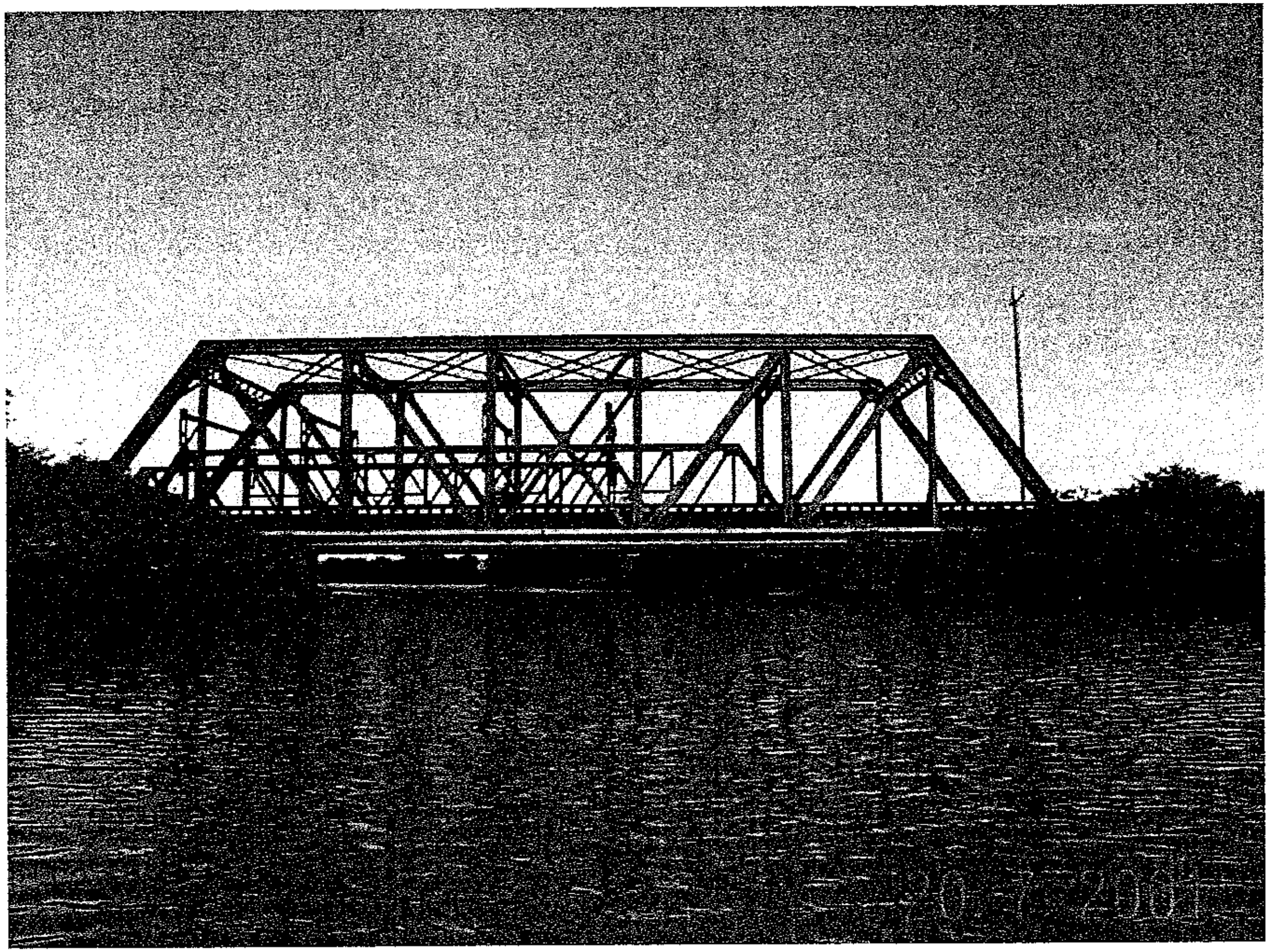
CLIENT: WBM Oceanics Pty Ltd

PROJECT: Ironbark Creek Rail Bridges

LOCATION: Hexham

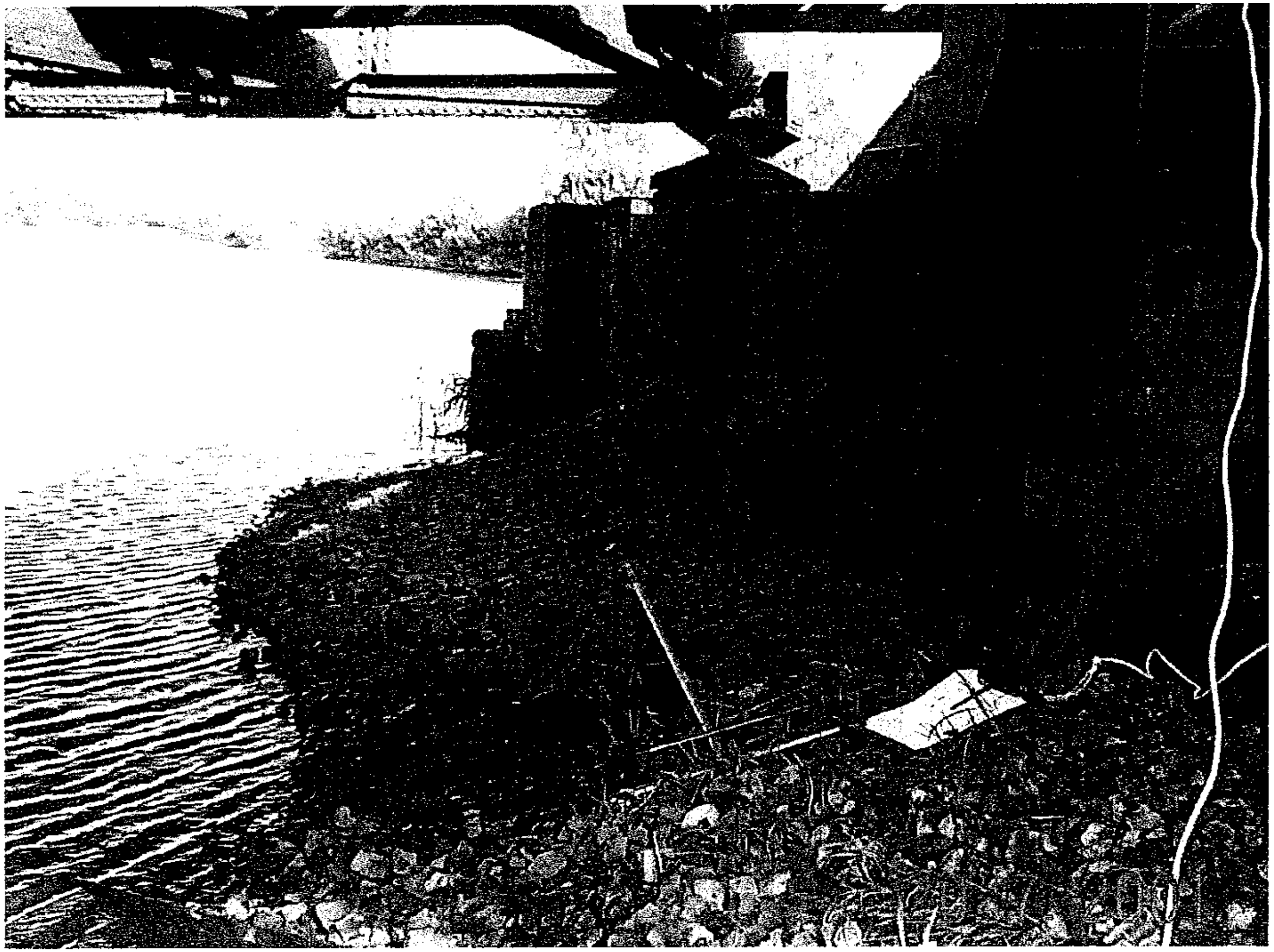
Robert Carr & Associates Pty Ltd

JOB NO. 928A



PHOTOGRAPH – No. 2. Downstream view of main rail line bridge.

CLIENT:	WBM Oceanics Pty Ltd	Robert Carr & Associates Pty Ltd
PROJECT:	Ironbark Creek Rail Bridges	
LOCATION:	Hexham	**JOB NO.** 928A



PHOTOGRAPH – No. 3. Maitland side foundations of coal line bridge.

CLIENT: WBM Oceanics Pty Ltd

Robert Carr & Associates Pty Ltd

PROJECT: Ironbark Creek Rail Bridges

LOCATION: Hexham

JOB NO. 928A

PHOTOGRAPH – No. 4. Maitland side of coal line bridge. Note crack in concrete pile cap foundations.

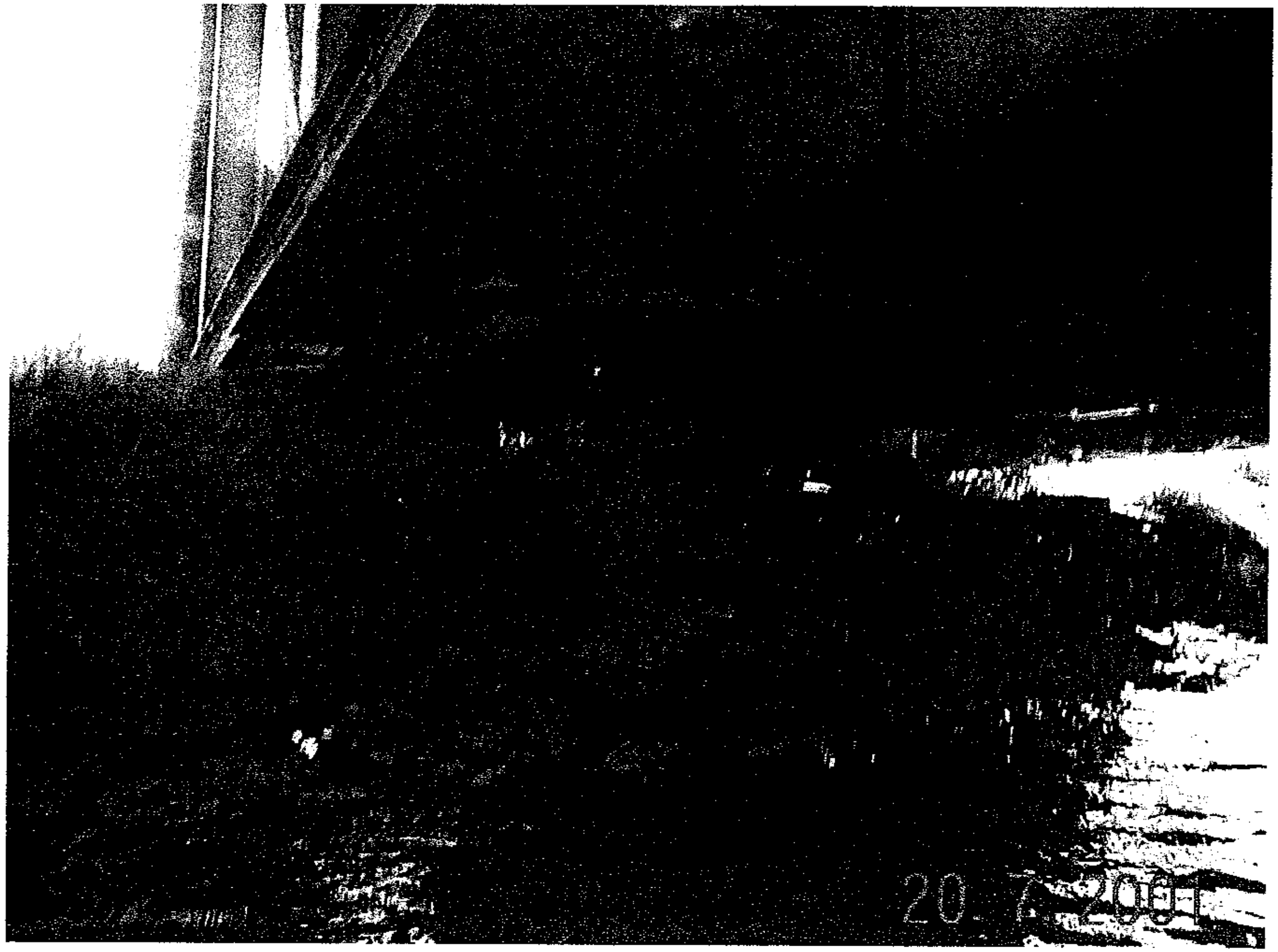
CLIENT: WBM Oceanics Pty Ltd

Robert Carr & Associates Pty Ltd

PROJECT: Ironbark Creek Rail Bridges

LOCATION: Hexham

JOB NO. 928A



PHOTOGRAPH – No. 5. Maitland side of main rail line. Note old bridge foundations.

CLIENT: WBM Oceanics Pty Ltd

Robert Carr & Associates Pty Ltd

PROJECT: Ironbark Creek Rail Bridges

LOCATION: Hexham

JOB NO. 928A