6. Soils and Geology

6.1 Existing Conditions

6.1.1 Geology

Regional Geology

Reference to the Geological Survey of Queensland 1:250,000 scale Proserpine geological map indicates that the site is located in an area of quaternary deposits of coastal mud, silt and minor evaporites, underlain by basement geology of the 'Airlie Volcanics' group comprising acid to intermediate Pyroclastics and flows.

Site Geology

Based on interpretation of regional geology and previous geotechnical investigations conducted in Boathaven Bay, the site geology appears to consist of three main horizons:

- a layer of Holocene silts and clays (ranging in depth from about 2.0m near the shore, up to 7.5m further out from the shore);
- a relatively shallow layer of Pleistocene material underlies the Holocene deposits; and
- underlying residual soils and weathered rock which are expected to comprise a variable sequence of stiff clays, with differing amounts of sand and gravel, grading into weathered tuff and microdiorite.

Preliminary investigations have shown that both Holocene and Pleistocene/Residual materials will be encountered in the dredging near-shore, while dredging of the channel will mainly involve the removal of material that is Holocene in origin.

Additional information on geological conditions at the site is contained within Section 4.6 of the 1998 IAS (Burchill 1998).

6.1.2 Geotechnical Characteristics

The Holocene deposits are subject to inundation for most of the time, thus they are saturated and retain very little shear strength. It is expected that the silt and clay profile will be very soft to firm for a depth of at least 4.0m (or the combined depth of the deposits). Underlying Pleistocene sediments and/or residual soils are expected to be stiff grading to very stiff with depth. The residual soils (weathering products) and underlying residual weathered rock stratum should form a sound foundation material for sheet piles.

Foundations for structures would be expected to be designed as either:

- very lightly loaded high level footings, able to accommodate significant differential soil movements; or
- piered to found in the underlying weathered rock strata.

More information on geotechnical characteristics is contained within Section 4.6.2 of the 1998 IAS (Burchill 1998).

6.1.3 Soils

Typical soil profiles in the area of the site to be disturbed (ie. dredging operations and shallow excavations for shore based infrastructure), comprise:

- Holocene silts and clays, which are generally regarded as having a high Acid Sulfate Soil (ASS) potential. However, it is considered that deposits which are characterised as occurring under "estuarine" or "mangrove swamp" conditions are more likely to contain ASS than true "Marine" deposits. Boathaven Bay is at a river mouth and is fully connected to the sea. Significant quantities of both fine calcareous material (coral debris) and coarser shell fragments have been identified in the upper Holocene stratum which should offer significant 'in-built' buffering capacity;
- A relatively shallow layer of Pleistocene silts and clays, the surface of which may be potentially acidic due to leaching of sulphides from the overlying Holocene materials; and
- Residual soils/weathered rock comprising a variable sequence of stiff clays with differing amounts of sand and gravel, grading into weathered tuff. Although the tuff is an acidic pyroclast, these materials are not likely to show the presence of ASS conditions.

Cross-sectional representations (based on the findings of earlier work by others) are included for reference in **Figure 6.1**.

6.1.4 Sediment

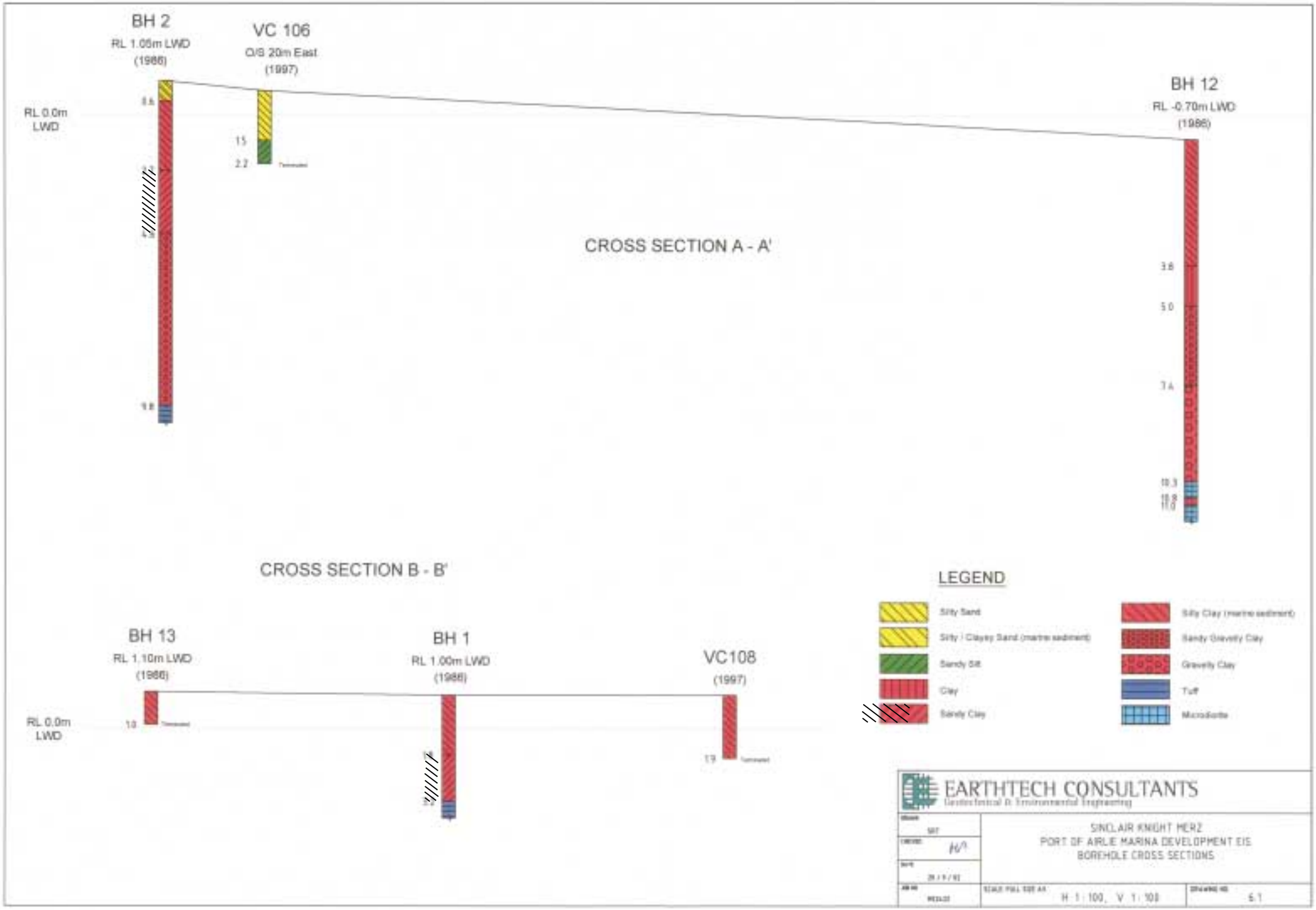
6.1.4.1 Sediment Composition

Based on the results of the preliminary sampling and analysis undertaken in September 2002, and reference to earlier work by others (report by Hollingsworth Consultants, November 1986), sediments in the area(s) to be disturbed are either Holocene or Pleistocene in origin, and comprise the following profiles, (described according to the '*Australian Soil and Land Survey Field Handbook (McDonald et al - 1990*):

- Coastal Deposits (adjacent the southern shoreline of promontory)
  - Sand [S], coarse sand, Apedal (incoherent), dark grey with some lighter flecks, wet, loose, nonplastic (few fines).
  - Loamy Sand [LS], coarse sand, Apedal (incoherent), grey, wet, loose, nonplastic silt fines.

- Coastal Deposits (adjacent the 'main' eastern shoreline)
  - Silt Loam [ZL], Apedal (massive), grey, wet, very weak, slightly to moderately plastic.

- Offshore Deposits (within the low tide region)
  - Sand [S], coarse sand, Apedal (incoherent), dark grey with some lighter flecks, wet, loose, nonplastic (few fines).
  - Silt Loam [ZL], Apedal (massive), grey, wet, very weak, slightly to moderately plastic.


BH 2
RL 1.05m LWD
(1986)
VC 106
O/S 20m East
(1997)
BH 12
RL -0.70m LWD
(1986)
RL 0.0m
LWD
8.5
1.5
2.2
9.8
3.8
5.0
7.4
10.3
10.8
11.0
CROSS SECTION A - A'
CROSS SECTION B - B'
BH 13
RL 1.10m LWD
(1986)
BH 1
RL 1.00m LWD
(1986)
VC108
(1997)
RL 0.0m
LWD
1.0
1.9
LEGEND
Silty Sand
Silty / Clayey Sand (marine sediment)
Sandy Silt
Clay
Sandy Clay
Silty Clay (marine sediment)
Sandy Gravelly Clay
Gravelly Clay
Tuff
Microdiorite
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PORT OF AIRLIE MARINA DEVELOPMENT EIS
BOREHOLE CROSS SECTIONS
H: 1:100, V: 1:100
6.1

– Medium Clay [MC], Apedal (massive), grey & dark grey, wet, weak, moderately plastic.

6.1.4.2 Sediment Analysis Program

The sampling program undertaken in September 2002, was of a preliminary nature, meant to characterise the surface sediments in areas accessible from the shore. The analysis undertaken is to be supplemented by additional testing on samples from deeper sediments and from less accessible areas of the site, to be undertaken in conjunction with an Acid Sulfate Soils (ASS) investigation, prior to any construction.

The testing program was designed to include analytes listed in the '*Interim Ocean Disposal Guidelines* - December 1998', for sediment and elutriate extractions issued by Environment Australia.

Grab samples of surface sediments (representative of approximately 0-0.3 m depth) were recovered from three locations within the proposed area of main disturbance (S1-S3) and two additional locations adjacent to the shoreline near the existing boat moorings (S4 & S5). In addition seawater was sampled (S6) for use in the undertaking elutriate extraction of the samples analysed. **Figure 6-2** indicates the sampling locations.

Four sediment samples were selected (S1-S3 & S4) and analysed for the presence of a wide range of organic and inorganic contaminants. Elutriate extraction was undertaken on each sample, and the extractions analysed for the presence of 'biologically active' levels of the same contaminants.

Appropriate sampling containers were provided by the analytical laboratory (ALS - Brisbane). Sample bottles were labelled and placed in ice filled eskies until dispatched to the laboratory with "Chain of Custody" (see **Appendix D**).

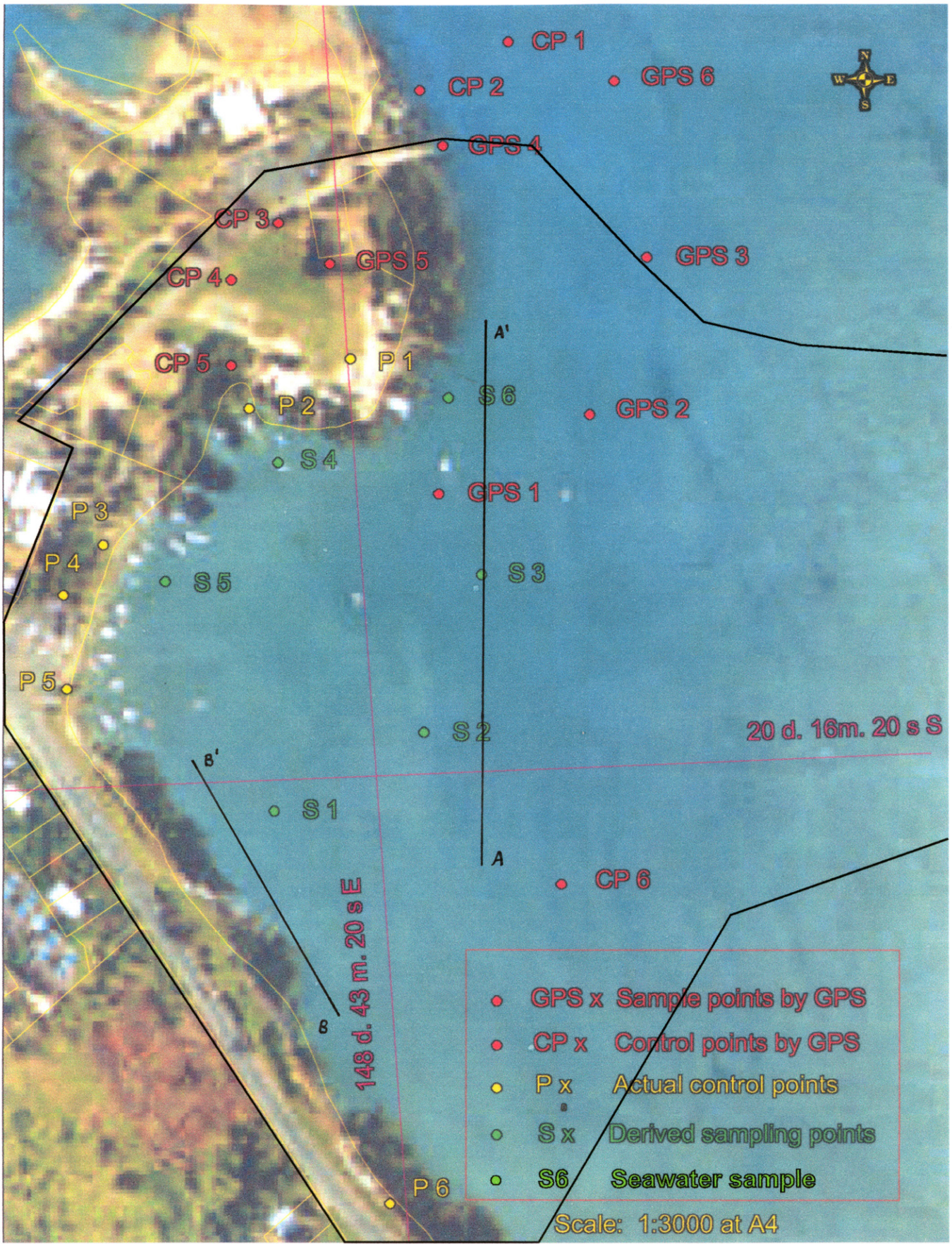
6.1.4.3 Sediment Analysis Screening Criteria

Levels of contaminants detected, as well as factored contaminant concentrations (expressed in terms of fines passing 0.075mm) were compared to the following environmental assessment criteria:

- Environmental Investigation Level (EIL) adopted by the Environmental Protection Agency (EPA), as contained in the 'Draft Guidelines for the Assessment & Management of Contaminated Land in Queensland - May 1998'; and
- The Australia and New Zealand Environment and Conservation Council (ANZECC) 'Interim Ocean Disposal Guidelines - 1998'.

Contaminant concentrations in elutriate extractions (using local seawater) were compared with the 'Guidelines for Protection of Aquatic Ecosystems (Marine Waters)' from the ANZECC '*Australian Water Quality Guidelines for Fresh and Marine Waters – 2000* (see **Table 6-1** and **Table 6-2**).

The testing program adopted was designed to address the requirements outlined in the TOR for preparation of the project Supplementary EIS. Analyses undertaken are summarised below:



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DATE SEPT 2002	AERIAL PHOTO SHOWING INVESTIGATION AREA	
JOB NO ME 2422	SCALE A4 AS SHOWN	Drawing No. 6.2

ME 2422

Sediment Analysis

- Particle Size Distribution (PSD) (fine fraction by Hydrometer analysis);
- Total Organic Carbon (TOC);
- The Metals - Cd, Cr, Cu, Pb, Ag, Hg, Ni & Zn & the Metalloid - As;
- Organochlorine and Organophosphorous Pesticides & Polychlorinated Biphenyls (OC/OP/PCB);
- Petroleum Hydrocarbons (TPH) & Polyaromatic Hydrocarbons (PAH); and
- OrganoTin Compounds (TBT, DBT and MBT).

Note that TOC is undertaken to enable normalisation of results of OrganoTin analysis. PSD analysis is undertaken to assist with classification of the sediments and to allow 'factoring' for fines content of each sediment sample. Volatile organic compounds typified by Benzene, Toluene, Ethylene & Xylene (BTEX) were not screened for, as it not considered likely that these would be present in such sediments (ie. they are lighter than water and would float, and are volatile and evaporate on contact with the air).

Elutriate Analysis

Elutriate extraction and analysis is undertaken to simulate leachable levels of contaminants that may impact on local seawater. The extractions were undertaken at a dilution of 1:4. However, a dilution ratio of 1:100 (total) was applied to elutriate contamination concentrations to simulate local dilution effects.

- Elutriation in sea water (including filtration);
- Dissolved Metals - Cd, Cr, Cu, Ag, Pb, Hg, Ni & Zn & the Metalloid - As;
- Organochlorine and Organophosphorous Pesticides & Polychlorinated Biphenyls (OC/OP/PCB) - (Ultratrace);
- Polyaromatic Hydrocarbons (PAH) - (Ultratrace); and
- OrganoTin Compounds (TBT, DBT and MBT).

6.1.4.4 Results of Laboratory Analysis

The samples were tested by Australian Laboratory Services (ALS) - Brisbane, in accordance with methods approved by NATA as part of the laboratory's registration.

Methods used were appropriate for the determination of contaminants in marine sediments. In-house Quality Assurance testing conducted by ALS - Brisbane included blanks and duplicates (splits).

Results of contaminant analyses are summarise in **Table 6-1** below. Results are compared with the EIL adopted by the Queensland EPA for assessment of Environmental Impact and 'Screening and Maximum Levels' as indicated in the ANZECC 'Interim Ocean Disposal Guidelines - 1998'.

Table 6-1 Analytical Test Results

Analyte	LOR	S1	S2	S3	S5	EPA EIL	ANZECC 2000 Screen Level [Range Low]	ANZECC 2000 Max Level [Range Med]
Fines Content (%)	0.1	86.2	96.8	98.0	11.4	n/a	n/a	n/a
TOC* (%)	0.04	0.46	1.02	0.87	0.18	n/a	n/a	n/a
Metals (mg/kg)								
Silver	1	<1	<1	<1	<1	1.0	1.0	3.7

Analyte	LOR	S1	S2	S3	S5	EPA EIL	ANZECC 2000 Screen Level [Range Low]	ANZECC 2000 Max Level [Range Med]
Arsenic	1	<1	2	1	4	20	20	70
Cadmium	1	<1	<1	<1	<1	3	1.5	10
Chromium	1	14	18	18	22	50	80	370
Copper	1	6	10	10	44	60	65	270
Nickel	1	8	9	10	19	60	21	52
Lead	1	5	7	7	35	300	50	220
Zinc	1	8	15	16	76	200	200	410
Mercury	0.1	<0.1	<0.1	<0.1	<0.1	1.0	0.15	1.0
OrganoTins (µg/kg)	0.5	<1.4	<1.5	<1.2	17.4	n/a	-	-
TriButyl Tin (µg/kg)	0.2	0.4	0.5	<0.2	12.0	n/a	5	70
Pesticides (µg/kg)								
OC								
Dieldrin (& Aldrin)	0.5	<0.5	<0.5	<0.5	<0.5	200	0.02	8
Lindane	0.5	<0.5	<0.5	<0.5	<0.5	-	0.32	1.0
DDT & Derivatives	0.5	<0.5	<0.5	<0.5	2.1	200	5.8	93
OP								
Chlorpyrifos	10	<10	<10	<10	<10	-	-	-
PCB (µg/kg)	5	<5	<5	<5	<5	1000	23	180
TPH (C_{6-9}/C_{10-14})	2 / 50	<2/<50	<2/<50	<2/<50	<2/<50	100	-	-
(mg/kg) (C_{15-28}/C_{29-36})	100	<100	<100	<100	<100	1000	-	-
PAHs (Total) (µg/kg)	10	<322	<350	<320	<1670	n/a	4,000	45,000
Benzo-a-pyrene	10	<10	<10	<10	201	n/a	430	1,600

* Indicates Total Organic Carbon, included for normalisation of OrganoTin levels only.

Analytical results indicate that levels of the contaminants screened for, in the sediment samples tested do not exceed either the EIL or the appropriate ANZECC Screening Level. Low level concentrations of concentrations of some metals including OrganoTins were detected. The TriButyl Tin concentration in sample S5 did slightly exceed the ANZECC 'Low Range' Screening Level, indicating the need to undertake Elutriate extraction and analysis (see below).

In addition, elutriate extractions were carried out on sub-samples of each sediment samples submitted for analysis, using a seawater sampled from the site. The elutriate extractions were then analysed at a 1:4 dilution ratio. Elutriate test results are summarised in **Table 6-2** below. Contaminant concentrations indicated in **Table 6-2** should be divided by a factor of 25 to achieve a final dilution ratio of 1:100, which is considered appropriate for waters in a tidal environment.

■ Table 6-2 Elutriate Test Results

Analyte	LOR	Sea Water	S1	S2	S3	S5	ANZECC - Guidelines for Protection of Aquatic Ecosystems - Marine 2000
Metals (mg/l)	*Concentrations extracted at 4:1*						
Silver	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Arsenic	0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.05
Cadmium	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.002
Chromium	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05
Copper	0.02	<0.020	<0.020	<0.020	<0.020	<0.020	0.005
Nickel	0.001	<0.001	0.002	0.002	0.003	0.003	0.015
Lead	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005
Zinc	0.02	0.022	0.029	**0.093**	**0.141**	**0.130**	0.05

Analyte	LOR	Sea Water	S1	S2	S3	S5	ANZECC - Guidelines for Protection of Aquatic Ecosystems - Marine 2000
Mercury	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001
TriButylTin (µg/l)	0.002	<0.002	<0.002	<0.002	<0.002	**0.015**	0.002
Pesticides (µg/l)			*Concentrations extracted at 4:1*				
Dieldrin	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	2
Aldrin	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	10
Chlordane	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	4
Endrin	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	3
DDT (Total)	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
DDE	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	14
Chlorpyrifos	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	1
Demeton	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	100
Parathion	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	4
PCB (µg/l)	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	0.004**
PAH (Total) (µg/l)	0.1	<2.3	<2.3	<2.3	<2.3	<2.3	no limit

NOTE: ** indicates beyond practical detection limit

Results of elutriate extraction analysis (undertaken at an extraction ratio of 4:1), indicate that minor exceedences of the ANZECC Protection Guidelines were detected for Zinc and TriButylTin (indicated in bold in **Table 6-2** above), however concentrations are well below these limits when adjusted to a dilution ration of 100:1 (as discussed above). All other contaminants screened for were at or below the appropriate Limit of Reporting (LOR) or detection limits.

The slightly elevated levels of zinc and organotin detected in the shallow sediments are likely to be associated with the historical use of the area for mooring, maintenance and re-painting of boats.

Copies of all analytical test results are included in **Appendix D**.

6.1.5 Acid Sulphate Soils and Sediments

The results of field and laboratory testing undertaken to date, includes:

- fieldwork and limited analysis of materials sampled from 10 shallow boreholes in the inter-tidal zone, undertaken in 1998 during a preliminary ASS investigation of part of the site; and
- additional fieldwork, screening and analysis of materials sampled from 5 boreholes within the general bay area, undertaken in October, 2002.

Results of this work indicated that the Holocene soils present to depths varying from about 1.5-2 m (near the shore) to 5.0m (at the outer limit of the proposed excavations in the bay), contained varying amounts of sulfidic sediments. All samples recovered also contained significant amounts of shell fragments and much finer calcareous material, possibly weathered coral debris (as much as 35% in some samples and typically about 15%). Much of this Calcium Carbonate ($CaCO_3$) was relatively fine grained (ie. less than 0.6mm) and its inherent buffering capacity would act to negate the acid forming potential of sulfides present and should be considered in any remediation strategies.

The analyses undertaken included the determination of Peroxide Oxidation Combined Acidity & Sulfate (POCAS) which includes Total Potential Acidity (TPA) & Percent Oxidisable Sulfur (POS). The results of the POCAS testing undertaken indicate POS values ranging from nil to 1.50%.

Of the twenty-seven samples tested, twenty-five returned TPA & TAA of < 1 moles H^+/tonne. One near-surface sample from near the shore had a TPA of 52 moles H^+/tonne and a POS of 0.6%; and a second sample from 2.75m depth further out in the bay had a TPA of 320 moles H^+/tonne and a POS of 1.2%. In these cases the POS was not satisfactorily balanced by the amount of $CaCO_3$ present, which indicates that additional neutralisation of this material may be necessary. However in all other cases the amount of $CaCO_3$ present outweighs the POS by at least 10 to 1 and further neutralisation would appear unnecessary.

The investigations were limited to the inter-tidal zone and parts of Boathaven Bay, and further investigation, in accordance with QASSET guidelines and the development of a final ASS Management Plan will be necessary.

POCAS test results from work undertaken at near-by Mandalay Point are understood also to have indicated POS values of up to 0.6 % in near surface sediments. An assessment of the ASS potential of sediment for the Vision Airlie Project did not indicate any ASS potential at this location (Whitsunday Tourism Strategy, 1998).

On this basis, although it is clear that some significant quantities of PASS materials do exist within the development site, the risk of acid generation is considered low due to the presence of high levels of $CaCO_3$, and further investigations are not warranted at this stage of the development process. However, a more detailed investigation (as outlined in **Appendix E**) will be necessary prior to construction.

6.2 Potential Impacts

6.2.1 Construction

Potential impacts during the construction stage are likely to be related to:

- Release of sediment to the waters of Boathaven Bay, either due to direct disturbance of the seabed or intertidal flats or from tailwaters within the dredge and excavation spoil disposal area;
- Release of contaminants to the marine environment through re-suspension of contaminated sediments; and
- Acidification of marine waters due to excavation of acid sulphate soils (ASS).

Fine Sediments

The sediments in the bay and channel contain a significant proportion of silt and clay fines, which if disturbed by dredging operations could result in local clouds of fine suspended solids that in turn may impact on local fauna (see also **Section 9.3**). Fine silt (10 -2µm) and clay (smaller than 2µm) particles disturbed by dredging activities may become suspended and impact on the quality and aesthetics of the near shore waters (see also **Section 7.2**).

Contamination

Results of sediment analysis undertaken as part of the TOR for preparation of this EIS indicate that the surface sediments tested did not contain environmentally significant concentrations of common contaminants. It is not considered likely that deeper sediments would contain higher contaminant concentrations, thus the potential for release of environmentally significant levels of contamination during dredging and/or disposal of sediments would be minimal.

Appropriate management of hydrocarbons and other environmentally hazardous chemicals during construction will prevent contamination of soils and sediments from spills and leaks. In the event that a spill or leak occurs this should be cleaned up promptly and any contaminated material removed for disposal at a suitably licenced landfill.

Acid Sulphate Soils

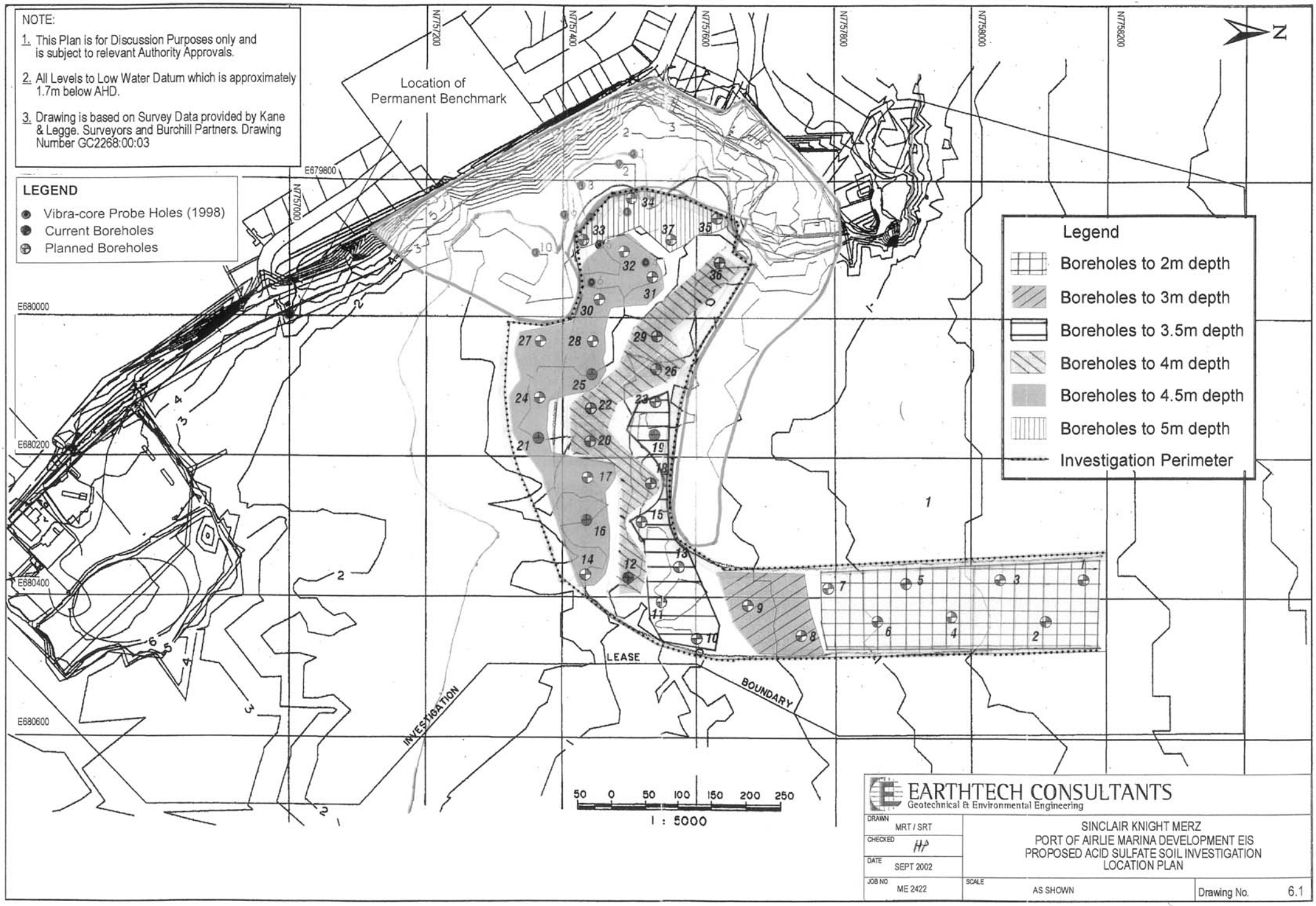
Pyritic or Acid Sulfate Soils (ASS), were deposited in coastal zones throughout the world at the end of the last sea-level rise, between 6,000 & 10,000 years ago. When exposed to air (for example following dredging or excavation), the iron pyrite in these sediments oxidises producing sulfuric acid which, (in the absence of sufficient quantities of neutralising substances ie. $CaCO_3$,) will lower the in-situ pH and that of any surface runoff and groundwater.

Impacts resulting from the disturbance of ASS/PASS soils include:

- Lowering of local pH levels which can result in damage to infrastructure (concrete and steel surfaces), and negative impacts on acid intolerant flora and fauna;
- Mobilisation of metals such as aluminium and iron, which may be present in the sediments disturbed, which can result in kills of fish and other marine life; *(It should be noted that metals like Iron & Aluminium are abundant in nature and are not considered as contaminants, they only become an issue when they dissolved and mobilised by acidic water conditions);*and
- Deposition of Iron precipitates (scum, which dries to a fine red dust,) on exposed surfaces and nearby vegetation, which permanently stains surfaces and reduces the aesthetic appeal of the area.

Disturbance of ASS is known to have caused degradation of some estuarine and associated fluvial ecosystems in Australia and may also occur in a marine environment. The importance of carefully managing ASS has become more fully recognised following these cases of habitat degradation. Results of various research projects undertaken on the distribution, management and impacts of ASS indicates that there are estimated to be between 1.2 and 5.0 million hectares of ASS along the coastline, concentrated mainly in eastern and northern Australia. In Queensland, the *State Planning Policy (SPP 2/02) Planning and Management of Coastal Development Involving Acid Sulphate Soils,* guides the management of ASS.

As discussed in **Section 6.1.5**, PASS sediments may be encountered during dredging and excavation of marine sediments in Boathaven Bay, however the likelihood of significant acid generation is considered low. More detailed investigations will be undertaken prior to construction to provide a better estimate of the extent and severity of ASS in the areas to be disturbed. **Figure 6-3** indicates proposed sampling locations



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DATE SEPT 2002	
JOB NO ME 2422	SCALE AS SHOWN — Drawing No. 6.1

and depths. Note that ASS left in-situ, for example beneath reclaimed land areas, does not pose any risk to the environment while these soils/sediments remain undisturbed.

In the event that ASS are encountered in the excavation area, these will be treated and managed in accordance with the State Planning Policy (SPP 2/02). Treatment usually involves neutralisation of acid in sediments with lime (calcium carbonate or $CaCO_3$). The proportion of $CaCO_3$ to be mixed with the ASS will depend on the potential acidity of the sediment utilising a minimum safety factor of 1.5. This approach will be used rather than less expensive methods such as reburial because of the close proximity to the GBRMPA and GBRWHA.

Based on geology of the area, most ASS within the marina basin excavation area are expected to occur in the upper layers of the sediment and will not be used for land reclamation. These will be transferred to the dredge and excavation spoil disposal area and treated there to neutralise acid (if required). Discharges of water from the dredge and excavation spoil disposal area will be monitored for pH to ensure that acidic water is not being discharged into the marine environment (**see Appendix E**). This will provide a controlled environment for treatment and further testing of ASS dredge and excavation spoil and minimise any risk to the environment.

Dredging of the access channel will be undertaken using a cutter suction dredge and dredge spoil will be pumped directly to the dredge and excavation spoil disposal area. This will allow dredge spoil and generated tailwaters to be monitored and treated in the following manner:

- Spoil representative of one day's operations (up to 5,000m^3), will be placed in a bunded cell in the Treatment Area and dewatered. The treatment area will contain four discrete treatment 'cells' as a minimum.
- Run-off will be pumped to the Treatment Basin for monitoring and if necessary treated to adjust the pH. Treatment and discharge of retained waters shall be undertaken regularly, to match pace with the on-going construction operation. The pH level of the water retained will be monitored using an automatic monitoring and data recording system.
- Monitoring will be undertaken four times each working day, during the period of disturbance by an experienced operator. The system employed will have an accuracy of not less than 0.1 pH units. Continual monitoring of discharges may be installed if warranted by the extent of ASS identified.

In the event that any ASS/PASS are to be placed in the land reclamation areas, these will also be treated with $CaCO_3$ and monitored to ensure that treatment has successfully neutralised acidity and acid potential, (see **Appendix E**).

A detailed ASS Management Plan has been prepared for the project and is included in **Appendix E**. This plan has been prepared with a "worst case" scenario in mind, to ensure that adequate provisions are made for management of ASS/PASS materials in the event that a large quantity of the sediments are identified as posing a significant risk to the environment. This also includes a detailed outline for the investigation program to be undertaken pre-construction which is based on *State Planning Policy (SPP 2/02) Planning and Management of Coastal Development Involving Acid Sulphate Soils*.

Any potential impacts from ASS can be avoided through appropriate management and mitigation strategies of acid sulfate soils/sediments. The costs for treatment are not expected to have any significant impact on project viability, even if a "worst case" scenario is encountered.

6.2.2 Operation

Maintenance dredging which will be carried out periodically during the operation of the Marina could potentially cause further disturbance of PASS sediments and promote the release of acid or other contaminants from recently deposited sediments. However, given that maintenance dredging is removing sediments deposited in the channel and marina basin, rather than disturbing previously undisturbed sediments, the likelihood of encountering further ASS/PASS materials during maintenance dredging is considered very low.

In the event that ASS/PASS materials are encountered, similar management and treatment to that employed during construction will be required to ensure no risk to the environment. This will include limited sediment sampling before each dredging event. As with capital dredging, dredge spoil will be pumped directly to the dredge spoil disposal area and will not come into contact with the natural environment.

Effects of ASS on steel sheet piling used for marina construction are likely to be minimal or nonexistent. Potential ASS must be exposed to oxygen as well as water before acid generation can commence. Sheet piling will not cause this disturbance since the natural layers of the sediments are not affected by the driving of the sheet piles and potential ASS are not exposed to oxygen by the process. Hence, the driving of sheet piles is not likely to generate ASS and there can be no risk to the sheet piles from acid corrosion.

Appropriate management of hydrocarbons and other environmentally hazardous chemicals during operation will prevent contamination of soils and sediments from spills and leaks. In the event that a spill or leak occurs this should be cleaned up promptly and any contaminated material removed for disposal at a suitably licenced landfill.

Speed restrictions in the channel should prevent any impacts from propeller wash on shorelines in Boathaven Bay.

6.3 Recommendations

6.3.1 Construction

Prior to construction, a detailed ASS investigation should be undertaken. Based on the results of the investigation, the ASS plan provided in **Appendix E** should be reviewed and, if the results are better than the worst case scenario envisaged, revised as appropriate.

Any acid producing or potential acid producing sediments excavated or dredged must be treated with lime ($CaCO_3$) and continual monitoring undertaken to ensure that treatment has been successful. This will include monitoring of waters released from the dredge and excavation spoil disposal area.

Further details are provided in the EMP in **Section 21** and **Appendix E**.

6.3.2 Operation

Prior to any maintenance dredging taking place, an investigation should be undertaken into the potential for ASS or PASS to be present in the material to be dredged. Similar management techniques to those outlined in **Section 6.3.1** should be employed where ASS or PASS is identified.

Further details are provided in the EMP in **Section 21** and **Appendix E**.