6. Soils and Geology

6.1 Management of Possible Contaminated Sediment

Results of sediment analyses are provided in Section 6.1.4 of the Supplementary Environmental Impact Statement (EIS). Minor contamination of some sediments with zinc and tributyl tin was identified, consistent with boat mooring and repairing activities in and near Boathaven Bay. Pesticides and other heavy metals were below acceptable criteria for sediments.

Nutrient analysis was not undertaken.

It is proposed that a sediment sampling program will be carried out as part of the baseline environmental studies proposed prior to commencement of construction. It is intended that the program include nutrient and heavy metal analysis. Results of the analysis will be compared with QEPA and ANZECC guidelines for sediment contaminants to identify whether the levels of contaminants identified present a risk to the environment.

If such contamination is present, it is expected to be restricted to surface layers of the sediment. This is based on the reasonably slow sediment deposition rates estimated for Boathaven Bay. (Conservative estimates from 2 dimensional modelling give siltation rates in the order of 15mm per year (WBM in Burchill 1998), estimates from actual measurements in different wave conditions out sedimentation in the order of 3mm per year (Section 5.2 of the Supplementary EIS)).

In the event that this sampling program identifies additional areas of contamination that may present a risk to the water quality of Boathaven Bay if disturbed, a range of mitigation measures are available. These depend on where the sediments are located.

Soft surface sediments located within the marina area are to be removed and placed in the area to be reclaimed for the marina facilities area. Excavation will take place within a sheet piled enclosure so risk of release of contaminated sediment/contaminants to Boathaven Bay is minimal. Depending on the level of contamination, it may be appropriate to encapsulate contaminated sediments within clean sediments. This would preferably occur within the land reclamation area so that future uses of spoil from the spoil disposal area are not compromised. More highly contaminated sediments may need to be removed and disposed of at an appropriately licensed landfill.

Where contaminated sediments occur within the access channel area, these may also be removed and encapsulated within the land reclamation area or taken to a suitably licensed landfill. Removal of contaminated sediments from the intertidal zone can take place during low tide events to minimise risk of release of contaminated sediment/contaminants to the waters of Boathaven Bay. Contaminated sediments in the subtidal zone will need to be removed by dredging. Techniques to minimise release of contaminants to water will include the use of sediment curtains and timing to minimise spread of the dredge plume by tide and wind currents. Monitoring of contaminant levels in the water column may be needed to ensure that harmful levels of contaminants do not occur in the water column and temporary cessation of dredging may be necessary if trigger levels for environmental harm are reached.

It must be emphasised however that the volume of contaminated sediment that may need to be managed by these means is likely to be very low.

In the event that contamination levels in sediment exceeded QEPA guideline limits, a Site Management Plan will be prepared in accordance with QEPA requirements (*Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland*). This will be incorporated with the Dredge Management Plan (see **Section 21.5** of this Addendum).

It should be noted that nutrient levels in deeper sediments may also be higher due to nutrients in terrestrial runoff from pre-European settlement times. FRC Environmental (2002) has observed reasonably high levels of nutrient runoff from undisturbed catchments in the vicinity of Airlie Beach. In the event that this is the case, trigger levels for nutrient concentrations will be developed for dredging activities. Trigger levels will be based on:

- Background nutrient concentrations in waters of Boathaven Bay
- Likely tolerance of ecosystems in Boathaven Bay to elevated nutrient concentrations
- ANZECC guidelines
- Experiences with dredging at Nelly Bay.

There is no evidence to suggest that the north facing orientation of Boathaven Bay may be related to an increase in the level of terrigenous nutrients in the bay compared to other non-north facing bays.

6.2 Ongoing Monitoring of Contaminated Sediments

If heavily contaminated sediments are identified and these are encapsulated on the site, ongoing monitoring of seepage from these sediments will be undertaken to ensure that contaminants are not being mobilised. The likelihood of such mobilisation is likely to be limited by the proposed construction of the land within a sheet pile enclosure and the low permeability surfaces that will ultimately be placed on the reclaimed land. In initial years (one to 5 years after land reclamation) some areas of the land will be undeveloped and some rain infiltration may occur.

Similarly, contaminants within the dredge spoil disposal area (future development area) may also be leached into Boathaven Bay. The likelihood of leaching will be minimised by containment of this spoil within a sheet piled and/or bunded area and suitable surface treatments to minimise rain infiltration.

If acid sulphate soils and potentially acid sulphate soils have been treated and disposed of in the land reclamation area or dredge disposal area (future development area), the potential may also exist for acidification of any leachate generated in these areas. It is intended that treatment and management of acid sulphate soils will be such that this risk is minimised.

Ongoing water quality monitoring in Boathaven Bay will include monitoring in the vicinity of the land reclamation area and spoil disposal area to detect any contaminants being leached from spoil and fill. The final parameters and frequency of this monitoring will be determined based on the outcome of additional sediment testing

and the methods used to manage any contaminated sediment or acid/potentially acid generating sediments. It may be appropriate to sample leachate from within the spoil/landfill areas with shallow bores to establish whether contaminated leachate is forming.

In the worst case scenario, where significant quantities of contaminated leachate form and are shown to be leaching to Boathaven Bay, leachate will be pumped out and treated. However, it should be noted that this worst case scenario is highly unlikely and it should be possible to manage any contaminated sediments such that this does not occur.

6.3 Acid Sulphate Soils

6.3.1 Full QASSIT Testing

Testing in accordance with the Queensland Acid Sulphate Soil Investigation Team (QASSIT) guidelines will be carried out prior to commencement of construction. This approach is acceptable to the Department of Natural Resources and Mines.

While it is acknowledged that testing to date has been limited, test results have shown no indication that substantial acid sulphate soil problems will be encountered during dredging and earthworks. An allowance for treatment of 200,000 cubic metres of ASS has been included in the financial feasibility study for the project which was submitted commercial in confidence to Department of State Development.

In managing any ASS identified on the site, key principles for management will include:

- Protection of adjacent coastal wetlands in the Campbell's Creek estuary
- Protection of water quality in Boathaven Bay from degradation.

Further details on the QASSIT testing program and its relationship to the ASS Management Plan are discussed in **Section 6.5** of this Addendum.

6.3.2 Remediation Area

If required, an area of approximately 20,000 m^2 will be bunded into five cells within development area C, D and E for the treatment of acid sulphate soils as described in the ASS EMP. Each cell will have the capacity of one day's earthworks production (approx 5000 m^3 wet volume). Walls and floor of the cells will be constructed of suitably low permeability material capable of withstanding attack by acidic material.

Tail water from the operation of the ASS treatment cells will flow or be pumped into the marina facilities area and then to the maintenance dredging area (treatment basin, see **Section 2.1** of this Addendum) before being discharged back into the sea. The pH levels of the tail water will be monitored at the point of discharge from the ASS treatment area using an automatic monitoring and data recording system and the water treated as required using a lime slurry. Additional samples of tailwater will be analysed using laboratory methods (eg titratable acidity) to ensure tht [H is providing an accurate measure of real acidity. Water will be treated with hydrated lime or similar if it becomes acidic.

Treatment and validation of ASS is expected to take 3-4 days, following which treated ASS will be removed and placed within the land reclamation areas. The cells can then be reused for further treatment as necessary.

There is adequate additional space within the land reclamation area for the establishment of additional cells for treatment of ASS if larger volumes are found or if treatment and validation takes longer than 3-4 days. The final area, volume and configuration of ASS treatment cells will be determined following the full ASS investigation during detailed design.

A key advantage of the remediation cell location is that it is within the fully enclosed sheet pile area of the development. This will provide extra assurance that there will be no releases to the environment during the treatment process.

The location of the remediation area within the land reclamation area is the most suitable location, notwithstanding the fact that is the preference of DNRM for treatment cells to be located above the high water mark. The treatment cells will be located behind a sheet pile walls, the top of which is above the HAT. There are no suitable locations on land within several kilometres of the site: land adjacent to the site is either developed urban areas or consists of remnant vegetation that should not be disturbed. Transport of ASS to a location in the Cannon Valley (the nearest location where suitable land might exist) would require trucking of wet material through the town of Airlie Beach and return of this material to the site.

Location within the land reclamation area provides an ideal secondary containment for ASS treatment cells as the entire area is contained within sheet piles and will have a water collection and treatment system installed. This provides a high level of protection for the environment in the event that the ASS treatment cells should fail.

6.4 Pleistocene Clays

At the request of EPA/DNRM, an additional 5 boreholes were sampled in Boathaven Bay for acid sulphate soils (see also Section 6.1.5 of the Supplementary EIS). While it was hoped to extend these boreholes to a depth of 1m below the deepest excavation depth proposed, the equipment available at the time was not capable of penetrating far into the very stiff Pleistocene clays that underlie the softer marine muds. It was agreed in two telephone conversations between Henry Parsons (Earthtech) and Paul Cridlin (NR&M – Mackay) on 18 & 23 November, 2002, that penetration to the underlying very stiff Pleistocene sediments or rock would suffice.

The cost of commissioning of a heavy duty ocean going rig capable of penetrating deeper into the Pleistocene clays was prohibitive for the limited round of sampling proposed. However, such a rig will be commissioned for the detailed geotechnical and ASS investigations that will take place during the detailed design stage of the project.

The excavation methods proposed for Pleistocene clays will be able to remove the clays and, if necessary, ensure they are workable for the purposes of ASS treatment (if required).

6.5 ASS Management Plan

It is acknowledged that full ASS testing of the site has not taken place. On this basis a credible worst case scenario has been adopted for the site and an outline ASS Management Plan developed on this basis. The ASS Management Plan is based on there being 200,000 m^3 of ASS/PASS material to be handled, based on an assumed depth of 2-4m of ASS across the site. Given that the limited testing undertaken to date has only identified a small quantity of ASS in these levels, and that the Pleistocene clays underlying the softer marine muds are not likely to be ASS, this is likely to be an overestimate. However, it is accepted that the testing undertaken to date is not complete, hence the full 200,000m^3 has been allowed for.

The worst case scenario is also based on 1.5% POS rather than 5% POS. There is no test data to date to suggest any POS higher than 1.5% and in all but one test this is adequately buffered by the presence of 'fine texture' calcareous material (< 0.03mm).

The ASS Management Plan is a dynamic document and is intended to be updated once the detailed QASSIT sampling program committed to by the proponent has been undertaken. It is not appropriate to incorporate more detail into the plan at this stage, as there are a wide range of possible management solutions, depending on the outcome of the QASSIT testing. To further amend the ASS Management Plan would appear to lock the proponent into following one ASS management path, when in fact the proponent is committed to responding to the results of the QASSIT sampling program in the most appropriate manner to achieve best practice management of any ASS/PASS identified on the site.

The proponent will develop a full sampling program plan in accordance with QASSIT guidelines prior to the sampling taking place.

The following points are noted however and will be addressed in the next version of the ASS Management Plan, or incorporated in the testing program as appropriate:

- Based on a development area of 36 hectares, a minimum of 72 boreholes with field tests every 0.25m and lab tests every 0.5m. The location and number of bores will be finalised early in the detail design stage, prior to the QASSIT testing taking place
- Provision will be made for additional boreholes depending on the results of the tests undertaken.
- When the QASSIT testing is undertaken, samples will analysed using the SPOCAS method (Method 23 – Suspension Peroxide Oxidation Combined Acidity and Sulfur method), specifying that the back titration step (ANC_{BT}) be performed to accurately quantify carbonates present in the sample. Additionally, the reacted calcium (Ca_A, Method 23X) and reacted magnesium (Mg_A, Method 23U) parts of SPOCAS should be requested. Alternatively, total inorganic carbon (C_{TI}) may be determined (LECO furnace method involving the calculation of carbonate content in the sample by the difference in soil carbon content before and after acid treatment – Method 19E1) on the samples, as well as Chromium Reducible Sulfur (S_{CR}, Method 22B) (and optionally TAA and TPA). Note that if a field pH of less than 5.5 is recorded, TAA must be analysed.
- Testing will include the Pleistocene clays to confirm that these layers are not ASS.

- Testing will include the distribution, variability and particle size of $CaCO_3$ fragments that might assist in neutralising any ASS/PASS
- Determination of $CaCO_3$ will be by approved analytical methods. SPOCAS and back titration tests may be used to establish the self neutralising capacity of sediments.
- Groundwater monitoring wells will be installed, and groundwater 'baseline' parameters established, prior to commencement of construction. Initially, 3-4 wells will be installed adjacent to the coastline and Campbell's Creek estuary and, depending on the outcome of the QASSIT sampling, additional groundwater wells may be installed.
- In the event that variable levels of ASS/PASS are identified across the site, the earthworks strategy will incorporate surveying of these areas and spatial tracking of material to ensure that all ASS is collected and treated. To minimise confusion, several levels of liming rates may be selected for different ranges of ASS/PASS.
- The final verification sampling frequency (verification sampling will be by SPOCAS/back titration or TIC/S_{CR})

6.6 Effects of Filling on ASS

Landfilling activities proposed for the Port of Airlie will take place within an enclosed sheet piled area with sheet piles extending into the stiff Pleistocene clays or to bedrock. The exception to this is the connection to the shoreline where there will not be sheet piles.

The landfill area will be included in the QASSIT testing to identify whether any ASS/PASS underlie this area and are at risk of becoming exposed to oxidising conditions if groundwater levels are lowered. It is proposed to include 4 additional shallow boreholes to 2.0m depth in these areas (ie the treatment area and areas marked for disposal of treated or clean spoil). In addition, four groundwater monitoring wells are to be installed in these areas to allow on-going monitoring of potential impacts to groundwater during and after treatment operations.

Groundwater monitoring will be undertaken to monitor groundwater levels and ensure that any ASS/PASS identified are not exposed to air through lowering of groundwater levels.

It should be noted that the limited investigation undertaken in 1998, indicates that the possible depth of any PASS layer present in close to the shore will be relatively shallow, and is likely to be removed in the excavation of the softer surface muds that must take place in the land fill areas prior to backfilling with stiffer clays. These muds can then be treated in the remediation area (**Section 6.3.2** of this Addendum)

6.7 Comments on Draft DNRM Conditions

Additional comments are made in relation to draft conditions outlined in a letter from DNRM regarding ASS, October 2002 are included in **Table 6-1**. It is noted that the conditions in the letter are draft only and cannot be finalised until the full QASSIT testing is undertaken. At this time, these conditions will be reviewed and incorporated into the Ass EMP.

■ Table 6-1 Comments on Draft DNRM Conditions

DNRM Draft Condition	Additional Response
7. Acid Sulphate Soils that have been drained, disturbed or excavated must only be stored and treated in areas that are designed to contain and collect all contaminants and prevent the contamination of surface and ground waters.	All soils identified as containing un-buffered ASS/PASS sediments will be dredged directly into the purpose built treatment area (see EMP).
11 The surface area of Acid Sulphate Soils exposed to oxidising conditions and the time exposed must be minimised to the greatest extent possible. An exception is during treatment when Acid Sulphate Soils may be deliberately spread out thinly on a lime pad for drying prior to immediate and complete treatment with neutralising agents (e.g. lime).	The only exposed surfaces in PASS sediments will be those during excavations within the sheet piled enclosed area of the site. Exposure during this time will be minimised, and groundwater monitored during the operation.
12 The only Acid Sulphate Soil management technique to be used is the neutralisation of Acid Sulphate Soils in suitably constructed Acid Sulphate Soil treatment areas that incorporate perimeter bunds, leachate collection drains/dams and an acid resistant and impermeable base.	In addition to the description of the treatment area included in the EMP, a lime 'Guard Layer', designed in accordance with current 'best practice' shall be placed before each new load of PASS material is dumped in each treatment cell.
16 A lime pad must always be pre-positioned prior to spreading soils for drying	As above
18 Verification sampling at a frequency of not less than 1 sample per 150m3 of soil treated must be implemented to demonstrate (via validated analytical techniques e.g. POCAS) that sufficient neutralising agent has been applied to treat Acid Sulphate Soils to prevent any acidification or leaching of metals.	Experience in the industry suggests that a rate of 1 test per 500m^3 is most often considered adequate. This will be reviewed following completion of the QASSIT testing.
19 Further neutralising treatment (including a further round of verification testing) must be applied to any Acid Sulphate Soils tested under condition 20 and where the soil does not comply with the action criteria of existing plus potential acidity of equal to or greater 18 moles H+ per tonne (oven-dry basis) (or equivalent 0.03%S oxidisable sulphur) and a soil pH >5.5.	If results of validation indicate any significant level of redundant acidity (ie 18 moles / tonne) then re-liming and re-testing would be required.
20 A spatial tracking system for soil lots must be implemented to demonstrate that verification testing has been performed as required. This must entail (as a minimum) being able to identify where each lot of soil tested has been located so that it can be correlated with laboratory analysis results to allow further treatment to be applied if necessary. This system must be documented, and the documents retained (including receipts, dockets or other records showing all acquisitions of neutralising agents along with records of how and where this neutralising agent was used on site).	We concur, a 'spatial tracking system' ie. Site Register, shall be adopted (and kept on-site) to keep track of material arrival, neutralisation, validation & disposal dates and residence times, (see section 10 of Management & Remediation - EMP).
21 Neutralising agents must be stored under conditions that will prevent the deterioration of their effectiveness.	A dry store will be provided for neutralising additives (lime) and that the lime be replenished regularly during operation of the treatment area
22 Neutralising agents used on the site (for example along drainage lines and at the base of treatment areas) must be replenished and or replaced regularly to remain effective against loss by wind or water erosion.	As above
24 Acid Sulphate Soil treatment areas must not be in locations which may be inundated by the Highest Astronomical Tide.	See **Section 6.3.2**
25 The soil must be managed to achieve a consistency that will allow for thorough mixing. This may entail drying (with associated management of any acid and other contaminants resulting) and mechanical turning and breaking up of the soil.	Thorough mixing and de-watering of all limed materials must be undertaken and closely supervised, (see section 8 of Management & Remediation - EMP)

26 Drying of Acid Sulphate Soils must not be undertaken during foreseeable wet weather.	A wet weather clause would be included in the updated ASSMP.
27 Acid Sulphate Soils must only be spread (on a lime pad) in treatment or storage areas to a depth of 20 to 30cm. Additional layers of soil must not be applied until verification testing has shown that further treatment of the soil is not required. The basal surface or 'treatment pad' must be limed before receiving any untreated material.	Reference to specific thicknesses of layers for treatment or drying of ASS/PASS soils is considered too prescriptive at this stage. Effective mixing will depend on material type and moisture state and will be explored further once QASSIT testing has been undertaken. Direct supervision of the treatment operations will be undertaken by suitably experienced personnel.
32 Excavation must be staged to ensure sufficient drying and mixing time can be achieved with the treatment areas available.	Staging of excavations & dredging will be staged and scheduled, based on the requirements of the 'spatial tracking' of treated materials in the treatment area.
33 Staging of excavations must ensure that adequate time is available to obtain the results of verification testing before placing further layers of soil in treatment areas. The location and total area required for treatment &/or storage of excavated material must be defined prior to commencement of excavation works.	(see item 32. above) no release of un-validated material is to occur
34 Contaminants must only be released to waters from Acid Sulphate Soil treatment areas at designated release points and in compliance with the release limits listed in table 1. All determinations of the quality of contaminants released must be: • performed by a person or body possessing appropriate experience and qualifications to perform the required measurements; and • made in accordance with methods prescribed in the Environment Protection Agency Water Quality Sampling Manual, 3rd Edition, December 1999, or more recent additions or supplements to that document as such become available.	Release points for treated water are yet to be designated, this can only be completed following detailed design & scheduling of earthworks and ASS treatment, following approval of the DA.
35 The holder of this development approval must conduct and keep records of contaminant releases to waters from any designated release points associated with the Acid Sulphate Soil treatment areas, frequency, and for the parameters specified in table 1 throughout the duration of the period of potential impact, with additional monitoring during periods that may represent higher risk of impact. The Cl:SO4 ratio for each affected water must be calculated. (Note: This data should regularly be graphed against time to allow a quick visual check to pick up any trends or events in a timely manner).	All monitoring activities are to be recorded in the site register and made available for audit. The auditing & reporting sections of the final EMP will be expanded to include these requirements.
36 Sufficient groundwater monitoring must be implemented and documented prior to the commencement of the works to determine seasonable fluctuations of the permanent groundwater table height. Similarly, sufficient groundwater monitoring must be implemented and documented to demonstrate that the permanent groundwater table height has not been lowered beyond the seasonable variation during the duration of works.	Four groundwater monitoring wells to be installed, and 'baseline' parameters established prior to commencement of any works.
37 Provide a financial assurance in the amount and form required by the Environmental Protection Agency prior to the commencement of activities proposed under this development approval.	Agreed, to be negotiated.
38 The financial assurance is to remain in force until the Environmental Protection Agency is satisfied that no claim on the assurance is likely	Agreed, to be negotiated.

6.8 Additional Reacted Calcium Results

Additional analysis of 'reacted Calcium' levels for the POCAS tests undertaken to date were done and are presented in **Table 6-2**. These results confirm previous conclusions that there is sufficient natural lime/buffering material in all but 1 of the 24 samples analysed (which is reflected in the TPA of <1moles / tonne), there was insufficient remaining of one sample to allow the analysis. It should be reiterated that all 'coarse' shell/coral fragments were removed prior to analysis and are not included in the determined 'reacted Calcium'. Sample locations refer to those reported in Section 6.1.5 of the Supplementary EIS.

■ **Table 6-2 Reacted Calcium Results**

Sample	POS (%)	Reacted Ca^{+} (%)	Remarks
BH12 – 0.25m	0.16	0.86	no net acidity - buffered
BH12 – 0.75m	0.19	0.57	no net acidity - buffered
BH12 – 1.25m	0.38	1.30	no net acidity - buffered
BH12 – 2.5 m	1.50	1.60	no net acidity - buffered
BH12 – 3.0 m	0.66	1.50	no net acidity - buffered
BH12 – 3.5 m	0.65	1.20	no net acidity - buffered
BH12 – 4.0 m	0.06	0.40	no net acidity - buffered
BH12 – 4.5 m	0.01	0.41	no net acidity - buffered
BH12 – 5.0. m	0.01	not determined	no net acidity detected
BH16 – 0.25m	0.19	0.72	no net acidity detected
BH16 – 2.0 m	0.67	1.60	no net acidity - buffered
BH16 – 3.25m	1.10	1.40	no net acidity - buffered
BH16 – 3.75m	0.21	0.59	no net acidity - buffered
BH16 – 5.0 m	0.01	0.22	no net acidity - buffered
BH19 – 0.75m	0.20	0.86	no net acidity - buffered
BH19 – 2.25m	0.50	1.60	no net acidity - buffered
BH19 – 2.75m	1.20	0.28	insufficient buffering (as prev. result)
BH19 – 3.0 m	0.01	0.25	no net acidity - buffered
BH21 – 0.0 m	0.20	0.47	no net acidity - buffered
BH21 – 0.5 m	0.35	0.63	no net acidity - buffered
BH21 – 1.0 m	0.32	1.50	no net acidity - buffered
BH21 – 2.5 m	0.01	0.35	no net acidity - buffered
BH25 – 0.5 m	0.15	0.58	no net acidity - buffered
BH25 – 1.75m	0.35	not determined	presume insufficient sample

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