APPENDIX G

Soil & Water Management Plan

ARDILL PAYNE & PARTNERS

Civil & Structural Engineers – Project Managers – Town Planners – Surveyors

SOIL & WATER MANAGEMENT PLAN

Proposed Sand Extraction Industry

At

Lot 32 DP1151612

Newrybar Swamp Road, Lennox Head

for:

Ballina Sands

March 2013

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1 Introduction and Purpose

Ardill Payne and Partners (APP) has prepared a Soil and Water Management Plan (SWMP) on behalf of Ballina Sands Pty Ltd in relation to the proposed sand extraction quarry and associated works on Lot 32 DP 1151612, Newrybar Swamp Road, Lennox Head. This SWMP is to be included in the Environmental Impact Statement (EIS) for the construction and operation of the proposed sand extraction quarry on Newrybar Swamp Road, Lennox Head.

A soil and water management plan is a key requirement of the Director Generals Requirements (DGR's) received in November 2012.

This report contains details on:

- the proposed works;
- a site description and physical characteristics of the site;
- acid sulphate soils management;
- erosion and sediment control;
- water management;
- flooding;
- air emissions;
- rehabilitation plan;
- management of potential impacts for construction;
- management of potential impacts during operations; and
- administration of the SWMP.

The SWMP is to be implemented by adoption of the strategies referred to in various sections of this report, with monitoring, reporting and corrective actions recorded in an Environmental Management Log (EML) or site diary. The EML is to be updated continuously in response to inspections on the site and any breaches of the SWMP that may occur.

The purpose of the management measures outlined in this SWMP are to minimise the impacts on the environment that may arise from disturbing of the site, and achieve the following outcomes:

- prevent dust nuisance;
- prevent the displacement of sediment and soil across and off the site;
- preserve water quality in receiving environments;

- control and treat surface runoff from the development during construction;
- maintain existing surface water conditions outside the construction area;
- divert 'clean' runoff around disturbed areas; and,
- achieve compliance with all statutory requirements.

This SWMP has been undertaken in accordance with the following guidelines:

- Managing *Urban Stormwater: Soils and Construction, "The Blue Book" – Landcom, 2004.*

Secondly, due to the nature of the proposal being an extractive industry, this report addresses the impacts during the design of the sediment basin and stormwater treatment system in accordance with:

- *Managing Urban Stormwater: Soils and Construction: Volume 2E Mines and Quarries (DECC June 2008).*

2 The Proposal

2.1 Proposed Development

The proposed development is an “extractive industry” within the meaning of the Environmental Planning and Assessment Model Provisions, 1980.

The objective of the operation is the commercial extraction of sand primarily to be used for site filling within the Shire. The proposed operations will be licenced to remove a maximum of 610,000 m^3 (in situ) of sand from the ground with a maximum annual extraction rate of 80,000 m^3 (in situ) per annum.

Mining operations will include stripping of topsoil (for use in minor site filling and construction of earthen acoustic and visual mounds), extraction using excavators, stockpiling treatment with lime and loading sand into haulage trucks for dispatch to market.

2.2 Quarry Operator

The operator of the extractive industry will be Ballina Sands. Ballina Sands have been operating the existing sand pit on Lot 33 DP 1151612 since July 2011. Contact details for the operator are as follows:

Ballina Sands Pty Ltd

Newrybar Swamp Road

Lennox Head NSW 2478

Site Manager: Mr Jack Krupski

Ph: 0488 001 002

3 Site Description and Physical Characteristics

3.1 Site Location

The site is located in the Northern Rivers Region of NSW some 4km to the north-west of Lennox Head. The site in relation to the broader locality is depicted on Figure 1 below.

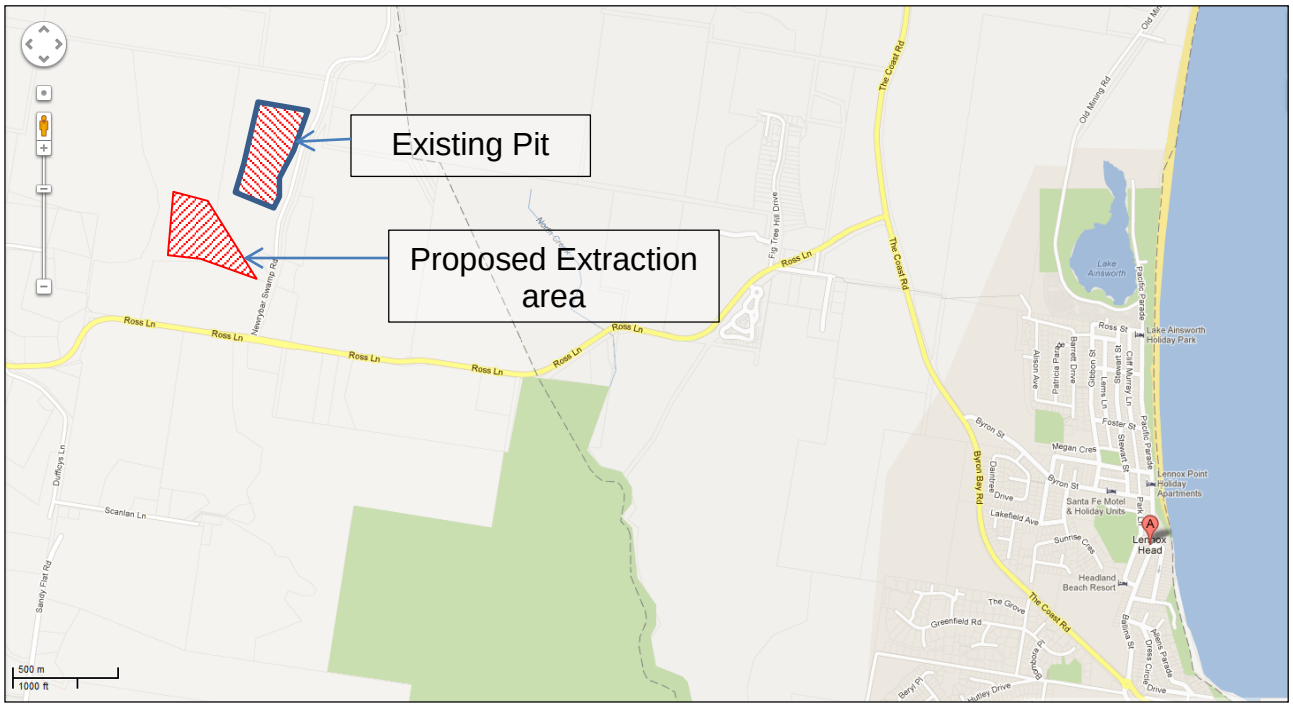


Figure 1: Site Locality Plan *(Google 2012)*

The land is described as Lot 32 DP 1151612, Parish of Ballina, County of Rous and is shown in Figure 2. The proposed activity will be undertaken generally in the southern half of the site.

Figure 3 shows the proposed layout of the mining operations including access to the site from Newrybar Swamp Road. The lot has an area of 48.9ha while the footprint of the extractive operations is approximately 15ha.

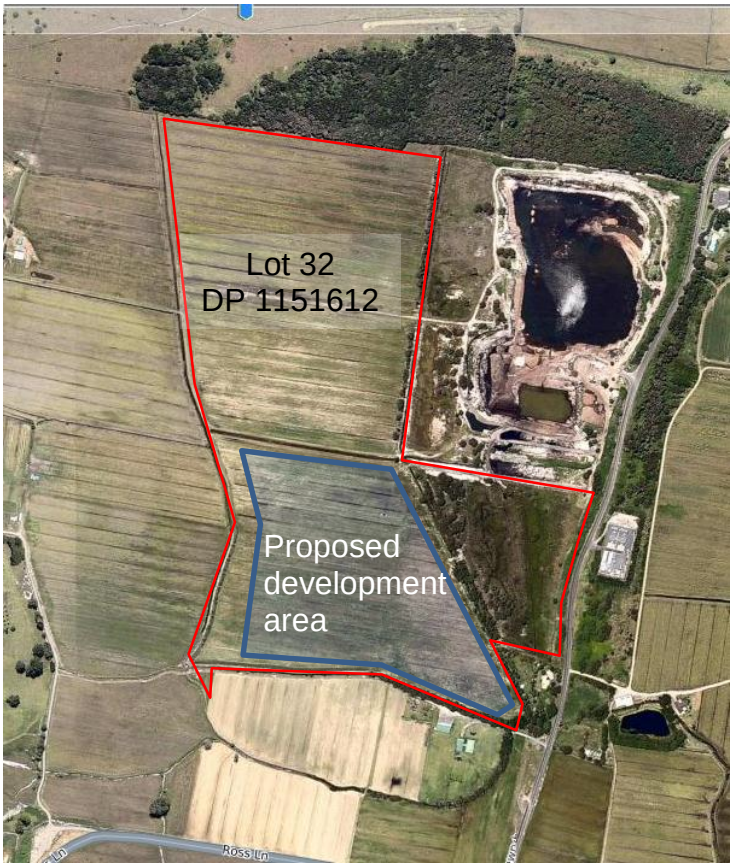


Figure 2: Subject Site

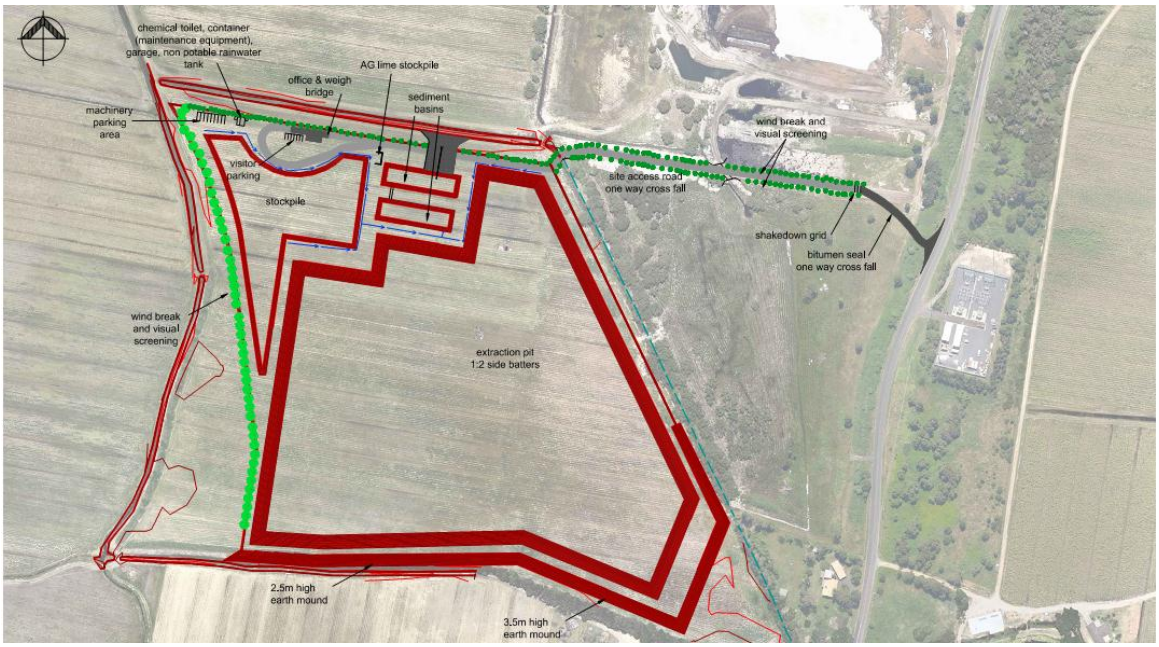


Figure 3: Proposed layout of mining operations

3.2 Site Topography

The extraction site is effectively flat and has surface elevations in the order of 3.0-5.0m AHD. The sands in this location are aeolian (wind deposited) from the adjacent beach dunes to the east. To the west the escarpment rises to an elevation of 50-80m. A topographic image of the site is presented in Figure 4.

Constructed drains are prominent in the vicinity, which are used to convey water from the flat low lying areas, allowing agricultural use of the land. Adjacent to the site to the east, are lower lying areas (0.5 – 1.5m AHD) around the Newrybar drain which along with levees, flood gates and drainage has allowed the land to be used for agriculture (primarily sugar cane). To the west, the slope is generally moderate, varying from around 5° to 17°.

The site is open prairie with remnant and regrowth to the east. The site has been historically used for sugar cane.

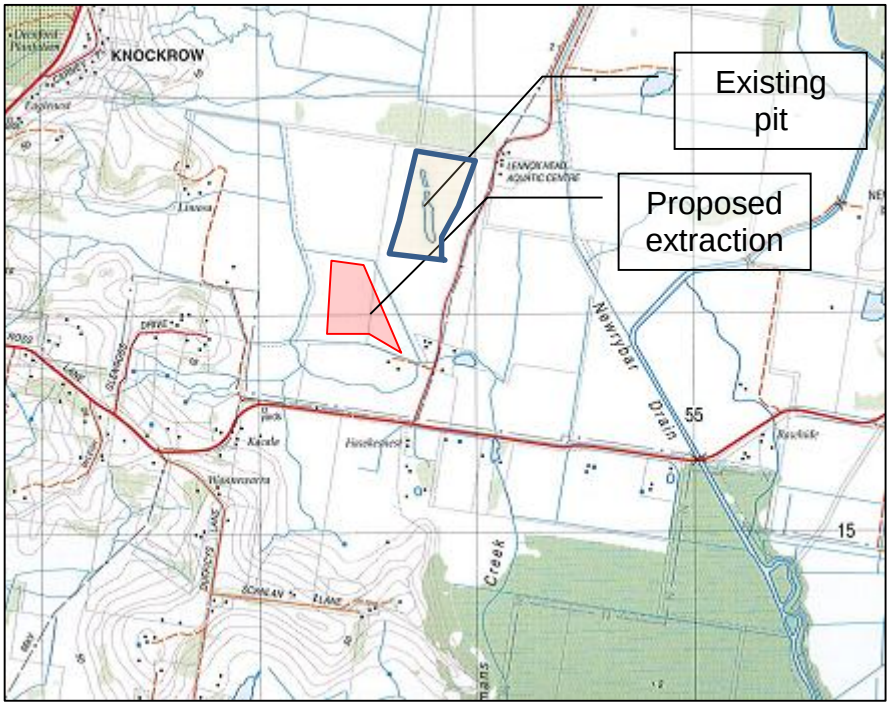


Figure 4: Topographic map of the surrounding area (LPI, 2002)

3.3 Geology and Soils

The Tweed Heads 1:250, 000 geological map issued by the NSW Geological Survey shows that the site is underlain by Quaternary estuarine Alluvial sediments overlaying Quaternary (Pleistocene) sands. Morand (1994) maps the area as a "ty – Tyagarah" landscape (Figure 5). The dominant soil materials in this soil landscape, when inland of inner barriers, consist of black loamy sands overlying bleached sand, then brown organic pan (coffee rock).

Boundaries between materials are wavy and depth to coffee rock varies. Black organic peat may occur as a surface layer in depressions and near swampy areas or as discrete layers within sands. Acid peats may also be found at varying depth.

Generally, the site is overlain by a fine, loose, silty sand. Some boreholes also contained clayey sand in their top layers, although no spatial pattern can be inferred from the borehole logs with respect to clay. The loose, finer layer was generally confined to the topsoil, but tended to extend to greater depths (up to 1.5 mbgl) on the western side of the site.

At depth, the entire site is underlain by clean, fine-grain sands with little or no fines. The soil can be generally described as non-plastic with no dry strength. The sand became increasingly dense down the soil profile. Indurated sand was observed at the base of boreholes BH1, BH5, BH2.6, BH2.7, BH2.10 and BH2.13. Striated indurated sand was observed at the base of BH2.2, BH2.3, BH2.8. Indurated material (both ‘blocks’ and ‘striations’) was encountered at shallower depths in BH1, BH2, BH2.12 and BH2.13.

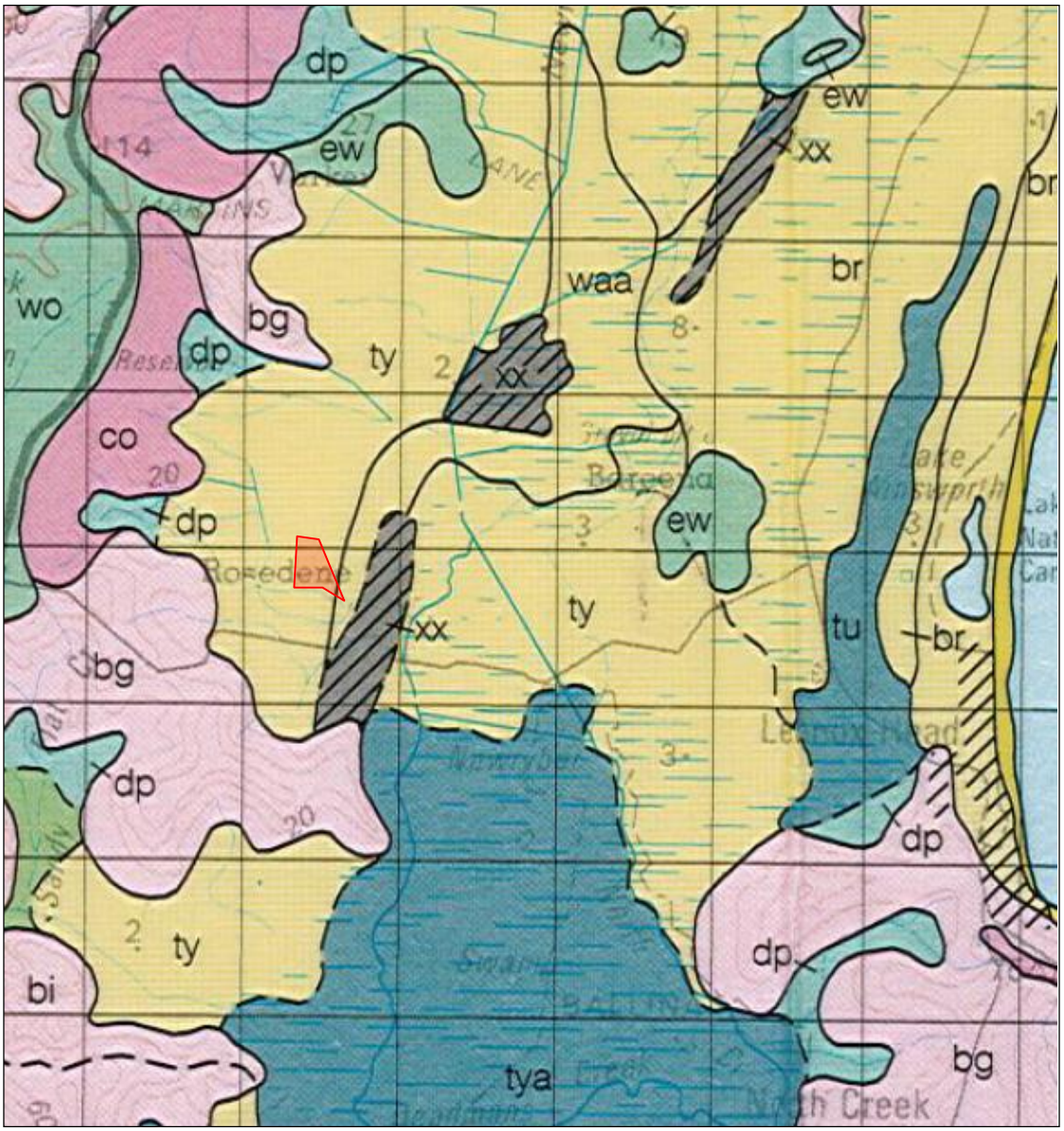


Figure 5: Soil Map (Morand, 1994)

3.4 Groundwater

Four peizometers were installed in March 2011 in order to measure groundwater levels on the site.

Groundwater levels observed were typically encountered at 0.4 – 2.0m below the ground level. The peizometer (NP4 at the south-western corner) has the lowest ground water level, indicating that groundwater flow along with surface water flow generally in this direction.

Groundwater levels also show variation in temporal levels, with up to 1.0m variation observed over the last 12-months.

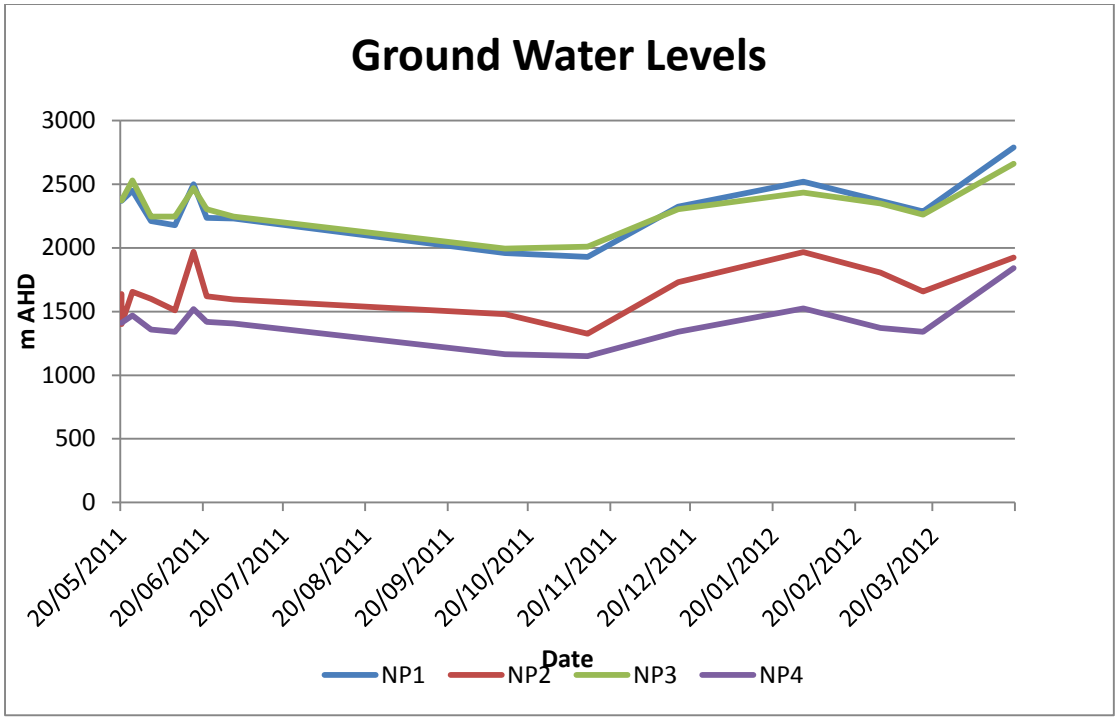


Figure 6: Seasonal Ground Water Level Fluctuations

A groundwater management assessment was undertaken by Douglas Partners in August 2011. This report is provided at Appendix L to the EIS.

3.5 Meteorology

The Ballina Airport weather station is located approximately 4km to the south of the site and would be representative of the meteorological conditions on the site. The following is a summary of conditions from this station:

3.5.1 Temperature

Temperature data for Ballina shows that the site is generally sub-tropical in nature. The temperatures are presented in Figure 7. Maximum temperatures in the mid to high 20's are expected in summer with a maximum of around 20 C expected in winter. Low temperatures of around 20 C are expected in summer, with average minimums of around 9 C in winter.

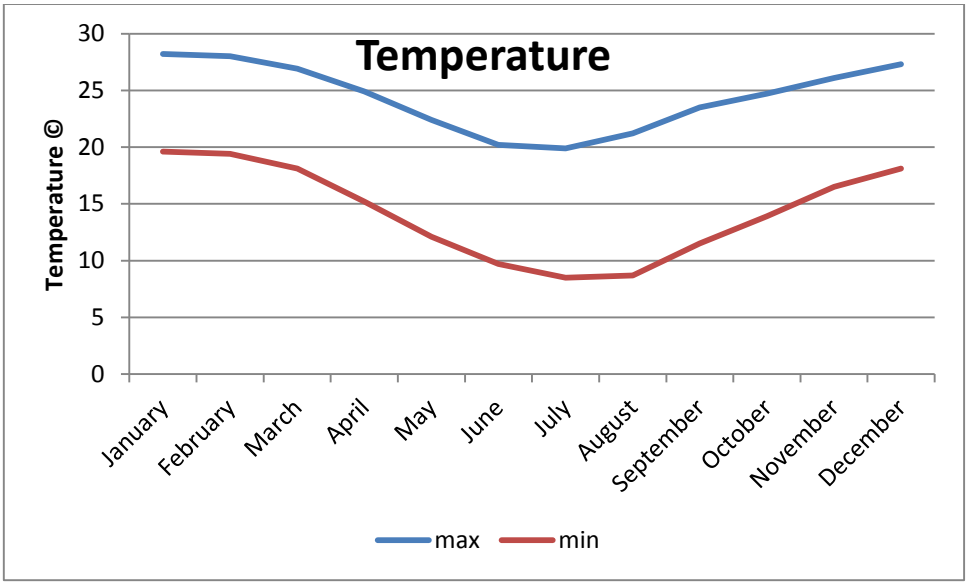


Figure 7: Monthly maximum and minimum temperatures for Ballina

3.5.2 Rainfall

The rainfall data for Ballina Airport is presented in Figure 8. The average yearly rainfall is 1796.9mm/year. There is higher rainfall during the summer months, with the driest months being July to October.

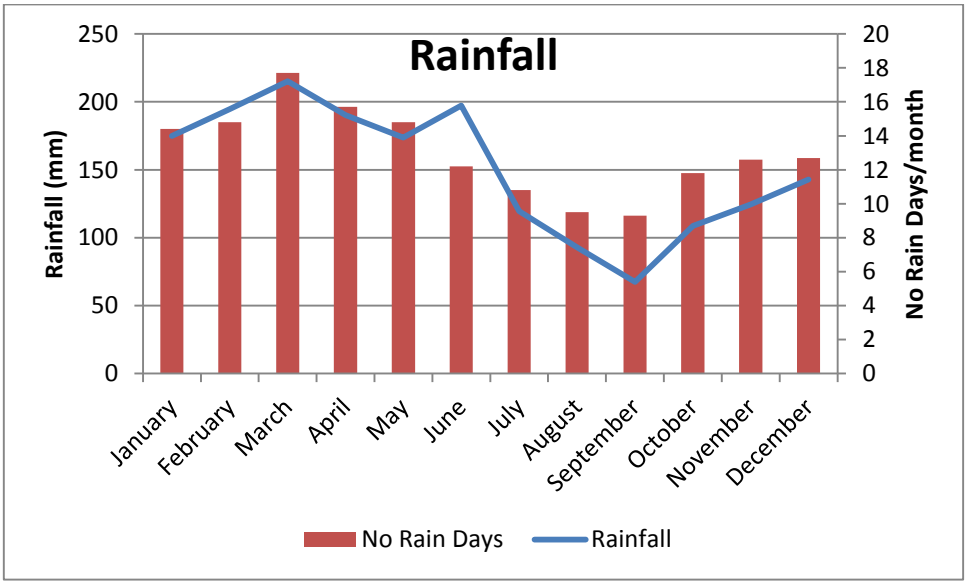


Figure 8: Mean Rainfall Data for the site

3.5.3 Wind

Wind data for Ballina is presented in Figure 9. The morning wind speed is relatively consistent throughout the year, however the afternoon wind speed is higher during the summer than the winter and is always higher than the morning wind speed.

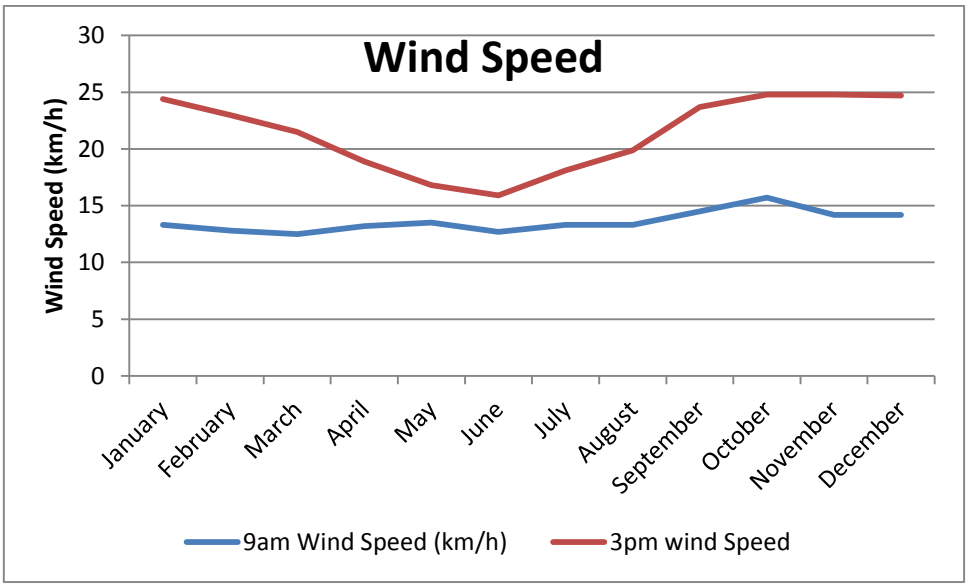


Figure 9: Mean 9am and 3pm wind speed for the area

Wind roses for summer and winter (9am and 3pm) are presented in Figure 10. These show the following trends:

- During the summer months, the morning winds tend to be light and variable while in the afternoon they are stronger and from the south to the north-east.
- In winter, the wind in the morning is from the west while in the afternoon the wind is more likely to come from the south.

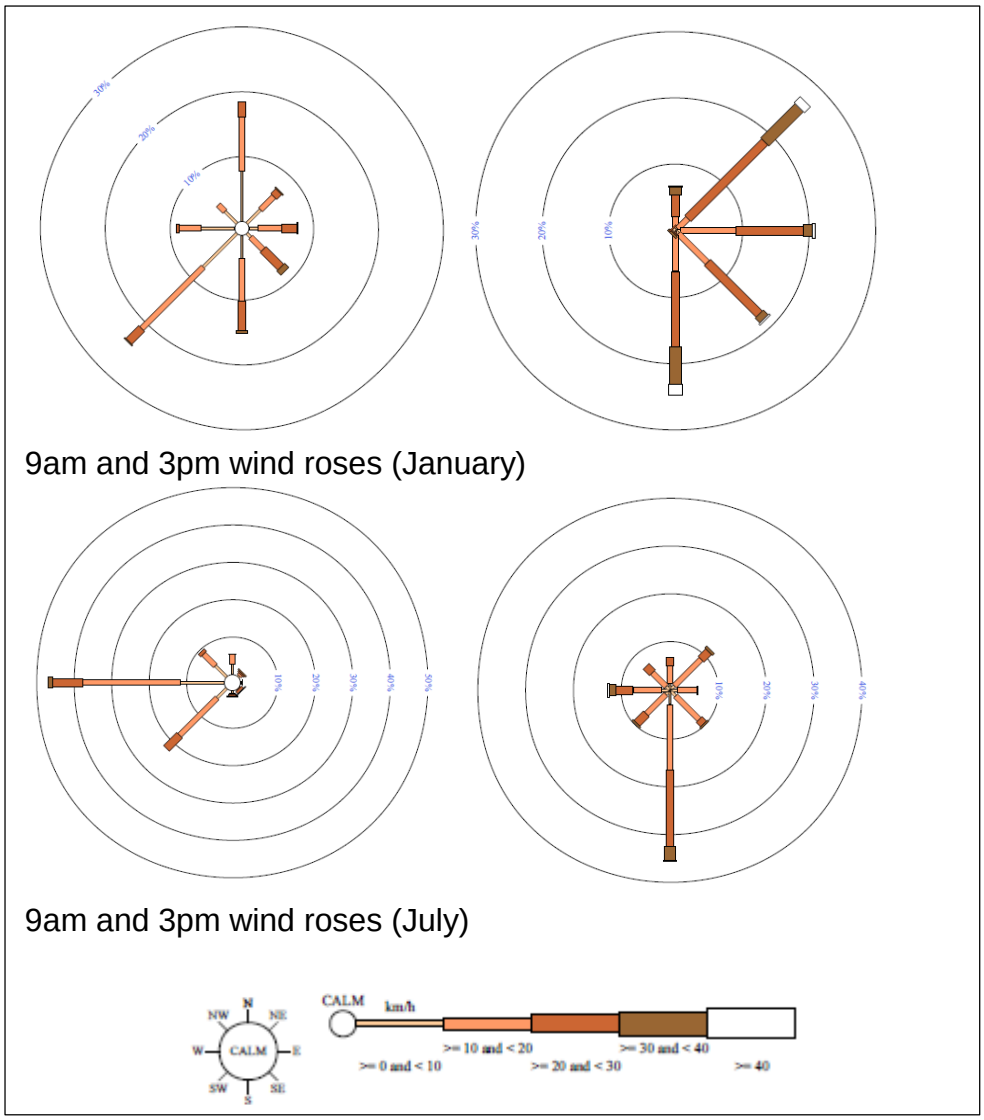


Figure 10: Wind Roses for Ballina

3.6 Soil Erodibility and Soil Erosion Hazard

Soil erosion is affected by the erodability and is based solely on the soils' properties. Erosion hazard is a measure of the susceptibility of an area to erode given the prevailing agents of erosion and a specific land use (Morand, 1994).

Table 1: Erodability and erosion hazard for the site (Morand, 1994 – Tyagrah soil type)

Erodability	K-factor:	*0.000*
	Non Concentrated Flows:	*Very Low*
	Concentrated Flows:	*Low*
	Wind:	*Moderate*
Erosion Hazard	Non Concentrated Flows:	*Slight*
	Concentrated Flows:	*Slight*
	Wind:	*Moderate*

Table 1 shows that the site has very low to low erodability and slight erosion hazard for water borne concentrated and non-concentrated flows. This means that the sandy soil type has low susceptibility for erodability and erosion hazard by water.

The wind hazard however is moderate. This means that due to the fine particles and lack of cohesion, wind erosion (dust) is likely during dry and windy periods.

Mitigation measures for wind erosion shall therefore be required.

4 Acid Sulphate Soils Management

An acid sulphate soils management plan (APP 2013) has been prepared for this project and is provided at Appendix N to the EIS. Reference to this report should be made for all acid sulphate management and operational matters.

5 Erosion and Sediment Control

This SWMP requires the operator to mitigate any environmental impacts associated with the proposed extractive industry. This SWMP specifies the management measures necessary to mitigate any impacts associated with possible soil erosion and sedimentation on the site.

5.1 Existing Surface Hydrology

The site is effectively flat with contour drains which flow to the surrounding constructed drains which surround the site. Given the sandy nature of the soil there is also significant infiltration. The contour drains run east-west throughout the site and were constructed when the site was used for sugar cane farming.

Once the site is developed, bunding will progressively follow the excavation extent to separate all dirty area and clean flows. Dirty water will be treated prior to discharge. Clean water will continue to flow to the exterior drainage network.

5.2 Objectives

The principle objectives of the Erosion and Sediment Control Plan for the development are to:

- minimise erosion and sedimentation from all disturbed areas
- ensure the separation of “dirty” water and “clean” water
- minimise pollution of receiving waters and groundwater
- maximise stormwater re-use

The proposed erosion and sediment controls include:

- minimising the areas of disturbance
- diverting clean water away from disturbed areas
- installing erosion and sediment control devices
- constructing sediment basins
- testing of all discharges prior to release
- dust mitigation measures such as windbreaks and watering

5.3 Erosion & Sediment Controls

The proposed erosion and sediment controls have been prepared in consultation with *managing urban stormwater - soils and construction* (Landcom, 2004) along with its supplement: *managing urban stormwater soils and construction volume 2E mines and Quarries* (DECCW, 2008)

5.3.1 Diversion Works

The site diversion works will segregate clean and potentially dirty stormwater as presented in Figure 11 below. Bunding will be achieved using a soil barrier which will progressively extend as excavation progresses. All areas within the bund shall drain to either the sediment basins or directly to the pit. Refer to Attachment 3 for bund heights and details.

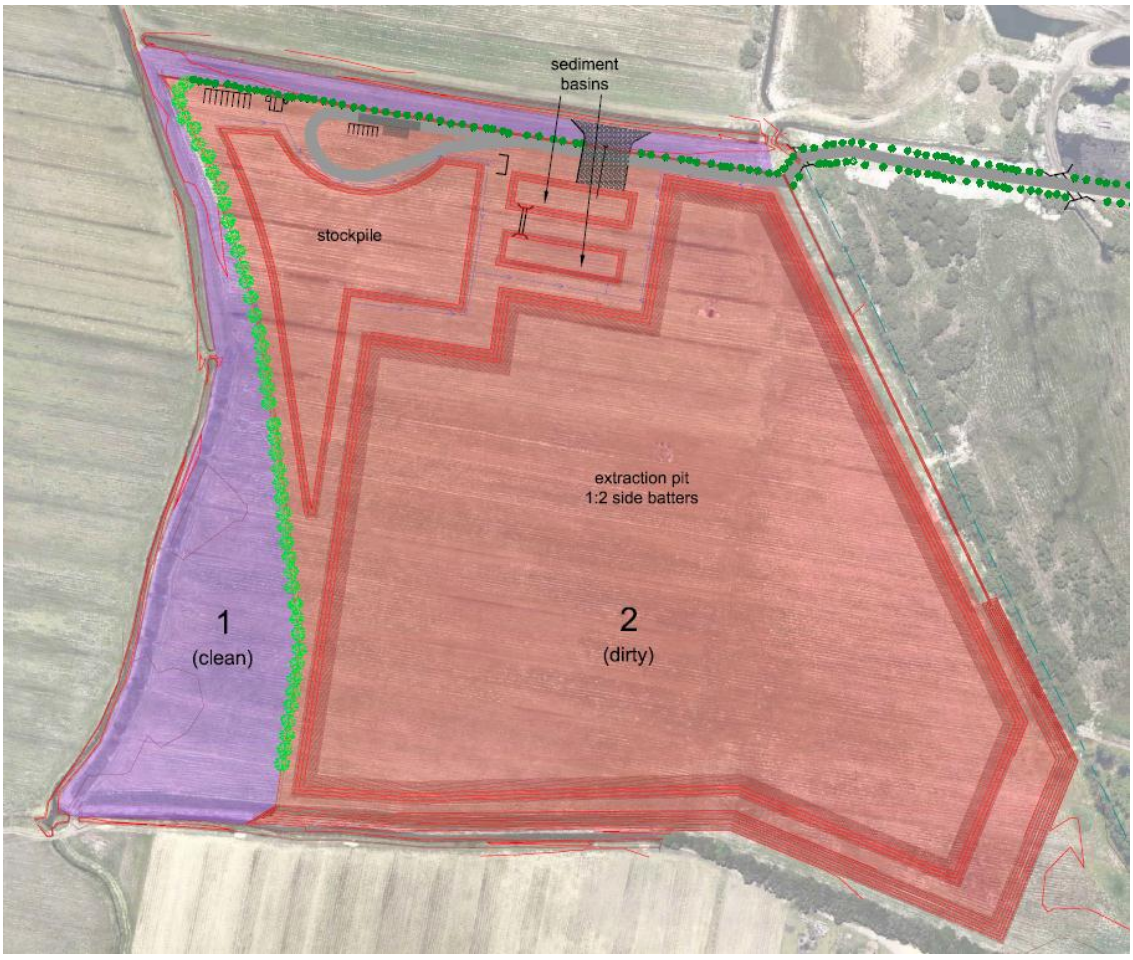


Figure 11: Catchment Areas

Table 2 shows the areas of the catchments illustrated in Figure 11 above.

Table 2: Catchment Areas

Catchment	Area (ha)
1	2.4
2	12.5

Sediment basin sizing calculations are presented in Attachment 4. The total volume of sediment basin required is presented in Table 3.

Table 3 Overall Sediment Basin Sizing.

	Settling Zone (m^3)	Sediment Zone (m^3)	Total (m^3)
Total Sediment Basin	3765	1885	5650

The operational management strategy for erosion and sediment controls is presented in section 11.2 of this report. Further details on how water will be managed on site is presented in section 6 of this report.

6 Water Management

Water management is of critical importance in order to maintain surface water quality during the operation of the extraction, treatment and stockpiling.

6.1 Surface Water Quality Monitoring

Water quality monitoring will be undertaken monthly at the locations shown below in Figure 12. These sites are described in Table 4.

Figure 12: Water Quality Monitoring Locations

The monitoring will be used to compare background data from upstream with discharge water and water quality downstream. This data can be used to identify temporal changes in water quality and the impact of the project on the water quality.

Table 4: Water Quality Monitoring Locations

Name	Location	Site
BS-01	BS - U/S	Upstream of extraction
BS-02	BS - SED	Sediment Basin
BS-03	BS - Discharge	Discharge point of Sediment Basin
BS-04	BS - D/S	Downstream of site at culvert under Newrybar Swamp Road
BS-05	BS - PIT	The excavation Pit

6.2 Potential Impacts on Water Quality due to Extraction Operations

Impacts on water quality could occur as a consequence of:

- naturally low pH groundwater/surface water
- naturally occurring low pH soils on the site
- generation of Acid Run-off due to the oxidation of Acid Sulphate Soils (refer Section 4)
- failure in erosion and sediment control measures releasing turbidity (refer Section 5)

Through effective design, management and on-going monitoring, these impacts can be effectively controlled on the site. A schematic of the water quality management operations is presented in Figure 13.

6.2.1 Low pH water

Naturally low pH water exists in these areas due to geological and anthropogenic changes to the landscape.

If low pH water is measured at both upstream and downstream monitoring locations, there could be cause to change the pH discharge levels, however as a default the ANZECC, 2000 levels remain.

There are low - moderate levels of acid sulfate soils on the site which are derived from pyrite. These minerals were deposited from estuarine processes. The estuarine silts, clays and muds have been covered over by Aeolian (wind blown) sand from adjacent beaches. Sand is the material which is being actively extracted from the site, has relatively low levels of pyrite, but will require some neutralisation with agricultural lime.

Water discharges on the site will be effectively treated by the addition of agricultural lime to a 'spillway' within the sediment basin. Spillway mixing will provide enough energy to dissolve lime to increase the pH to within the discharge limits.

6.2.2 Sediment and Erosion Control

The types of sandy soils found on this site are not prone to dispersion or high levels of erosion. The presence of a sediment basin has proven effective at removing suspended solids within discharge waters at the adjoining extractive operation.

6.2.3 Acid Generation on site

If levels of acidity are generated on site, such that they cannot be neutralised by an agricultural lime spillway, it is proposed that:

1. neutralisation of all site water be undertaken to discharge standard 6.5<pH<8.5 using hydrated lime
2. an investigation be carried out as to the source of the acid generation (such as a hotspot of ASS)
3. additional agricultural lime shall be applied over areas identified as acid generating until the source of acid is neutralised.

6.3 Water Quality Management

All working areas of the site are surrounded by a bund. This bund will be formed by filling the surrounding areas of the site to 3.5m AHD in order to enable drainage towards the sediment basin.

All stormwater falling on the site shall be collected, treated and tested as shown in Figure 13 prior to discharge back to the drainage system. The operation of the water management system is described below.

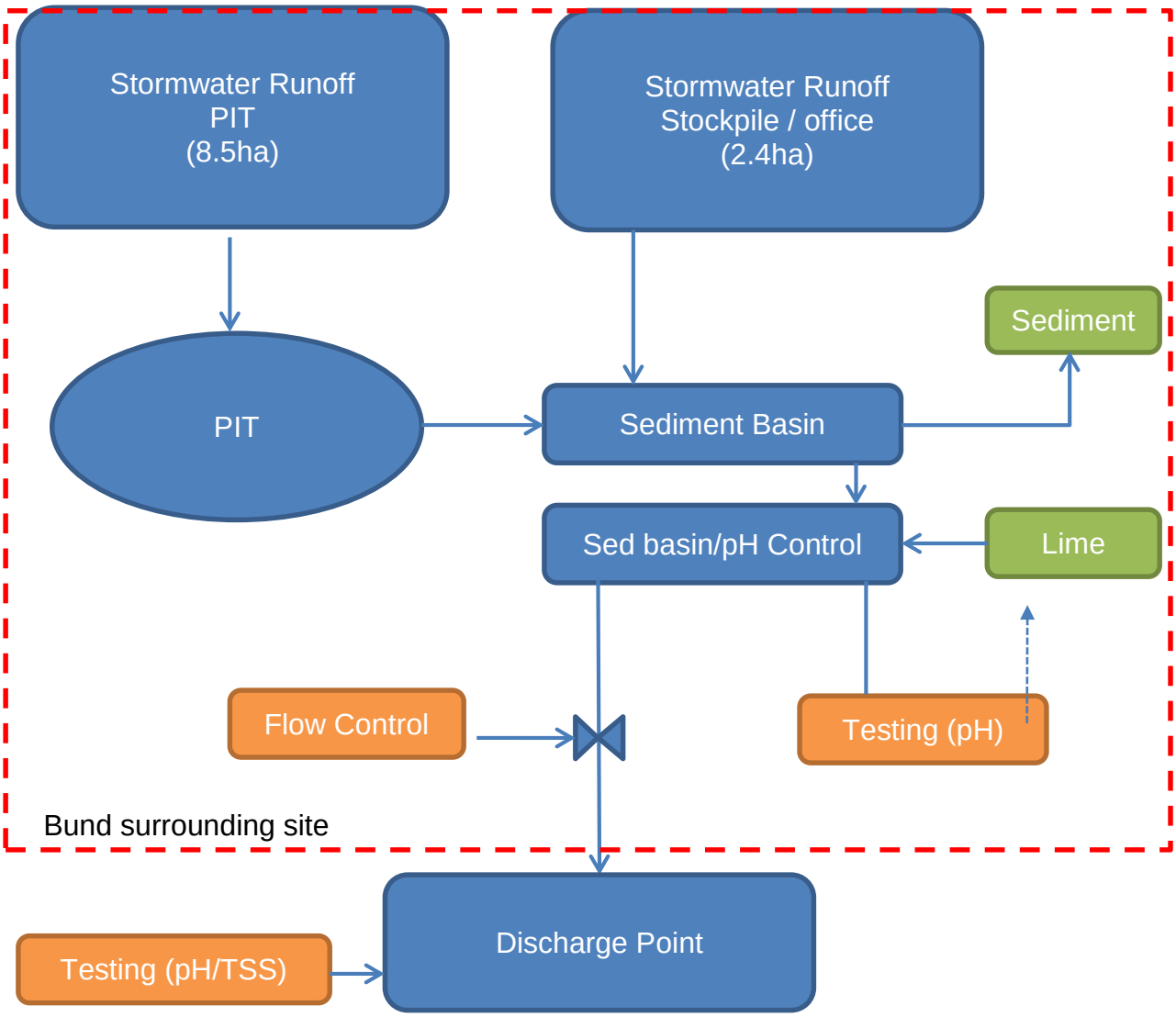


Figure 13: Stormwater run-off, collection and treatment block diagram

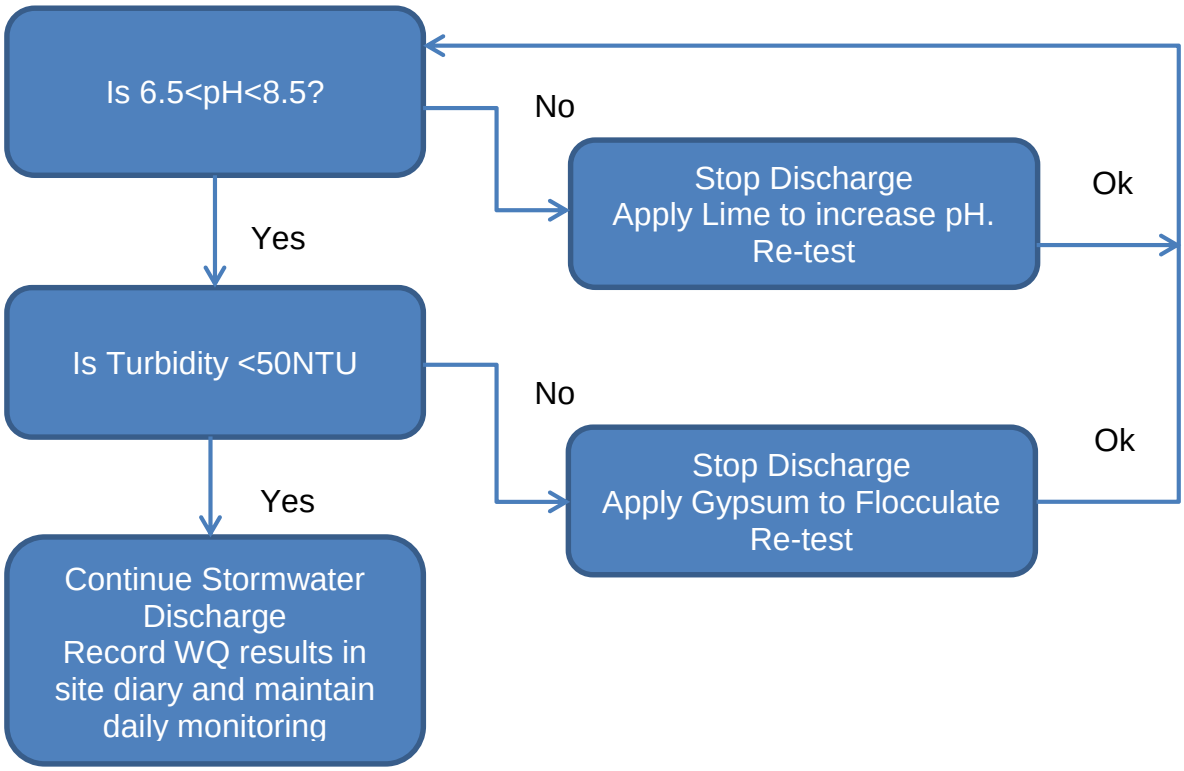


Figure 14: Discharge monitoring procedure

6.3.1 Sediment Accumulation

Once the sediment basin reaches approximately 1/3 capacity (measured using a stake placed within the basin), accumulated sediment shall be removed using an excavator.

6.3.2 pH adjustment

Daily pH monitoring will be undertaken and recorded. Agricultural lime shall be added to the spillway(s) of the basin(s) as required to maintain pH to within the discharge license.

6.3.3 Turbidity Treatment

If excess turbidity is encountered, gypsum or another flocculant is to be dosed to the sediment basin at the required rate while the basin is off-line. Once settled and turbidity is within discharge criteria, discharges can commence once again.

6.3.4 Flow Control

A flow control device capable of stopping discharge shall be installed on the outlet of the sediment basin. This device shall consist of an additional elbow and riser installed on the outlet pipe (refer Figure 15). The invert level of this pipe is 2.4m AHD. The over-flow level is 2.7m with the final spillway at 2.8m AHD. This 300mm level adjustment allows an additional 738m^3 of storage within the basins.

If the pH or turbidity is above the discharge criteria, the discharge flow shall be stopped and the pH/turbidity treated. Flow can be resumed once discharge criteria are once again met.

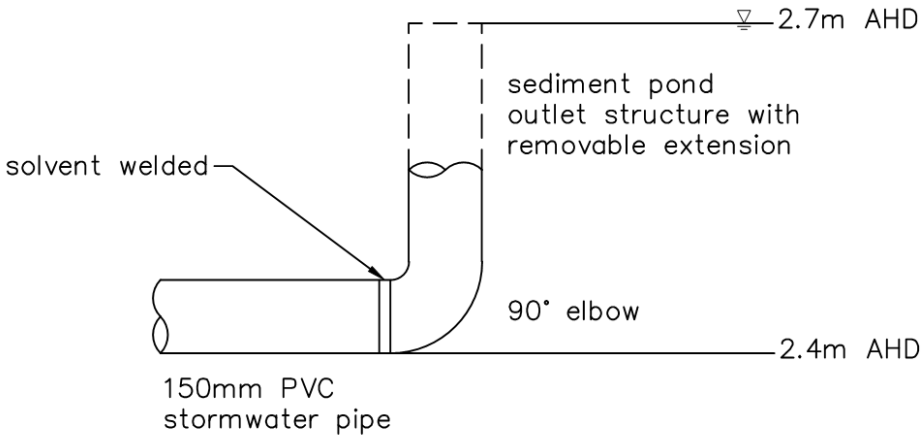
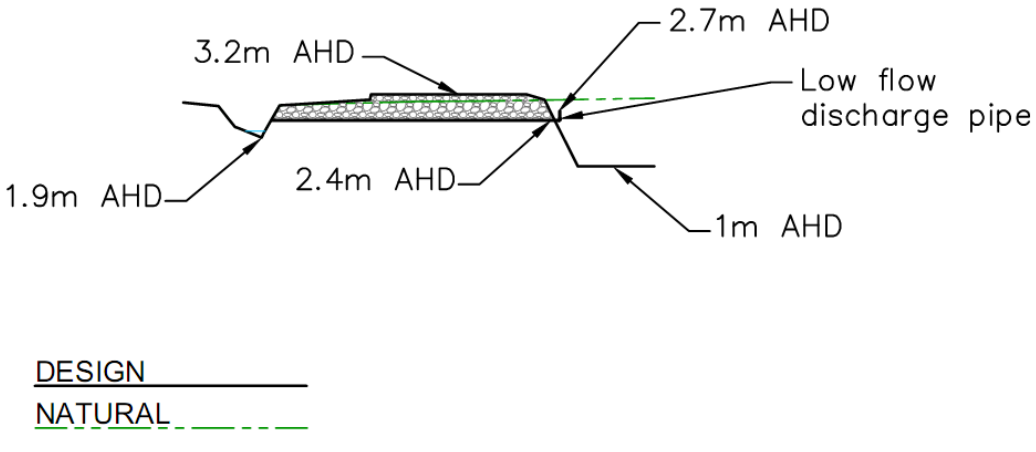


Figure 15: Detention Basin Outlet

6.3.5 Spillway Design

The spillway has a spill level of 3.2m AHD. The details of the spillway are provided in Figure 16.



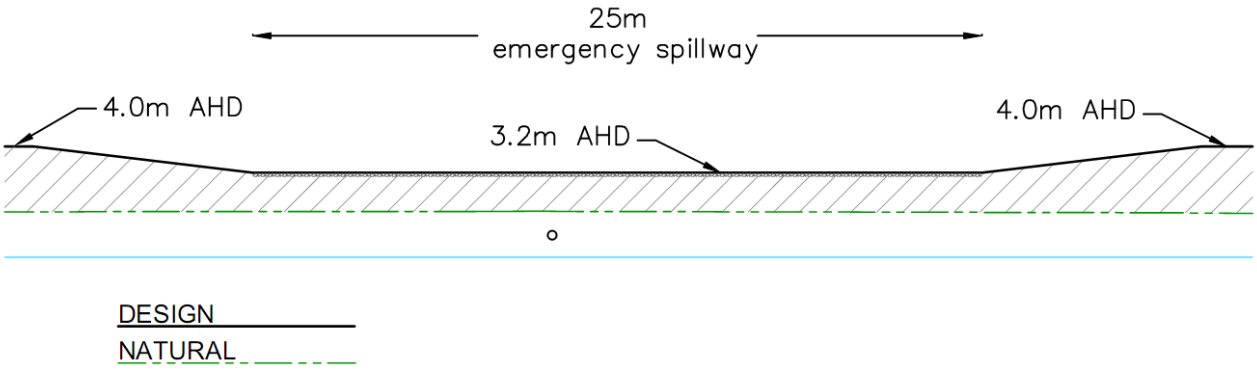


Figure 16: Spillway Detail

The spillway has been designed to discharge a 20-year ARI of 1.5m^3/s. The levels are designed to prevent backflow during local flooding.

6.4 Water Quality Monitoring

Monitoring is required in order to ensure that discharges are within license limits. The monitoring requirements are presented in Table 5.

Daily monitoring of the pH in the sediment basin will be undertaken to capture any deviation of pH. The pH and turbidity shall be monitored for each discharge event.

Monthly monitoring of upstream, downstream, discharge point and pit water quality shall be recorded for the analytes below. These monitoring events will allow trending of physio/chemical parameters over the life of the operations.

Table 5: Monitoring Requirements

Site	Monitoring Frequency	Analytes
Sediment Basin	Every working day	pH
Discharge Point	Each Discharge Event	pH Turbidity (NTU)
U/S D/S Discharge Point Pit	Monthly	pH Turbidity(NTU) EC (mS/cm) TDS (mg/L) DO (mg/L)

6.4.1 Monitoring methodology

All monitoring will be conducted in accordance with *Approved Methods for the sampling and Analysis of Water Pollutants in NSW (DEC, 2004)* and sampled in accordance with *AS/NZS 5667.1:1998.*

Where a multi-parameter water quality analyser is used, the date and time of last calibration check shall be noted.

7 Groundwater

A groundwater management plan has been undertaken by Douglas Partners, a copy of which is provided at Appendix L of the EIS.

7.1 Monitoring Program

Installed licenced groundwater monitoring bores are indicated on Figure 3 (Attachment 1). As extraction proceeds, these will be relocated around the perimeter of the excavation area. The groundwater monitoring program is shown in Table 6. The results will indicate any impact on the groundwater from the operation.

Groundwater flow contours (relative to AHD) show that the site drains to the south-east.

All relevant parties shall be notified of all results of any pumping tests, water analysis and other details as required in the conditions the groundwater license.

Table 6: Groundwater monitoring program

Component	Testing Frequency	Physical Parameters Monitored	Laboratory Analysis
Groundwater Levels	Monthly	Standing water levels in the excavation and the monitoring piezometers	N/A
Groundwater Bores	Quarterly	▪ pH ▪ Electrical Conductivity ▪ Dissolved Oxygen ▪ Redox Potential ▪ Total Dissolved Solids	▪ Cations/Anions (Ca, Mg, Na, K/HCO_3, SO_4, Cl) ▪ Total Iron ▪ Ferrous Iron (Fe) ▪ Arsenic (As) ▪ Aluminium (Al)

7.2 Groundwater Model

Groundwater at the site requires careful management. Where possible, all groundwater will be managed within the site, however a groundwater discharge licence will be required due to balance the overall surface/ground-water balance for the site. A conceptual groundwater / surface water balance model is presented in Figure 17 below.

Ardill Payne
Engineers - Planners - Surveyors - Environmental - Project Management

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Ballina NSW 2478
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Job Number: 6542W Ballina Sands EIS
Subject: Water Balance Model - Proposed Ballina Sands Extraction
Engineer: James Foster
Date: 26/02/2013

	Calculation		Notes/assumption/source
Proposed area of pit:	12.5	ha	(area within bund)
	125000	m2	
Mean Annual Rainfall	1790.5	mm/yr	(Ballina AWS BOM 2012)
Mean Evaporation	-1533	mm/yr	(Alstonville Ag Station Class A evaporation pan BOM 2012)
Gross Rainfall into Pit	223813	m3/yr	
Gross Evaporation from Pit	-191625	m3/yr	
Net Water Balance - Pit	32188	m3/yr	
Pit water balance	32	ML/yr	(Water Balance Rainfall/Evaporation)
Extraction	-80000	m3/yr	(maximum extraction rate)
Voids ratio	30%		(assumed - indurated sand)
	-24000	m3/yr	(Assuming all sand is extracted wet, drains back to pit)
	10%		(moisture content of exported sand)
	-8000		(Water loss in product)
Extraction Loss	-8	ML/yr	(Maximum water lost in sand sales)
Water Cart	-7000	L/ cart	(truck capacity)
Operating	3	days per week	(on average)
	156	days per year	
	-1092	m3/yr	(assuming 1 cart used per day)
Water Cart use	-1	ML/yr	(lost to runoff/evaporation from roads)
Mass Balance	23	ML/yr	
Permitted Discharge	23	ML/yr	Proposed Groundwater Extraction License to Maintain the Existing GW levels within Pit

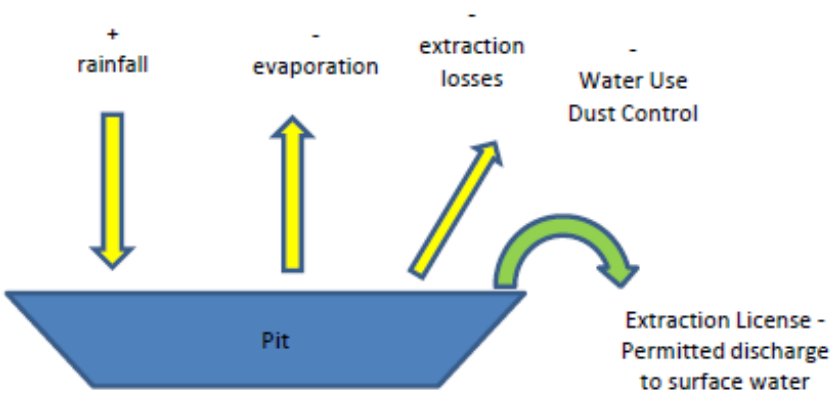


Figure 17 – Conceptual water balance model

7.3 Discharge Licenses

A groundwater discharge licence will be required permitting an annual discharge of up to 23ML/yr. from the site.

This license will be required under Part 5 of the *Water Act 1912.*

This discharge will also be licenced under the *Protection of the Environment Operations (POEO) Act 1997.*

8 Flooding Impacts

8.1 Regional Flooding Impact

The subject site has elevations ranging between 3.0-5.0m AHD. A regional scale flooding assessment has previously been undertaken by Ballina Shire Council in order to determine the impacts of flooding on residential development in the Shire. The most recent results are presented in the Draft Ballina Local Environment Plan 2011 (DBLEP 2011). The results of this modelling (Figure 18) show that the minimum fill level for residential development in the operational area is 2.6m AHD. This modelling indicates that the site should not be impacted by the 1 in 100 year flood event as the ground level higher than the minimum required fill level.

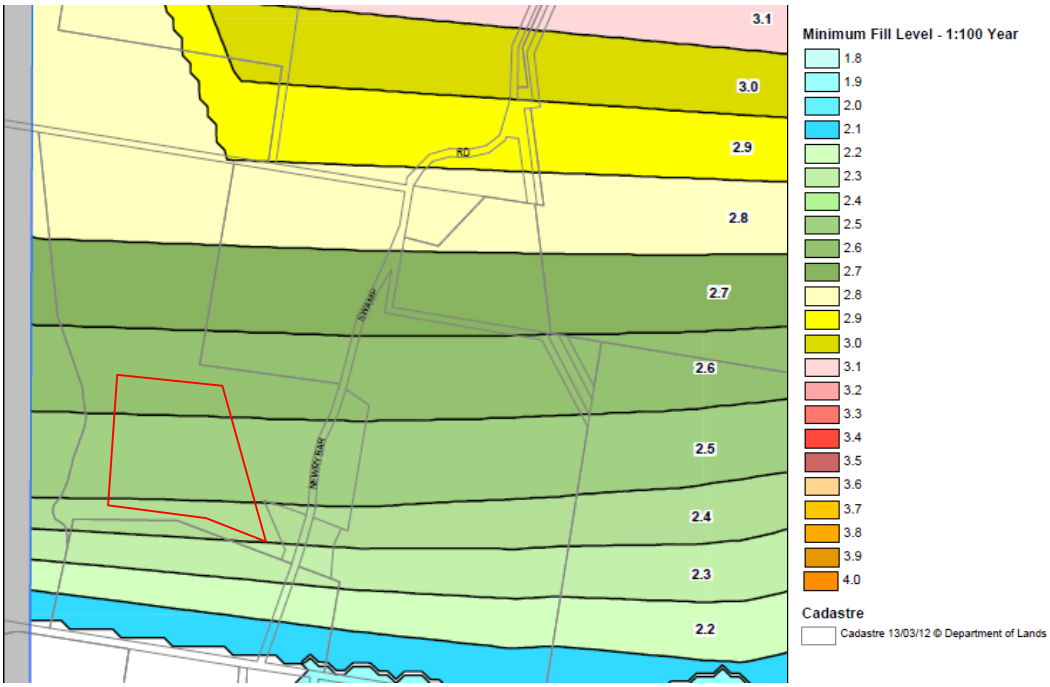


Figure 18: Minimum Fill Levels (BSC - LEP, 2011)

8.2 Local Flooding

The site is located on a flat sand ridge adjacent to foot slopes which rise from 3m to 80m in elevation. East of the site the ground drops away to approximately 1m AHD. The upstream catchment, shown in Figure 19, has an area of approximately 79.9ha. Flows from this catchment have been calculated using the Rational Method (QUDM, 1992). The calculated flows are presented in Table 7 below.

This catchment represents the flows meeting the upstream boundary of the site. This flow then splits to travel down the northern and western sides of the site (Figure 20). The drainage of this area has historically been enhanced to

improve the land drainage for agricultural purposes. Due to the soil type (sand) and flat topography, the site becomes saturated during periods of wet weather. The site readily dries due to the presence of the lower lying floodplain to the east.

Using Manning's open channel flow equation (Figure 21), the capacity of the drains has been assessed. Given the existing channel cross sections, the channel has sufficient capacity to convey the 100-year ARI flows within the channel, as long as the channel is well maintained and free of major snags (Manning's n = 0.022). Routine maintenance of all drains shall be undertaken to ensure this conveyance is maintained and to prevent any upstream afflux.

The site is bunded to an elevation of 3.5m AHD in order to contain and drain any stormwater run-off towards the sediment basin where it can be treated prior to discharge. The spillway outlet of the sediment basin has been set at 2.8m AHD. As this is below the calculated 100-year ARI storm event water level, flap gates shall be installed on the 3 x 600mm RCP outlets to prevent backflow into the sediment basins during flood events.

Table 7: Local Catchment Flows

Average Recurrence Interval ARI (years)	Flow (m^3/s)	Calculated Water Level (mAHD)
10	14.3	2.79
20	16.4	2.84
50	20.6	2.94
100	23.5	3.01

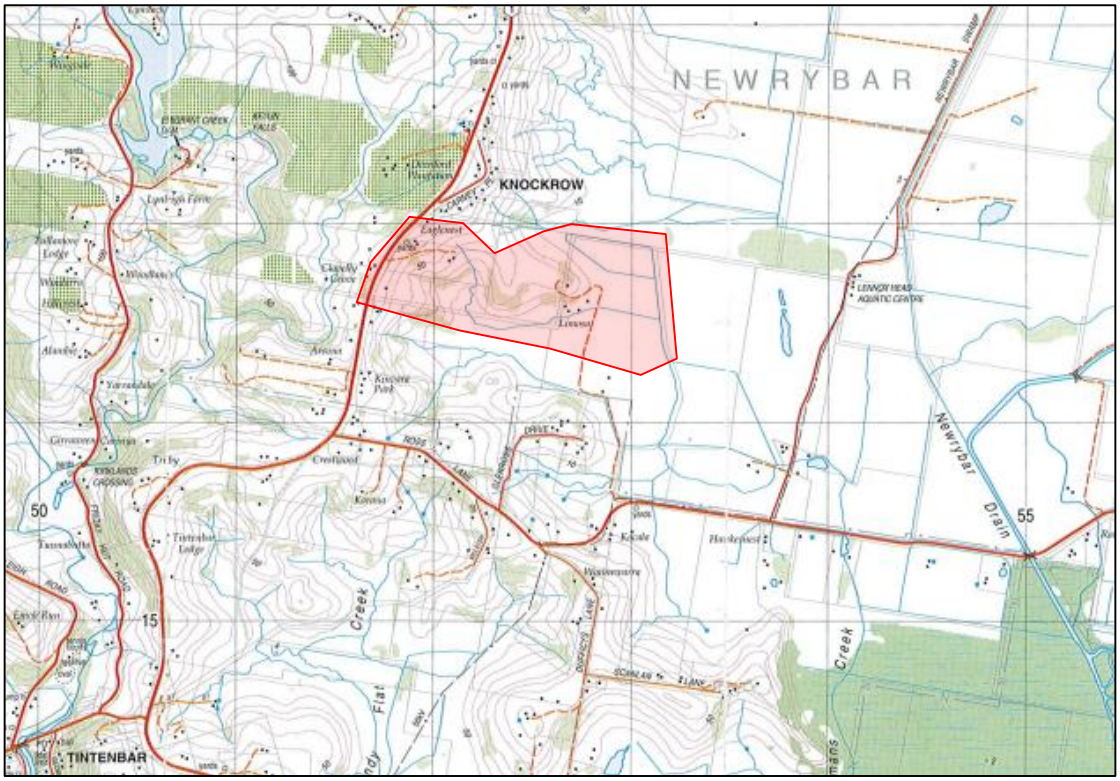


Figure 19: Upstream Catchment from the Site

Figure 20: Local Flood Flows

Input Data		
Base Width	3	
Side Slope 1 (1V:xH)	3	
Side Slope 2 (1V:xH)	3	
Side Slope 3 (1V:xH)		
Side Slope 4 (1V:xH)		
Channel Depth 1	1.01	
Channel Depth 2	0.00	
Manning's (n)	0.022	
Longitudinal Slope (%)	0.33	
Calculated Results		
Waterway Area	**6.0903**	**m^2**
Wetted Perimeter	**9.39**	**m**
Hydraulic Radius (R)	**0.65**	**m**
Velocity (m/s)	**1.96**	**m/s**
Discharge (m3/s)	**11.92**	**m^3/s**

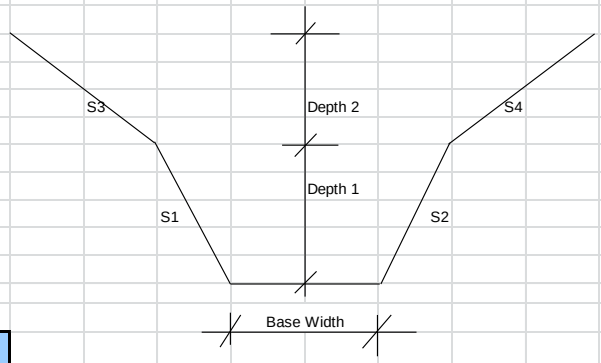


Figure 21: Channel Capacity Calculations (Northern and Western Drains)

9 Air/Dust

Dust from the site shall be managed to prevent excessive degradation in air quality or nuisance to adjacent sites. This will be measured by limiting complaints from neighbours to less than one per week.

During construction and operational works, dust will be controlled on-site using a site based water truck with dribblers or sprays as well as the following when necessary:

- temporary road construction with gravel or road base
- limiting traffic on disturbed areas
- providing wind breaks and vegetation adjacent to stockpile areas
- dust covers provided on trucks and dumpers
- regular watering with the water truck

Where wind speed exceeds about 10m/s (20 knots or 36km/hr), or a watering spray/truck is not available, activities generating dust shall cease unless the Site Manager certifies that dust controls are operating effectively and air quality does not cause a nuisance.

In the event that dust control is unsatisfactory, then some of the following measures may be utilised:

- inspect existing controls and clean, upgrade or improve as required
- open weave barrier fencing is to be provided on the windward side in accordance with Landcom's manual "Managing Urban Stormwater: Soils and Construction", March 2004
- disturbed areas are to be covered with geotextile
- temporary access roads and parking areas shall be sealed with a gravel layer
- construction activities to stop, disturbed areas stabilised and the dust control measures reviewed

In the event of continuing complaints from neighbours, dust monitoring shall be conducted in accordance with AS3580.10.1 (2003). The Site Manager is responsible for visually monitoring air quality and the adequacies of dust control measures at least daily, and as required to ensure that the above requirements are satisfied and performance is satisfactory. In the event of unsatisfactory dust control as indicated by excessive complaints, the Site Manager is responsible for initiating a review of the dust controls and dust monitoring as required.

10 Rehabilitation Plan

Rehabilitation of the proposed pit area will be undertaken in a progressive manner over the life of the proposed extraction.

The staging of rehabilitation is provided in Attachment 2. These plans show:

1. site establishment and set-up
2. commencement of extraction
3. conclusion of extraction
4. final rehabilitation and revegetation of site

10.1 Revegetation Plan

The aim of the revegetation plan is to:

- minimise operational erosion and sediment controls by controlling wind velocities, dust generation and stabilise loose sand to reduce runoff erosion
- reduce the visual impact of quarrying actives
- provide future habitat for flora and fauna

10.1.1 Outcomes of Ecological Assessment

Based on the highly disturbed and modified vegetation at the site, the absence of threatened flora species (including lack of suitable habitat) and absence of endangered ecological communities, the operational areas of the site are considered as having relatively low conservation values. While flanking vegetation along constructed drains to the south and east has some conservation significance, these areas will be retained and should not require any specific mitigation apart from the provision of nominal buffers.

10.1.2 Revegetation of Acoustic Mounds

Acoustic screens consisting of earthen mounds will be constructed as indicated in Figure 3. The earthen mounds including bunds shall be planted with trees and shrubs to provide a windbreak and minimise dust generation. Plant species to be utilised in this area are listed in Table 8. Tree species should be densely planted at 2.0m centres in two offset rows spaces 2.0m apart.. Shrub species (*Leptospermum laevigatum* and *Lomandra longifolia*) will be interplanted between the trees at 1.5 m centres.

10.1.3 Final Rehabilitation and Revegetation

The rehabilitation will occur in one main area at the final stage of the quarry, in conjunction with the lake planting upon cessation of extraction. The south eastern corner of the site (approximately 1ha) is proposed for rehabilitation. Planting should occur at 3.0m centres and species from Table 8 used as to conform to the flora currently at the site.

A Vegetation Management Plan should be prepared to guide the works and include information on densities, care and maintenance and monitoring prescriptions.

Table 8: Plant Species to be used in the Revegetation Plan

Botanical name	Common name	Form	Road access	Western screening	Lake surrounds	Dividing drain
Leucopogon parviflorus	Beard Heath	ST	✓		✓	✓
Elaeocarpus reticulatus	Blueberry Ash	ST	✓		✓	
Melaleuca quinquenervia	Broad-leaved Paperbark	T		✓	✓	✓
Commersonia bartramia	Brown Kurrajong	T		✓	✓	✓
Glochidion ferdinandi	Cheese Tree	T		✓		
Duboisia myoporoides	Corkwood	ST		✓	✓	✓
Persoonia stradbrokensis	Geebung	ST		✓	✓	
Lomandra longifolia	Mat-rush	G	✓		✓	✓
Leptospermum polygalifolium	May-bush	ST	✓	✓	✓	✓
Austromyrtus dulcis	Midyim	G	✓			
Corymbia intermedia	Pink Bloodwood	T		✓	✓	✓
Melicope elleryana	Pink-leaved Doughwood	T		✓		✓
Eucalyptus signata	Scribbly Gum	T			✓	✓
Leptospermum trinervium	Slender Tea-tree	ST	✓	✓	✓	✓
Eucalyptus robusta	Swamp Mahogany	T		✓	✓	✓
Callistemon salignus	Willow Bottlebrush	ST	✓		✓	✓

Form:
ST = Small tree/shrub
T = Tree
G = Groundcover

10.1.4 Mosquito control

The construction of steep lake edges can assist in controlling mosquitoes. Plantings around the lake edge will also assist in the control of mosquitoes by providing habitat for mosquito predators. In the event that the vegetation on the edge becomes dense and attracts large numbers of mosquitoes, sections can be systematically harvested to alleviate this problem. In addition, predatory native fish species (e.g. Empire Gudgeon, *Hypseliotris compressa* and/or Pacific Blue-Eye, *Pseudomugil signifer*) may be introduced if deemed a necessary control measure. The Site Manager shall monitor the growth and functionality of the plants, especially in the case of

controlling mosquitoes, to allow for appropriate measures to be undertaken during the site rehabilitation and restoration works period.

10.2 Expected Quarry Life

As a consequence of fluctuations in demand for the resource and having regard to the proposed extraction rates, the quarry is expected to have an operational life of around 15 years.

10.3 Post Quarry Activities

The extraction will result in the formation of a lake. At the conclusion of the sand pit's life, the perimeters of the formed lake and associated sound mounding along the Newrybar Swamp Road frontage will be vegetated as indicated in Attachment 3.

The lake will comprise a water feature which may be used for recreational purposes by the property owner. The balance of the property will continue to be used for agricultural purposes. Any subsequent additions or development on the site will be subject to Council approval.

11 Management of Potential Environmental Impacts

This part of the SWMP acknowledges the environmental impacts associated with the development and presents strategies to mitigate them.

Each impact has a mitigation measure which is designed to provide a safeguard to protect the environment. Each safeguard requires a commitment of the operator to ensure compliance with the requirements and the reporting obligations.

The following works have been grouped into control strategies for both construction and operation.

11.1 Dust Management

Person responsible	Site Operations Manager
Issue	Minimisation of dust movement off-site
Operational policy	To achieve acceptable air quality standards through the control of the movement of dust off-site from site operations
Performance criteria	Target level for complaints is no more than one per week. Ambient air quality should not deteriorate by more than 30% over a period of 7 consecutive days. Dust deposition at nearby receptors should not exceed 100µg/m^2/day
Implementation strategy	The minimisation of the movement of dust off-site will be achieved through the following on-site practices: 1. All constructed sound mounds to be grass seeded and revegetated within 10 days of completion 2. Stockpiling will only be undertaken in designated areas 3. Windbreaks will be installed to the south/west and south/east of designated stockpile areas 4. An on-site water cart will be available at all times 5. Water cart will apply water to all roads, stockpiles and identified dust generating areas as required to minimise the generation of dust 6. Work on-site will cease if wind speed exceeds 10m/s unless all dust mitigation (such as a water cart) measures are in place and functioning adequately
Monitoring	Daily inspections will be carried out to verify that dust mitigation measures are being implemented. Dust monitoring will be conducted upon receipt of continued (>1 per week) complaints by local residents. If dust monitoring is to take place the following will occur: 1. Temporary dust deposition gauges will monitor the movement

	of dust off-site at the neared residences adjacent to the proposed workings given the predominant wind direction 2. Monitoring will be undertaken in accordance with AS3580.10.1 (2003)
Auditing	Management to examine the complaints register weekly and review corrective action taken
Reporting	• The operator to notify the NSW EPA of a possible environmental nuisance on receipt of 3 or more dust complaints in 24 hours • Reports will be provided to the BSC upon request • Complaints by residents are to be recorded in complaints register and notified to BSC
Identification of incident or failure	Any dust related complaints by residents will indicate a failure of the dust control measures
Corrective action	Locate the source of the dust and implement the following measures: • Apply water sprays using water cart • Cover or water exposed areas • If dust persists, cease the dust generating activities All dust complaints to be addressed in consultation with Council officers

11.2 Sediment and Erosion Controls

Person responsible	Site Operations Manager, Consulting Engineer
Issue	Sediment and erosion controls
Operational policy	To prevent the displacement of sediment off-site during storm events
Performance criteria	Off-site discharges to comply with requirements and no visual sediment leaving the site
Implementation strategy	Erosion and sediment control devices shall be installed during site construction activities. These are to include: 1. Install temporary erosion and sediment controls 2. Construct roadways and road crossings, including: • Turning lane along Newrybar Swamp Road • Minimum 50m bitumen seal site driveway • Site access shakedown grid 3. Construct sediment basins 4. Construct bunds around site including containment areas and stockpile areas 5. Install drainage from these bunded areas to sediment basin 6. Construct sound mounds and re-vegetate as specified in Section 10 of this report. 7. Construct truck turning areas, office, weigh-bridge and other site facilities
Monitoring	Visual inspections to be carried out weekly and after rainfall events to ensure that erosion measures are in place, operational and suitable for the activities taking place Surface water quality to be monitored during storm events (see Section 11.3 below)
Auditing	Management shall undertake visual inspections monthly and after storm events that control measures are in place and properly maintained
Reporting	Monitoring of sediment basin pH and TSS (turbidity) to be recorded as required by the discharge licence (POEO License) Reporting required as part of annual returns
Identification of incident or failure	1. Signs of erosion on site 2. Damaged or failed erosion control devices 3. Falling water quality 4. Build-up of sediment
Corrective action	Apply remedial measures to improve sediment and erosion control measures, for example hay bales, silt fences and flocculation of sediment basins

11.3 Surface water Quality

Person responsible	Site Operations Manager, Consulting Engineer
Issue	Surface water quality
Operational policy	To establish background water quality conditions and maintain these conditions wherever practicably possible during construction
Performance criteria	All water discharged from the site will comply with the following criteria:

Water quality Parameter	Discharge Criteria	Criteria Type
pH	6.5 – 8.5	Range
TSS (Turbidity)	50mg/l (50NTU)	Maximum

Implementation strategy	• Bunding to be installed around the site to direct all site run-off to the sediment basin or pit • The sediment basin to be fitted with a valve or other means to regulate discharges. Discharges only to occur once discharge criteria is tested and met • Where pH or TSS does not meet discharge criteria, sediment basin to be limed and or flocculated until both criteria are met • During initial rainfall events (defined as first rainfall >25mm in any 24 hour period of every month) sampling is also to be undertaken from the upstream and downstream watercourse (culvert under Newrybar Swamp Road) and reported
Monitoring	Surface water monitoring will be conducted at the monitoring points for pH, EC, TSS (Turbidity), DO, oil and grease
Auditing	Management to audit water quality results to ensure all discharges comply with the performance criteria
Reporting	Results sheets to be compiled relating to water quality of upstream, downstream and sediment basin quality. These results to be kept on site for inspection by local and State government representatives Annual returns to be compiled and submitted to EPA and BSC
Identification of incident or failure	Degradation of surface water quality at the sediment basin below background levels or below pH 6.5 or greater than 8.5
Corrective action	If pH is detected outside the criteria range, then such waters will be contained and the pH adjusted to within the range 6.5-8.5 prior to release If total suspended solids exceed the water quality criteria, then water will be contained on-site for sufficient time to allow suspended solids to settle out prior to release, or treated with a flocculent

11.4 Acid Sulphate Soil Identification

Person responsible

Site Operations Manager, Consulting Engineer

Issue

Acid sulphate soil identification

Operational policy

Identify potential and actual acid sulphate soils (PASS and ASS) and determine their potential prior to treatment

Performance criteria

Treated soil will be considered effectively treated, and suitable for removal off-site, when it complies with the following:

- %SCR<0.03 AND/OR sufficient buffering capacity in the soil to prevent the generation of acid
- pH>5.5 in 1:5 water suspension

Implementation strategy

An acid sulphate soils management plan has been prepared for the site. This plan was produced in the ASSMP (Fig 4) which characterised soils into 3 classes as shown below. These classes require the following liming rates:

Rating	Liming Rate (kg $CaCO_3$/tonne)
High	13
Moderate	9
Low	4

Monitoring

Field testing is to be undertaken to assist with the PASS classification tool shown below based on the field pH and peroxide test – (Appendix 1, Acid Sulphate Soils Manual – (ASSMAC, 1998)):

	$pH_{FOX}<2$	$2 \le pH_{FOX}<3$	$3 \le pH_{FOX}<4$	$pH_{FOX} \ge 4$
pH drop>5	HIGH	HIGH	MODERATE	MODERATE
5≥pH drop>3	HIGH	MODERATE	MODERATE	LOW
3≥pH drop>1	MODERATE	MODERATE	LOW	LOW
pH drop<1	MODERATE	LOW	LOW	LOW

NB: pH drop = pH_F - pH_{FOX}

Field testing shall be used, along with the map in Attachment 1 to determine the ASS rating, and therefore the initial lime application rate

Auditing

Management to audit laboratory results to ensure all treated soils comply with the performance criteria prior to dispatch from site

Reporting

Records to be kept on-site and available for inspection

Annual returns to be compiled and submitted to EPA and BSC

Identification of incident or failure

Laboratory samples returning high %SCR values >0.03 together with insufficient acid neutralising capacity and/or, pH <5.5 in a 1:5 water suspension

Corrective action

Additional lime to be applied at a default rate of 4kg/tonne or higher if indicated in laboratory results

11.5 Acid Sulphate Soil Treatment

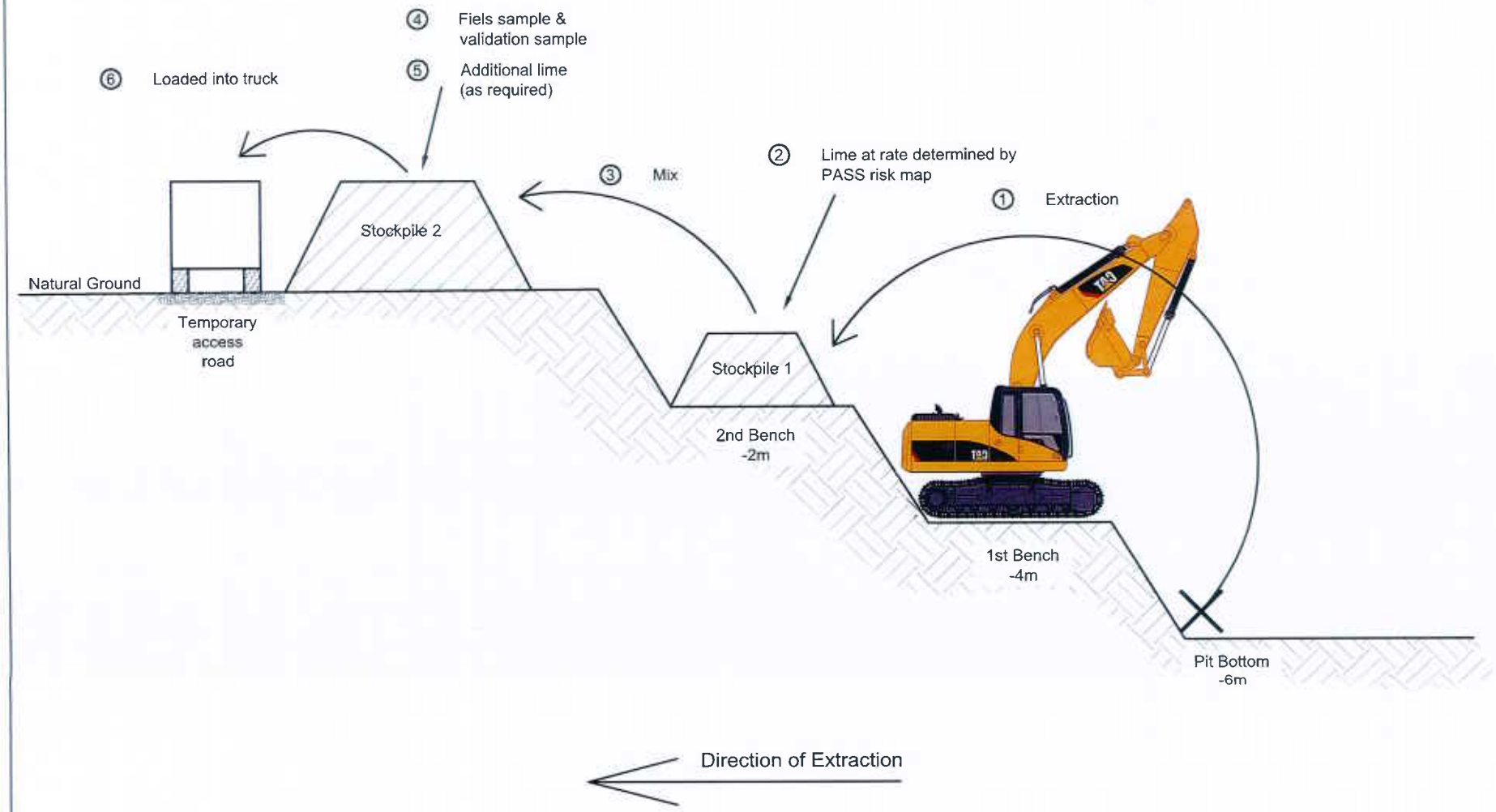
Person responsible	Site Operations Manager, Consulting Engineer
Issue	Acid sulphate soils assessment and treatment
Operational policy	Assess and treat all acid sulphate soils effectively
Performance criteria	Treated soil will be considered effectively treated, and suitable for removal off-site, when it complies with the following: • %SCR<0.03 AND/OR sufficient buffering capacity in the soil to prevent the generation of acid • pH>5.5 in 1:5 water suspension
Implementation strategy	Good quality, fine agricultural lime, with a neutralising value of 100, will be used. Lime will be applied by spreading out excavated soils in 0.3m layers over a thin bed of lime, air drying and mechanically breaking up clods. The appropriate lime quantity will be applied given the identified rating and thoroughly mixed. Material will be stockpiled and validation testing will be undertaken prior to removal from site
Monitoring	On-site validation testing is required at the following rates: • 0 -2m below surface: One (1) sample per 2500m^3; and • Below 2m: One (1) sample per 1000m^3
Auditing	Management to audit laboratory results to ensure all treated soils comply with the performance criteria prior to dispatch from site.
Reporting	Records to be kept on-site and available for inspection Annual returns to be compiled and submitted to EPA and BSC
Identification of incident or failure	Laboratory samples returning high %SCR values >0.03 together with insufficient acid neutralising capacity and/or, pH <5.5 in a 1:5 water suspension shall be re-limed and revalidated
Corrective action	Additional lime to be applied at a default rate of 4kg/tonne or higher if indicated in laboratory results

Attachments

Attachment 1	ASS Management Plan and Map
Attachment 2	Proposed Extraction Plans
Attachment 3	Staging and Rehabilitation Plans
Attachment 4	Sediment Basin Sizing Calculations

ATTACHMENT 1

Attachment 1
ASS Management Plan



PROJECT:

Environmental Management Plan

Watsons Sand Quarry,
Newrybar Swamp Road
Lennox Head

TITLE:

ASS Management Plan

CLIENT:

Ballina Sands

ARDILL PAYNE & PARTNERS
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Website: www.ardillpayne.com.au

Scale at A4 NTS	Datum AHD
Design JF	Date 10-5-12
Drawn RMcG	File 6542 ASS MANAGEMENT PLAN
Dwg No.	Job No. 6542

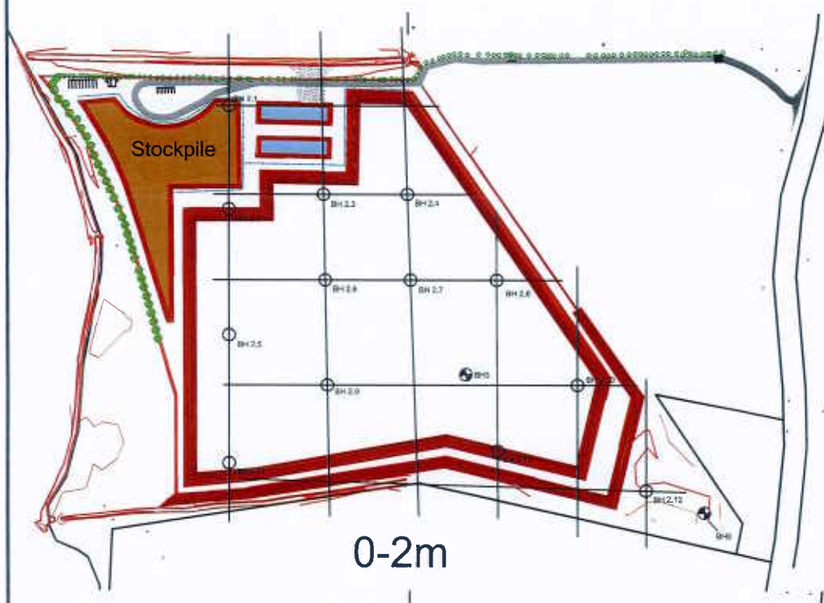
Existing Test borehole locations

Borehole for ASS testing

High risk/severity PASS ~ 13Kg/tonne

Moderate risk/severity PASS ~ 9Kg/tonne

low risk/severity PASS ~ 4Kg/tonne



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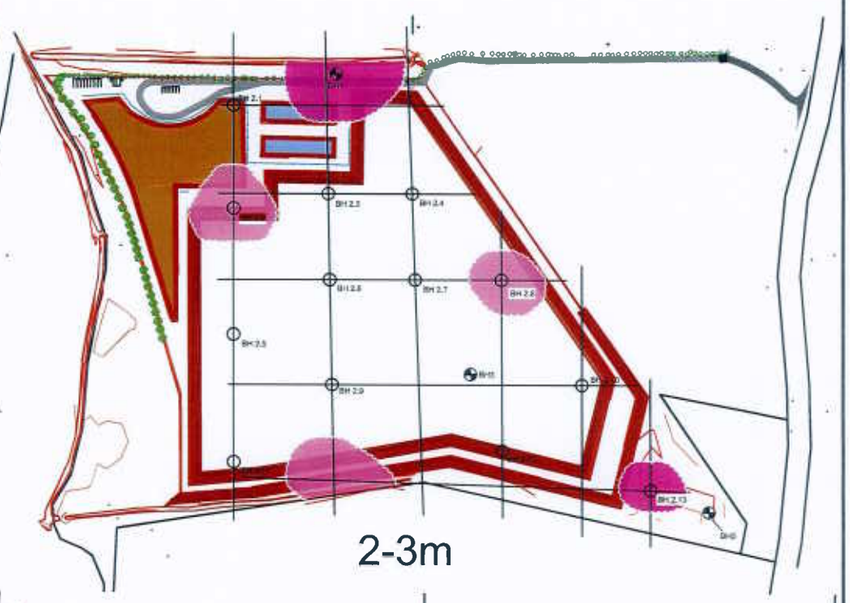

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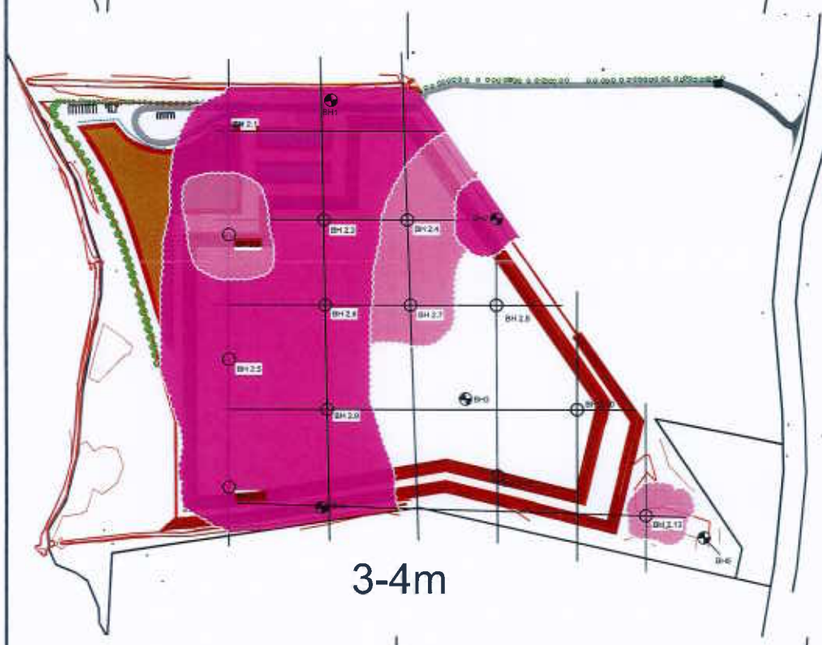
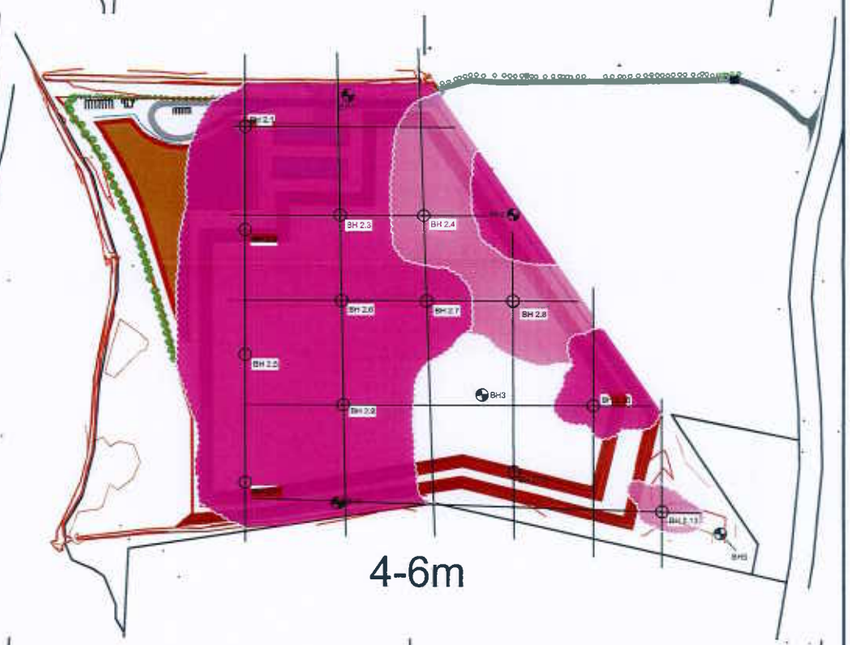
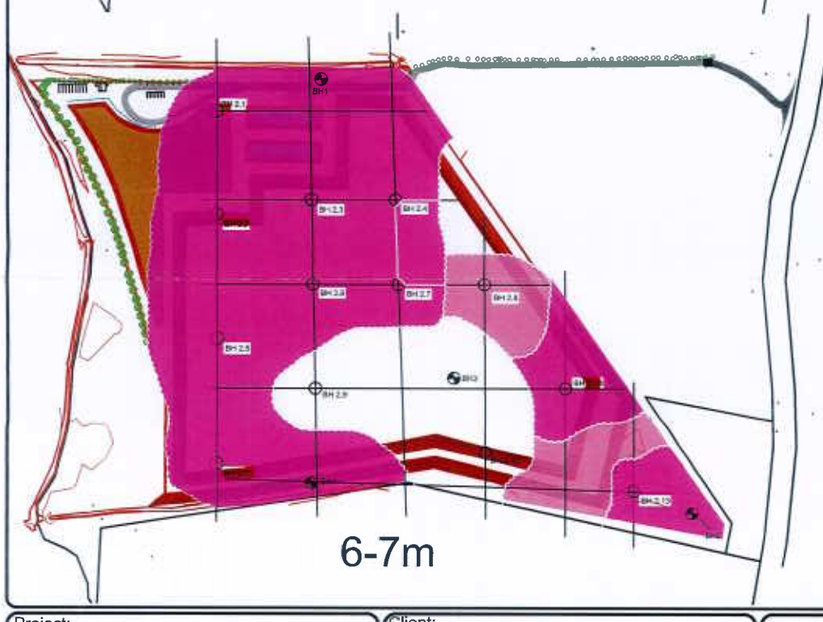


3-4m



4-6m



6-7m

7-8m

Project:
Lot 32 DP 1151612
Newrybar Swamp Rd
Lennox Head

Client: Ballina Sands

Title:
PASS Risk/Severity Map for ASS Management During Operations

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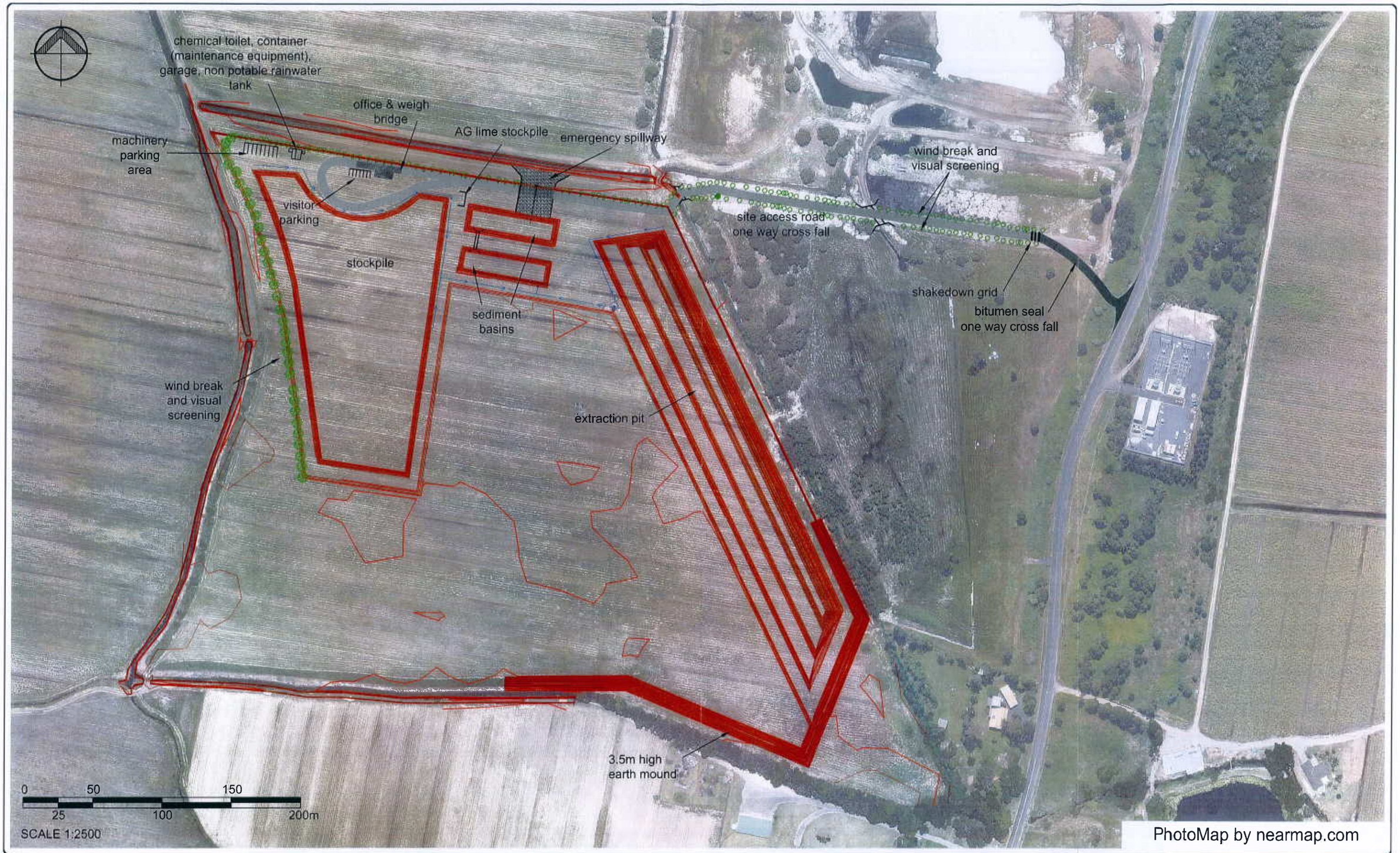
Design	MP	Scale at A3	NTS
Drawn	RMcG	Datum	N/A
Checked		Date	29/08/12
Filename	6542w-PASS MAP 29-8-2012		
Job No.	6542	Dwg. No.	FIG4
		Issue	

ATTACHMENT 2

Attachment 2
Proposed Extraction Plan



Project: Lot 32 DP 1151612 Newrybar Swamp Road Lennox Head	Client: Ballina Sands Title: Proposed Extraction Plan Stage 1	**ARDILL PAYNE & PARTNERS** Consulting Civil & Structural Engineers Project Managers Town Planners & Surveyors 79 Tamar Street P.O. Box 20 BALLINA NSW 2478 Telephone: 02 6686 3280 Facsimile: 02 6686 7920 Email: info@ardillpayne.com.au Website: www.ardillpayne.com.au

Design JF		Scale at A3 1:2500	
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Date 14.01.2013		Filename 6542 2nd PIT	
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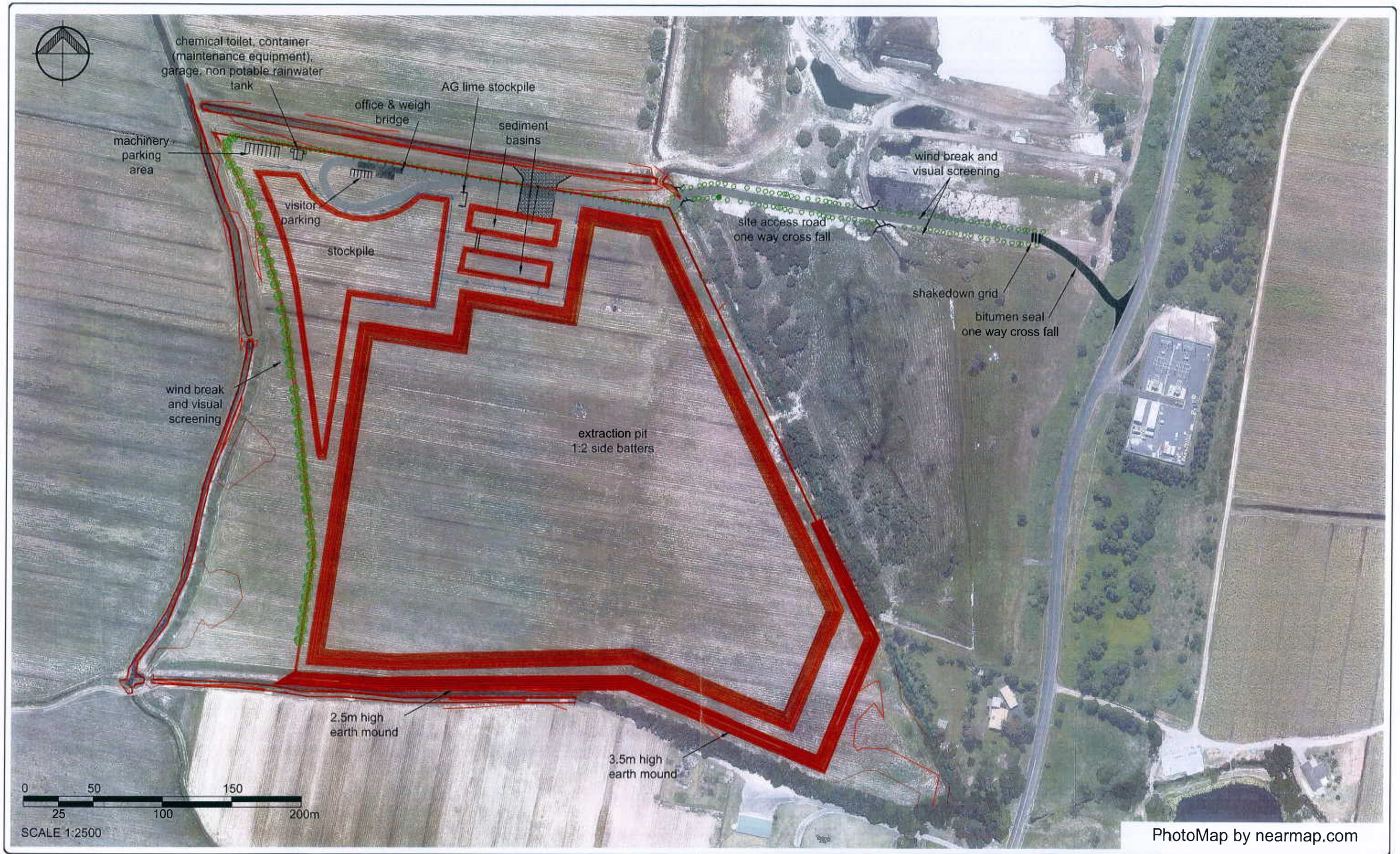
Job No. 6542		Dwg. No. FIG 1	Issue



Project:

Lot 32 DP 1151612
Newrybar Swamp Road
Lennox Head

Client: Ballina Sands

Title:

Proposed Extraction Plan
Final Stage

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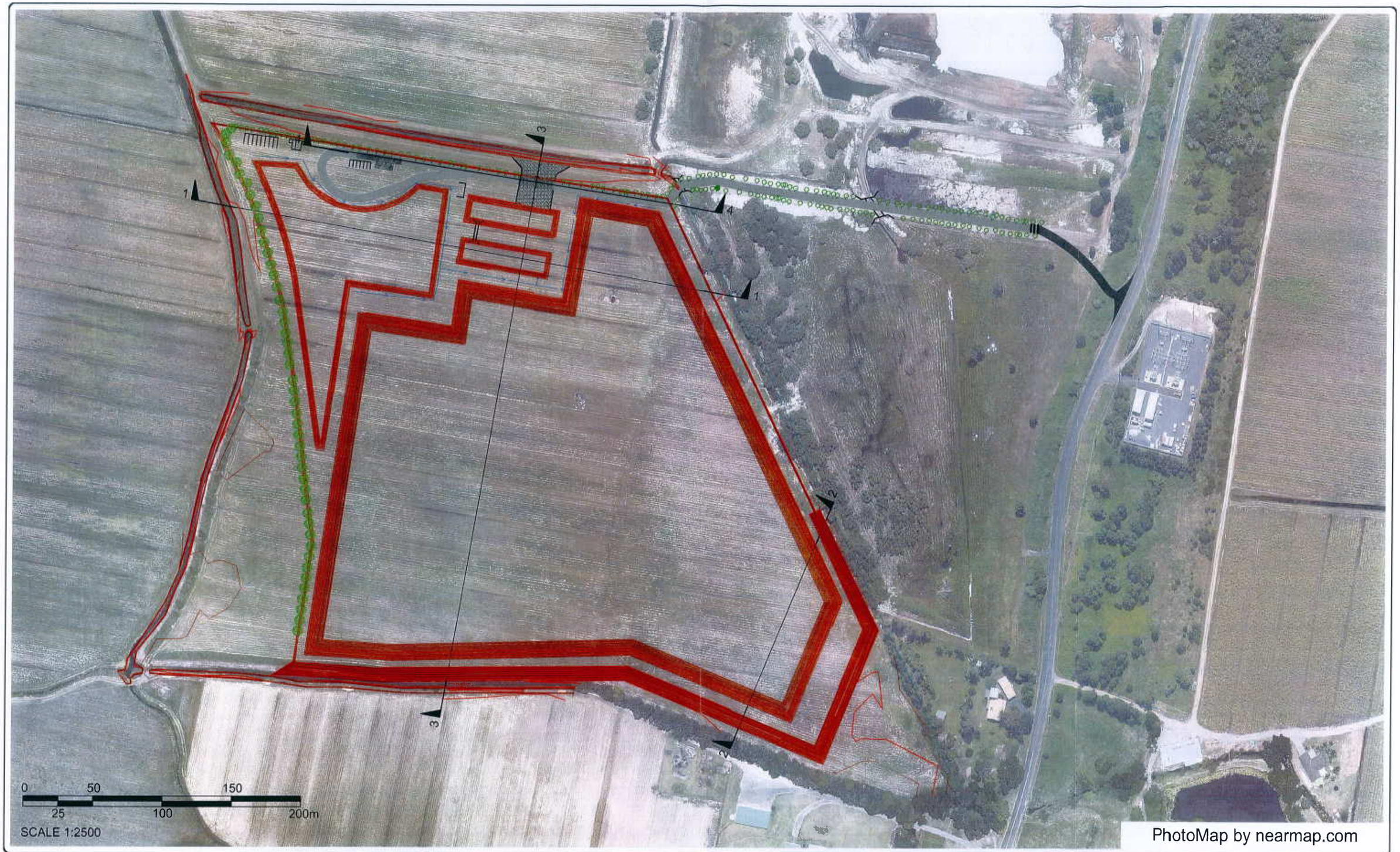

Project:
Lot 32 DP 1151612
Newrybar Swamp Road
Lennox Head

Do not scale drawing. Use written dimensions only

Client: Ballina Sands

Title:
Proposed Extraction Plan
Section Map

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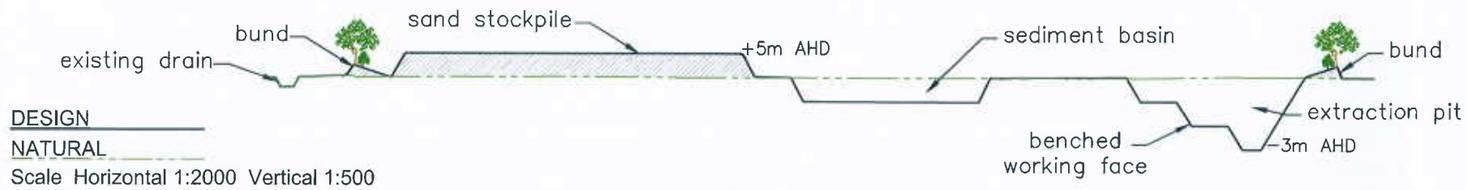
Design	JF	Scale at A3	1:2500
Drawn	RMcG	Datum	A.H.D
Date	14.01.2013	Filename	6542 2nd PIT
Checked		Approved	
Job No.	6542	Dwg. No.	FIG 3
		Issue	



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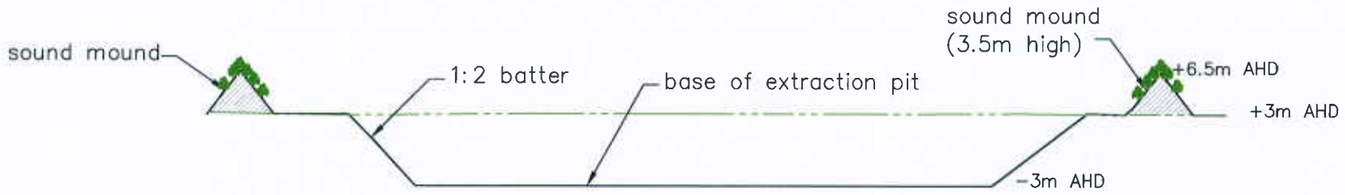
Cross Section 1-1



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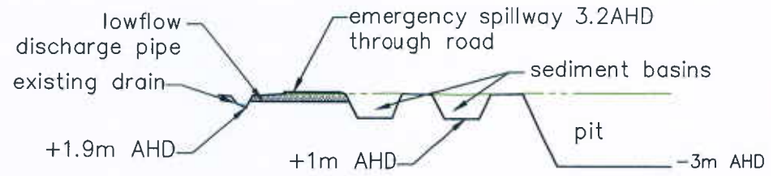
Cross Section 2-2



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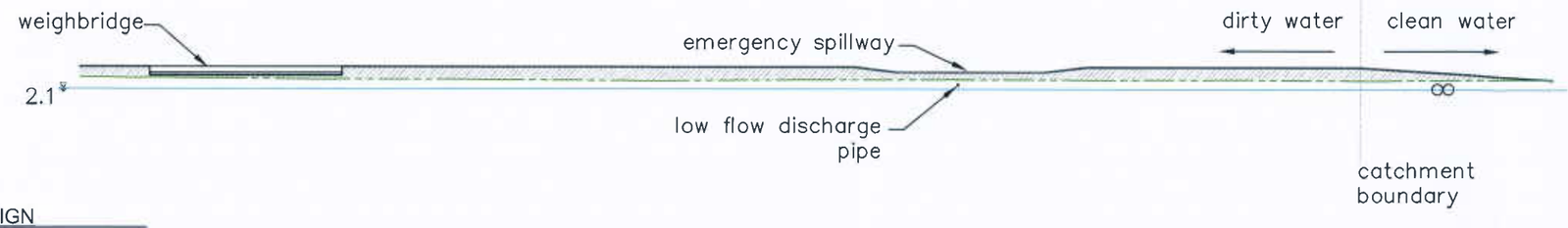
Cross Section 3-3



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INDICATIVE WATER LEVEL
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Cross Section 4-4

Project:
Lot 32 DP 1151612
Newrybar Swamp Road
Lennox Head

Client: Ballina Sands

Title:
Proposed Extraction Plan
Cross-Sections

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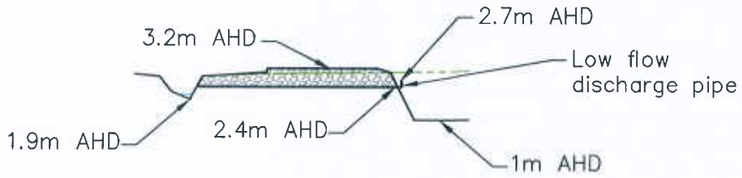
Design	JF	Scale at A3	AS SHOWN
Drawn	RMcG	Datum	A.H.D
Date	14.01.2013	Filename	6542 2nd PIT
Checked		Approved	
Job No.	6542	Dwg. No.	FIG 4
		Issue	



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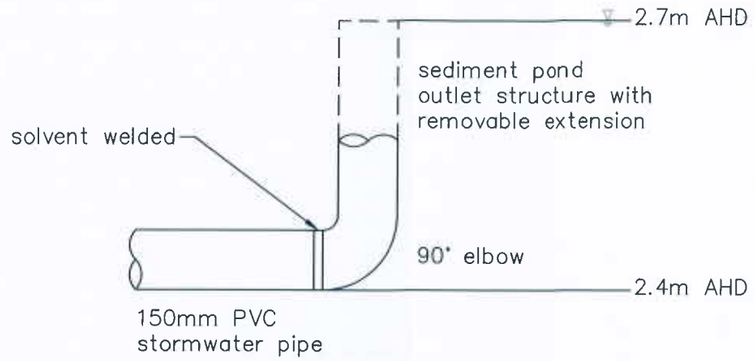
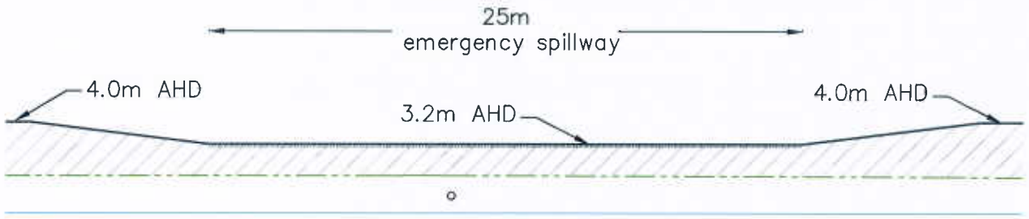
Section 1-1



Low Flow Discharge Pipe Detail



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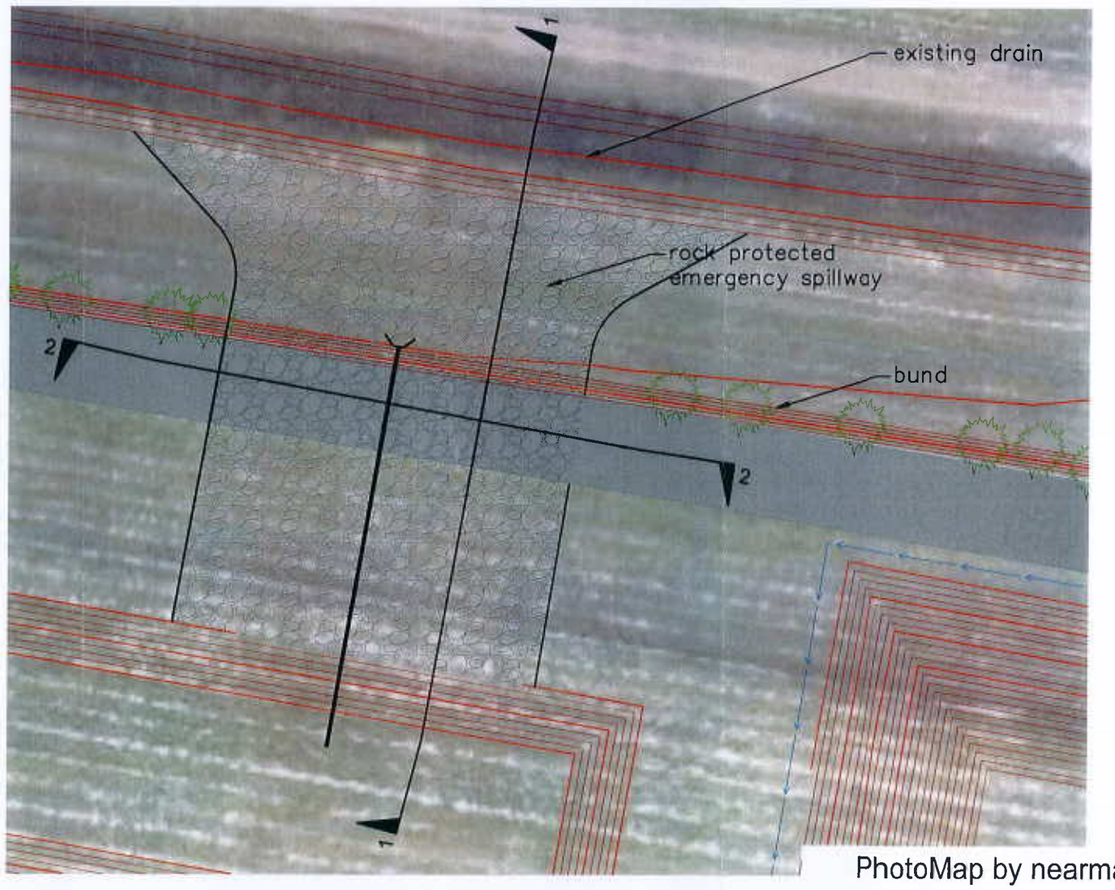
Section 2-2



PhotoMap by nearmap.com

Project:
Lot 32 DP 1151612
Newrybar Swamp Road
Lennox Head

Do not scale drawing. Use written dimensions only

Client: Ballina Sands

Title:
Proposed Extraction Plan
Sediment Basin Outlet

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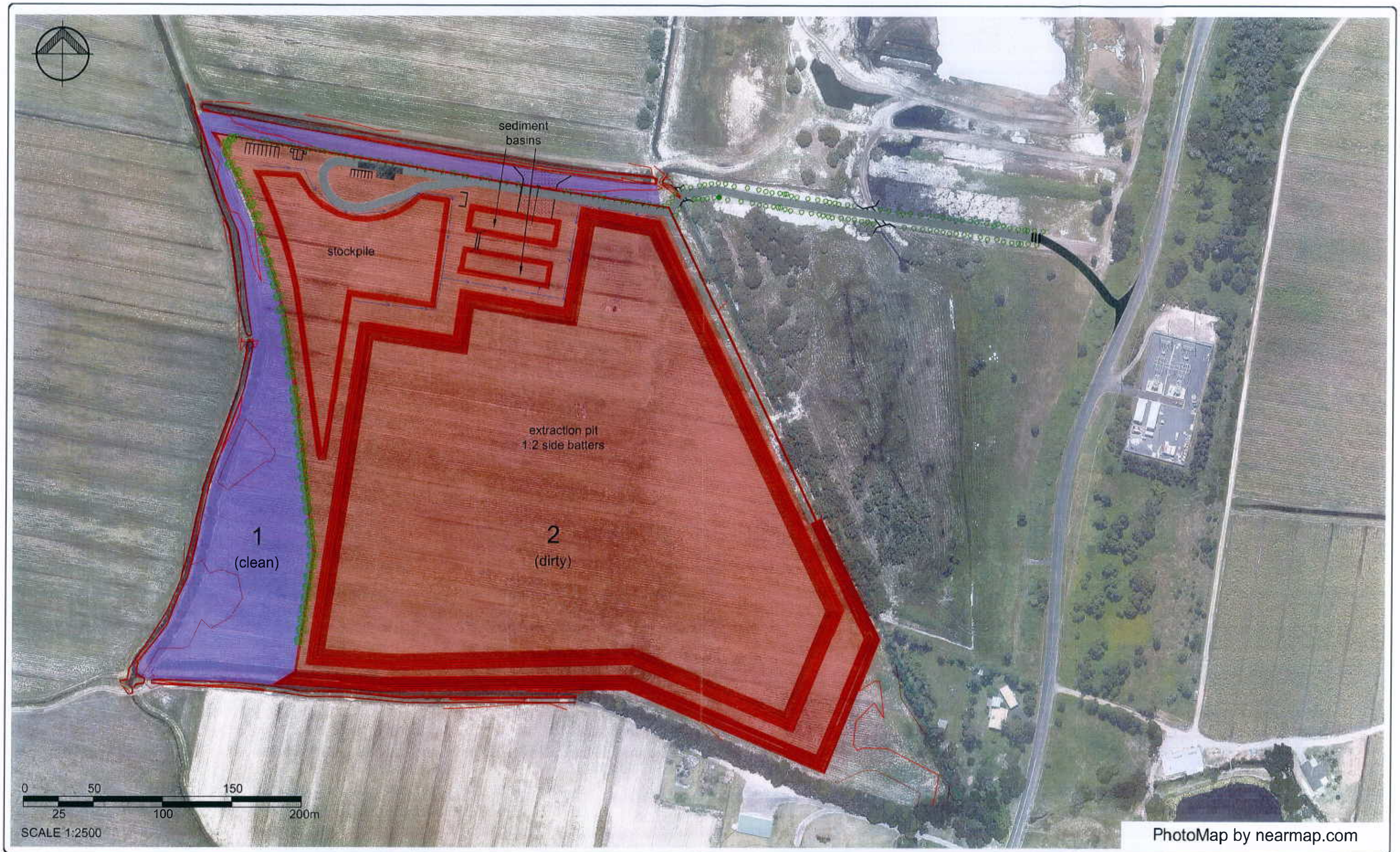
Design JF		Scale at A3 NTS	
Drawn RMcG		Datum A.H.D	
Date 14.01.2013		Filename 6542 2nd PIT	
Checked		Approved	
Job No. 6542	Dwg. No. FIG 5		Issue



Project:

Lot 32 DP 1151612
Newrybar Swamp Road
Lennox Head

Do not scale drawing. Use written dimensions only

Client: Ballina Sands

Title:

Proposed Extraction Plan
Final Stage

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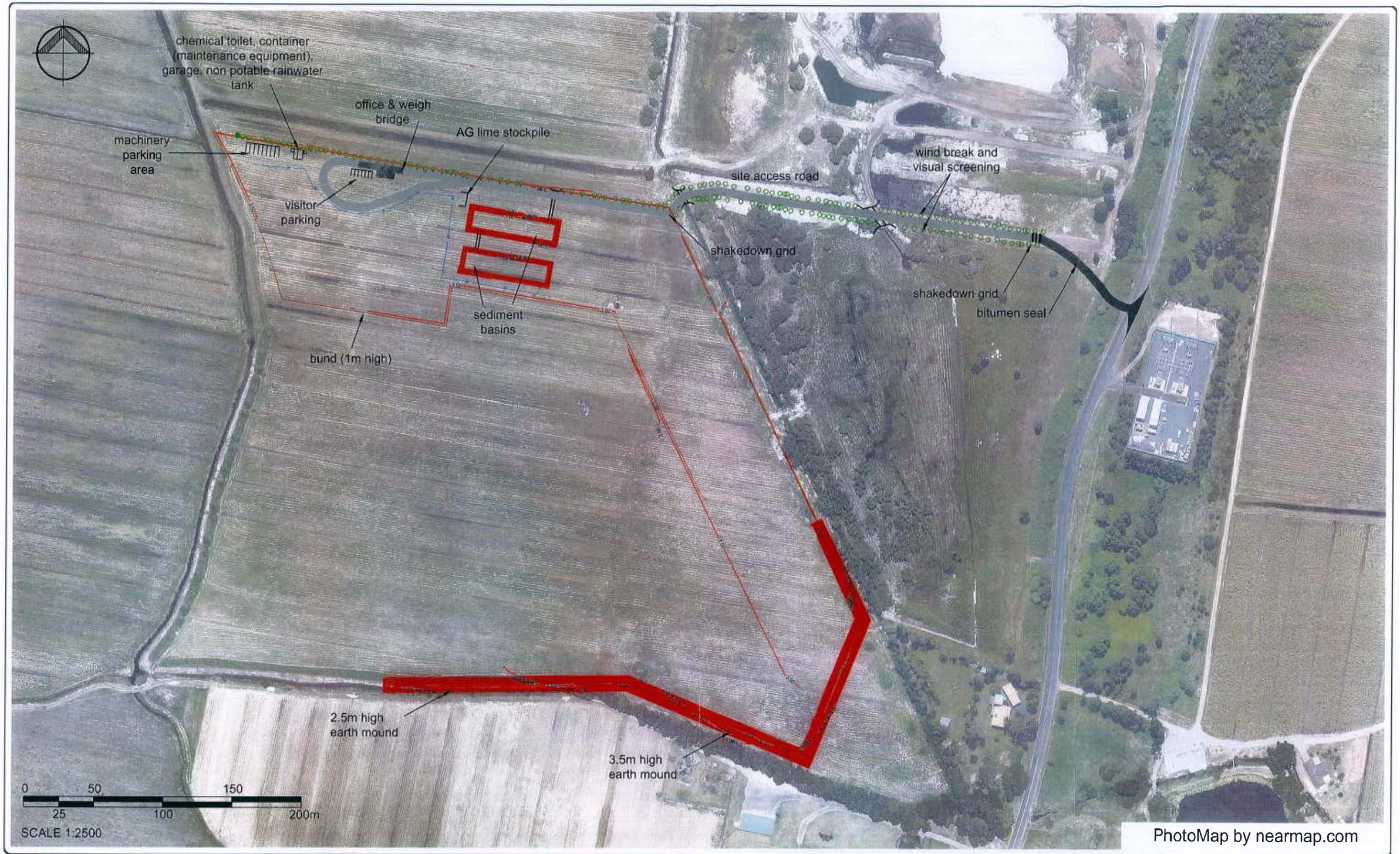
Design	JF	Scale at A3	1:2500
Drawn	RMcG	Datum	A.H.D
Date	14.01.2013	Filename	6542 2nd PIT
Checked		Approved	
Job No.	6542	Dwg. No.	FIG 6
		Issue	

ATTACHMENT 3

Attachment 3
Staging and Rehabilitation Plan



Project:

Lot 32 DP 1151612
Newrybar Swamp Road
Lennox Head

Client: Ballina Sands

Title:

Staging Plan
Stage 1: Site Establishment & Setup

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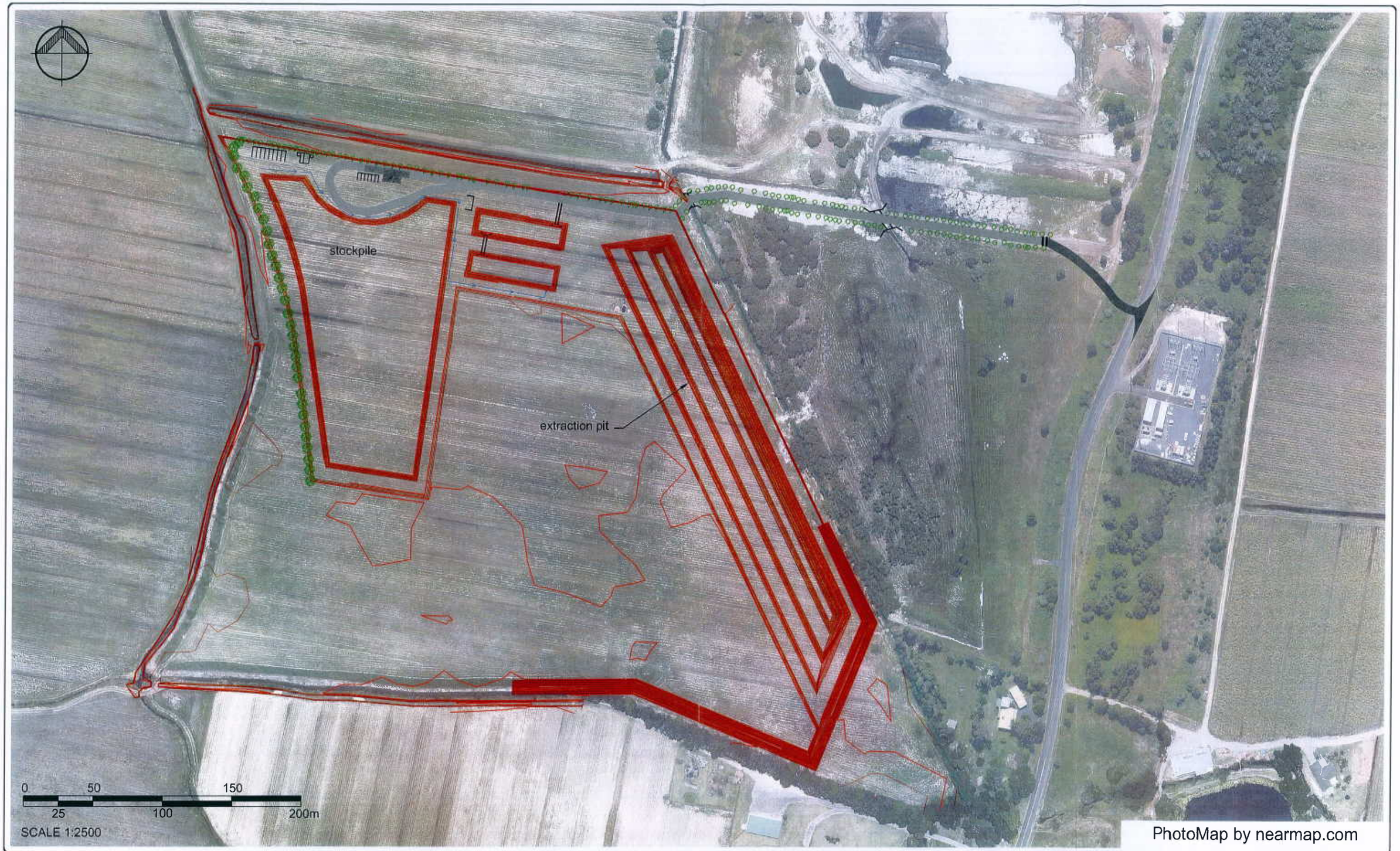
Design	JF	Scale at A3	1:2500
Drawn	RMcG	Datum	A.H.D
Date	14.01.2013	Filename	6542 Rehab Plans
Checked		Approved	
Job No.	6542	Dwg. No.	STAGE1
		Issue	



Project:

Lot 32 DP 1151612
Newrybar Swamp Road
Lennox Head

Do not scale drawing. Use written dimensions only

Client: Ballina Sands

Title:

Staging Plan
Stage 2: Commence Extraction

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Design	JF	Scale at A3	1:2500
Drawn	RMcG	Datum	A.H.D
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Job No.	6542	Dwg. No.	STAGE2
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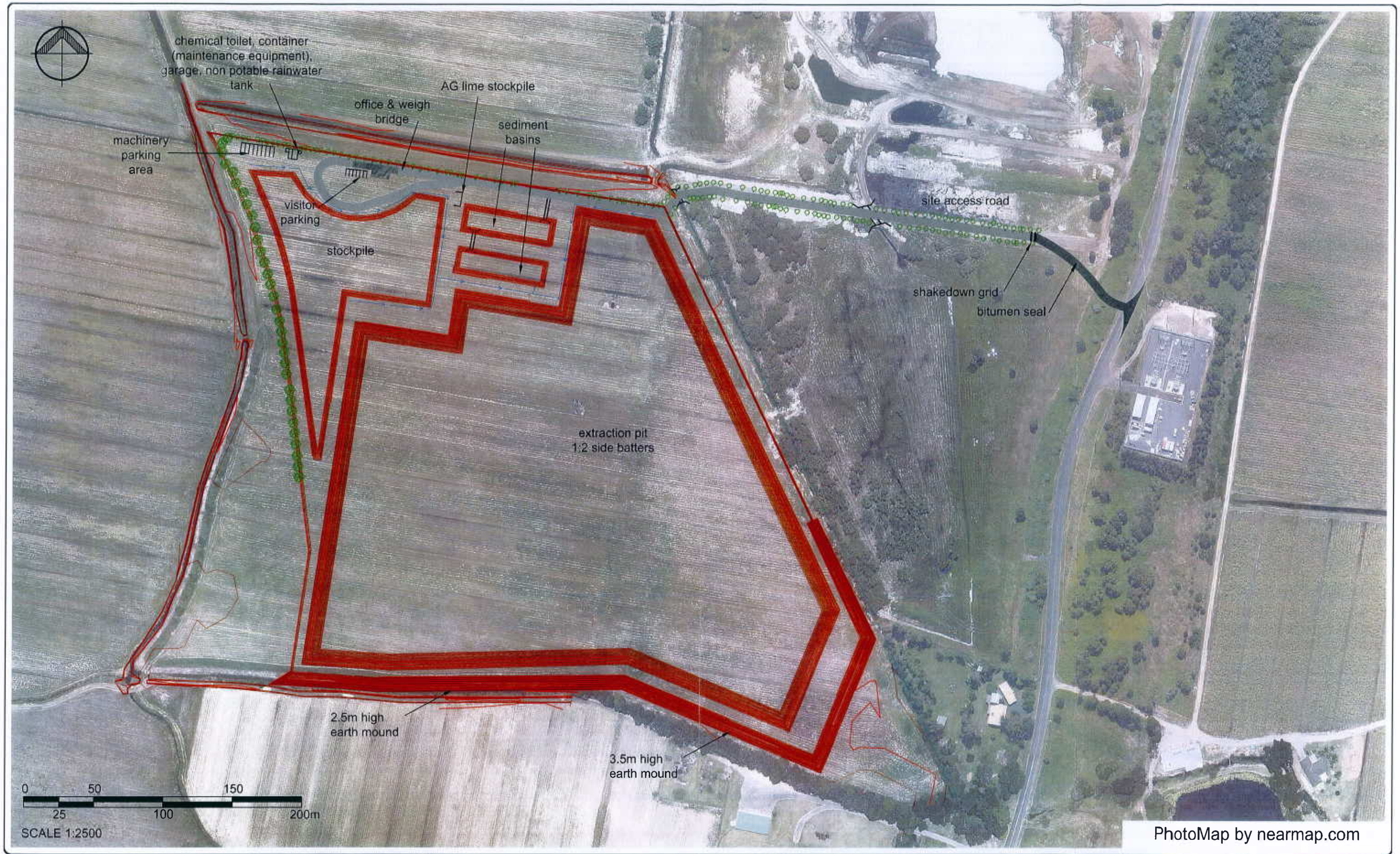

Project:

Lot 32 DP 1151612
Newrybar Swamp Road
Lennox Head

Client: Ballina Sands

Title:

Staging Plan
Stage 3: Conclusion of Extraction

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Design	JF	Scale at A3	1:2500
Drawn	RMcG	Datum	A.H.D
Date	14.01.2013	Filename	6542 Rehab Plans
Checked		Approved	
Job No.	6542	Dwg. No.	STAGE3
		Issue	

Project:

Lot 32 DP 1151612
Newrybar Swamp Road
Lennox Head

Client: Ballina Sands

Title:

Staging Plan
Stage 4: Final Rehabilitation & Revegetation of Site

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Date	14.01.2013	Filename	6542 Rehab Plans A
Checked		Approved	
Job No.	6542	Dwg. No.	STAGE4
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ATTACHMENT 4

Attachment 4
Sediment Basin Sizing
Calculations

Sediment Basins

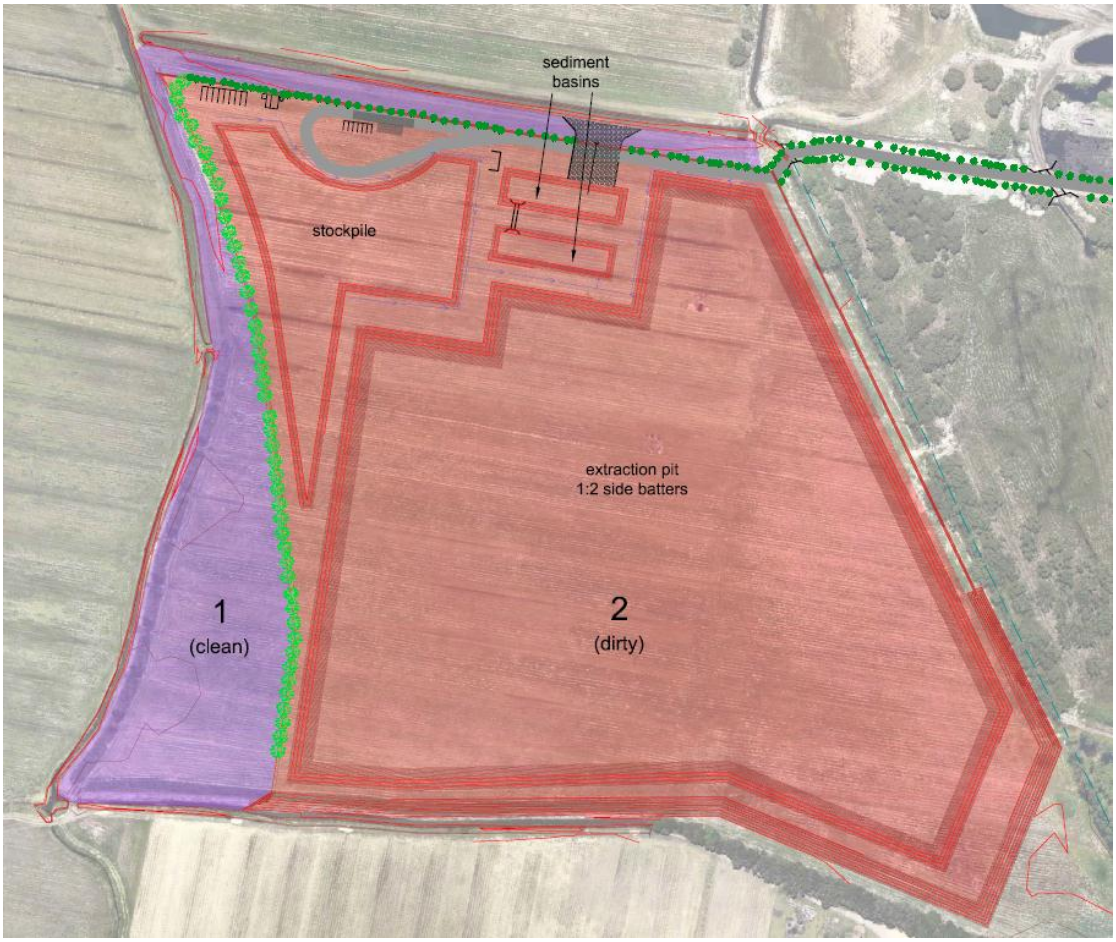


Figure 22: Indicative Layout

- Stockpile, office and final stage pit extent area (12.5ha)
- Assumed K-factor of: 0.020
- Calculated soil loss: 1.188 tonnes/ha/year

Site Characteristics & Constraints

The site constraints and characteristics criteria are presented in **Table 1** below:

Table 9: Constraints and characteristics

Constraint/Characteristic	Value
Rainfall	R-factor = 5500 (from **vol. 1**: appendix B) # 1860.6mm mean annual rainfall (from Bureau of Meteorology station 058198)
Rainfall zone	Zone 1 (from **vol. 1** figure 4.9)
Slope gradients	0-1% Flat ground, and an elevation of 2.75m AHD to 3.00m AHD
Potential erosion hazard	Low (from **vol. 1**: figure 4.6)
Soil erodibility	Generally low erodibility, K-factor of 0.020
Calculated soil loss	1.188 tonnes/ha/yr
Soil loss class	Class 1 (from **vol.1**: table 4.2)
Soil texture group	Type F
Soil dispersiveness	Very low potential for dispersive soils.
Runoff coefficient	0.5 (adopted)
Disturbed site area	12.5ha

#**vol.1** = reference to Landcom 2004. Managing urban stormwater: soils and construction, volume 1, 4th edition, Sydney.

Soil Loss Calculation

Soil loss is calculated using the Revised Universal Soil Loss Equation (RUSLE) as detailed in Appendix A of Managing urban stormwater: soild and construction, Volume 1, 4th Edition (Landcom 2004). This publication is referred to as vol.1 throughout this ESCP.

The RUSLE values used are:

- R: 5500 (from table 1)
- K: 0.020 (from table 1)
- LS: 0.27 (assuming slope length of 300m, and gradient of 1%)
- P: 0.8 (from **vol.1**: table A2 of Appendix A)
- C: 0.05 (from **vol.1**: table A5 of Appendix A)

Therefore, the soil loss (A) for the site follows:

A = R K LS P C

= 5500 x 0.020 x 0.27 x 0.8 x 0.05

= 1.188 tonnes/ha/yr

Sediment Basin Sizing

The design of a sediment basin is such that suspended solids and coarse sediment are able to settle out of suspension as the water flows towards the basin outlet. The capacity of a sediment basin is the combination of two components:

- the settling zone, in which water is stored allowing the settlement of suspended solids
- the sediment storage zone, where deposited sediment is stored until the basin is cleaned

Landcom's *'Managing Urban Stormwater: Soils and Constructions' Volume 1 (The Blue Book)* provides formulae to determine the required sediment basin size given a specific area and soil type. The basin has been sized using the Type F soil equations. The settling zone volume is established using the following equation:

$$\text{Volume} = 10 \times C_v \times A \times R_{(Y\ \%ile,\ 5\ day)}$$

Where:

- 10 is a conversion factor
- C_v is a volumetric run-off coefficient obtained through charts
- A is the catchment area of the basin (hectares)
- $R_{(Y\ \%ile,\ 5\ day)}$ is the 5-day rainfall depth (mm) that is not exceeded in y percent of rainfall events. 5-day 85%ile event has been used for calculations, obtained through charts.

The volume required for the sediment storage zone is provided in Table 10 below.

Table 10: Minimum Volumes Required for the Sediment Basin

	Settling Zone (m^3)	Sediment Zone (m^3)	Total (m^3)
Overall Sediment Basin	3765	1885	5650
Sediment Basin 1	1885	945	2825
Sediment Basin 2	1885	945	2825

Sediment Basin Layout

The sediment basins are designed to contain all the run-off from the 'dirty' water site. Refer to Figure 23 and Figure 24 below for indicative sediment basin layout.

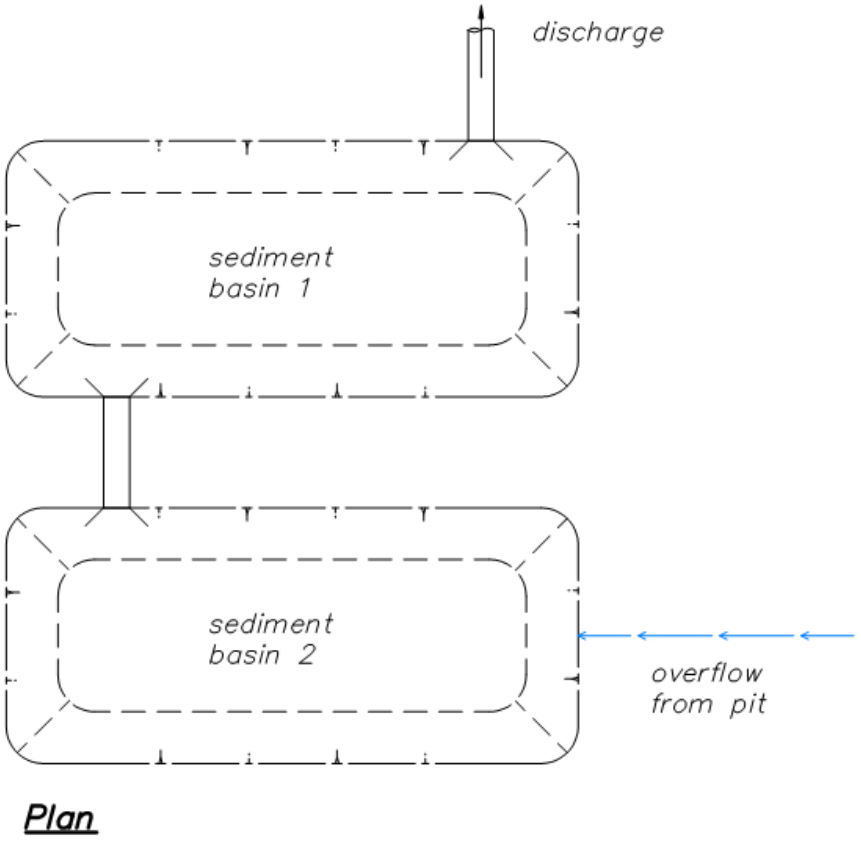


Figure 23: Sediment Basin Plan Layout

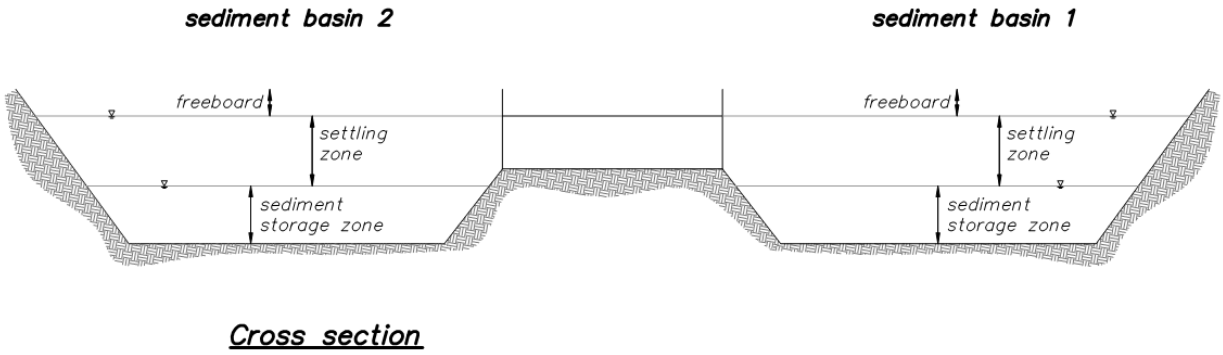


Figure 24: Sediment Basin Cross Section

Haul Road

The haul road will be constructed to ensure surface drainage is optimised and stabilised, thereby reducing road-side erosion and sedimentation. Check dams will be installed at regular intervals along the haul road drains to slow down concentrated flows, thereby reducing scour and erosion.

Reuse

Unsealed roads should be regularly watered at a rate of 1-2 litres/m^2 during high traffic loads. Stockpiles may require watering to reduce dust generation during wind events in excess of 10m/s.

Maintenance

The site manager will undertake regular general environmental inspections to ensure that all the water management controls are functioning as designed and required. Site drainage and sediment control structures will be inspected regularly after storm events (>25mm in 24 hours) to check for scouring of diversion drains and accumulation of materials in sediment traps.

Controls

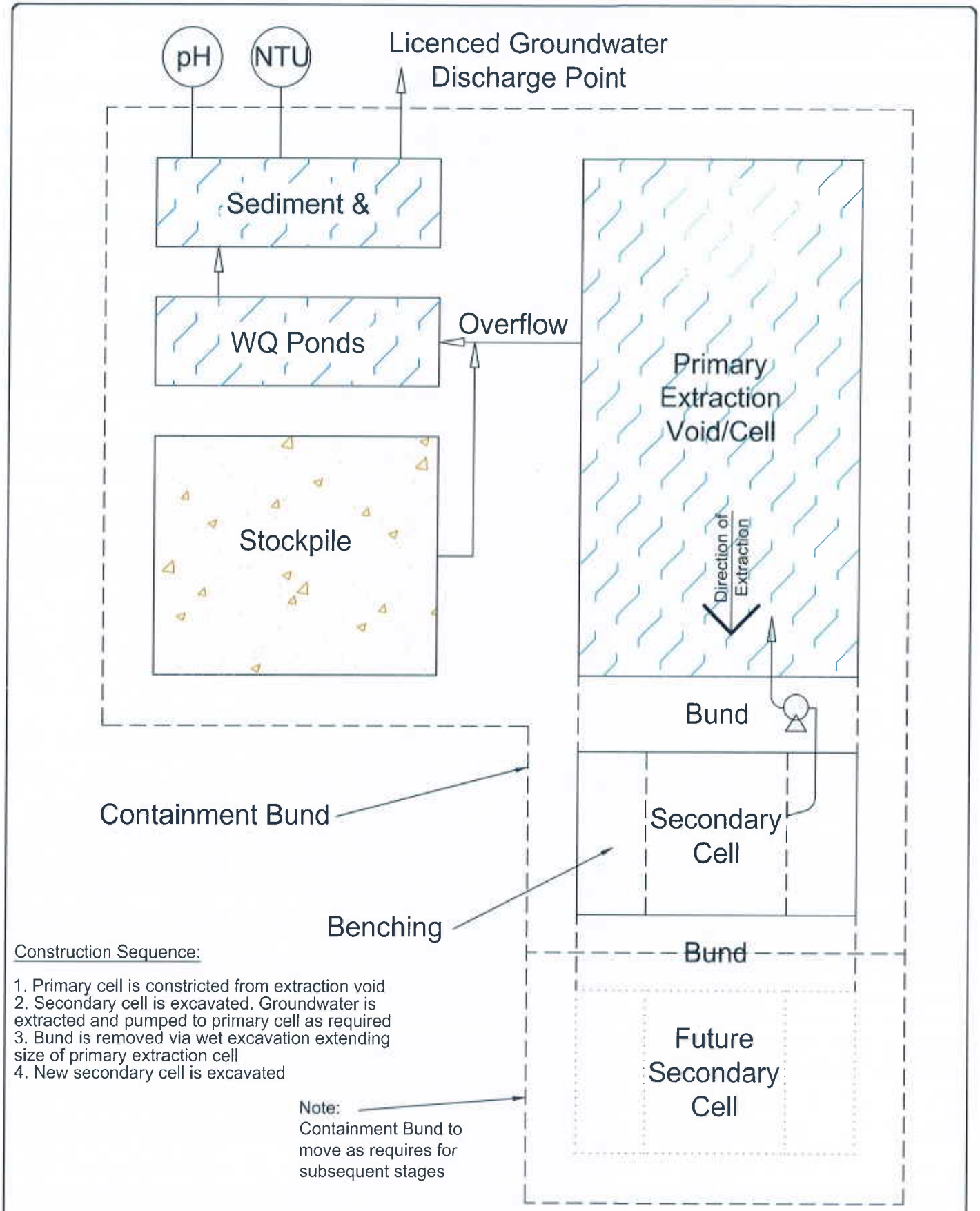
Where these are not functioning correctly, the surface will be restored to meet the required standard. Where significant erosion is occurring regularly, APP is to be contacted and additional controls will be constructed.

Sediment Basin

Regular visual checks will be made to ensure that there is no noticeable increased discolouration or sediment build up in the dams and they remain in a stable condition. A stake shall be installed to mark the sedimentation volume that will require removal.

Haul Road

Will be visually inspected to ensure that the appropriate mitigation measures are functioning to convey the surface flows from the road and work areas without causing erosion to the adjacent land. Where significant erosion is occurring regularly, additional controls will be constructed.



Construction Sequence:

1. Primary cell is constricted from extraction void
2. Secondary cell is excavated. Groundwater is extracted and pumped to primary cell as required
3. Bund is removed via wet excavation extending size of primary extraction cell
4. New secondary cell is excavated

Do not scale drawing. Use written dimensions only

Client: Ballina Sands

Title: Groundwater Management

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ENGINEERS PLANNERS SURVEYORS
ENVIRONMENTAL PROJECT MANAGEMENT
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SOUTH BRISBANE 89 Grey Street Ph. 07 3123 6675
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Job No.	6542w	Dwg No.	FIG.1
		Rev.	