

GALES-KINGSCLIFF

PTY LTD
ABN: 75 093 540 080

Landscape Management Plan

for the

Cudgen Lakes Sand Quarry

Approved

Project Approval No. 05_0103B

Prepared by:



R.W. CORKERY & CO. PTY. LIMITED

In conjunction with:



WETLANDCARE AUSTRALIA

July 2016

- Notes:
1. References to the conditional requirements referred to throughout this report relate to the Project Approval issued on 16 June 2009 and modified 19 February 2016.
 2. This document makes reference to a range of government agencies which were in existence at the time of the document's approval. In recognition of the fact that the names of government agencies may change throughout the life of the Cudgen Lakes Sand Quarry, a reference should be made to the prevailing name of the respective agency at the relevant time.

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Prepared for:

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Document Control

Document Title	Landscape Management Plan			
Document Number	617/10			
Revision	Issue Date	Originator	Reviewed	Approved
Version 1	28/02/14	SH	NSW P&I	Comments (01/04/14)
Version 2	04/04/14	SH	NSW P&I	-
Version 3	29/06/16	RWC	NSW DPE	13/07/16
Next Review Due	July 2017			

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1. INTRODUCTION

This Landscape Management Plan for the Cudgen Lakes Sand Quarry (“the quarry”) has been prepared in accordance with *Conditions 3(28 to 30)*, of Project Approval 05_0103B and relevant guidelines.

In accordance with *Condition 3(28)* this Landscape Management Plan incorporates:

- a Rehabilitation Management Plan (Section 2); and
- a Long Term Management Plan (Section 3).

These plans have been prepared in conjunction with qualified consultants in the fields of hydrology and coastal engineering and wetlands ecology and in consultation with Tweed Shire Council, NSW Office of Water (now DPI Water) and NSW Fishing and Aquaculture (now DPI Fisheries). It is noted that the Strategic Development Plan has been developed in conjunction with Allen Jack and Cottier (architects) and will be reviewed closer to site closure¹.

The Landscape Management Plan builds upon and refines the rehabilitation and landscape concepts in the 2008 *Environmental Assessment* and *Specialist Consultant Studies Compendium* prepared for the quarry and has been prepared for the life of the quarry. However, the Landscape Management Plan will be reviewed periodically (as a minimum following each independent audit) and, if required, updated to reflect any changes to rehabilitation procedures or the intended long term management of the site post closure. In particular, it is noted that the Long Term Management Plan is necessarily conceptual with further detail intended to be included closer to closure of the site. Any updates to the Landscape Management Plan will be submitted to the Department of Planning and Environment (DPE) for endorsement.

The approach to implementing the Landscape Management Plan will directly reflect the establishment and development stages for the quarry and the intended uses of the sand extracted from the quarry. In the event the need for fill sand is not present in Year 1, the quarry would simply be established as a source of sand for the construction industry. Notwithstanding this possibility, the Landscape Management Plan presents the relevant plans assuming all activities commence and achieve maximum production in a comparatively short period of time. It is similarly recognised that the dredging operation to supply fill sand would be an intermittent activity undertaken on a campaign basis. Therefore, planning for rehabilitation activities will need to reflect this intermittent style of operation.

Gales-Kingscliff Pty Ltd intends to review its extraction and rehabilitation plans annually and present updated plans in each Annual Report.

¹ Parts of the Strategic Development Plan are currently in review by Roberts Day and Tweed Shire Council to prepare a Kingscliff Locality Plan. Approved updates to the Strategic Development Plan will be included within the Landscape Management Plan during future reviews.



2. REHABILITATION MANAGEMENT PLAN

2.1 INTRODUCTION

Condition 3(29) of Project Approval 05_0103B requires that the Rehabilitation Management Plan include:

- a) the rehabilitation objectives for the site and pipeline corridors (see Section 2.2);
- b) a description of the short, medium, and long term measures that would be implemented (see Section 2.3) to:
 - rehabilitate and stabilise the site and pipeline corridors; and
 - manage the restored vegetation and wetland habitat established on the site;
- c) detailed performance and completion criteria for the rehabilitation and stabilisation of the site (see Section 2.5);
- d) consideration of outcomes if Virgin Excavated Natural Material (VENM) material received for backfilling is less than optimum (see Section 2.4.6);
- e) a detailed description of how the performance of the rehabilitation of the site would be monitored over time to achieve the stated objectives (see Section 2.6);
- f) a detailed description of what measures would be implemented over the next 5 years to rehabilitate and manage the landscape of the site and revegetation areas including the procedures to be implemented for (see Section 2.3):
 - progressively rehabilitating and stabilising areas disturbed by quarrying;
 - implementing revegetation and regeneration within the disturbance areas (see also Section 2.4);
 - protecting areas outside the disturbance areas, including vegetation adjoining pipelines (see also Section 2.4.7);
 - managing impacts on fauna, including measures to enable Wallum Froglet to cross the eastern pipeline (see also Section 2.4.7);
 - controlling terrestrial and aquatic weeds and pests (see also Section 2.4.8);
 - controlling access; and
 - reducing the visual impacts of the quarry (see also Section 2.4.3);
- g) a description of the potential risks to successful rehabilitation and/or revegetation, and a description of the contingency measures that would be implemented to mitigate these risks (see Section 2.7); and
- h) details of who is responsible for monitoring, reviewing, and implementing the plan (see Section 2.8).



2.2 REHABILITATION AND CLOSURE OBJECTIVES

In the short term, the objectives of rehabilitation will be to:

- stabilise all earthworks, drainage lines and disturbed areas no longer required for quarry-related activities in order to minimise the potential for erosion and sedimentation; and
- reduce the visibility of the activities from adjacent properties and the local road network through establishment of a vegetative screen and landscaping of the eastern and southern sides of the initial processing area.

The medium term objectives for rehabilitation are to continue progressive rehabilitation with rehabilitation progressing towards meeting long term rehabilitation objective.

The long term rehabilitation and closure objectives for all areas disturbed in association with the quarry are to:

- provide a low maintenance, geotechnically stable landform that would provide for planned recreational uses including sporting fields and recreational lake;
- ensure the final landform is free of contaminants, and therefore poses no ongoing pollution hazard to the local environment;
- ensure that final landform and use does not pose unacceptable public health or safety hazard; and
- provide wetlands, surrounding parklands and facilities that would complement the broader development plans of Gales-Kingscliff Pty Ltd and its related companies.

The principal objective for the rehabilitation of the pipeline corridors is to remove the pipelines and stabilise any ground disturbance using an appropriate groundcover.

2.3 REHABILITATION PLAN

2.3.1 Introduction

The rehabilitation plan has been divided into a detailed short term (Years 1 to 5) plan and medium and long term plan. Sub-sections 2.3.2 to 2.3.6 provide a summary of the operational and rehabilitation activities at yearly intervals following the commencement of operations assuming extraction occurs at maximum production rates and receipt of maximum volumes of Virgin Excavated Natural Materials (VENM). In the event maximum extraction or VENM rates do not occur, it is intended that the activities will continue to progress as shown but at a slower rate. Sub-section 2.3.7 provides an overview of the operational and rehabilitation activities over the medium and long term.

2.3.2 Year 1

Figure 2.1 presents the proposed status of the quarry at the completion of the first year of operations. The first year of operations will include a range of site establishment and operational activities. Relevant operational and rehabilitation activities are highlighted on this figure whilst a summary of these activities is provided as follows.



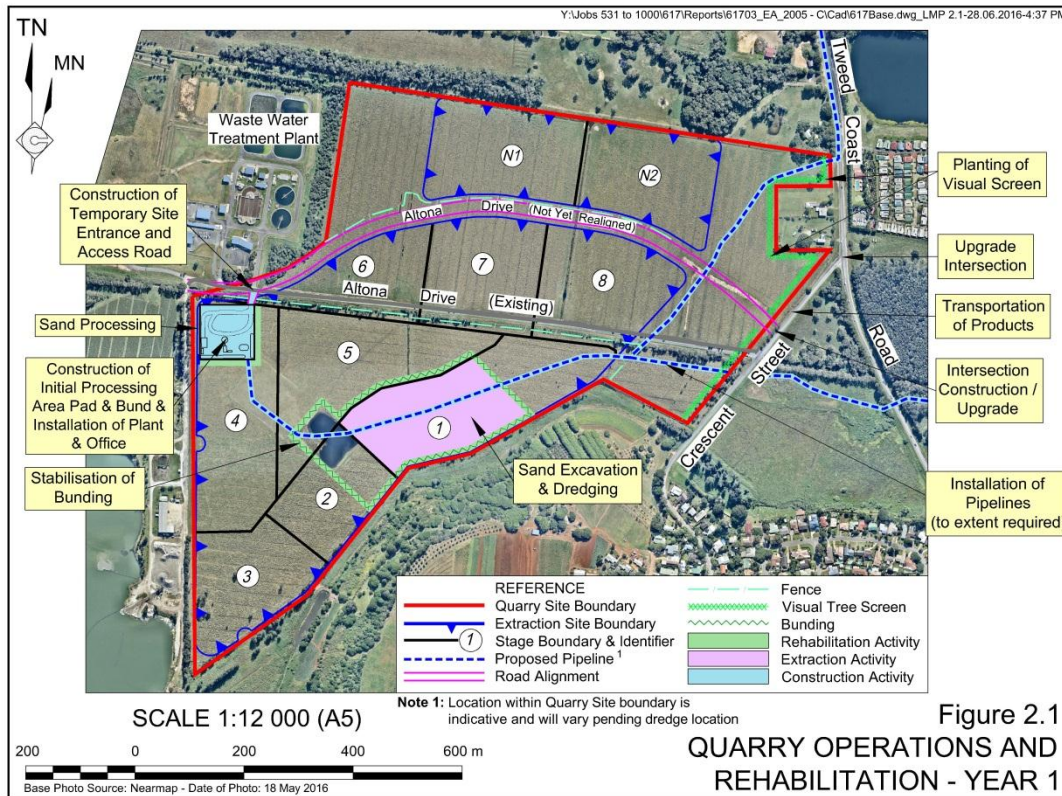


Figure 2.1

QUARRY OPERATIONS AND REHABILITATION - YEAR 1

Planned Establishment and Operational Activities

- Boundaries of project components, including the extraction areas, will be surveyed and clearly defined.
- Soil removal and construction of the initial processing area pad and bund walls using sand and soil recovered from an existing sand stockpile.
- Acceptance of VENM suitable for use in construction of bunding surrounding extraction stages.
- The wash plant will be constructed including limited earthworks.
- Internal access roads and access from Altona Drive (existing alignment) will be established and, prior to the transport of sand by road, the upgraded intersections of Altona Drive and Crescent Street and Tweed Coast Road and Crescent Street will be constructed.
- Installation of the fill sand and tailwater pipelines within the eastern and northern pipeline corridors (to the extent required for planned fill works at that time).
- Commencement of sand excavation and dredging from the southern extraction site (Stage 1) to supply fill sand and/or for sale of construction materials.
- Washing of sand and road transportation of construction materials.
- Hydraulic transportation of fill sand via the established pipelines.

Planned Environmental Management Activities

- Vegetative screening of the eastern quarry boundary.
- Fencing of the site to reduce potential for unauthorised access (existing fences will be retained, upgraded and extended where required).
- Vegetative landscaping will be established on the eastern and southern sections of the initial processing area to soften the appearance of the initial processing area.
- Bunding to contain ‘dirty water’ and divert ‘clean water’ will be constructed around the extraction ponds.
- Earthen ramps will be installed or alternatively sections of the eastern pipeline will be raised using stands or blocks to provide for passage of small animals such as the Wallum Froglet (see Section 2.4.7).

Planned Rehabilitation Activities

- Any exposed soil material from the burying of the northern pipeline will be stabilised using a sterile grass cover as required (see Section 2.4.7).
- Stabilisation of bunding that has not established a groundcover from the natural seed bank within 3 months using woodchip / mulch or pasture seed mix.

During the initial year of operations, no areas will be available within the extraction sites for backfill or creation of wetland habitat.

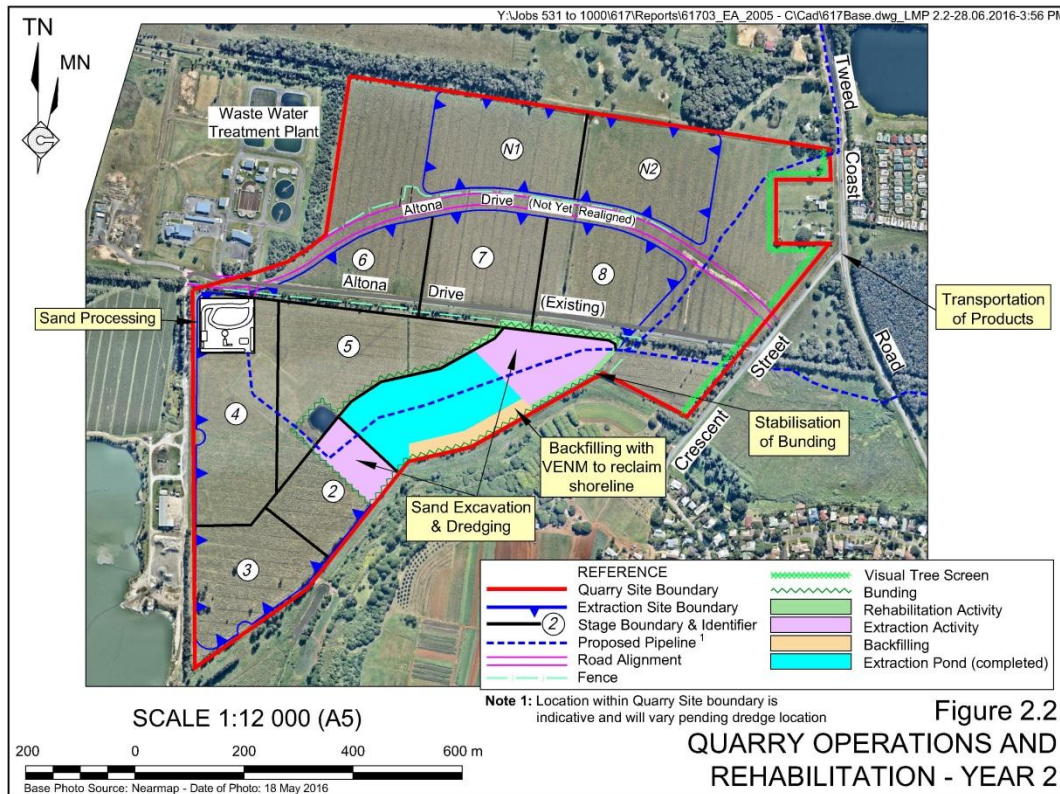
2.3.3 Year 2

Figure 2.2 presents the indicative status of the quarry at the completion of the second year of operations. Relevant operational and rehabilitation activities are highlighted on this figure whilst a summary of these activities is provided as follows.

Planned Operational Activities

- Continued excavation and dredging of sand from the southern extraction site (Stages 1 and 2) at a rate of up to 450 000m³ per year to supply fill sand and sale of construction materials.
- Continued washing of sand and road transportation of construction materials.
- Continued hydraulic transportation of fill sand via the established pipelines (with extension or retraction of the pipelines within the approved corridors as necessary to meet filling location requirements).
- Acceptance of (VENM) suitable for use in construction of bunding surrounding extraction stages and/or use in backfilling of terminal batters to create a final shoreline and wetland areas.





Planned Environmental Management Activities

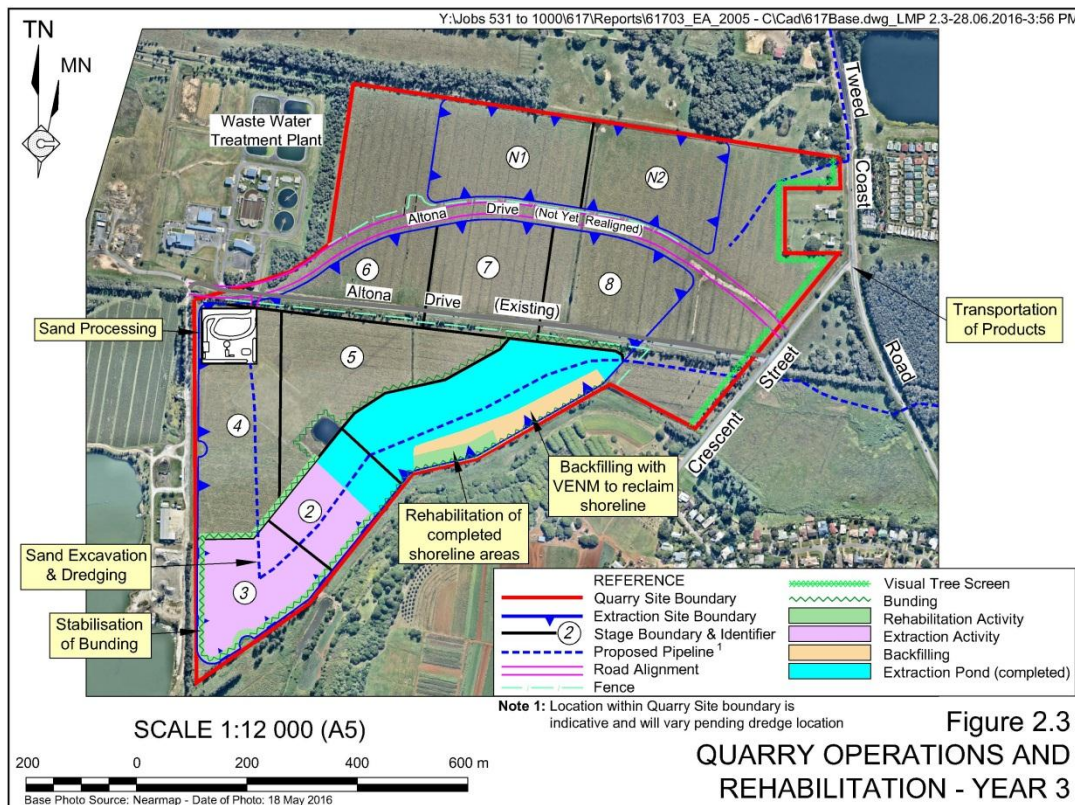
- Extension of bunding around extraction Stage 2 to contain ‘dirty water’ and divert ‘clean water’.
- Continued maintenance of vegetation screening and landscaping established in Year 1.

Planned Rehabilitation Activities

- Stabilisation of bunding that has not established a groundcover from the natural seed bank within 3 months using woodchip / mulch or pasture seed mix.
- Commencement of backfilling and creation of the final shoreline and wetland areas on the completed Stage 1 southern batter. Extent of backfilling will be dependent on volumes of VENM received.

2.3.4 Year 3

Figure 2.3 presents the indicative status of the quarry at the completion of the third year of operations. Relevant operational and rehabilitation activities are highlighted on this figure whilst a summary of these activities is provided as follows.



Planned Operational Activities

- Continued excavation and dredging of sand from the southern extraction site (Stages 2 and 3) at a rate of up to 650 000m³ per year to supply fill sand and for sale of construction materials.
- Continued washing of sand and road transportation of construction materials.
- Continued hydraulic transportation of fill sand via the established pipelines.
- Acceptance of VENM suitable for use in construction of bunding surrounding extraction stages and/or use in backfilling of terminal batters to create a final shoreline and wetland areas.

Planned Environmental Management Activities

- Extension of bunding around extraction Stages 2 and 3 to contain ‘dirty water’ and divert ‘clean water’.
- Continued backfilling and creation of the final shoreline and wetland areas on the completed Stage 1 southern batter. Extent of backfilling will be dependent on volumes of VENM received.

Planned Rehabilitation Activities

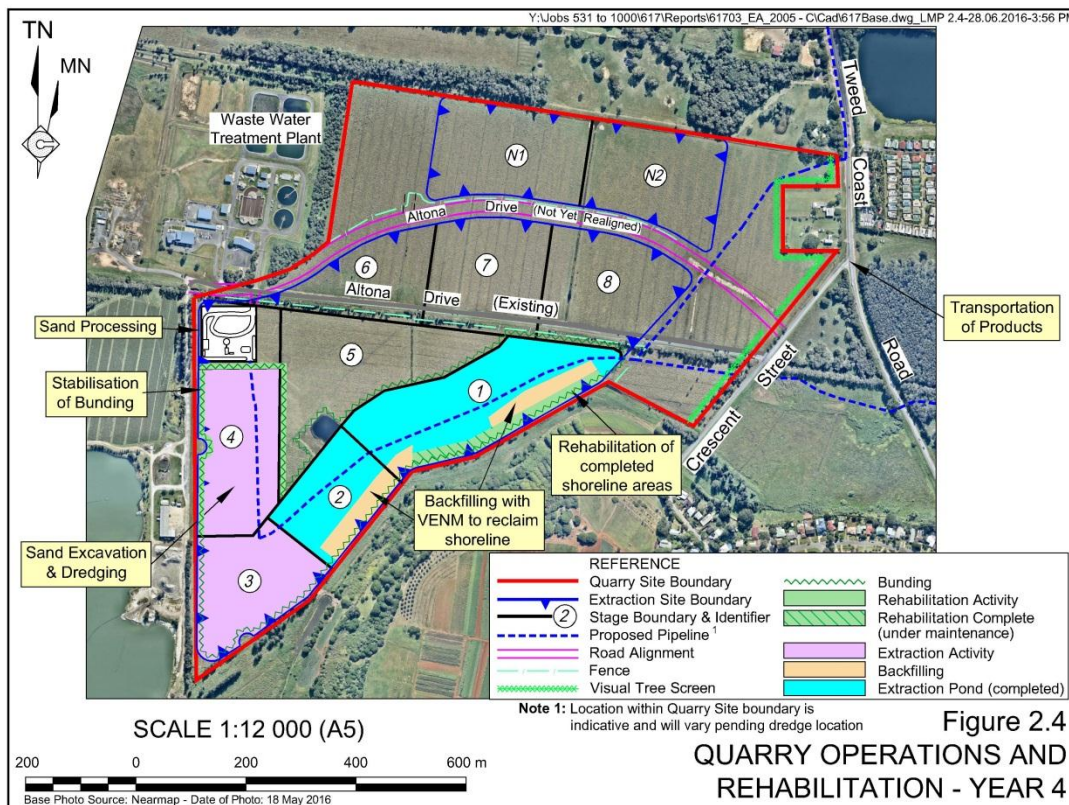
- Stabilisation of bunding that has not established a groundcover from the natural seed bank within 3 months using woodchip / mulch or pasture seed mix.



- Commence revegetation of completed shoreline and wetland areas within Stage 1 (see Section 2.4.6). Extent of area available for revegetation dependent on volumes of VENM received.

2.3.5 Year 4

Figure 2.4 presents the indicative status of the quarry at the completion of the fourth year of operations. Relevant operational and rehabilitation activities are highlighted on this figure whilst a summary of these activities is provided as follows.



Planned Operational Activities

- Continued excavation and dredging of sand from the southern extraction site (Stages 3 and 4) at a rate of up to 650 000m³ per year to supply fill sand and sand for processing and sale of construction material.
- Continued washing of sand and road transportation of construction materials.
- Continued hydraulic transportation of fill sand via the established pipelines.
- Acceptance of VENM suitable for use in construction of bunding surrounding extraction stages and/or use in backfilling of terminal batters to create a final shoreline and wetland areas.

Planned Environmental Management Activities

- Extension of bunding around extraction Stage 4 to contain ‘dirty water’ and divert ‘clean water’.
- Continued backfilling and creation of the final shoreline and wetland areas on the completed Stage 1 southern batter and commencement of backfilling the completed Stage 2 southern batter. Extent of backfilling will be dependent on volumes of VENM received.

Planned Rehabilitation Activities

- Stabilisation of bunding that has not established a groundcover from the natural seed bank within 3 months using woodchip / mulch or pasture seed mix.
- Continue revegetation of completed shoreline and wetland areas within Stage 1 (see Section 2.4.6). Extent of area available for revegetation dependent on volumes of VENM received.

2.3.6 Year 5

Figure 2.5 presents the indicative status of the quarry at the completion of the fifth year of operations. Relevant operational and rehabilitation activities are highlighted on this figure whilst a summary of these activities is provided as follows.

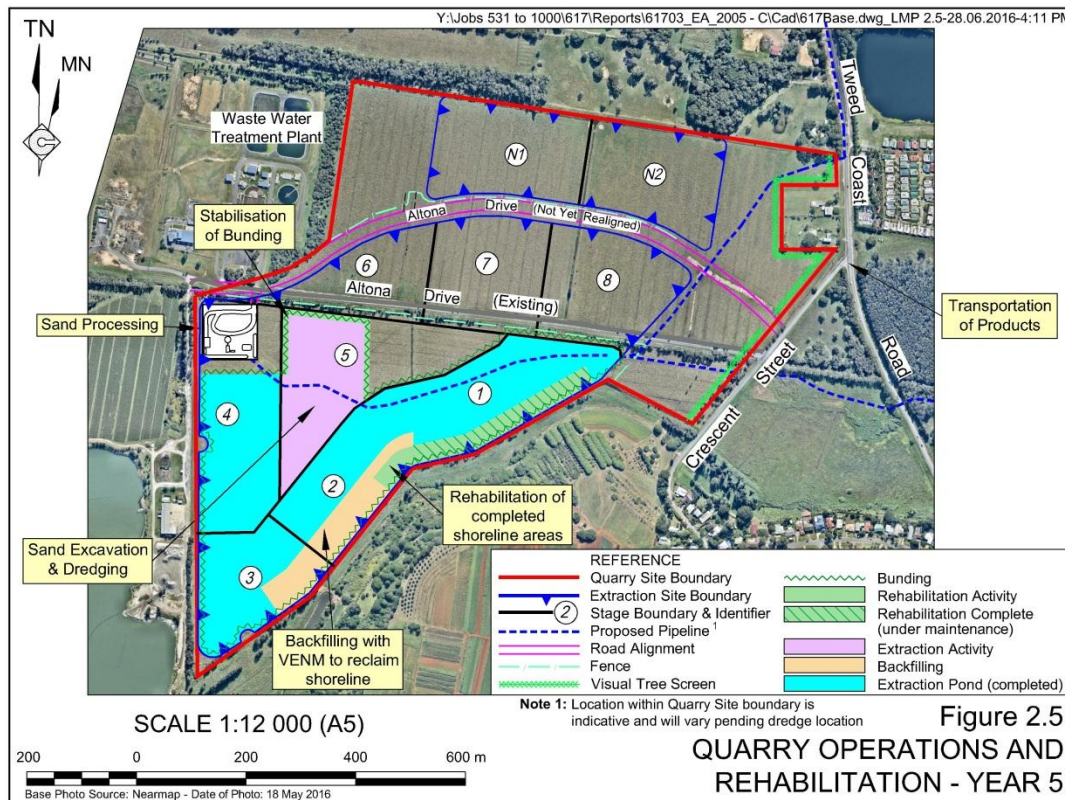
Planned Operational Activities

- Continued excavation and dredging of sand from the southern extraction site (Stages 4 and 5) at a rate of up to 650 000m³ per year to supply fill sand and sand for processing and sale of construction material.
- Continued washing of sand and road transportation of construction materials.
- Continued hydraulic transportation of fill sand via the established pipelines.
- Acceptance of VENM suitable for use in construction of bunding surrounding extraction stages and/or use in backfilling of terminal batters to create a final shoreline and wetland areas.

Planned Environmental Management Activities

- Extension of bunding around extraction Stage 5 to contain ‘dirty water’ and divert ‘clean water’.
- Continued backfilling and creation of the final shoreline and wetland areas on the completed Stage 2 southern batter. Extent of backfilling will be dependent on volumes of VENM received.





Planned Rehabilitation Activities

- Stabilisation of bunding that has not established a groundcover from the natural seed bank within 3 months using woodchip / mulch or pasture seed mix.
- Continue revegetation of completed shoreline and wetland areas within Stage 1 and commencement within Stage 2 (see Section 2.4.6). Extent of area available for revegetation dependent on volumes of VENM received.

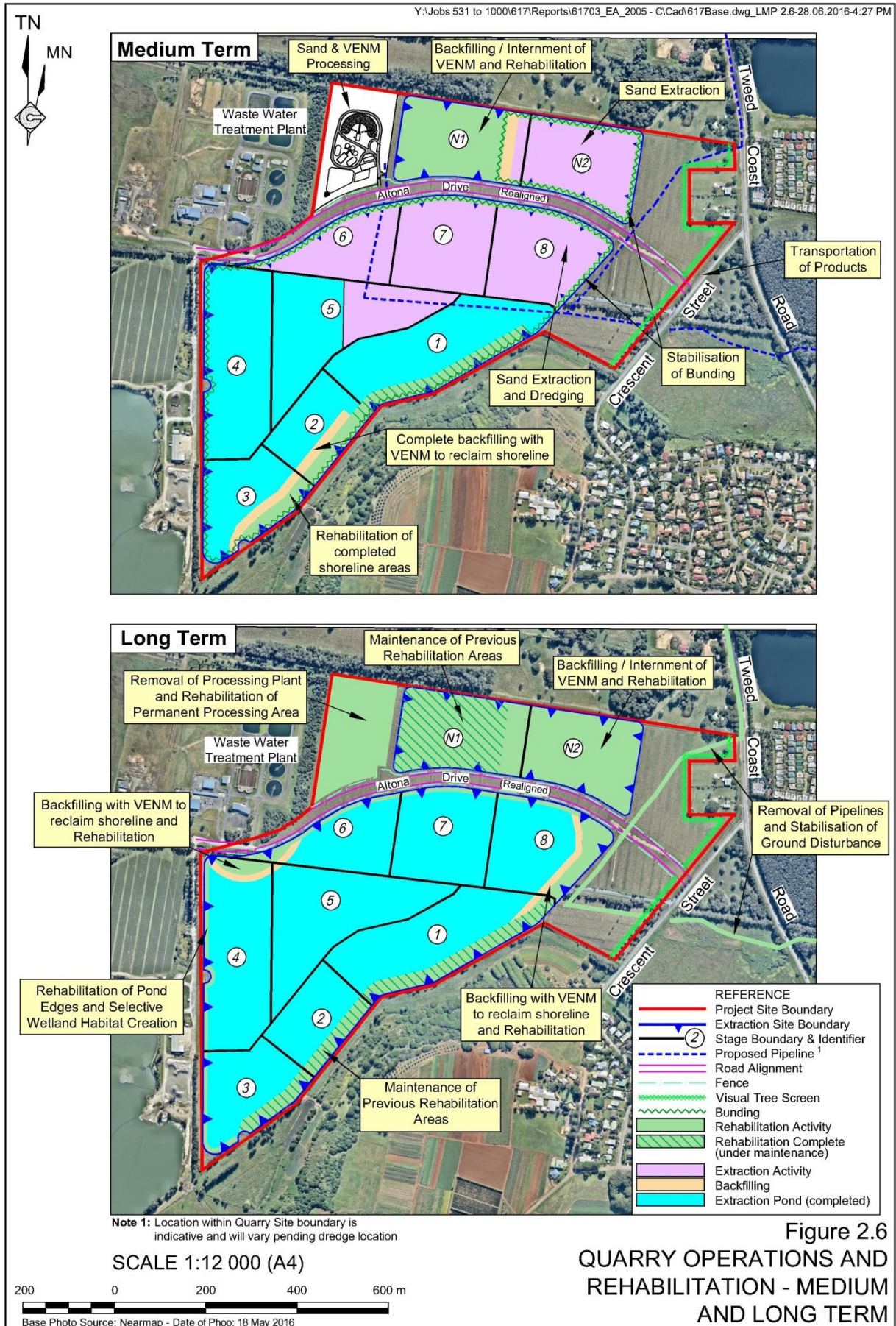
2.3.7 Medium and Long Term Rehabilitation

Figure 2.6 presents the medium (Year 10) and long term (Year 20 / quarry closure) operational and rehabilitation activities whilst a summary is provided as follows. It has been assumed that operations continue at maximum production and ongoing receipt of VENM following completion of sand extraction for backfilling and rehabilitation purposes. At maximum production, extraction operations would be completed within the medium term (10 years) whilst backfilling and final rehabilitation would be completed within the long term (20 years).

Medium Term

- Continued excavation and dredging of sand from the southern extraction site (Stages 5 to 8) and the northern extraction site (Stages N1 and N2) at a combined rate of up to 650 000m³ per year to supply fill sand and sand for processing and sale of construction material.





- Extension of bunding around extraction Stages 5 to 8 and N1 and N2 to contain ‘dirty water’ and divert ‘clean water’ and stabilisation using woodchip / mulch or pasture seed mix if required.
- Acceptance of VENM suitable for use in construction of bunding surrounding extraction stages and/or use in backfilling of terminal batters to create a final shoreline and wetland areas and backfilling of the northern extraction area.
- Continued revegetation of completed shoreline and wetland areas and creation of sandy or stabilised lake edges (see Section 2.4.6).
- Removal of bunding and rehabilitation of completed backfill areas within the northern extraction area (see Section 2.4.5).

Long Term

- Continued acceptance of VENM for use in backfilling of terminal batters to create a final shoreline and wetland areas within the southern extraction area.
- Completion of backfilling of the northern extraction area (Stages N1 and N2) and removal of bunding (see Section 2.4.5).
- Removal of bunding surrounding the southern extraction pond and final rehabilitation of the final pond edges including creation of sandy or stabilised lake edges.
- Removal of all processing plant and equipment from site.
- Removal of all concrete footings and hardstand areas, internal access roads and other infrastructure not required for ongoing land uses.
- Retention of the vegetated permanent processing area bund wall for future land use.
- Remediation of any contaminated material (e.g. fuel spillages).²

2.4 REHABILITATION AND REVEGETATION METHODS

2.4.1 Water Management Structures

Bunding used to retain dirty water within, and divert clean water away, from operational areas that does not establish a groundcover from the natural seed bank within 3 months will be stabilised either through placement of chipped vegetation / mulched shrubs or vegetated with a pasture seed mix similar to that listed in **Table 2.1**. Based on experience from stabilisation of the initial dredge pond and the lack of a source of mulch on site, it is expected the stabilisation through sowing of the pasture mix will provide sufficient stabilisation.

² It is proposed that any contaminated materials will be remediated throughout the life of the quarry.



Table 2.1
Pasture Species Seed Mix

Season	Common name	Rate (kg/ha)
Autumn and Winter	Perennial Ryegrass	10
Spring and Summer	Japanese Millet	20

Source: Idyll Spaces (2008) – Section 4

2.4.2 Bund Walls

Following construction, the outer surfaces of the perimeter bund wall (surrounding the permanent processing area) will be covered with approximately 50mm of topsoil and initially stabilised with a pasture seed mix (see **Table 2.1**). A range of shrub species (see **Table 2.2**) will also be seeded and / or tube stock planted on the outer faces of the eastern and southern bunds. Any tube stock planted would be protected against wind and cold by installation of biodegradable plastic or cardboard tree guards around the planted seedlings. Additionally, the 'long-stem' planting technique will preferentially be utilised where seedlings are available. The long-stem technique involves the use of seedlings which have been grown in pots for 10 to 18 months and have long woody stems. The seedlings are then planted approximately three quarters their length below the soil which protects the plant roots and generally improves survival rates (APSCCG, 2010).

Table 2.2
Typical Shrub and Small Tree Species for Revegetation

Scientific name	Common name	Final height (m)
<i>Acacia sophorae</i>	Coast wattle	3
<i>Allocasuarina littoralis</i>	Black oak	10
<i>Austromyrtis dulcis</i>	Midyim	1
<i>Banksia integrifolia</i>	Coast banksia	10
<i>Banksia robur</i>	Swamp banksia	3
<i>Callistemon pachyphyllus</i>	Thick-leaved bottlebrush	1

Source: Idyll Spaces (2008) – Section 4

2.4.3 Visual Screening

A range of shrub species will be planted along the eastern boundaries of the Quarry Site to provide a visual screen for motorists travelling on Tweed Coast Road and Crescent Street. In addition to species listed in **Table 2.2**, the species listed in **Table 2.3** may also be used for screening purposes.

Table 2.3
Additional Tree Species for Visual Screening and Landscaping

Scientific name	Common name	Final height (m)
<i>Archontophoenix cunninghamiana</i>	Bangalow palm	13
<i>Callistemon salignus</i>	Willow bottlebrush	10
<i>Casuarina glauca</i>	Swamp oak	30
<i>Glochidion sumatranum</i>	Umbrella cheese tree	20
<i>Melaleuca quinquenervia</i>	Broadleaved paperbark	25
<i>Cryptocarya foetida</i> *	Stinking Cryptocarya	20
<i>Acronychia littoralis</i> #	Scented acronychia	6

Source: Idyll Spaces (2008) – Section 4 and WetlandCare Australia

* Listed as Vulnerable under the *Threatened Species Conservation Act 1995* (TSC Act)

Listed as Endangered under the TSC Act and *Environmental Protection and Biodiversity Act 1999*



2.4.4 Landscape Areas

Landscaped areas will be established adjacent to the eastern and southern boundaries of the initial processing area and the access road and entry points following site establishment and the realignment of Altona Drive. Plant species to be utilised in landscaping will include a selection of species from **Table 2.2**.

2.4.5 Northern Extraction Site

The northern extraction pond will be backfilled progressively from west to east following the recovery of the sand resource. VENM(b)³ will always be placed within the pond and pushed by the excavator bucket below -1m AHD whilst VENM(a)⁴ will preferentially be used to backfill sections of the extraction pond between -1m AHD to ground level (approximately 1.0m AHD). Management of VENM(a) and VENM(b) material is further addressed within the Soil and Water Management Plan. Approximately 380 000m³ of VENM will be required to backfill the northern extraction pond to existing ground level.

As sections of the backfilled northern extraction pond reach the final elevation, topsoil material will be spread to a depth of approximately 100mm over the reclaimed section before being seeded with a suitable pasture mix (if required) (see **Table 2.1**). This topsoil material will be sourced from the southern extraction site during stripping campaigns and from the material placed within the bunding surrounding the northern extraction site.

This will effectively recreate the existing landform and use, however, pending separate approval, the elevation of required portions of the northern extraction site would be raised and landscaped to provide for sporting fields and recreational facilities.

Ongoing weed control of rehabilitated areas will be undertaken as outlined within Section 2.4.8.

2.4.6 Southern Extraction Site

As discussed in Section 2.3.7, final edges of the southern extraction pond will be rehabilitated to either reclaimed areas, wetland areas and sandy or stabilised lake edges. **Figure 2.7** shows the conceptual locations and cross sections for these edge treatments whilst a description of the rehabilitation procedures is described as follows.

Reclaimed Areas

Selected edges of the southern extraction pond will be backfilled to reclaim sections of the pond to provide a wider shoreline area, between approximately 30m and 50m wide. In order to create these reclaimed areas, between an average⁵ of approximately 225m³ and 525m³ of VENM will

³ VENM(a) is material meeting the definition for VENM as outlined in the *Waste Classification Guidelines* (EPA, 2014). VENM “means natural material (such as clay, gravel, sand, soil or rock fines):

- that has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial, mining or agricultural activities
- that does not contain sulfidic ores or soils, or any other waste,
- and includes excavated natural material that meets such criteria for virgin excavated natural material as may be approved from time to time by a notice published in the NSW Government Gazette.”

⁴ VENM(b) is material that, except for the presence of sulfidic soil (i.e. potentially acid sulfate soil), would otherwise be classified as VENM.

⁵ Based on an average depth of 15m and VENM batter slope of 1:3 V:H.



be required for each lateral metre of shoreline reclaimed. The reclaimed areas will be above the final pond water level and, as for the northern extraction area, topsoil material will be spread to a depth of approximately 100mm over the reclaimed section. If required, a suitable pasture mix will be sowed (see **Table 2.1**). This topsoil material will be sourced from the southern extraction site during stripping campaigns and from the material placed within the bunding surrounding the southern extraction site. Tree and shrub species will also be planted in selected areas to create a parkland area. The width and extent of reclaimed shoreline areas will depend upon the availability of suitable VENM for backfilling.

Wetland Areas

Selected edges of the southern extraction pond will also be backfilled to provide a gently sloping lake edge in which to create wetland areas. This will be undertaken using the swamp dozer and / or 30t excavator to push / move VENM into the edges of the extraction pond to create a slope beneath the water of approximately 1:10 (V:H) for a distance of 10m from the final shoreline. It is expected that backfilled material further than 10m from the edge of the extraction pond will settle underwater at an angle of between approximately 1:3 and 1:5 (V:H) depending on the nature of the VENM (see **Figure 2.7**).

In order to create these wetland areas, between approximately 9m³ and 15m³ of VENM(a) will be required as backfill for each lateral metre of shoreline of the final lake. Topsoil will then be placed along the edges of the pond and the backfilled wetland area to a depth of approximately 0.3m and, where possible, directly transferred to maintain the soil structure and organic content. The topsoil placed to form the bed of the wetland areas will also be treated with gypsum or lime at an approximate rate of 0.4kg/m² to facilitate flocculation.

The final surface on the pond edges will be revegetated through use of seed and planting of tube stock. For the lake edges, similar species to those specified in **Tables 2.2** and **2.3** will be used whilst the backfilled wetland area will be planted with appropriate wetland species such as those outlined in **Table 2.4**. Planting densities will vary locally with periodic clustered random plantings reflective of natural conditions. It is noted that WetlandCare Australia considers that the listed species will provide an appropriate wetland species diversity for a water body the size of the final lake.

Table 2.4
Typical Wetland Species for Site Revegetation

Scientific Name	Common Name	Max Water Depth(m)	Density
<i>Bacopa monniera</i>	Bacopa	0.1	6-8/m ²
<i>Baumea articulata</i>	-	0.2	6-8/m ²
<i>Carex appressa</i>	-	0.1	6-8/m ²
<i>Eleocharis sphacelata</i>	Tall Spike-rush	2.0	4/m ²
<i>Leersia hexandra</i>	Swamp Rice-grass	0.1	seeded
<i>Lepironia articulata</i>	-	1.5	4/m ²
<i>Schoenus validus</i>	-	0.5	4/m ²

Source: Idyll Spaces (2008) – Section 4 and WetlandCare Australia



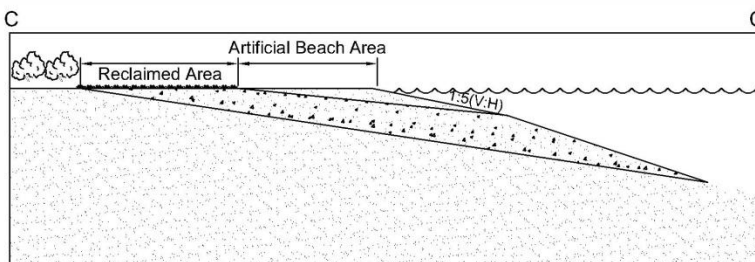
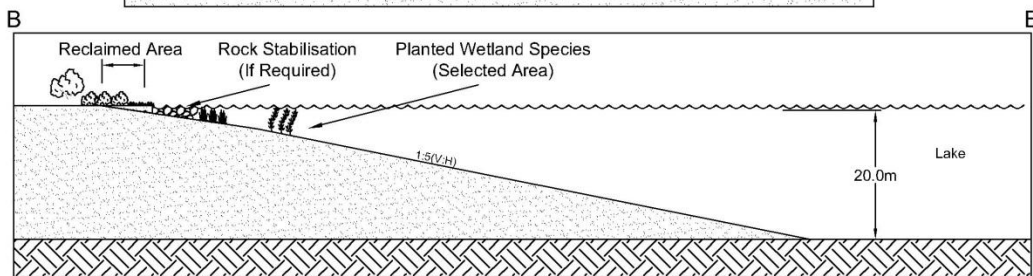
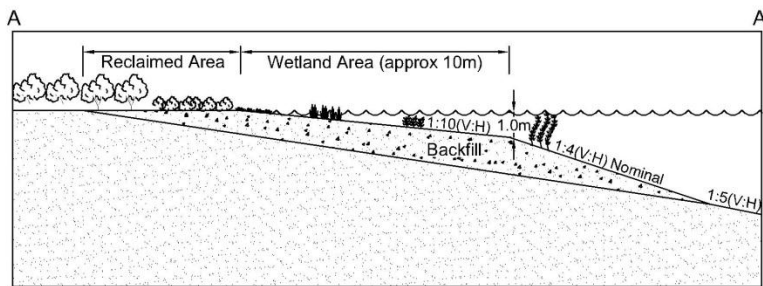
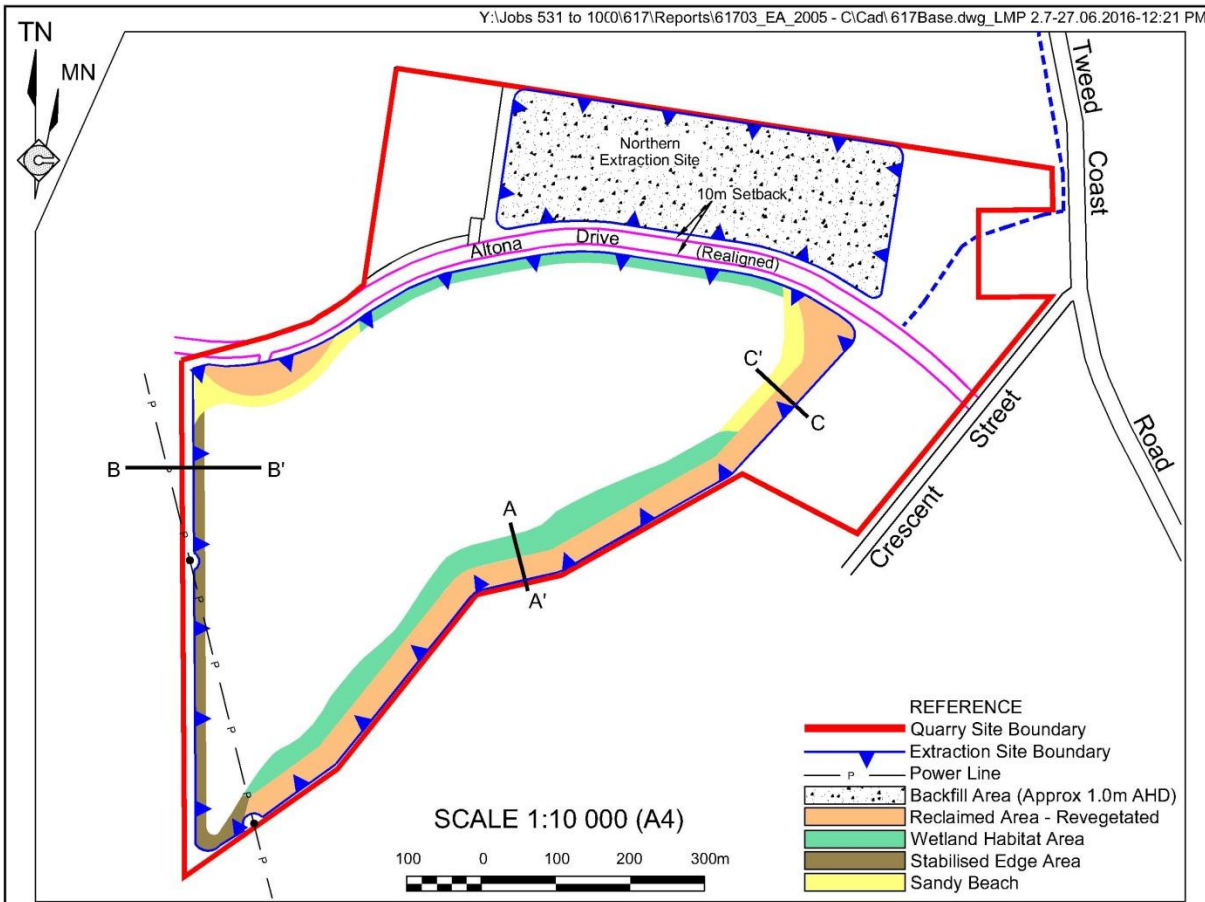


Figure 2.7
INDICATIVE WETLAND AREAS
AND EDGE TREATMENT

Sections Not to Scale



Planting of wetland species will preferentially be undertaken during October and November as macrophytes are more tolerant of inundation in warmer waters but this will also allow for adequate establishment and root growth before the heavy summer rainfall period. The sourced plant stock will also be mature, sun-hardened and contain a fully established root ball and have heights of approximately 0.3m to 0.5m. A sufficient lead time of 18 months will be provided to source the required stock.

In the event that drawdown from the dredge during operations fully exposes the planted wetland species, watering will be undertaken (according to prevailing conditions) to preserve the 'muddy' condition of the wetland substrate until the plants become fully established. As a guide the following watering program will be undertaken, if required, following the planting of wetland species.

- Weeks 1 to 6 - 5 waterings per week.
- Weeks 6 to 10 - 3 waterings per week.
- Weeks 11 to 15 - 2 waterings per week.

The length of the shoreline backfilled to create wetlands and reclaim lake edges will be dependent on the volume of suitable VENM received. In the event that limited volumes of suitable VENM are received, focus would be placed upon the formation of a consolidated wetland area, preferentially across the southern boundary of the southern extraction site to provide a functional role in nutrient removal, sediment trapping and erosion prevention from runoff from the Cudgen Plateau (see **Figure 2.7**). Given the possible future recovery of sand between the Cudgen Lakes Sand Quarry and Hanson Tweed Sand Quarry, rehabilitation of the western boundary of the southern extraction site will preferentially be completed last. As the recovery of this sand is subject to future development approval, the Landscape Management Plan assumes the rehabilitation of this area.

It is noted that wetland areas would still be able to be established on non-backfilled edges as the slope will be 1:5 V:H, however, the width of wetland area would be reduced.

Sandy Lake Edges

Sandy lake edges will be constructed in selected areas to provide natural access to / from the final lake (in addition to any jetties / pontoons which may be constructed). These will be constructed through the backfilling of selected areas using the swamp dozer and / or 30t excavator to push / move VENM to create gently sloping areas similar to wetland areas. However, sand will then be pumped from the extraction pond to fill the area above the maximum water level (approximately 0.75m AHD) to provide a dry sandy 'beach' and sloping for a short distance below the naturally occurring water fluctuations (approximately -0.75m AHD) (see **Figure 2.7**).

The pond edge and reclaimed areas will be topsoiled and revegetated with grasses and groundcover species favoured for areas adjoining the beach area. The sandy beach area will not be topsoiled or vegetated.



Stabilised Lake Edges

Final edges of the lake not reclaimed or backfilled for wetland or sandy beach areas will be retained with a slope of approximately 1:5 (V:H). Selected pond edges which have not been backfilled will also be planted to create wetland areas using a selection of species preferring slightly deeper water (see **Table 2.4**). Similar to wetland areas, the pond edges will be topsoiled and revegetated with a range of terrestrial plant species such as those **Tables 2.2** and **2.3**.

No other specific rehabilitation measures are considered likely to be required, however, in the event of any ongoing erosion problems that cannot be successfully stabilised through the use of vegetation, ‘hard’ erosion control measures, such as rock armouring, would be investigated and implemented, where required.

2.4.7 Pipeline Corridors

Within the northern pipeline corridor, during the excavation of the soil material to create the trench for the pipeline, areas of grass / groundcover would be carefully excavated and placed separately to the remaining soil material. Following installation of the underground pipelines, all soil material will be replaced followed by the recovered grass / groundcover. If required, bare areas will be sown with a suitable sterile grass seed mix for stabilisation until the existing groundcover re-establishes.

Similarly, upon removal of the underground pipelines, any void arising from the removal of the pipeline will be backfilled with sand from the quarry and the soil material replaced and a sterile grass seed mix applied, as required. The sections of the pipeline beneath the respective roads will be retained and capped off for the future use by Gales-Kingscliff or a related entity, Council, RMS or an authority to convey utilities under the road(s) at any future date.

As the pipelines within the eastern corridor will be above ground and will not necessitate the removal of trees, it is envisaged that, following removal of the pipelines, no specific rehabilitation measures will be required. However, whilst the pipeline within the eastern corridor is in place, sand from the quarry will be used to create earthen ramps over the pipelines every approximately 50m within Lots 26C and 26D DP 10715 to assist the passage of frogs and other small animals. Alternatively, the pipelines may be raised in some area using stands / blocks to provide fauna passage beneath the pipelines.

Operators installing and removing the pipelines would be instructed to avoid disturbance to any trees and shrubs, particularly any outside of the pipeline corridor. Where required, survey pegs will be used to delineate the pipeline route and temporary high visibility fencing installed around ‘no go areas’.

2.4.8 Pest Animal Control

Introduced pest animal species previously recorded within the Quarry Site and pipeline corridors include the following.

- House Mouse (*Mus musculus*).
- Black Rat (*Rattus rattus*).



- Cane Toad (*Bufo marinus*).
- Fox (*Vulpes vulpes*).
- Mosquito Fish / Plague Minnow (*Gambusia holbrooki*).
- Brown Hare (*Lepus capensis*).
- Common Myna (*Acridotheres tristis*).

The principal control for the House Mouse, Black Rat, Fox and Common Myna will be the appropriate management of any domestic type / putrescible waste generated on site, including storage within waste receptacles with lids. In the event that water birds develop breeding areas within the site, where practicable, these areas may be fenced to prevent predation by foxes. No controls for the Brown Hare are considered necessary, however, trapping or baiting would be undertaken in consultation with NSW Office of Environment and Heritage (OEH) in the event that excessive impacts to revegetation attributable to this species are identified.

Unfortunately there are few efficient control methods for the Cane Toad, however, in the event that local cane toad populations impact upon rehabilitation, control options will be discussed with OEH. This may include planting a barrier of native sedges and grasses which will assist in excluding Cane Toad access to the lake. Similarly, there are few effective controls for the Mosquito Fish / Plague Minnow other than chemical controls which can affect other aquatic life or draining of the water body. In the event Mosquito Fish / Plague Minnow are identified within the southern extraction pond, NSW Fishing and Aquaculture would be consulted in relation to the most appropriate action.

2.4.9 Weed Control

Weed species previously recorded within or surrounding the Quarry Site and pipeline corridors include the following.

- *Baccharis halimifolia* (Groundsel Bush).
- *Cinnamomum camphora* (Camphor Laurel).
- *Ipomoea cairica* (Coastal Morning Glory).
- *Lantana camara* (Lantana).
- *Ligustrum sinense* (Small-Leaved Privet).
- *Senna pendula* var. *glabrata*.
- *Sporobolus fertilis* (Giant Parramatta Grass).

Basic identification information for these species sourced from Weeds Australia is provided in **Appendix 1**.



Of these species, only Coastal Morning Glory was recorded within the Quarry Site. In order to control Coastal Morning Glory and other environmental weeds, the following weed management actions will be implemented.

1. If required, the Quarry Manager or Environmental / Compliance Officer will liaise with a Council Weed Officer, OEH or Department of Primary Industries - Agriculture for the appropriate identification of weed species.
2. All employees will be made aware of noxious weed species which may potentially occur on site and will maintain relevant identification notes / pictures in the office for reference (see **Appendix 1**).
3. Any machinery being brought onto site will be cleaned prior to entry to the site to ensure that no new weed species are introduced.
4. Rehabilitation areas will be regularly (at least quarterly) visually inspected for the presence of weed species. Should weed species be identified on the rehabilitation areas, control actions will be implemented. This may include removal by hand or spot spraying (taking care to avoid regenerating plants). For Coastal Morning Glory, this follow up treatment would be undertaken every 3 to 5 weeks until it is removed.
5. The extraction ponds will be also be inspected regularly (at least quarterly) for the presence of any aquatic weeds such as Salvinia, Water Hyacinth, Hymenachne, Alligator Weed, Parrots Feather and Sagittaria (see **Appendix 1**). Control measures may include physical removal or herbicide application. These controls would be undertaken in consultation with Department of Primary Industries - Fisheries. Importantly, control measures would be implemented promptly to reduce the extent of any infestation and subsequent control costs.

All weed management actions will be reported in each Annual Report.

2.5 REHABILITATION COMPLETION CRITERIA

2.5.1 Pipeline Corridors

As the pipeline corridors will not require the clearing of any trees, the principal rehabilitation requirement is to ensure the re-establishment of groundcover and ensuring that no erosion will occur. Therefore the completion criteria for the rehabilitation of the pipeline corridors are as follows.

- All pipelines and associated infrastructure have been removed.
- A groundcover equivalent of the surrounding area (e.g. gravelled road shoulder) or 70% vegetated cover for vegetated areas.
- No active erosion evident on rehabilitated areas.



2.5.2 Quarry Site

Completion criteria for rehabilitation of the quarry reflects the intended final land use for a combination of recreation, sporting facilities and parkland (see Section 3.4). **Table 2.5** outlines the preliminary rehabilitation completion and closure criteria. These criteria will be further developed throughout the operation of the quarry.

Table 2.5
Preliminary Rehabilitation Completion Criteria

Environmental Aspect	Preliminary Rehabilitation Criteria
Landform	<ul style="list-style-type: none"> • All processing plant and equipment is removed from site. • All concrete footings or hardstands not required for the final land use are ripped up and removed. • Completed slopes of the final southern extraction pond which are not backfilled with more competent VENM or otherwise stabilised do not exceed 1:5 V:H⁶. • The banks of the final southern extraction pond are stable with no signs of active erosion. • No VENM(b) material has been placed above -1m AHD within the northern extraction site and 8m below the final water level of the southern extraction pond. • Surface layer to be free of any hazardous materials and any contaminants are below accepted criteria.
Soil	<ul style="list-style-type: none"> • The pH of the upper 0.5m of soil material to be greater than 5.0 and less than 9.0. • Electrical conductivity within the range suitable for plant growth. • No significant erosion or active erosion is present.
Water	<ul style="list-style-type: none"> • Water quality within the southern extraction pond will consistently meet applicable water quality criteria (refer to Soil and Water Management Plan). • Levels of Blue-Green Algae remain within acceptable levels and nutrient levels within the lake do not pose a significant risk of algal blooms.
Flora	<ul style="list-style-type: none"> • Areas to be retained as a vegetated surface have at least a 70% groundcover. • Weed species do not dominate and noxious weeds are appropriately controlled. • Species present reflect the intended final land use (e.g. sporting field, recreational area, wetland).
Fauna	<ul style="list-style-type: none"> • The final southern extraction pond and fringing wetland and vegetation provides habitat for native fauna species.
Visual Amenity	<ul style="list-style-type: none"> • Exposed (non-vegetated) surfaces are minimised. • Appropriate vegetative screens are maintained.
Air Quality	<ul style="list-style-type: none"> • The site does not result in excessive dust generation.

⁶ Unless otherwise agreed with DPE and based upon geotechnical advice.



2.6 REHABILITATION MONITORING AND REPORTING

An important component of revegetation would be the maintenance program to ensure the soil substrate and range of plants are maintained and any weed infestations are controlled. A rehabilitation monitoring program will be undertaken to record the progress of revegetation and the establishment success. This program will include the following.

- Quarterly inspections for the presence of weeds.
- Quarterly inspections and following significant rainfall events for the presence of active erosion or siltation.
- Annual inspection (following completion of terminal extraction boundaries within the southern extraction site) by an ecologist or rehabilitation consultant to assess the progress of establishment of wetland areas and the final lake shore.

As a minimum, the annual inspections will involve the following.

- Photographic monitoring of rehabilitated areas. Photos will be taken from the same reference location (preferably at the same time of day).
- An assessment of flora establishment success including vegetation cover and species diversity within wetland areas.
- Any evidence of natural regeneration.
- Recording the presence / absence of any pest animal or weed species.

Other monitoring relevant to the rehabilitation of the quarry site will include surface water quality monitoring within the southern extraction pond. Water quality monitoring is outlined within the Soil and Water Management Plan.

A record of each quarterly inspection will be maintained on site and a summary of the outcomes of the quarterly inspections together with the results of the annual rehabilitation monitoring will be reported in each Annual Report.

2.7 REHABILITATION RISKS AND CONTINGENCIES

Table 2.6 provides a summary of the identified risks to successful rehabilitation and subsequent quarry closure and the contingency measures that will be implemented should these occur.

Table 2.6
Rehabilitation Risks and Contingency Measures

Page 1 of 2

Risk to Successful Rehabilitation	Contingency Measure
Soil resources have chemical or physical parameters detrimental to vegetation establishment and growth.	<ul style="list-style-type: none"> • Soil testing will be undertaken and appropriate soil conditioning agents or ameliorants added to improve soil properties for growth.
Excessive erosion of lake edges or rehabilitated areas from runoff or wave action.	<ul style="list-style-type: none"> • Regular inspections of rehabilitation will identify eroding surfaces and as these are identified, they will be immediately remediated either through 'soft' measures such as establishment of groundcover or 'hard' measures such as rock armouring.



Table 2.6 (Cont'd)
Rehabilitation Risks and Contingency Measures

Page 2 of 2

Risk to Successful Rehabilitation	Contingency Measure
Disease affecting growth of vegetation.	<ul style="list-style-type: none"> • A qualified botanical / horticultural professional will be commissioned to identify the type, source and effect of any such disease. • The advice of the qualified botanical / horticultural professional will be followed.
Establishment of wetland community with a poor flora species diversity, e.g. restricted number of dominant plant species, which provide minimal habitat value.	<ul style="list-style-type: none"> • A qualified wetland ecologist will be consulted. • The number of the dominant flora species(s) would be reduced and other species increased in accordance with advice received.
Dominance of weed species.	<ul style="list-style-type: none"> • Additional and targeted weed spraying will be undertaken to reduce the number and distribution of identified weeds. The weed spraying will be undertaken following appropriate consultation with a Council Weeds Officer, OEH or DPI Agriculture. • Re-seeding or tubestock planting will be undertaken as required and to increase competition against weed species.
Poor water quality within the southern extraction pond (not meeting relevant criteria).	<ul style="list-style-type: none"> • A qualified specialist would be consulted in relation to the appropriate treatments and these treatments implemented (such as addition of ameliorants to rectify pH).

2.8 RESPONSIBILITIES AND ACCOUNTABILITIES

The procedures contained within this management plan will be made available to all members of the workforce and will be discussed, when necessary, through inductions or toolbox talks / meetings. The ultimate responsibility for the implementation of the Rehabilitation Management Plan is the Quarry Manager.

Table 2.7 outlines the accountable positions and tasks.

Table 2.7
Accountable Positions and Tasks (Rehabilitation)

Position	Accountable Task
Quarry Manager or Environmental / Compliance Officer	<ul style="list-style-type: none"> • Manage delegation of individual responsibilities related to the implementation of the Landscape Management Plan. • Management / supervision of weed and pest control activities as required. • Regular (quarterly) visual inspections of progressive rehabilitation areas for potential weed infestations. • Coordination of annual rehabilitation monitoring and annual reporting.
Dredge Operator	<ul style="list-style-type: none"> • Ensure that final extraction slopes of southern extraction pond do not exceed 1:5 V:H.
Earthmoving Operator	<ul style="list-style-type: none"> • Ensure all VENM(b) is placed below at least -1m AHD in the northern extraction site and 8m below the water level within the southern extraction site.
All employees	<ul style="list-style-type: none"> • Reporting any weed or pest infestations. • Reporting any active erosion or sedimentation.



3. LONG TERM MANAGEMENT STRATEGY

3.1 INTRODUCTION

Condition 3(30) of Project Approval 05_0103B requires that the Long Term Management Strategy:

- a) define the objectives and criteria for quarry closure and post-extraction management (see Section 3.2);
- b) investigate options for the future use of the site (see Section 3.3);
- c) describe the measures that would be implemented to minimise or manage the ongoing environmental effects of the project (see Section 3.4); and
- d) describe how the performance of these measures would be monitored over time (see Section 3.5).

3.2 QUARRY CLOSURE OBJECTIVES

The key quarry closure objectives are as follows.

- To provide a low maintenance, geotechnically stable landform that will provide for planned recreational uses including sporting fields and recreational lake.
- To ensure the final landform is free of contaminants, and therefore poses no ongoing pollution hazard to the local environment.
- To ensure that final landform and use does not pose unacceptable public health or safety hazard.
- To provide wetlands, surrounding parklands and facilities that would complement broader development plans of Gales-Kingscliff Pty Ltd and its related companies.

3.3 QUARRY CLOSURE CRITERIA

3.3.1 General Quarry Closure Criteria

General quarry closure criteria have been taken from the guideline document “*Strategic Framework for Mine Closure*” (ANZMEC, 2000). Each of the criteria along with a description of how each will be achieved is provided as follows.

1. **Rehabilitation and rehabilitation outcomes consistent with the EIS (Environmental Assessment) which formed the basis of approval.**

The planned rehabilitation outlined in Section 2 reflects the concepts and designs initially presented in the *Environmental Assessment*.



2. Based on closure criteria and rehabilitation outcomes developed through stakeholder consultation.

The quarry closure objectives (outcomes) identified in Section 3.2 have been developed following consideration of the final landform and feedback received through the environmental assessment process for the quarry and consultation regarding Gales-Kingscliff Pty Ltd's master structure plan for its landholdings.

Ongoing consultation with local landholders and relevant NSW government agencies will be undertaken during quarry operations and as part of the assessment and approvals process for the various developments proposed within the master structure plan. Any changes to closure criteria and rehabilitation outcomes will be reflected in future revisions of the Landscape Management Plan.

3. Integrates rehabilitated native vegetation with undisturbed native vegetation to provide larger areas and wildlife corridors.

As the site and surrounding landholdings are largely cleared of vegetation and utilised for agriculture, the return of the majority of the Quarry Site to sporting fields and parkland is considered an acceptable outcome. In relation to aquatic habitat, the retention of the southern extraction pond and creation of wetland areas will increase the available aquatic habitat.

4. Suitable for an agreed subsequent land use as far as possible compatible with the surrounding land fabric and land use requirements.

The intended final landform and use was assessed during as part of the environmental assessment as being compatible and complimentary to the surrounding land fabric and land use requirements. This includes the intended final land use of the adjoining Hanson Tweed Sand Quarry.

Should the preferred final land use be modified future versions of the Landscape Management Plan will demonstrate compatibility of any such modification with surrounding land fabric and land use requirements.

5. Addresses limitations on the use of rehabilitated land.

As the existing land within the Quarry Site has previously proven unsuccessful for use in cultivation and is subject to flooding, the proposed rehabilitation and final land uses are considered to appropriately address and incorporate the applicable limitations.

6. Sustainable in terms of that land use.

The ongoing use of the site for sporting and recreation is considered to be a sustainable land use.



- 7. Stable and permanent landforms, with soils, hydrology, and ecosystems with maintenance needs no greater than those of surrounding land. (may include waste emplacements, voids, pits and water-bodies providing that they are part of the accepted final outcome).**

The approved final landform will largely be a recreation of the existing landform except for the creation of a lake (the completed southern extraction pond). The final slope of the pond that has not been backfilled or otherwise stabilised will be no greater than 1:5 V:H which provides for long term stability. The edged of the extraction pond will also be set back at least 10m from the boundaries and 15m from the existing power poles on the western boundary with reclaimed areas providing between approximately a 40m and 60m setback from the boundary.

Due to the flat nature of the site, establishment of a vegetative cover is expected to provide a sufficiently stable landform. However, in the event that ongoing erosion issues occur within particular areas of the lake edge, these will be stabilised using rock armouring reducing potential future maintenance needs.

- 8. Securely and safely contain waste substances that have the potential to affect land use or result in pollution.**

No waste substances have been identified on site and all wastes will be removed at the completion of quarry operations and remediation testing undertaken as required.

- 9. Not present a hazard to persons, stock or native fauna.**

The retained southern extraction pond could present a drowning hazard similar to other natural and artificial lakes such as the nearby Noble Lake and the adjoining Hanson Tweed Sand Quarry. As the lakes edges will generally have a gradual 1:5 slope this will provide suitable access for humans, stock and native fauna to safely exit the lake. Additionally, the site will be appropriately signed to inform the public of relevant hazards.

- 10. Addresses threatened species issues.**

Due to the existing disturbed nature of the site there are no threatened species issues. However, the long term ecological value of the site will increase with the creation of the lake and wetland areas. This is likely to contribute to the habitat of rare and threatened species.

- 11. Addresses heritage issues.**

No sites of heritage significance will be disturbed as a result of quarry operations.



12. Clean and tidy, and free of rubbish, metal and derelict equipment/structures, except for heritage and other agreed features.

All non-production waste materials generated will be disposed of off-site by waste contractors licensed for this function. All infrastructure not required for future land uses will be removed and rehabilitated during quarry closure.

13. Free from unacceptable air and water pollution, and other environmental effects outside the disturbed area.

Monitoring programs for air quality, noise, surface water and groundwater have been prepared and provided to the relevant government agencies. These programs will be implemented to verify compliance with applicable criteria both pre and post closure.

3.3.2 Specific Quarry Closure Criteria

Specific quarry closure criteria have been outlined in **Table 2.5** (see Section 2.5) and will be further developed and refined based upon the results of rehabilitation monitoring programs, research trials that may be undertaken and consideration of stakeholder feedback.

3.4 FUTURE LAND USES

The proposed long term land uses on the Quarry Site will be generally consistent with the overall strategic development plan for the development of Gales-Kingscliff Pty Ltd's landholdings within Kingscliff, Chinderah and Cudgen (see **Figure 3.1**)⁷. In accordance with this strategic development plan and dependent on the relevant approvals, the Quarry Site will comprise the following land uses upon completion of extraction and site rehabilitation (see **Figure 3.2**).

- Multipurpose sports fields.
- Recreation pond with parkland, walking tracks and picnic facilities.
- Equestrian club.
- Boat house.
- Tennis club.
- Athletics tracks.
- Bowling club.
- Indoor pool.

It is noted that the formation of a recreational pond and parkland would be consistent with the proposed final land use for the Hanson Tweed Sand Quarry.

⁷ Parts of the Strategic Development Plan are currently in review by Roberts Day and Tweed Shire Council to prepare a Kingscliff Locality Plan. Approved updates to the Strategic Development Plan will be included within the Landscape Management Plan during future reviews.



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KEY	
1	District Centre
2	Bulky Goods and Light Industrial
3	Existing Local Centre
4	Higher Density Residential
5	Mixed Density Residential
6	Environmental Protection
7	Parks, Sport Fields and Recreation Facilities
8	Special Uses
9	Lake
10	Civic Square
11	Transport Interchange

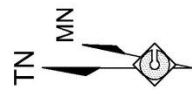
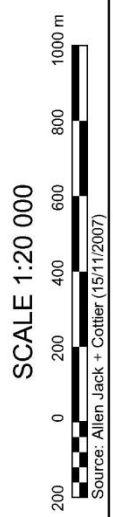
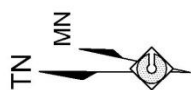


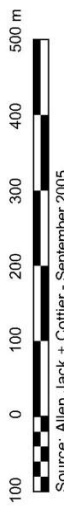
Figure 3.1
STRATEGIC DEVELOPMENT PLAN



\\SERVER\RW\617\61710\CAD\617\617Base_3.2 Final Land Use.DWG



SCALE 1:10 000



Note: Detail subject to change

Figure 3.2
CONCEPTUAL FINAL LAND USE

3.5 LONG TERM ENVIRONMENTAL MANAGEMENT

The quarry closure criteria have been designed to minimise the potential for ongoing environmental effects following the closure of the quarry. Adverse impacts on the environment would generally be as a result of one or more of these criteria not being met.

It is expected that the maintenance of the sporting fields and recreational facilities will be low and be undertaken by the operator of the facilities. Similarly, following successful establishment of vegetation and any additional stabilisation measures on the edges of the lake created by the southern extraction pond, it is expected any long term management requirements will be low.

3.6 POST-CLOSURE MONITORING

Monitoring of rehabilitation will be continued until the final specific quarry closure criteria are satisfied and the rehabilitation bond required by *Condition 3(31)* of PA 05_0103B is returned. As a minimum, the long term monitoring program will:

- compare results against quarry closure objectives and targets;
- identify possible trends and continuous improvement;
- assess effectiveness of environmental controls implemented;
- where required, identify modifications required for the monitoring program, rehabilitation practices or areas requiring research;
- assess the water quality and presence of any aquatic weeds within the southern extraction pond; and
- assess the effectiveness of wetland habitat creation.

Where necessary, rehabilitation procedures will be amended accordingly to ensure the successful achievement of quarry closure objectives (see Section 3.2).



4. REFERENCES

NSW Environment Protection Authority, 2014. *Waste Classification Guidelines. Part 1: Classifying Waste.*

The Australian Plants Society Central Coast Group, 2010. *The Long-stem Planting Guide.*

Idyll Spaces, 2008. *Flora Assessment for the Cudgen Lakes Sand Project.*



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Appendix 1

Weed Identification Information

(All information sourced from Weeds Australia www.weeds.org.au)

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Terrestrial Weeds

Coastal Morning Glory (*Ipomoea cairica*)

Alternative Name(s): Mile-A-Minute

Family: Convolvulaceae.

Form: Vine

Origin: Probably native of tropical areas of Africa and Asia although its native range now obscure.

Flowers/Seedhead: Surrounded by sepals 0.4–0.8 cm long, stamens and style included in flower tube. Flowers most of year.

Description: Perennial herb with twining and trailing stems. Roots tuberous and plant rooting at nodes. Plants hairless. Leaves round in outline, 3–10 cm long and wide, leaf stalk 2–6 cm long. Inflorescence axillary, 1–3 flowered. Capsule almost globe-shaped, 9–12 mm wide, with 2 chambers, splitting into 4 valves, contains up to 4 seeds. Seeds dark brown to black, 5–6 mm long, flattened ovoid, hairy with pale brown long hairs on outer ridges.

Distinguishing features: Distinguished by deeply 5-segmented leaves with basal segments often lobed; funnel-shaped violet (rarely white) joined petals 3.5–6 cm long, 6–8 cm wide, with darker violet hairless mid-petal bands, throat usually darker.

Dispersal: Spread by seed and locally by spreading stems.

Notes: Garden escape. Localised major weed of the coastal regions of NSW and Queensland, especially along creeks. *Ipomoea cairica* is also naturalised in North and South America, New Zealand, Pacific islands, Taiwan and Japan.



Giant Parramatta Grass (*Sporobolus fertilis*)

Family: Poaceae.

Form: Grass

Origin: Native of tropical Asia and Malesia.

Flowers/Seedhead: Seedhead: Flowers spring to autumn.

Description: Tufted perennial with seedhead to 1.6 m high. Leaf blades to 50 cm long.

Distinguishing features: Distinguished by leaf blades to 1.5–5 mm wide; seedhead 25–50 cm long with branches appressed to the axis and overlapping, although lower ones generally spreading at maturity, lowest node of seedhead with 1 main branch; spikelets 1.6–2 mm long with upper glume about a third of spikelet length, lower glume about 50% length of upper glume; grain 0.8–1.0 mm long.

Dispersal: By seed by water, wind and machinery. At maturity seeds become sticky and may attach to hair or fur.

Confused With: Other *Sporobolus* species, see taxonomic texts for detailed distinguishing features. Often confused with Parramatta Grass (*Sporobolus africanus*, previously known as *Sporobolus indicus* var. *capensis*) that is generally shorter (15–90 cm high), lower branches of seedhead close to stem and spikelets 2.1–2.5 mm long.

Notes: Summer growing unpalatable tough grass. Widespread and locally common in coastal areas of NSW and Queensland. Weed of low fertility soils. When established will exclude native plants. Recovers rapidly from fire. Major weed of disturbed and pastoral land



Small-Leaved Privet (*Ligustrum sinense*)**Alternative Name(s):** Chinese Privet.**Family:** Oleaceae.**Form:** Tree**Origin:** Native of China, Hong Kong, Taiwan, Laos and Vietnam.**Flowers/Seedhead:** Flowers: Flowerhead dense, branched (panicle) 5–10 cm long. Flowers fragrant with 4 white petals, each 3–5 mm long. Flowers late winter and spring.**Description:** Evergreen to semi-deciduous (in cooler areas) small tree to 5 m high. Leaves elliptic to ovate, margins entire, similar colour on both surfaces. Mature leaves 2–6 cm long, 1.5–2.5 cm wide, on stalk 0.3–0.7 cm long. Berry 4–7 mm long, black and succulent when ripe; seeds 3–4 mm long.**Distinguishing features:** Distinguished by small leaves; white fragrant flowers with pink to purple pollen bearing parts of the flower (anthers); at least midvein of lower leaf surface with short, weak, soft hairs; small branches with whitish corky areas through which gaseous exchange takes place (lenticels). Leaf edges on seedlings often wavy (see photo).**Dispersal:** Seed spread by water and birds.**Notes:** Often cultivated as a hedge plant. Small-leaved Privet invades wasteland, streambanks and margins of rainforest. Pollen spread by insects and unlikely to cause allergic reactions in humans. May be grazed by cattle, reducing vigour of the plant. May be confused with *Ligustrum vulgare* which has small, hairless leaves and yellow anthers.

Camphor Laurel (*Cinnamomum camphora*)

Family: Lauraceae.

Form: Tree

Origin: Native of China, Japan and Taiwan.

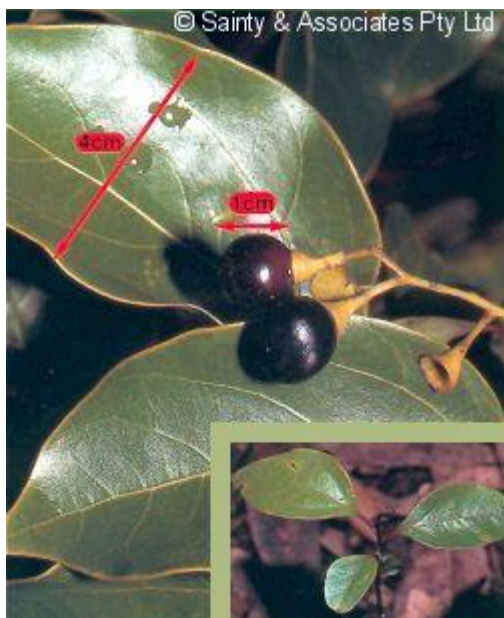
Flowers/Seedhead: Flowers: White, in branched heads (panicles), each flower about 3 mm long. Flowers spring and summer.

Description: Evergreen hardy spreading tree to 20 m high. Bark greyish, with numerous fissures. Leaves ovate, 5–11 cm long, 2–5 cm wide, glossy on upper surface; small depressions on the lower surface (domatia) between the bases of the 3 main veins. Fruit spherical, shining black, about 1 cm wide, ripening late autumn.

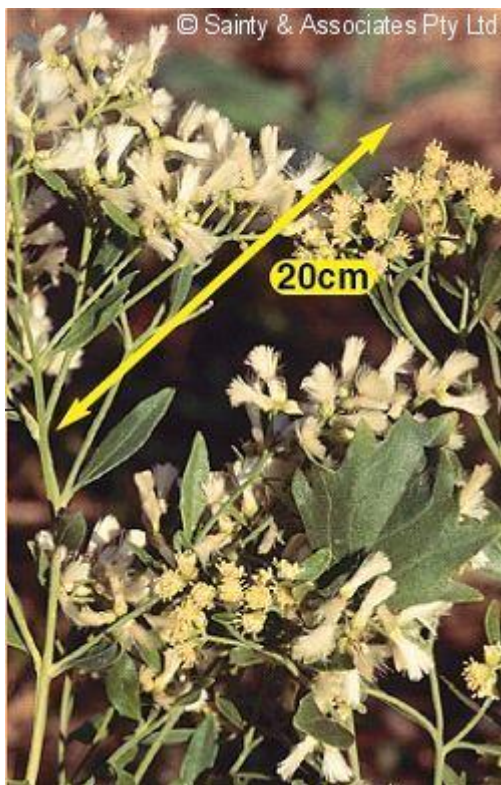
Distinguishing features: Distinguished by aromatic camphor oil smell when leaves are crushed; alternate leaves with leaf stalks 1.5–4 cm long; flowers with 6 petal-like lobes; base of fruit on an expanded part of the fruit stalk (receptacle).

Dispersal: Seed distributed by birds and water.

Notes: Common park and shade tree. Now extensively naturalised and in some localities a major problem of grazing land, disturbed rainforest and urban bushland. Especially invasive of stream banks, reducing light and crowding out other species. In some areas forms a monoculture for the entire length of a watercourse. Aromatic oil, camphor, is produced by distillation. This oil possibly causes death of fish and invertebrates. Wood is valued for carving and some types of furniture.



Mature leaves & fruit
Inset: Seedling

Groundsel Bush (*Baccharis halimifolia*)**Family:** Asteraceae.**Form:** Shrub**Origin:** Native of eastern North America and West Indies.**Flowers/Seedhead:** Flowerheads to 5 mm wide, consisting of a number of small flowers (florets); hair-like bristles (pappus) of female florets to 12 mm long; hair-like bristles of male florets to 4 mm long. Female plants enveloped in white hairs during seeding. Flowers mostly autumn.**Description:** Erect perennial shrub or small tree to 2.5 (rarely to 7) m high. Stems much branched, small branches striate and hairless. Leaves to 7 cm long and to 4 cm wide on a stalk to 1.5 cm long. Seeds ribbed, hairless, to 1.7 mm long with hair-like bristles at apex.**Distinguishing features:** Distinguished by wedge-shaped leaves usually with a few large teeth towards the apex (ones at ends of branches often lack teeth) and on a stalk; plants male or female; flowerheads in panicles, male florets cream to pale yellow, female florets white; receptacle (where seeds attach) without scales.**Dispersal:** Most spread by wind-dispersed seed. Long distance dispersal also by seeds on animals, in stock feed or in mud on vehicles.**Notes:** Seeds germinate at any time; plants mature after 2 years. Normally evergreen. Introduced in mid 1800s. Has low feed value and is suspected of poisoning livestock. Favours low-lying land near the sea (plants moderately salt tolerant) but also occurs in disturbed hinterland sites. Major weed; currently spreading. Eradicated from Busselton area in WA. A number of insects and a rust have been introduced for biological control of this shrub.

Lantana (*Lantana camara*)

Family: Verbenaceae.

Form: Shrub

Origin: Hybrid of garden origin; parents from tropical America.

Flowers/Seedhead: Flowers: Flowers yellow, orange, red, pink, purple, white or a combination of these. Flowerheads terminal, to 3 cm wide. Flowers most of the year.

Description: A variable sprawling thicket-forming perennial shrub to 5 m high and many metres wide or climbing to 15 m high. Leaves mostly to 7 cm long and to 4 cm wide, opposite, upper surface wrinkled and with rigid short hairs, lower surface often hairy, margins toothed. Leaves exude unpleasant odour when crushed. Fruit green at first, ripening black, 1-seeded. Seeds yellow-brown, to 4 mm long.

Distinguishing features: Distinguished by colourful Flowerheads composed of tubular flowers, to 12 mm long; recurved thorns on young stems of some varieties; stems 4-angled at first but becoming round with age.

Dispersal: Spread mainly by bird-dispersed seed. Also spread by stems touching the ground and developing shoots and roots (adventitious roots).

Notes: Introduced to Australia before 1850. Hardy, showy plant. Invasive from tropics to warm temperate zones. Plants smother vegetation to 15 m tall. Leaves and seeds of some varieties are toxic to stock, causing photosensitisation and damage to liver, kidneys and gut. Lantana infests over 4 million hectares of pasture and many millions of hectares of open woodland and open forest in Australia. Programs aimed at biocontrol of Lantana began in 1914 but without a lot of success.



Aquatic and Wetland Weeds

Salvinia (*Salvinia molesta*)

Family: Salviniaceae

Form: Water plant

Origin: Southern Brazil and Paraguay.

Description: Free-floating, mat-forming perennial. Individual plants 5–30 cm long, with 'leaves' (fronds) in whorls of 3 at each node, consisting of a pair of floating leaves and a submerged modified leaf that looks like and functions as a root. Upper surface of leaves covered with waxy egg-beater-shaped hairs; lower surface of leaves and root-like leaf covered with dark hairs. Fruiting bodies containing sterile spores hang from the divided leaf. Appearance varies depending on degree of crowding and availability of nutrients. The primary form occurs as isolated plants with small oval leaves that lie flat on the surface. The tertiary form is when plants multiply and become crowded; leaves are up to 6 cm wide.

Distinguishing features: Distinguished from other species of *Salvinia* by its egg-beater-shaped hairs on the upper 'leaf' surface.

Dispersal: Does not produce fertile spores. Reproduces by fragmentation.

Notes: Often survives for a short time after being stranded by receding waters. In nutrient rich water where temperatures are optimum, it is capable of doubling in area in less than 5 days. Prolific growth is a good indicator of the nutrient status of the water. A serious weed that will choke and cover wetlands and lakes, excluding fish and invertebrates. The *Salvinia* weevil, *Cyrtobagous salviniae*, provides effective control under certain conditions.



Water Hyacinth (*Eichhornia crassipes*)

Form: Water plant

Origin: Native of tropical South America.

Flowers/Seedhead: Flowers: In clusters on stems mostly taller than leaves. Flowers to 7 cm wide, lasting for 1 to 2 days and when all flowers on the spike have matured the spike turns down into the water.

Description: Free-floating perennial to 65 cm tall. Leaves basal, young plants with leaf stalks to 25 cm long and inflated at the base and older plants with leaf stalks to 60 cm long and without inflated bases. Roots feathery, black to purple, to 1 m long; usually short if water nutrient rich. Seed ovate–oblong, ribbed, about 1 mm long.

Distinguishing features: Distinguished by pale blue–lavender flowers with darker purple and yellow blotch, and some leaves with a swollen, buoyant base of leaf stalk.

Dispersal: Seeds may germinate within days or may remain dormant for up to 15 or more years. Mainly increases in density by daughter plants produced on stolons.

Notes: Attractive but troublesome plant that has spread worldwide, obstructing waterways, reducing fish production, harbouring mosquitoes, and severely disrupting life in some communities along rivers and lakes, mostly between latitudes 35° north and south of the equator. Luxuriant growth is usually a symptom of nutrient enrichment (eutrophication). Water Hyacinth will not thrive in good quality tap water. Biological control has been effective in some regions, particularly in tropical areas.



Olive Hymenachne (*Hymenachne amplexicaulis*)

Family: Poaceae.

Form: Grass

Origin: Native of Mexico, central America, tropical South America, West Indies.

Flowers/Seedhead: Seedhead: Spikelets lanceolate, to 4.5 mm long. Flowers summer and autumn.

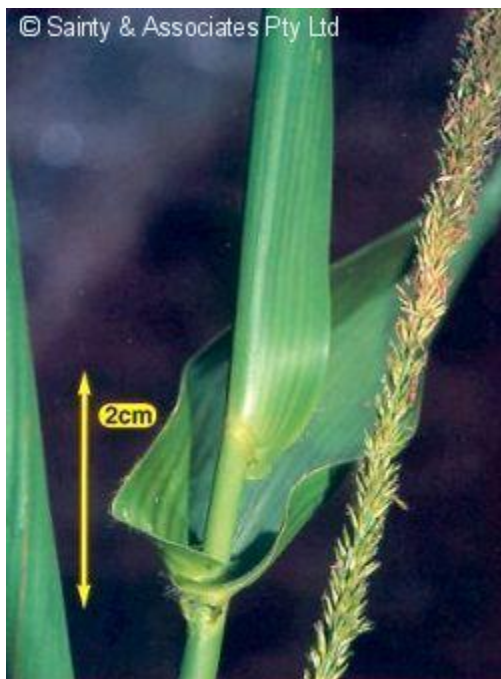
Description: Robust rhizomatous perennial grass to 1.5 (rarely to 2.5) m high. Stems floating or spreading over moist soil and then erect, often stoloniferous at the base and rooting at the nodes. Leaf blade to 3 (rarely to 6) cm wide and to 35 (rarely to 45) cm long; base of leaf blade with a membranous rim (ligule) against the stem.

Distinguishing features: Distinguished by stems containing pith; leaf blades stem-clasping at the base; cylindrical seedheads about 8 mm wide and to 40 cm long.

Dispersal: Spread by seed, in stockfeed, by waterbirds or by flood waters. Also planted as a ponded pasture species.

Confused With: *Hymenachne acutigluma* is a similar native species that does not have a stem-clasping leaf base.

Notes: Thrives in water to 2 m deep in areas with wet and dry cycles, tolerates deeper water than Para Grass, *Urochloa mutica*. Introduced as a ponded pasture species. Provides high quality feed all year round, even as waterbodies dry during extended periods of no rain. Displaces native species from deeper water threatening native wetland habitat.



Alligator Weed (*Alternanthera philoxeroides*)

Family: Amaranthaceae.

Form: Water plant

Origin: Native to South America.

Flowers/Seedhead: Flowerheads: White, cylindrical to globe-shaped heads that are papery to touch.

Description: Perennial with mostly hairless surface stems that root at the nodes (stoloniferous) and underground stems producing shoots & roots (rhizomatous). Can form dense mats in or out of water.

Distinguishing features: Distinguished by white flowerheads on stalks to 9 cm long that arise from the leaf-stem junction, opposite leaves and hollow stems especially when growing in water.

Dispersal: Viable seed not recorded in Australia. Spread by pieces in mud attached to machinery, in turf and by flood. Breakup of stems and further spread is increased by herbicide use and the plant's reaction to the damage caused by the flea beetle, *Agasicles hygrophila*.

Confused With: Other species of *Alternanthera* or species of Water Primrose, *Ludwigia* spp. or Smartweeds, *Persicaria* spp. Difficult to identify in dense vegetation and when not in flower.

Notes: Amongst the worst aquatic weed threats in Australia. Adapted to growing on damp land, occasionally flooded land, in shallow water (rooted in the substrate), attached to the bank (in deep water) or free floating. Will survive for a few days in sea strength salinity and thrive in 10% sea strength (3,500 mg/l) saline water. Introduced to Newcastle NSW in 1940s, it has spread to all States, aided by its misguided use as a culinary herb.



Parrot's Feather (*Myriophyllum aquaticum*)

Alternative Name(s): Brazilian Water Milfoil.

Family: Haloragaceae.

Form: Water plant

Origin: Native of South America

Flowers/Seedhead: Male and female flowers produced on separate plants. Only female plants found in Australia. Flowers have 4 triangular white sepals, 0.4–0.5 mm long; petals absent.

Description: Perennial aquatic herb. Stems spreading and erect, hairless, to 5 m long and to 5 mm wide, rooting at lower nodes. Leaves hairless with blade of submerged leaves to 4 cm long, emergent leaves 2.5–3.5 cm long, 0.5–0.8 cm wide, crowded towards tip.

Distinguishing features: Distinguished by all leaves in whorls; blue-green emergent leaves, toothed in whorls of 4–6; leaves with 18–36 teeth, lack of fruit (in Australia).

Dispersal: Spread by stem fragments as seed is not produced in Australia.

Notes: Forms dense stands that impede flow, especially in nutrient enriched water. If male plants are introduced the species may become more of a problem. This species is now widespread around the world.



Sagittaria (*Sagittaria platyphylla*)

Alternative Name(s): *Sagittaria graminea* subsp. *platyphylla*.

Family: Alismataceae.

Form: Water plant

Origin: Native from USA to Panama.

Flowers/Seedhead: Inflorescence on a leafless stalk, always below leaf height, with 2–12 whorls of fls. Flowers with 3 white petals and 3 sepals, male flowers c. 3 cm wide and with reflexed sepals. Flowers mainly spring to autumn, depending on latitude.

Description: Perennial aquatic to about 1.2 m high with tubers commonly formed. Submerged leaves translucent, strap-like, to 50 cm long. Emergent leaves lanceolate to linear-lanceolate, blade to 28 cm long and to 10 cm wide on a long stalk. Fruit a cluster (head) 0.5–1.5 cm across, consisting of 1-seeded segments, each segment flattened, winged, 1.5–3 mm long.

Dispersal: Spread by seed, rhizomes, tubers and floating entire plants. Cultivated as an ornamental and this has aided spread.

Notes: Now widespread and common in N Victoria, SW NSW and around Sydney, Newcastle and SE Qld. Becoming increasingly common in irrigation supply channels, drains, shallow creeks and wetlands. Shade tolerant. Forms dense patches, obstructing water flow and producing luxuriant growth in enriched conditions. Competes vigorously with native water plants.

