G7 | Marine Ecology

Santos | PETRONAS

Report

Survey of the Laird Point Dredge Material Placement Facility Intertidal Area

NOVEMBER 2009

Prepared for

Santos

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Abbreviations

Abbreviation	Description
AHD	Australian Height Datum
DEWHA	Department of Environment, Water, Heritage and the Arts
DMP	Dredge Management Plan
DMPF	Dredge Material Placement Facility
EIS	Environmental Impact Statement
GDA	Geocentric Datum of Australia
GLNG	Gladstone LNG
HAT	Highest Astronomical Tide
LAT	Lowest Astronomical Tide
LNG	Liquefied Natural Gas
MOF	Materials Offloading Facility
RE	Regional Ecosystem
URS	URS Australia Pty Ltd

Introduction

1.1 Background

Santos is proposing the development of a liquefied natural gas (LNG) liquefaction and export facility at Hamilton Point West in the south-west section of Curtis Island, near Gladstone, Queensland. As part of the proposed Gladstone LNG (GLNG) Project, Santos proposes capital dredging of up to approximately 6,800,000 m^3 for a shipping channel and swing basin, and up to 100,000 m^3 for access to the proposed Materials Offloading Facility (MOF).

Santos has proposed the development of a Dredge Material Placement Facility (DMPF) in a bay south of Laird Point for the disposal of the dredge spoil generated. Phase 1 of the DMPF proposal is to initially construct a bund wall along the foreshore of the bay to a height of 10 m above AHD (Australian Height Datum) thus creating a lagoon area on the landward side. Phase 2 includes increasing the bund wall height to approximately 22 m above AHD, which would have the capacity for approximately 10.1 million m^3 of dredged material. Dredged material would be pumped to the DMPF as slurry from the dredger.

The proposed DMPF footprint includes some 500,000 m^2 of intertidal areas, mostly comprised of salt flats, with small areas of mangroves. The DMPF area is a low lying valley area, with elevated areas to the north, south and east. To the west the valley opens up into Port Curtis, with a margin of mangroves separating the valley floor from the sea. The base of the valley is broad and is predominantly salt pan which is inundated with sea water during higher tides.

The June 2008 intertidal survey (see Appendix R1 of the GLNG Environmental Impact Statement [EIS]) included four sites in the vicinity of the DMPF (see Figure 2-1 of Appendix R1 of the EIS). The June 2008 survey found that salt flats were the dominant habitat type within the DMPF area.

A number of other studies have investigated this area, including:

- Traffic and Transport – to assess the potential impacts of the ferrying of workforce and barging of equipment and material to the dredge material placement facility;
- Land, Terrain and Soils – provides a summary of the local topography and soils;
- Nature Conservation – a summary of the terrestrial flora and fauna of the area and targeted investigations into the possible presence of the water mouse and wader birds along the coastal margins of the area, and an assessment of the presence of the powerful owl in southern Curtis Island;
- Surface water – an assessment of the potential impacts from surface water discharges and failure of the proposed facility bund walls;
- Groundwater – a hydrogeological assessment of the suitability of the DMPF;
- Coastal Environment – a summary of the local coastal environment and a comparative assessment of marine sediment studies undertaken for the GLNG Project and other local projects where dredging has been undertaken;
- Air Quality – a summary of the potential air quality impacts and mitigation measures;
- Noise and Vibration – an assessment of the potential impact of construction of the dredge material placement facility on local noise levels;
- Land Use and Infrastructure – an assessment of the impacts on land use resulting from construction and operation of the proposed facility;

- Cultural Heritage – an assessment of existing non indigenous cultural heritage values in the vicinity of the proposed facility; a review of potential impacts and development of mitigation measures. In addition, a summary of Santos' approach to Indigenous cultural heritage management of the site is provided;
- Social Impact Assessment – a review of possible effects on local values; and
- Decommissioning and Rehabilitation – a summary of Santos' approach to site decommissioning and rehabilitation, including assessment and mitigation measures.

1.2 Objectives

The primary objective of the field survey was to provide a description of the intertidal areas potentially impacted by the DMPF. The survey focused on providing a photographic record of the intertidal area. Notes were also taken on key features.

An assessment of the area of mangroves and saltmarsh/saltpan communities potentially impacted by the DMPF was also undertaken. Field studies were conducted at low tide to assess the intertidal areas between Lowest Astronomical Tide (LAT) and Highest Astronomical Tide (HAT) in order to address comments received by the Department of Environment, Water, Heritage and the Arts (DEWHA).

1.3 Regional Context

Section 8.4.2.2 of the GLNG EIS provides a description of the study area and Section 8.4.3 describes the regulatory framework. Section 8.4.4.5 provides further detail on the regional context.

1.4 Intertidal Habitat

Mangroves and salt marshes grow in the intertidal zone of quiet estuaries and bays, protected from strong currents and wave action. Salt marshes are frequently associated with mangroves and abut against them, with saltmarsh growing inshore of the mangroves (Hutchings & Saenger, 1987). The mangrove zone occurs inshore of sand and mud flats. This strong zonation typifies Port Curtis intertidal areas and is common on Curtis Island. These distinct communities occur generally parallel to the shore, except where drainage channels or creeks alter the surface topography (Chamberlain, 1979).

1.4.1 Mangrove communities

Mangrove communities are considered ecologically important for a number of reasons (Galloway 1982; Connell Wagner 2008; UNEP-WCMC 2006). It is considered that they:

- Support recreational and commercial fisheries by providing essential nursery, feeding and breeding areas for many species of fish, invertebrates and migratory birds;
- Facilitate biologically productive natural systems by contributing organic matter to estuaries;
- Act as a filter of sediments and other substances that may accumulate from land runoff;
- Provide important buffering against natural and/or anthropogenic processes, including overland runoff, flooding and storms;
- Provide key areas for educating the community and the general public on the nature and significance of coastal wetlands (http://www.derm.qld.gov.au); and
- Assist in oxygenating substrates through the root systems of mangrove communities.

1 Introduction

The buffering capacity of mangrove communities protects the near shore environment from influences such as flooding, sedimentation, eutrophication and pollutants (UNEP-WCMC 2006).

1.4.2 Saltmarsh communities

Saltpans are hypersaline, unvegetated areas high in the intertidal zone that are inundated only at high spring tides (Saenger, 1996). They are characterised by poorly drained clay soils, high evaporation rates and a low, highly seasonal rainfall (Saenger, 1996). The surface of the saltpan is devoid of vascular plants, but can be covered by a thick algal mat. The mat combines with the top layer of clay to form a leathery surface which peels off and cracks into sheets as the saltpan dries (Olsen et al., 1980).

In Port Curtis, saltmarsh occurs at the seaward edge of extensive saltpans, usually just landward of mangroves. Saltmarsh can also occur at the terrestrial side of salt flats where freshwater input reduces salinity (Morrisey, 1995).

Although saltpan environments are generally only inundated with the high tides they can play an important role as fisheries habitat. These communities can be an important nursery and/or feeding area for smaller fish species. Saltpans may also support a diverse invertebrate assemblage, including crustaceans, molluscs and insects. These assemblages are important food sources for a number of species, including species of commercial and recreational value (Morrisey, 1995).

2

Methodology

The survey was conducted during the low tide on 30 August 2009 between approximately 9:30 am and 1:30 pm. Field scientists took photographs and notes at a number of sites (Table 2-1 and Figure 2-1). Photographic evidence and field observations were recorded during this study.

Table 2-1 Laird Bay Sites (GDA 94)

Site	Northing	Easting
LB-01	23.75290	151.17987
LB-02	23.75428	151.18109
LB-03	23.75563	151.18137
LB-04	23.75638	151.18126
LB-05	23.75660	151.18077
LB-06	23.75580	151.18275
LB-07	23.75434	151.18553
LB-08	23.75512	151.18599
LB-09	23.75555	151.18596
LB-10	23.75702	151.18431
LB-11	23.75742	151.18387
LB-12	23.75615	151.18704
LB-13	23.75371	151.18839
LB-14	23.75167	151.18915
LB-15	23.75139	151.18709

N
W E
S

0 200 400m

Scale: 1:10,000 (A4)
Datum: GDA94

Dredge Material Placement Facility Footprint

Laird Bay Survey Sites

Source: This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright.

Client	Project	Title	
LNG	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT MARINE ECOLOGY	**LAIRD BAY INTERTIDAL SITES**	
URS	Drawn: RG · Approved: JB · Date: 06-11-2009	Figure: **2-1**	Rev:C
	Job No: **4262 6440**/6220 · File No: 42626440-g-2027.wor		**A4**

Results

3.1 Site LB-01

Site LB-1 is located in a narrow tongue of salt flat to the west of the DMPF. The salt flat was covered with a cyanobacterial algal mat (a and b) with very little vegetation or evidence of fauna. The landward side (c) had a thin strip of mangroves, approximately two to three trees wide, with several species; *Excoecaria agallocha* (milky mangrove), *Aegiceras corniculatum* (river mangrove, *Lumnitzera racemosa* (white-flowered black mangrove), *Bruguiera gymnorhiza* (large-leafed orange mangrove), *Osbornia octodonta* (myrtle mangrove), *Ceriops australis* (smooth-fruited yellow mangrove) and *Avicennia marina* (grey mangrove). Beyond this mangrove strip there was Eucalypt woodland. The seaward side (d) consisted of a narrow zone (approximately 10 – 30 m wide) of shrubland communities dominated by *Ceriops australis* and *Avicennia marina.* Minor species included *Aegialitis annulata* (club mangrove) and *Lumnitzera racemosa.*

Plate 3-1 Site LB-01

(a) Looking north-west

(b) Looking south-east

(c) Looking north-east

(d) Looking south-west

3.2 Site LB-02

Site LB-2 is located approximately 200 m to the south-east of LB-1. The salt flat (Plate 3-2 a, b and c) is the same as described for site LB-1. Plate 3-2 (d) shows the presence of cheniers or beach ridges (shoe-string shaped sand/shell deposits formed during storm events) with a species-rich and very localised habitat. The cheniers, which are supratidal in elevation (approximately 1. 5 m above the salt flat), provide localised freshwater seepage at their margins with the surrounding mudflats and, together with a different substrate type (calcareous sands and shell gravel), these conditions have developed narrow mangrove habitats of either a mixed species woodland on the chenier crests (*Excoecaria agallocha, Lumnitzera racemosa, Bruguiera gymnorhiza, Xylocarpus moluccensis* and *Xylocarpus granatum*) or a mixed species shrubland on chenier slopes (*Avicennia marina, Rhizophora stylosa, Ceriops tagal, Aegialitis annulata, Aegiceras corniculatum, Lumnitzera racemosa and Osbornia octodonta*). Coastal dune species and halophytic grasses (*Sporobolus virginicus*) and shrubs (*Sueada* sp.) also occur on the cheniers together with some non-mangrove tree species. Plate 3-3 shows the view from the top of the chenier ridge (a), along with some of the plants found there.

Plate 3-2 Site LB-02

(a) Looking north-west

(b) Looking south-east

(c) Looking north-east

(d) Looking south-west

3 Results

Plate 3-3 Detail of chenier ridge at Site LB-02

(a) Looking south-west from top of chenier ridge

(b) Prickly pear on swale

(c) Ruby saltbush (*Enchylaena tomentosa*) and salt couch (*Sporobolus virginicus*)

(d) Bearded samphire (*Sarcocornia quinqueflora*)

Site LB-03

Site LB-3 is located approximately 200 m to the south-south-east of LB-2 along the chenier ridge. Eucalypt woodland can be observed on the higher reaches of the chenier ridge, with low mangroves at its base (Plate 3-4 a, b and c). Plate 3-4 (d) shows the view to the south-west where dense mangrove habitat occurs (primarily stilt mangroves, *Rhizophora stylosa*).

Plate 3-4 Site LB-03

(a) Looking north-west

(b) Looking south-east

(c) Looking north-east

(d) Looking south-west

Site LB-04

Site LB-4 is located approximately 100 m to the south-south-west of LB-3, amongst the mangrove habitat fringing the seaward edge (Plate 3-5). *Rhizophora stylosa* is the dominant species. North Passage Island is visible in the background of Plate 3-5 (c). Numerous crab holes were observed at this site.

Plate 3-5 Site LB-04

(a) Looking north-west

(b) Looking south-east

(c) Looking south-west

3 Results

3.3 Site LB-05

Site LB-5 is located approximately 75 m to the south-west of LB-4. This site is on a mudflat spit (with rubble) on the seaward edge of the mangroves (6). The mouth of the creek leading into the DMPF area is visible in Plate 3-6(a).

Plate 3-6 Site LB-05

(a) Looking east towards mouth of creek

(b) Looking north

(c) Looking north-east

(d) Looking south towards North Passage Island

3.4 Site LB-06

Site LB-6 is located approximately 200 m to the east-north-east of LB-3. It is located on the northern edge of the mangrove habitat fringing the creek leading into Laird Bay. Plate 3-7 (a) and (d) show the interface between the mangroves and the salt flat. Small saltbush and samphire plants are visible near the edges of the mangroves. *Ceriops australis* and *Avicennia marina* are the dominant mangrove species.

Plate 3-7 Site LB-06

(a) Looking east

(b) Looking north

(c) Looking west

(d) Looking south

3.5 Site LB-07

Site LB-7 is located approximately 300 m to the east-north-east of LB-6 at the north-eastern edge of the mangroves adjacent to the creek. Plate 3-8(a) shows the low mangroves. To the west (d) and north (b) can be seen the drainage channel, with low shrubs.

Plate 3-8 Site LB-07

(a) Looking south

(b) Looking north

(c) Looking east

(d) Looking west

3.6 Site LB-08

Site LB-8 is located approximately 100 m to the east-south-east of LB-7 where the main drainage channel emerges from the creek. Plate 3-9 (e) is a photograph taken looking along the drainage channel and shows stunted mangroves and a slight depression. Plate 3-10 shows some of the fauna found in this drainage channel.

Plate 3-9 Site LB-08

(a) Looking south-west

(b) Looking east

(c) Looking north-west

(d) Looking south

(e) Looking north-east. End of creek where mangroves meets salt flat

3 Results

Plate 3-10 Fauna at Site LB-08

(a) Mud whelk (*Telescopium telescopium*).

(b) Unidentified crab

(c) Mudskipper (*Periophthalmus* sp.)

3.7 Site LB-09

Site LB-09 is located approximately 75 m south of LB-08 at the south-eastern edge of the mangroves adjacent to the creek. The salt flat is as described for site LB-01.

Plate 3-11 Site LB-09

(a) Looking south

(b) Looking south-east

(c) Looking east

(d) Looking north

(e) Looking north-west

3.8 Site LB-10

Site LB-10 is very similar to site LB-01. To the south-west is a chenier ridge with a fringe of mangroves and Eucalypt woodland behind (Plate 3-12 b).

Plate 3-12 Site LB-10

(a) Looking south

(b) Looking south-west

(c) Looking north-east

(d) Looking north-west

3.9 Site LB-11

Site LB-11 is approximately 100 m to the south-west of LB-10 within the chenier ridge. This ridge is approximately 1.5 m above the salt flat and contains a Eucalypt woodland community (Plate 3-13).

Plate 3-13 Site LB-11

(a) Looking south-east

(b) Looking north-west

(c) Looking south-west

(d) Looking north-east

3.10 Site LB-12

Site LB-12 is located within a small embankment on the south-eastern edge of the salt flat. The salt flat was softer at this location, possibly from the influx of water from the adjacent gully. Grasses occurred on the landward fringes, prior to grading into open Eucalypt woodland (Plate 3-14 d).

Plate 3-14 Site LB-12

(a) Looking east

(b) Looking north

(c) Looking west

(d) Looking south

3.11 Site LB-13

Site LB-13 is approximately 300 m to the north-east of LB-12 and displays many similarities. A small eroded edge is visible in Plate 3-15 (a) and (c) where the salt flat meets the grassed area, with open woodland in the background.

Plate 3-15 Site LB-13

(a) Looking north-east

(b) Looking south-west

(c) Looking south-east

(d) Looking west

3.12 Site LB-14

Site LB-14 is located at the extreme north-east end of the salt flat (Plate 3-16). The salt flat is as described previously.

Plate 3-16 Site LB-14

(a) Looking north-east

(b) Looking south-west

(c) Looking south-east

(d) Looking west

3.13 Site LB-15

Site LB-15 is located approximately 200 m to the west of LB-14. The salt flat is as described previously (Plate 3-17). Several horses were observed feeding on the grassy edges approximately 200 m to the west (Plate-18).

Plate 3-17 Site LB-15

(a) Looking west

(b) Looking north-west

(c) Looking south-west

(d) Looking south

3 Results

(e) Looking east

(f) Looking north

Plate 3-18 Horses to the west of site LB-15

Potential Impacts and Mitigation Measures

4.1 Background

Potential impacts on mangrove and intertidal areas at the Laird Point DMPF area include the direct impacts from the construction of a bund wall and associated infrastructure, and the disposal of spoil on the intertidal areas behind the wall. Indirect impacts may occur on the seaward side of the bund wall including: degradation of habitat due to increased sedimentation; altered local hydrology; pollution or potential disturbance of acid sulphate soils; and indirect impacts to fauna breeding and feeding activities (Stewart & Fairfull, 2008; Connell Wagner, 2008).

The intertidal wetlands within the area are reflective of the general zonation present within Port Curtis, with closed *Rhizophora* on the seaward side and saltpans and isolated patches of closed *Ceriops* to the landward side (Connell Wagner, 2008). The near shore environment consists primarily of exposed banks devoid of vegetation. Rasheed *et al.* (2008) suggest that seagrass meadows are not found along these mudbanks and they were not detected during the intertidal and subtidal field surveys conducted in 2008 as part of the GLNG EIS.

The quantification of areas of mangroves and intertidal habitats potentially impacted by the DMPF was derived from maps based on the Queensland DERM Regional Ecosystems (RE) datasets. The RE mapping (see Table 8.4.1 of the GLNG EIS) reported that there is 16,580 ha of mangrove shrubland (RE 12.1.3) and 15,242 ha of saltpan vegetation (RE 12.1.2) within the subregion (Qld Herbarium, 2009). Figure 4-1 shows the areas at the Laird Point DMPF area that will be directly impacted by spoil disposal and construction activities, along with calculations of areas outside of the DMPF that may be indirectly impacted.

4.2 Direct Impacts

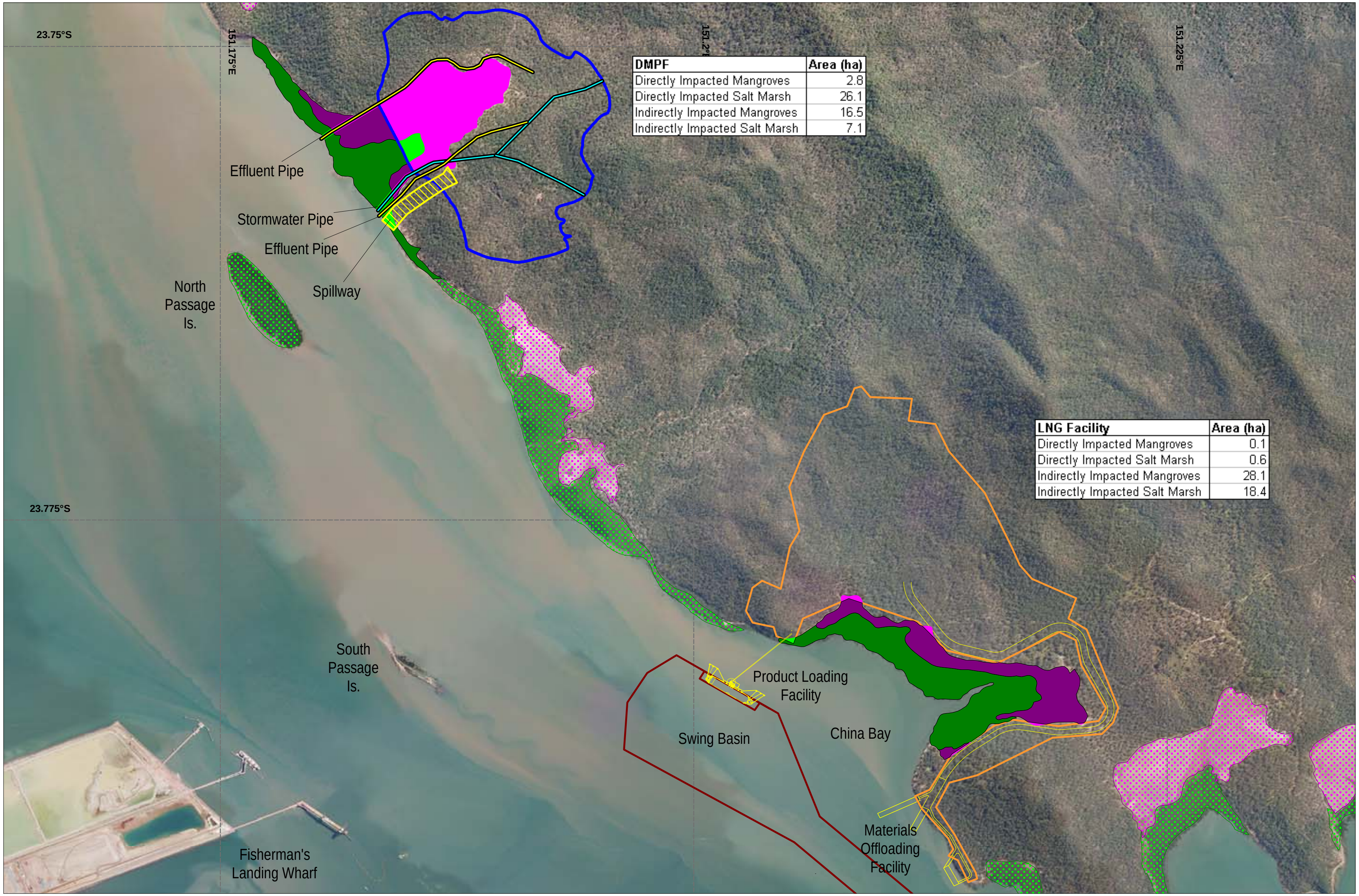
The construction of the DMPF and the subsequent infilling with dredge spoil is calculated to result in the total loss of 2.79 ha of mangrove and 26.06 ha of saltpan communities. This represents 0.017 % of the mangroves and 0.171 % of the saltpan communities within the subregion (Table 4-1). It is not expected that there will be any recovery in these areas directly impacted.

The loss of these communities has the potential to cause direct mortality to individual animals that are residing within this area at the time of construction/spoil disposal (Stewart & Fairfull, 2008). The survey found few animals living within the DMPF footprint and these were generally restricted to the drainage channels.

Table 4-1 Direct loss of mangroves and saltpan communities

Regional Ecosystem (RE)	Vegetation Community Description	Area in DMPF study area (ha)	Area within subregion (ha)[1]	% of subregional extent represented within study area
12.1.2	Saltpan vegetation comprising *Sporobolus virginicus* grassland and samphire herbland on Quaternary estuarine deposits	26.06	15,242	0.171
12.1.3	Mangrove shrubland to low closed forest on Quaternary estuarine deposits	2.79	16,580	0.017

1 Derived from RE data for the Burnett-Curtis Hills and Ranges subregion as per Accad *et. al*. (2006)



DMPF	Area (ha)
Directly Impacted Mangroves	2.8
Directly Impacted Salt Marsh	26.1
Indirectly Impacted Mangroves	16.5
Indirectly Impacted Salt Marsh	7.1

LNG Facility	Area (ha)
Directly Impacted Mangroves	0.1
Directly Impacted Salt Marsh	0.6
Indirectly Impacted Mangroves	28.1
Indirectly Impacted Salt Marsh	18.4

N W E S

0 500 1000m

Scale 1:30,000 (A4)
Datum: GDA94

Mangroves
Salt Marsh
Directly Impacted Mangroves
Directly Impacted Salt Marsh
Indirectly Impacted Mangroves
Indirectly Impacted Salt Marsh
LNG Facility Site Layout Disturbed Area Footprint
LNG Facility Proposed Wharves and Haul Road
Laird Point Dredge Material Placement Facility
Proposed Dredging

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Client

Project
GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT
SUPPLEMENT
MARINE ECOLOGY MANGROVE ASSESSMENT

Drawn: CA | Approved: JB | Date: 22-10-2009

Job No: 4262 6440/6220 File No: 42626440-g-2074.wor

Title
LNG FACILITY
POTENTIAL IMPACTS TO MANGROVES AND SALT MARSH COMMUNITIES

Figure: **1-1**

Rev: B

A4

4.3 Potential Indirect Impacts

Potential indirect impacts include degradation of habitat due to increased sedimentation, altered local hydrology, pollution or potential disturbance of acid sulphate soils and indirect impact to fauna breeding and feeding activities (Stewart & Fairfull, 2008; Connell Wagner, 2008).

The calculation of the areas of mangrove and saltpan communities adjacent to the DMPF footprint and associated infrastructure is shown in Figure 4-1 and Table 4-2. 16.47 ha of mangrove and 7.10 ha of saltpan communities are calculated as potentially being impacted by the construction and operation of the DMPF representing 0.099 % of the mangroves and 0.047 % of the saltpan communities within the subregion. Estimates of the actual extent of indirect potential impacts are not possible given possible accretion and re-colonisation of mangroves over time due to changes in surface water run-off, impacted soil adjacent to mangrove communities, smothering of pneumatophores and other possible indirect potential impacts. The table below sets out the total area of adjacent communities which may be indirectly impacted by these processes.

Table 4-2 Areas of mangroves and saltpan communities potentially affected

Regional Ecosystem (RE)	Vegetation Community Description	Area in DMPF study area (ha)	Area within subregion (ha)[1]	% of subregional extent represented within study area
12.1.2	Saltpan vegetation comprising *Sporobolus virginicus* grassland and samphire herbland on Quaternary estuarine deposits	7.10	15,242	0.047
12.1.3	Mangrove shrubland to low closed forest on Quaternary estuarine deposits	16.47	16,580	0.099

[1] Derived from RE data for the Burnett-Curtis Hills and Ranges subregion as per Accad *et. al*. (2006)

4.3.1 Increased Sedimentation

A very important feature of mangrove forests is their ability to trap and bind sediment within their extensive root structures (Saenger, 1982). Under a moderate sedimentation rate, a mangrove forest will accelerate the process of land formation (Cahoon *et. al.,* 2002). Too much sedimentation, on the other hand, can lead to mangrove mortality as the sediments asphyxiate the respiratory structures (e.g., lenticels and aerenchyma) which mangroves have developed to allow for gas exchange within the roots (Cahoon *et. al*., 2002; Duke, 2006). Therefore, there is the potential for either an increase in the area available for mangrove colonisation, or the potential for sedimentation to result in mortality of mangroves in the area.

4.3.2 Coastal Processes

Construction and operation of the DMPF may alter existing surface water drainage patterns adjacent to the mangroves with potential negative effects, such as build-up of sediments resulting in depletion of dissolved oxygen in the sediments (Pollard & Hannan, 1994; Stewart & Fairfull, 2008). Since mangroves acquire their oxygen via their root system, anaerobic sediments can lead to mortality and loss of key fish habitat. Altered water courses and drainage can also affect the salinity of these ecosystems. Saltmarshes in particular do not tolerate constant freshwater inputs (Duke, 2006;

Nybakken & Bertness, 2005). Hence frequent freshwater inputs may potentially negatively impact adjacent saltmarsh communities.

4.3.3 Recovery from Sedimentation and altered Hydrology

Minor disturbances to mature mangrove and saltmarsh communities in protected estuaries are generally self-repairing, but major disturbances can result in altered coastal dynamics and make recovery problematic. At this latitude mangroves grow quickly and have the potential to recover effectively from such removals (Stewart & Fairfull, 2008). In the interim, the saltmarshes behind the mangroves can become exposed to pollutants and freshwater inputs and can be lost in a secondary coastal damage scenario (Morrisey, 1995).

Mangroves and saltmarshes require gradated shorelines that can dissipate wave energy and allow periodic invasion of saltmarshes by seawater (Morrisey, 1995; Duke, 2006; Field, 2004). Mangrove and saltmarsh coastlines need sufficient buffer area to provide for retreat and advance phases that naturally occurs over time (Xiaolin & Quiaomin, 1997).

Overall trends in recovery of mangroves and salt marshes are not clear given the nature of these sediments and potential altered hydrodynamics resulting from the dredging activities (Cahoon *et. al*., 2002).

Mangroves will not establish or survive along high energy coastlines. Mature mangroves will however survive medium and infrequent tidal energy episodes, especially where retreat and advancement space is available (Morrisey, 1995; Duke, 2006; Field, 2004). In this case, the coastline will not be subjected to significant clearance; so the considerable supply of propagules coming from the surrounding areas is very likely to enhance the re-settlement of mangroves in areas potentially impacted (Saenger, 1982).

In the unlikely event that the tidal energy may be too severe for seedlings to establish naturally, replanting techniques may then be required (Saenger, 1982; Weir *et. al*., 2006). In addition, consideration may need to be given to additional construction of controlled coastal inundation mechanisms to ensure conditions required for healthy mangroves and saltmarshes are retained or created where losses have occurred (Pollard & Hannan, 1994).

Chemical and freshwater pollutants may also be a concern. Both mangroves and saltmarshes can be severely impacted upon by pollutants such as oil, meaning that adjacent marine operations need to be well managed (Stewart & Fairfull, 2008). This aspect is discussed in detail in Attachment B4 of the EIS Supplementary.

4.4 Mitigation Measures

In accordance with the Primary Industries and Fisheries Fish Habitat Management Operational Policy FHMOP 005 (2002) *Mitigation and Compensation for Works or Activities Causing Marine Fish Habitat Loss* (Queensland Fisheries, 2002), mitigating actions such as best practice methodologies will be used to remove mangroves and saltmarsh to be directly impacted by the construction of the DMPF. Santos will discuss the options for appropriate environmental offsets under the Queensland Government Environmental Offsets Policy (2008) with Primary Industries and Fisheries and any other relevant agency to establish an offset agreement with the regulator.

4 Potential Impacts and Mitigation Measures

Santos is committed to educating all staff and construction workers on the fisheries values of mangroves and saltmarsh and the protection of these values. Santos will also discuss with Primary Industries and Fisheries the mitigation and environmental offsets options in accordance with the FHMOP005 and the *Queensland Government Environmental Offsets Policy* (Queensland Fisheries, 2002).

A draft Dredge Management Plan (DMP) has been developed as part of the GLNG Supplementary EIS. The DMP includes detailed management and mitigation measures for controlling potential impacts from:

- The construction of the DMPF;
- The disposal of spoil into the DMPF;
- The operations of vessels associated with spoil disposal; and
- Discharges from the DMPF.

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