Draft environmental management plan

Land release management plan

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Enter ▶ Go back to contents ▶

Santos
GLNG Project

Santos GLNG Upstream

Land Release Management Plan

Santos
GLNG Project

Table of Contents

Tables

Figures

Santos
GLNG Project

Abbreviations and Units

Acronym	Description
AS	Australian Standard
BUA	Beneficial Use Approval
CEC	Cation Exchange Capacity
CSG	Coal Seam Gas
CS Water	Coal Seam Water
EA	Environmental Authority
EC	Electrical Conductivity
EC_{se}	Root zone salinity (measured as EC)
EHS	Environmental Hazard Standard
EHSMS	Environment Health and Safety Management System
EP Act	*Environmental Protection Act 1994*
EP	Equivalent Persons
EP Reg	*Environmental Protection Regulation 2008*
ESA	Environmentally Sensitive Area
ESP	Exchangeable Sodium Percentage
GED	General Environmental Duty
GLNG	Gladstone Liquid Natural Gas
HDPE	High Density Polyethylene
L	Litre
LF	Leaching Fraction
LPD	Low Point Drain
LRMP	Land Release Management Plan
M	Metre
MEDLI	Model for Effluent Disposal using Land Irrigation
mg/L	Milligrams per Litre
mL	Millilitre
mm	Millimetre
µg/L	Micrograms per Litre
µS/cm	Microsiemens per Centimetre
P&G Act	*Petroleum and Gas Act 2004*
RMP	Resource Management Plan
SAR	Sodium Adsorption Ratio
STP	Sewage Treatment Plant
WRR Act	*Waste Reduction and Recycling Act 2011*

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1.0 Introduction

Santos GLNG activities in the gas fields of Queensland have the potential to generate a variety of fluid streams as a product of gas extraction activities including coal seam water (CS water), low point drain (LPD) condensate, hydrostatic test water and treated sewage effluent. The management of these waters can be costly and impractical if they are required to be transported large distances for treatment and disposal.

Alternatively, controlled application to land allows for the efficient management and in many circumstances, the beneficial reuse of waters. Properly managed reuse can be an economical and environmentally sound use of these resources, particularly in remote areas, where appropriately licensed disposal facilities can be hundreds of kilometres away as well as during construction phases of projects and where water availability is limited or there are competing interests for water use. Despite these management constraints, if not managed appropriately, the release of waters to land may present a potential threat to agricultural productivity, the health and diversity of native ecosystems and human health.

This Land Release Management Plan (LRMP) outlines the management principles to minimise the potential for impacts to, or contamination of, land resulting from land release activities and provides an overview of the measures utilised by Santos GLNG to manage land releases of waters in the Santos GLNG Upstream Project Area.

1.1 Purpose and Scope

1.1.1 Purpose

When undertaking land release activities, Santos GLNG has both a legal and social responsibility to manage the application of waters to land and to prevent the unauthorised release of contaminants or environmental harm. This LRMP has been prepared to satisfy these obligations and complements the overarching Santos Environment, Health and Safety Management System (EHSMS).

The objectives of the LRMP are to:

- facilitate compliance with relevant Commonwealth, State and Local Government legislation, regulations and approvals;
- support compliance with the Santos EHSMS*;*
- provide a framework to:
  - identify and appropriately manage land releases of waters associated with the construction, operation and decommissioning of Santos GLNG assets and activities;
  - adequately monitor and collect relevant data to record and report quality, volumes and movements of waters;
  - identify and respond to impacts associated with land releases of waters to maintain compliance with relevant approvals and prevent landholder or community complaints; and
  - develop site-specific / activity specific land release management procedures as required during the project lifetime.

1.1.2 Scope

This LRMP outlines the general principles, methods and controls to prevent environmental harm being caused by releases of waters to land and to ensure contaminants are not directly or indirectly released to land or waters, except as permitted under the relevant Santos GLNG gas field Environmental Authorities (EA).

This LRMP addresses the most common and highest volume waters generated by and released to land within the Santos GLNG Upstream Project Area as listed below:

- coal seam water use for irrigation purposes;
- coal seam water use for dust suppression, construction and operational purposes;
- treated sewage effluent releases to land;
- use of treated sewage effluent for dust suppression, construction and operational purposes;
- low point drain water releases to land; and
- hydrostatic test water releases to land.

The management and potential release to land of all other sources of water will consider the principles discussed in this LRMP and will be addressed on a case by case basis.

This LRMP does not address:

- the land release requirements for those activities operated in accordance with a beneficial use approval (BUA) issued under the *Waste Reduction and Recycling Act 2011* (WRR Act). Where required, site-specific Resource Management Plans (RMP) should to be developed for these activities; or
- direct releases to waters.

The LRMP will be implemented by Santos GLNG Project personnel responsible for managing wastewaters throughout the exploration, construction, production, decommissioning and rehabilitation phases of the Project.

This LRMP applies to activities carried out within the Santos GLNG Upstream Project Area. The Santos GLNG Upstream Project Area consists of Santos GLNG petroleum tenements comprising the Arcadia, Fairview, Roma and Scotia gas fields and as illustrated in Figure 1.

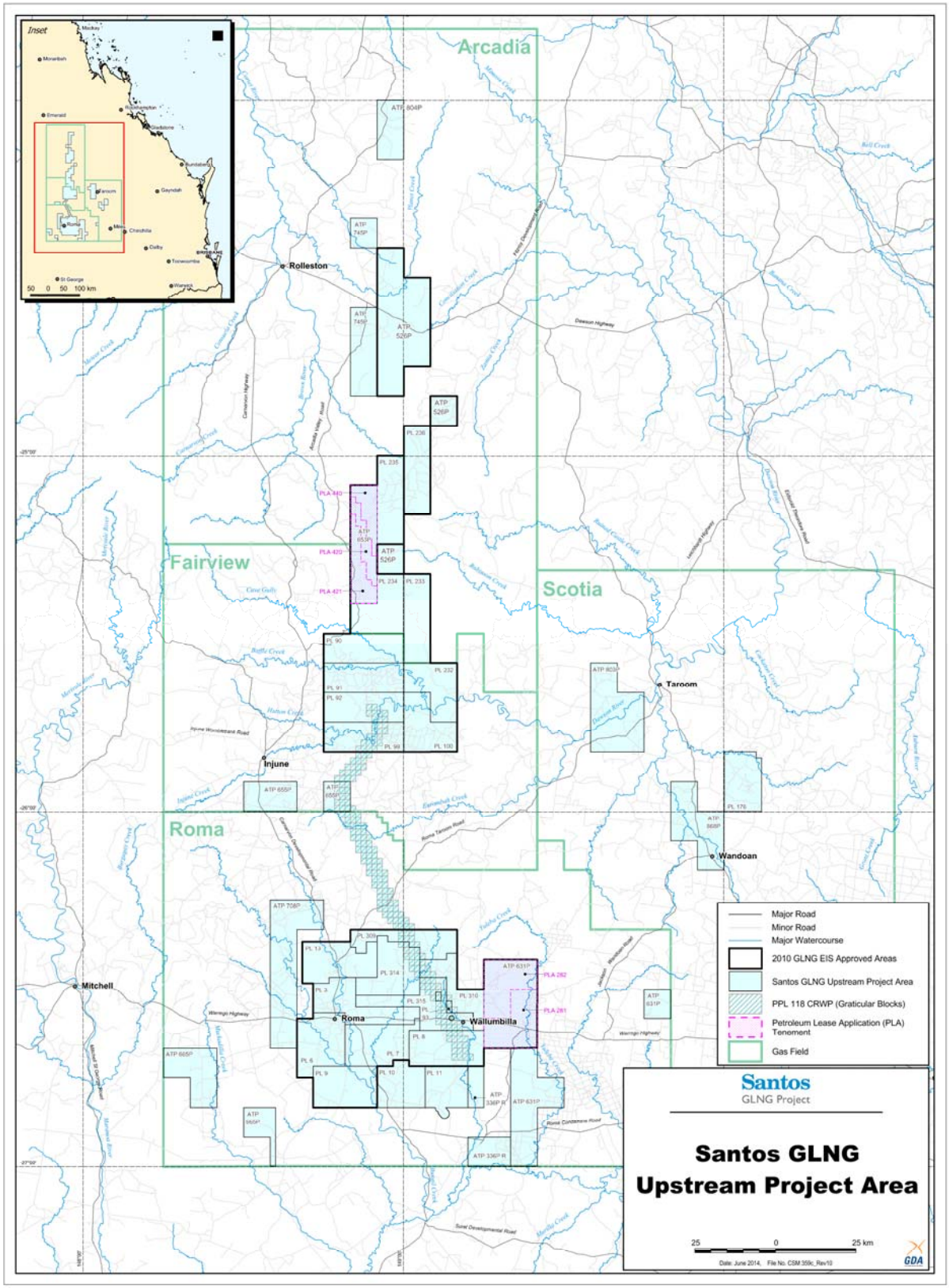

Figure 1: The Santos GLNG Upstream Project Area

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2.0 Roles and Responsibilities

Santos GLNG Project personnel are responsible for the environmental performance of their activities, for complying with relevant approval / permit requirements and for ensuring that all environmental objectives associated with the work are achieved. Santos GLNG Project personnel must also be mindful of the General Environmental Duty (GED) as outlined in the *Environmental Protection Act 1994* (Qld) (EP Act). Section 319(1) of the EP Act states that "*a person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practical measures to prevent or minimise the harm.*"

Roles, responsibilities and accountability under the LRMP will be assigned in accordance with the *Santos EHSMS05 – Responsibility and Accountability*.

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GLNG Project

3.0 Legal and Other Requirements

3.1 State Legislation and Strategies

An overview of Queensland legislation and strategies considered in the development of the LRMP is presented in Table 1. The EP Act is the principal State legislation governing Santos GLNG's land management activities.

Table 1: Summary of Key Applicable State Legislation and Strategies

Act / Regulation / Code	Summary of Act
Environmental Protection Act 1994 **(EP Act)**	The EP Act provides for environmental approvals, environmental management practices and environmental offences. Santos GLNG currently holds a number of EAs issued under the EP Act, which authorise the development of the Santos GLNG Upstream Project Area. These EAs can include release authorisations for fluids and can contain associated release limits, monitoring and reporting requirements. The EP Act also requires Santos GLNG to take all reasonable and practicable measures to prevent or minimise environmental harm.
Environmental Protection Regulation 2008 **(EP Regulation)**	The EP Regulation establishes the environmental objectives and strategies required under the EP Act relevant to defined activities and receiving environmental values. The treatment and disposal of fluids as part of petroleum activities is regulated by the EP Regulation.
Waste Reduction and Recycling Act 2011 **(WRR Act)**	The WRR Act provides for beneficial use approvals (BUAs), including both general and specific BUAs. Activities can be conducted in accordance with the *General BUA – Irrigation of Associated Water (including CSG Water)* and *General BUA – Associated Water*. These BUAs include release authorisations for waters and can contain associated release limits, monitoring and reporting requirements. Santos GLNG also holds one specific BUA issued under the WRR Act.
Coal Seam Gas Water Management Policy 2012 **(CSG Water Policy)**	The CSG Water Policy is designed to encourage the beneficial use of CS water in a way that protects the environment and maximises its productive use as a valuable resource. CS water is to be preferentially used for a purpose that is beneficial to the environment, water users and/or water dependent industries. Where this is not possible, treating and disposing CS water in a way that avoids, minimises and mitigates impacts on the environment is to be adopted.

3.2 Santos Environment, Health and Safety Management System

The Santos EHSMS, provides a framework for environmental and safety practices across Santos operations worldwide. The framework is consistent with *AS 4801:2000 Occupational Health and Safety Management Systems*, and *AS/NZS ISO 14001:1996 Environmental Management Systems*.

This LRMP complements the requirements of the EHSMS, in particular *EHSMS08 Document and Records Management* and *EHSMS14 Monitoring, Measurement and Reporting*.

This LRMP specifically addresses unique features and requirements relating to the Santos GLNG Project. Santos GLNG specific documentation is based on identified environmental and reputational

risks and account for Santos GLNG's legal and other obligations, commitments made by the Santos GLNG Project and Santos GLNG's Social Licence to Operate. In this context, the LRMP provides additional guidance for the management of environmental issues and supports the development of asset / activity / department based guidelines and work instructions, in order to secure compliance with legal requirements as well as deliver on company environmental standards.

The Santos approach to environmental management is illustrated in Figure 2.

Figure 2: The Santos Approach to Environmental Management

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4.0 Waters Released to Land in the Santos GLNG Upstream Project Area

The following sections identify and discuss the most common and highest volume waters generated by project activities that are released to land within the Santos GLNG Upstream Project Area for either disposal or reuse.

4.1 Coal Seam Water

CS water is naturally occurring groundwater that is a by-product of coal seam gas (CSG) extraction. The quality of CSG water varies greatly, however it is generally rich in salts and other minerals dependent on the geographic and subsurface area from which it is extracted. The average electrical conductivity of raw or untreated CS water in the Santos GLNG Upstream Project Area varies from approximately 300 µS/cm to 15,000 µS/cm. CS water can be treated by desalination to achieve electrical conductivity as low as 50 µS/cm or by processes of chemical amendment to manage specific salt or contaminant levels.

The volume of CS water produced over the life of a project area is subject to the volume of water in the coal seams, the permeability of the coal seam, and the rate and volume of gas production. The rate at which CSG water is produced is generally the highest in the early stages of a well's productive life and declines over time. Consequently, the management of CS water is likely to require a number of approaches or solutions working together.

CS water is typically gathered into dams, where it is stored prior to reuse with or without treatment. CS water reuse (raw, treated or amended CS water) requires considered management to prevent uncontrolled concentrated applications, however CS water provides Santos GLNG and project related landholders a significant resource for construction, operational and agricultural activities, such as dust suppression, compaction, hydrostatic testing and broad-scale crop irrigation.

CS water management solutions may vary through the life of the Project, and will often be different between geographical areas. This is because of the differing geological characteristics of the coal seams, the proximity of the extraction site to available beneficial uses, the qualities and characteristics of the surrounding environment, and the quality and quantity of the CS water.

There are no prescribed quality release criteria within the Santos GLNG Upstream Project Area EAs for the release of CS water to land.

4.2 Treated Sewage Effluent

Sewage treatment plants (STPs) exist at differing locations throughout the Santos GLNG Upstream Project Area. These consist of both permanent and temporary facilities and are of varying design capacities (up to 450 EP), dependent on the asset or facility they are servicing at any one time. Temporary (or mobile) STP's are typically associated with construction sites, camps and drilling rigs which move across the landscape. Temporary facilities are utilised on an as needs basis only. The number of permanent STPs operated across the Santos GLNG Upstream Project Area is likely to increase into the future as the gas fields continue to develop.

Treated sewage effluent quality can vary and is regulated dependent of volume and proposed use or disposal methods. There are no prescribed quality release criteria within the Santos GLNG Upstream Project Area EAs for sewage treatment works with a total daily peak design capacity of less than 21 equivalent persons (EP). Treated effluent from sewage treatment works with a total daily peak design capacity of between 21 to 450 EP are authorised to release the treated sewage effluent to land,

however effluent must be of a prescribed quality and is subject to monitoring requirements as outlined in Table 2.

Table 2: Treated Sewage Effluent Water Quality Release Criteria (Disposal to Land)

Quality Characteristic	Sampling and in situ measurement point location	Limit Type	Release Limit	Monitoring Frequency
5-day Biochemical oxygen demand (BOD)	Release pipe from sewage treatment works	Maximum	20 mg/L	Quarterly
E. coli		80th percentile based on at least 5 samples with no less than 30 minutes between samples	1,000 cfu per 100 mL	
		Maximum	10,000 cfu per 100 mL	
pH		Range	6.0-8.5	Monthly
Dissolved Oxygen		Minimum	2 mg/L	
Electrical Conductivity		Monitor only	-	

Treated sewage effluent from any size sewage treatment works is authorised to be used for the purposes of dust suppression and for construction and operational purposes, provided it is meets the prescribed water quality release criteria in Table 3.

Table 3: Treated Sewage Effluent Water Quality Release Criteria (Dust Suppression, Construction and Operational Purposes)

Quality Characteristic	Sampling and in situ measurement point location	Limit Type	Release Limit	Monitoring Frequency
5-day Biochemical oxygen demand (BOD)	e.g. treated sewage effluent storage	Median	20 mg/L	Weekly[1]
E. coli		Median	<10 cfu per 100 mL	
pH		Range	6.0-8.5	
Turbidity		95%ile (max)	2 (5) NTU	
Electrical Conductivity		Maximum	1,600 µS/cm	
Total Suspended Solids		Median	5 mg/L	

[1] Monitoring is to be conducted weekly until 12 months of monitoring demonstrates no exceedances of the release limits. Monthly monitoring can occur thereafter excluding E. Coli.

Due to the isolation of many of the STPs and the associated expense of removing and treating effluent off-site, Santos GLNG treats sewage effluent to a compliance standard where it can be safely released to land for dust suppression or disposal.

4.3 Low Point Drain Condensate

CS water is separated from CSG using gas / water separators at the gas well and this accounts for the majority of produced water in the CSG extraction process. From the separator, CS water is directed into a water gathering line and gas into a gas gathering line. The gas is generally water saturated and as such, condensate forms under standard operating conditions as temperature and pressure changes in the gas gathering lines. This condensate accumulates at 'low points' in the gas gathering network.

These accumulation areas have LPDs associated with them, enabling the release of the condensate from the pipeline. The removal of condensate through LPDs from the pipelines is critical to operations as its presence can reduce the efficiency of gas production and transfer to the gas compression facilities.

LPDs are drained routinely, either manually or automatically, dependent on the drain design. The approach to LPD water management is dependent on a range of factors including environmental risk, remoteness of infrastructure, positioning of surrounding assets and cost.

The electrical conductivity of condensate from LPDs typically ranges between 50 µS/cm and 500 µS/cm. Typically water from LPDs or condensate from these LPDs is slow to accumulate and at very low rates ranging from no water to 10L per hour. There are no prescribed quality release criteria within the Santos GLNG Upstream Project Area EAs for the release of condensate from low point drains.

4.4 Hydrostatic Test Water

Hydrostatic test water is produced from the hydrostatic testing of new pipelines. Pipelines are filled with water under pressure to ensure the structural integrity of the pipes and welds prior to the commissioning and operation of the pipeline.

The type of water used to conduct the hydrostatic test is dependent on the water availability at the time and location of the hydrostatic test and may comprise of CS waters, groundwaters or surface waters. The hydrostatic test water however must be of a quality that will not result in the introduction of foreign matter, sediment, biological contaminants or cause internal corrosion. To ensure this quality, the water may in some cases, require treatment with chemicals such as biocides, oxygen scavengers and corrosion inhibitors.

The quality of spent hydrostatic test water will be largely dependent on the source water quality, any chemical additives and the extent of matter collected from the pipeline such as metals, welding debris and sediments. The potential for increased metal concentrations in the spent hydrostatic test water is expected to be greater in uncoated steel pipelines compared to coated pipelines.

The release of hydrostatic test water to land is typically a one-off discrete event and is the least preferred option for the management of this water. Preferential management options include the reuse / treatment in existing Santos GLNG operations. However, opportunities to treat and/or reuse spent hydrostatic test water are often constrained due to the location of the hydrostatic tests, other construction or operational activities occurring in the area and the volumes of water involved.

There are no prescribed quality release criteria within the Santos GLNG Upstream Project Area EAs for the release of hydrostatic test waters. For releases to land however, the water quality criteria most

applicable to the end use should be adopted (e.g. the quality of hydrostatic test water to be used for irrigation purposes must be of a prescribed quality as detailed in ANZECC 2000).

Santos
GLNG Project

5.0 Land Release Management Principles

The inappropriate application of waters to land has the potential to result in adverse environmental impacts including a build-up of nutrients, salts and other contaminants in the soil, degradation of the soil structure, impacts to surface and groundwater resources via run-off and infiltration and damage to vegetation.

In each case of release of waters to land, Santos GLNG must implement all reasonable and practicable measures to avoid environmental harm and comply with EA conditions relevant to the particular activity undertaken. Common across all EA's, Santos GLNG must be able to demonstrate compliance with any relevant water quality release limits and that releases of fluids to land are carried out in a manner that ensures the following **land release outcomes** are achieved:

- vegetation is not damaged;
- soil quality is not adversely impacted;
- there is no surface ponding or runoff to waters;
- there is no aerosols or odours;
- deep drainage below the root zone of any vegetation is minimised; and,
- the quality of shallow aquifers is not adversely affected.

To ensure the above **land release outcomes** are achieved, land release activities within the Santos GLNG Upstream Project Area will generally adhere to the following four principles:

1. **Evaluation of Site Conditions** – Before the application of waters to land, a site-specific evaluation of the proposed release is to be conducted. This evaluation will be dependent on the release type proposed and is to consider factors such as:
    - proximity to waters, Environmentally Sensitive Areas (ESAs) and Matters of National Environmental Significance (MNES);
    - topography and terrain, including depressions where water may pool, and slopes which cause waters to flow outside of target / designated release areas;
    - soil types, to assess the magnitude of any infiltration and potential for impacts to shallow groundwater or subterranean flow into watercourses; and
    - vegetation presence and its coverage, which has the ability to impact on infiltration rates and erosion potential.

    These factors, in combination with the quality of the waters, determine the volume that can be sustainably applied to an environment and the extent of site-specific management and mitigation measures required to be implemented.
2. **Quality is Fit for Purpose** - Before the application of water to land, an evaluation of the suitability of the water will be conducted to determine if the quality of the waters is safe and compliant for the intended use and protection of relevant environmental values. Environmental values are those values or uses of waters that the community believes are important for a healthy ecosystem - for public benefit, welfare, safety or health. These include protection of aquatic ecosystems, drinking water, primary and secondary recreation, visual amenity, and agricultural water for irrigation, livestock and growing aquatic foods. This evaluation is to consider factors such as:
    - Environmental Authority (EA) or other approval conditions prescribed water quality release criteria;

- receiving environment environmental objectives for the particular use or protection of relevant environmental values as documented in relevant environmental guidelines, such as:
    - Ecosystem protection:
        - *Australian and New Zealand Environment Conservation Council (ANZECC) Guidelines for Fresh and Marine Water Quality 2000* (ANZECC 2000);
        - *Queensland Water Quality Guidelines* (QWQG 2009);
    - Agricultural use:
        - ANZECC 2000;
    - Recreational use:
        - ANZECC 2000;
        - Natural Resource Management Ministerial Council (NRMMC) *Guidelines for Managing Risks in Recreational Waters 2008;*
    - Human consumption:
        - *Australia New Zealand Food Standards Code*;
        - *Queensland Public Health Regulation 2005;*
    - Drinking water supply:
        - NRMMC *Australian Drinking Water Guidelines 2011.*

3. **Responsible Land Application** – Dependent on the outcomes of the site evaluation and the water quality evaluation, site-specific management and mitigation measures are to be developed and implemented to ensure the responsible application of the water to land, ensure compliance with the requirements of the relevant EA and prevent the potential for harm.

   The following general principles are to be considered for the release of water to land in addition to any site-specific requirements determined as a result of the site evaluation:

   - discharges are to be conducted on land exhibiting grades of less than 5% to minimise the potential for surface water runoff;
   - discharges are to be conducted at a distance of at least 100 m from a surface water body to prevent the potential for direct entry into surface water or infiltration and discharge into surface-water;
   - discharges to land are to be controlled to ensure that the rate of discharge is less than the infiltration capacity of soils and evaporation rates for the area. This will mitigate the potential for ponding and runoff, as well as minimise the degradation of soil structure;
   - discharges are to be controlled to ensure that the discharge avoids and/or minimises scouring and erosion;
   - discharges are to be conducted in suitably large areas of land to facilitate infiltration and evaporation and eliminate the potential for overland flow and discharge to surface water;
   - manual discharges of released waters are to be supervised to ensure that the activities are conducted in a manner to prevent erosion and runoff;
   - no discharges are to be conducted in areas of shallow groundwater or where sand or gravel soils exist whereby impacts to groundwater could occur and/or subterranean flows of discharged water could occur; and
   - waters to be released to land must comply with the release criteria specified in the EA to ensure that impacts to soil and soil structure does not occur.

4. **Monitoring Impacts, Reporting and Response –** All releases of waters to land are to be monitored to ensure compliance with EA conditions and to ensure that the potential for environmental harm is minimised. Monitoring requirements are prescribed within the EA for some land release types and are to be adhered to. Where the EA is silent, Santos GLNG is to develop and comply with a monitoring program designed to detect any impacts to the environment. Monitoring requirements and frequencies are to be based upon the risk associated with the activity.

   All monitoring is to be conducted by a suitably qualified person. If any monitoring conducted in accordance with the EA indicates a condition or contaminant level has caused (or has the potential to cause) environmental harm, the appropriate corrective actions will be identified and implemented as soon as is practicable to rectify the condition or contaminant level so as to avoid or minimise environmental harm.

   All monitoring records will be kept for a minimum period of five years.

A description of how each of these principles is to be applied to each of the most common land releases conducted within the Santos GLNG Upstream Project Area is provided in Section 6.0.

Santos
GLNG Project

6.0 Land Release Management

6.1 Coal Seam Water for Irrigation

6.1.1 Site Evaluation

The extent of application of CS water for irrigation purposes at any one location is dependent on a number of factors, including primarily the soil type and depth to groundwater within the proposed irrigation area, the length of time the irrigation is to be conducted and the characteristics of the receiving environment. These key factors are presented in Table 4.

Table 4: Site Evaluation Factors for the Use of CS Water for Irrigation Purposes

Element	Factors to be Evaluated	Examples
Irrigation Waters	Quality	EC, SAR, heavy metal and metalloid concentrations
	Quantity	Total volume, application rates
Soils	Soil properties	Clay content, structure, permeability, CEC
	Average root zone salinity	ECse, leaching fraction (LF)
	Soil structural stability and sodicity	ECse, SAR, ESP, CEC
	Contaminant build up in surface soils	ECse, heavy metal and metalloid concentrations
	Soil biota toxicology	heavy metal and metalloid concentrations
Plants	Crop yield	Salinity thresholds
	Salt tolerance	Salinity thresholds
	Foliar injury	Salinity thresholds, major ions
	Bioaccumulation of toxicants	heavy metal and metalloid concentrations
Receiving Waters	Deep drainage	SALF modelling
	Groundwater depth and quality	
	Migration of contaminants to groundwater and surface waters	
Other	Climate	Temperature, humidity, rainfall
	Management practises	Application methods, soil amelioration
	Landscape and terrain	Land use, slope
	Monitoring requirements	
	Landholder agreements	

Any irrigation scheme involving the release of waters directly to land will generally require a site-specific detailed evaluation / feasibility assessment that addresses the key factors presented in Table 4. In addition, the feasibility assessment is to demonstrate compliance with ANZECC 2000 including the development of site specific trigger values if required.

ANZECC 2000 allows for, and outlines, a framework for assessment and development of site-specific criteria and this methodology can be used to define a “no effects level” as well as an “effects” level that can be effectively monitored managed and mitigated. Through this process a number of additional management and mitigation measures can be adopted including soil amelioration, allowing for more marginal CS water to be applied to the land in a manner that will not result in harm to the environment, including to soils, groundwaters and/or vegetation.

Due to the extent and variability of factors influencing broad scale irrigation of CS water, a site-specific RMP is to be developed for each CS water irrigation scheme. The RMP must be able to demonstrate compliance with this LRMP as well as ANZECC 2000.

6.1.2 Application

A summary of some general principles and mitigation measures to be implemented when releasing CS water to land for irrigation purposes are provided in Table 5.

Table 5: Site Set-Up and Operational Requirements for Irrigation of CS Water

Phase	Mitigation Measure
Site Set-Up	Terrain that has extensive depressions where water may pool and slopes which cause waters to flow outside of target / designated release areas should be avoided.
	Stormwater diversion channels to be constructed on the up-gradient side of the irrigation area so that any overland stormwater flows are directed away from the irrigation area
	The irrigation area is to be designated and fenced with a vehicle access gate for maintenance purposes.
	The irrigation system should be preferentially designed and constructed so that there is an even distribution of CS water over the whole area.
	Irrigation pipelines to be placed (where practicable) underground to reduce the risk of damage from impact with machinery or livestock.
Land Application	Large droplet or sub-surface irrigation infrastructure should be utilised to eliminate the possibility of spray drift from the area.
	Lockable valves or removable handles should be used for any release pipes situated in public access areas.
	Pipelines and fittings associated with the irrigation system should be clearly marked and identified to prevent damage and accidental releases.
	Water application rates to be managed to prevent run-off.
	Inspect and maintain irrigation equipment to ensure optimal performance.
	Modify the application rate of the water based on soil moisture conditions and anticipated frequency of application.
	Irrigation activities should not be conducted immediately following or during rainfall events.

Phase	Mitigation Measure
	If erosion and sedimentation is noted, address the deficiencies as soon as practicable (e.g. install erosion and sediment control measures, regrade the roadway, etc.).
	Locate sufficient signage at the irrigation area to advise of the application of CS water and not to drink
	Restrict access to the irrigation area during the application of CS water until the area is sufficiently dry.
	Maintain sufficient wet weather storages when the CS water cannot be applied to the irrigation area.
	Conduct irrigation at a distance of at least 100m from a surface water body to prevent the potential for direct entry into surface water or infiltration and discharge into surface-water.
	Ensure CS water is appropriately treated, stored and applied so that there are no unauthorised or unintended releases to land or waters (including groundwater).
	Ensure compliance with the water quality criteria specified in the RMP.

6.1.3 Monitoring Impacts and Response

Due to the potential expanse of CS water irrigation areas and variability of factors influencing broad scale irrigation of CS water, site-specific monitoring requirements are to be developed and included within each site-specific RMP developed.

As a minimum, the following records will be kept on the use of CS water for irrigation purposes:

- extent of irrigation area;
- source of CS water used for irrigation purposes;
- volumes of CS water being applied to the irrigation area;
- water quality for the respective source of CS water;
- baseline and ongoing soil quality information, including both physical and chemical analysis;
- meteorological monitoring at or in the vicinity of the irrigation area;
- irrigation application and management methodologies; and
- other relevant details of the irrigation activity as deemed necessary.

Where monitoring indicates an exceedance, possible future exceedance or potential system malfunction, immediate actions will be taken to rectify the issue.

6.2 Coal Seam Water for Dust Suppression, Construction and Operational Purposes

6.2.1 Site Evaluation

The use of CS water as a dust suppressant or for construction and operational purposes requires limited site evaluation. The risk to the environment from the activity is deemed to be low due to the small quantities and discrete applications of water applied to land at any one time, provided that activity is carried out in a controlled manner and the water is being applied to a discrete construction / operational facility.

Where the water is being used for construction and operational purposes, some evaluation may be necessary to determine any impacts the CS water may have on the construction project (i.e. engineering considerations) as salinity can alter some soil properties, including moisture retention.

6.2.2 Application

In addition to the general principles of land application of waters previously discussed, a summary of some general principles and mitigation measures to be implemented when releasing CS water to land for the purposes of dust suppression, construction and operations are provided in Table 6 below.

Table 6: Site Set-Up and Operational Requirements for Use of CS Water for Dust Suppression, Construction and Operational Purposes

Phase	Mitigation Measure
Site Set-Up	Review forecast weather conditions to ensure rainfall is not predicted to occur within 2 to 3 hours following a dust suppression event.
	Equip the truck or trailer with a spray bar to deliver water evenly over the respective roadway(s).
Land Application	When applying CS water for dust suppression using mechanical devices, sufficient water coverage will be applied to minimise generation of dust, but minimise runoff.
	Inspect and maintain spray equipment to ensure optimal performance.
	More frequent (lighter water applications) dust suppression events should be implemented rather than less frequent, heavier applications of water.
	Modify the application rate of the water based on road conditions and anticipated frequency of application.
	Do not undertake dust suppression activities immediately following or during rainfall events.
	Dust suppression events should be conducted in the middle of the carriageway to prevent spraying of water on areas outside the road or directly onto vegetation.
	If erosion and sedimentation is noted, address the deficiencies as soon as practicable (e.g. install erosion and sediment control measures, regrade the roadway).

6.2.3 Monitoring Impacts and Response

Records will be kept on the use of CS water for dust suppression specific to each application including:

- source of CS water used for dust suppression;
- water quality information for the respective source of CS water;
- volumes of CS water being transported and applied; and
- details of the dust suppression event (e.g. location of dust suppression activity).

Where monitoring indicates an exceedance, possible future exceedance or potential system malfunction, immediate actions will be taken to rectify the issue.

6.3 Treated Sewage Effluent Disposal to Land

6.3.1 Site Evaluation

Principal considerations in the selection of an effluent disposal area include soil and vegetation types suitable to assimilate predicted effluent volumes and quality.

To inform the selection of appropriate effluent disposal areas for STPS greater than 20 EP, an evaluation of factors such as soil type, vegetation type and cover in conjunction with effluent quality, hydraulic flow and period of application will be undertaken. This evaluation will provide guidance as to the appropriate size of any STP related land application area required, the maximum irrigation rate and minimum volume of wet weather storage required. Additional considerations when applying the outcomes of the assessment include those general principles described above in Section 5.0.

To assist with this site evaluation, a generic MEDLI (Model of Effluent Disposal using Land Irrigation) model has been developed for the Santos GLNG Upstream Project Area. This model considered the land application of effluent of a standard quality for a range of STP capacities (20 – 450 EP) for application periods of either six months or five years on the four main soil types present within the Santos GLNG Upstream Project Area (Chromosols, Dermosols, Sodosols and Vertosols). Where appropriate to any one land disposal scheme, the outcomes of the generic MEDLI model can be used to determine the appropriate release location.

6.3.2 Application

Once the location has been determined as suitable for the release of treated sewage effluent to land, the site is required to be appropriately set-up to ensure the potential for harm to be caused to the environment and to people is minimised as far as practicable. Similarly, the treated sewage effluent must be applied to the land in a careful and controlled manner to ensure compliance with approval requirements and to minimise the potential for harm.

A summary of some general principles and mitigation measures to be considered when releasing treated sewage effluent to land are provided in Table 7.

Table 7: Site Set-Up and Operational Requirements for Disposal to Land of Treated Sewage Effluent

Phase	Mitigation Measure
Site Set-Up	Terrain that has extensive depressions where water may pool and slopes which cause waters to flow outside of target / designated release areas should be avoided.
	Stormwater diversion channels may be required on the up-gradient side of the effluent irrigation area so that any overland stormwater flows are directed away from the area.
	The land disposal area is to be designated and fenced with a vehicle access gate for maintenance purposes.
	The effluent irrigation system should be designed and constructed so that there is an even distribution of effluent over the whole area.
	Irrigation pipelines to be placed (where practicable) underground to reduce the risk of damage from impact with machinery or livestock.
	Large droplet or sub-surface irrigation infrastructure should be utilised to eliminate the possibility of spray drift from the area.

Phase	Mitigation Measure
	Notices should be prominently displayed in areas undergoing effluent irrigation, warning the employees and the general public that the area is irrigated with effluent and not to use or drink the effluent.
	Lockable valves or removable handles should be used for any release pipes situated in public access areas.
	Pipelines and fittings associated with the effluent irrigation system should be clearly marked and identified to prevent damage and accidental releases.
Site Operation	All waters released to land must comply with the release criteria and any other approval requirements.
	Irrigation of treated sewage effluent to land should cease during and following rain events, with effluent directed to wet weather storage for the purpose of preventing surface run-off.
	The application of effluent to the irrigation areas should cease when the sub-soil becomes saturated and ponding is occurring until such time as the soil moisture content has sufficiently reduced to eliminated further ponding. In these circumstances the effluent can be directed to wet weather storage or taken off -site for disposal.
	Ensure that the wet weather storage is immediately emptied following a wet weather period in readiness for the next wet weather event.
	Action should be taken if the condition of vegetation over the irrigation area is determined to be degraded, including if necessary replanting of the irrigation area with a species more suited to the soil type based on an agronomist's recommendation.
	The land disposal area may be regularly slashed or mowed to enhance evapotranspiration rates and to prevent any ponding of effluent.

6.3.3 Monitoring Impacts and Response

Monitoring will be conducted in accordance with approval requirements and is to be focussed upon ensuring that the treated sewage effluent to be released to land complies with the prescribed quality discharge limits outlined in Table 2 (for STPs greater than 21 EP).

Additional monitoring may include (but not be limited to) the following:

- the quantity of sewage effluent released to land each day;
- STP function; and
- regular visual inspections of the land disposal area to monitor soil moisture absorption capabilities and to ensure that the sprinkler system is operating satisfactorily i.e. no blockages or other malfunctions and no leaks or pipe damage.

Where monitoring indicates an exceedance, possible future exceedance or potential system malfunction, immediate corrective actions will be identified and implemented to rectify the issue.

6.4 Treated Sewage Effluent for Dust Suppression, Construction and Operational Purposes

6.4.1 Site Evaluation

Treated sewage effluent from any size STP may be released to land for the purposes of dust suppression and for construction and operational purposes provided it is released in a manner that does not result in environmental harm and the treated sewage effluent meets the prescribed water quality criteria presented in Table 3.

Treated sewage effluent to be used as a dust suppressant or as part of general construction / operational activities, requires limited site evaluation. The risk to the environment from the activity is deemed to be low due to the small discrete quantities of waste water applied to land at any one time (discrete applications) and the high quality of the effluent to be released (equivalent of Class A or A+ water).

Treated sewage effluent to be used as a dust suppressant or as part of general construction / operational activities is not to be stored in a dam or tank prior to use.

There is a potential risk to human health from the inappropriate management and re-use of treated sewage effluent. Consequently, site evaluation may be necessary to ensure that areas subject to high human exposure or proximity to areas where drift my contact surfaces used for the consumption of food or high human activity, are avoided.

Prior to use on local government controlled roads, written approval is to be obtained from the relevant local government.

6.4.2 Application

In addition to the general principles of land application of waters previously discussed, a summary of some general principles and mitigation measures to be implemented when releasing treated sewage effluent to land for the purposes and dust suppression, construction and operations are provided in Table 8.

Table 8: Site Set-Up and Operational Requirements for Use of Treated Sewage Effluent for Dust Suppression, Construction and Operational Purposes

Phase	Mitigation Measure
Site Set-Up	Signage is to be provided at the collection location, on the application device and application area to advise of the use of recycled water and not to drink.
	Vehicles transporting and applying recycled water are to be signed to notify of the contents of the vehicle and must not also be used to transport potable water.
	Vehicles applying treated sewage effluent must be equipped with a spray bar located closed to the ground to deliver water evenly over the respective roadway(s) and to minimise the likelihood of spray drift.
	Controlled access should be maintained in areas where treated sewage effluent is being applied to minimise inadvertent consumption or inhalation of aerosols.
	Access to the use of treated sewage effluent is only to be provided to those trained in its handling or use.

Phase	Mitigation Measure
Site Operation	Spray equipment should be regularly inspected and maintained to ensure optimal performance.
	When applying treated sewage effluent using mechanical devices, sufficient water coverage should be achieved to minimise generation of dust, but minimise runoff.
	More frequent (lighter water applications) dust suppression events should be implemented rather than less frequent, heavier applications of water.
	The application rate of the water should be modified based on road and ambient climatic conditions (temperature, wind and humidity).
	Treated sewage effluent is not to be applied in areas where spray drift is likely to contact surfaces used for the consumption of food (e.g. crib huts with outside eating areas).
	The application of treated sewage effluent should not be conducted immediately prior to, during or following rainfall events.
	Santos GLNG Project personnel in direct contact with treated sewage effluent should apply appropriate hygiene standards prior to the consumption of food.

6.4.3 Monitoring Impacts and Response

Monitoring is to be conducted in accordance with approval requirements and is to be focussed upon ensuring that the treated sewage effluent to be released to land complies with the prescribed water quality discharge limits outlined in Table 3.

In addition to the monitoring of water quality, the following information is also to be recorded:

- quantity of treated sewage effluent released to land (volume litres/m^3);
- application area (approximate m^2);
- location of application;
- date and time of application;
- duration of application;
- the application method (e.g. vehicle, sprinkler);
- the operator of the application method; and
- weather conditions at the time of application (e.g. low wind).

Where monitoring indicates an exceedance, possible future exceedance or potential system malfunction, immediate corrective actions are to be taken to rectify the issue.

6.5 Low Point Drain Water Releases

6.5.1 Site Evaluation

The land to which LPD condensate can be released is dependent on topography and the coincident location of the LPD. LPD's are typically located directly above the gas gathering line at the centre of the gathering line right of way, however release can be directed through additional pipeline infrastructure.

6.5.2 Application

The release of water from LPDs occurs either automatically or manually, dependent on the specific LPD design. Following accumulation, LPD water is released from the drain and can take between five minutes to one hour, depending how much water has accumulated. Automatic LPDs release water based on water pressure (head) within the gathering line and as such the volume of the releases are generally minimal and occur more intermittently than manual LPDs.

A summary of some general principles and mitigation measures to be implemented when releasing LPD water to land are provided in Table 9.

Table 9: Site Set-Up and Operational Requirements for Release of Low Point Drain Water

Phase	Mitigation Measure
Site Set-Up	Ensure the selection and location of LPD infrastructure considers any potential issues or impacts associated with localised flooding.
	Ensure the selection and construction of LPD infrastructure is appropriate to managing erosion potential from releases.
Land Application	Any release of accumulated water in pipelines to the receiving land environment must comply with the conditions of the environmental authority relevant to the pipeline.
	Condensed water in pipelines maybe released to land without testing prior to release as it considered good quality.

6.5.3 Monitoring Impacts and Response

A LPD release monitoring program will be designed and implemented to:

- regularly inspect LPD infrastructure for any necessary maintenance, impacts from flooding and erosion; and
- regularly sample and analyse representative samples of LPD condensate or accumulated waters to identify any potential for environmental harm.

Where monitoring indicates an exceedance, possible future exceedance or potential system malfunction, immediate corrective actions will be taken to rectify the issue.

6.6 Hydrostatic Test Water Releases

6.6.1 Site Evaluation

Where hydrostatic test water is to be disposed of to land, the selection of the location and total area must consider all of the following:

- the general principles as discussed in Section 5.0, in particular the location of the release point in relation to
  - surface waters and shallow groundwaters;
  - ground depressions that will concentrate and accelerate flow;
  - soils possessing high EC, or soils that are highly dispersive or sandy;
  - steep slopes;
- the land disposal area is not to be in an ESA or a protection zone of an ESA that prevents the conduct of petroleum activities;

- the land disposal area does not have depressions and/or low lying areas that will result in surface water ponding; and
- the size of the land disposal area will account for soil type, release volume, season and proposed duration of release.

Where large volumes of water are proposed to be released over a prolonged period (i.e. not a one-off event), a site-specific evaluation (feasibility) assessment, in accordance with principles outlined in Section 5.0 is required to better understand the soil composition and permeability.

6.6.2 Application

The release to land of spent hydrostatic test water is typically conducted as a single event at any one location. Hydrostatic test water is typically either flood irrigated or spray irrigated to land, dependent on the volumes to be released and the degree of topographical change/complexity.

Flood irrigation is better suited to low water volumes, releases of short duration and flatter ground (< 5%), however is not recommended for very coarse textured soils due to potentially high infiltration rates.

In addition to the general principles of land application of releases previously discussed, a summary of the general principles and mitigation measures to be implemented when releasing hydrostatic test water to land are provided in Table 10.

Table 10: Site Set-Up and Operational Requirements for Hydrostatic Land Releases

Phase	Mitigation Measure
Site Set-Up	Review forecast weather conditions to ensure rainfall is not predicted to occur immediately prior, during or within a few hours following a hydrostatic test water release event.
	Ensure that any selected land disposal area is located so that no overland flow of hydrostatic test water occurs within 100m of a watercourse, ESA or a protection zone of an ESA that prevents petroleum activities.
	Where the hydrostatic test water is flood irrigated, riprap, hay bales or other energy dissipation devices should to be utilised at the point of release, to minimise the potential for scouring and erosion.
Land Application	The disposal to land of hydrostatic test water should cease during and following rain events to prevent surface ponding and/or unauthorised run-off.
	The disposal to land of hydrostatic test water should cease in the event the sub-soil becomes saturated and ponding occurs. Release shall only resume when the soil moisture content has sufficiently reduced to prevent further ponding and/or unauthorised run-off.
	The disposal to land of hydrostatic test water should be appropriately supervised to prevent erosion and run-off.

6.6.3 Monitoring Impacts and Response

The objective of the monitoring is to ensure that hydrostatic test water to be released to land complies with the water quality criteria most applicable to the end use (e.g. ANZECC 2000 for irrigation).

In addition to hydrostatic test water quality monitoring data (both source and spent water), the following information will also be recorded:

- quantity of water released to land (volume m^3);
- location of application;
- date and time of application;
- duration of application; and
- the application method (e.g. flood vs sprinkler);

The release area will be regularly inspected to monitor soil moisture absorption capabilities and to ensure that the release is not causing environmental harm.

Where monitoring indicates an actual exceedance of the release criteria, possible future exceedances or any unacceptable level of non-conformance risk, immediate corrective actions will be taken to rectify the issue, prior to resumption of the hydrostatic test and/or land release activity.

Where conforming CS water or blended CS water is used as a source water for hydrostatic test, any land releases of the spent test water shall be in accordance with the criteria most applicable to the end use, this LRMP, the HTWMP and other relevant approval conditions in the EA.

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GLNG Project

7.0 Evaluation and Review

7.1 Evaluation

The implementation and effectiveness of this management plan and any associated procedures are to be regularly reviewed to ensure:

- Santos GLNG is demonstrating compliance with legal and landholder obligations;
- the overall management strategy remains relevant and up to date; and
- management of the environmental risks is being adequately achieved.

Effectiveness is to be assessed by a number of methods as shown in Table 11.

Table 11: Methods to Assess Procedural Effectiveness

Assessment Tool	Description
Checklists – Santos GLNG Compliance Management System	• Checklists, developed to reflect legal and procedural requirements / outcomes will be used by individual Santos GLNG Departments to assess and manage compliance. The results of the checklists will be evaluated for trending non-compliances that may be resolved through procedural change or by implementing another measure or process.
Audits	• Conduct internal and third party audits to formally assess the level of compliance with both regulatory requirements and with Santos GLNG procedures. • Audit outcomes are used to develop corrective actions which may include changes to this plan and/or procedures.
Review of Incidents	• A review of internal incidents, near misses or hazards will be undertaken to identify recurrences of similar incident types. This may highlight a requirement for a change in the existing plan and/or procedures require the development of a new procedure or by implementation of another measure or process to address the recurring issue.
Review of Data	• Analyse all relevant data collected for negative and/or undesirable trends that may be prevented by procedural changes or by implementing another measure or process.

7.2 Review

The LRMP shall be reviewed at least every three years or sooner if required or if any of the following occur:

- the plan is not adequately managing the issue (refer Section 7.1);
- legislative requirements change;
- the area of activity changes; and
- additional releases to land are identified.

Reviews and changes to the LRMP are to be communicated to relevant Santos GLNG Project personnel.

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GLNG Project

8.0 Definitions

Term	Definition
Authorised person	A person holding office as an authorised person under an appointment under the *Environmental Protection Act 1994* by the chief executive or chief executive officer of a local government.
Checklist	Checklists assist in assessing the implementation of a Procedure. Checklists contain a list of key items required, things to be done, or points to be considered and are a tool to assess compliance with a Procedure.
Coal Seam Water	Groundwater that is necessarily or unavoidably brought to the surface in the process of coal seam gas exploration or production. Coal seam water typically contains significant concentrations of salts, has a high sodium adsorption ratio (SAR) and may contain other contaminants that have the potential to cause environmental harm if released to land or waters through inappropriate management. Coal seam water is a waste, as defined under s13 of the *Environmental Protection Act 1994*.
Dam	A land-based structure or a void that is designed to contain, divert or control flowable substances, and includes any substances that are thereby contained, diverted or controlled by that land-based structure or void and associated works. A dam does not mean a fabricated or manufactured tank or container, designed and constructed to an Australian Standard that deals with strength and structural integrity of that tank or container.
EHSMS	Santos Environment, Health and Safety Management System (EHSMS) which forms the overall framework under which all Santos GLNG activities are undertaken.
Management Plan	Management Plans are specific to an environmental issue and/or topic. They primarily serve to provide a high level overview of the legislative and approval requirements and the Santos GLNG management strategy in place for the relevant environmental issue. Management Plans are also suitable for providing environmental regulators an overview of Santos GLNG environmental management, and in many cases, may be a direct requirements of an environmental approval.
Procedure	Procedures are designed to assist in the implementation of the Management Plan, by prescribing a series of processes and actions for a specific topic.
Rehabilitation	The process of reshaping and revegetating land to restore it to a stable landform and in accordance with the acceptance criteria set out in this environmental authority and, where relevant, includes remediation of contaminated land.
Santos GLNG Upstream Project Area	Comprises all current and future gas fields for the Santos GLNG Project, including Arcadia, Fairview, Roma and Scotia project areas.
Sodic Soil (Sodicity)	Is a measure of exchangeable sodium in relation to other exchangeable cations. It is expressed as the Exchangeable Sodium Percentage (ESP). A sodic soil contains sufficient exchangeable sodium to interfere with the growth of plants, including crops. A soil with an ESP greater than 6 is generally regarded as being a sodic soil in Australia. ESP levels are further classified in the Australian Soil Classification.

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GLNG Project

9.0 References

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