Santos

NARRABRI GAS PROJECT

Produced Water Management Plan

PHASE 1

0041-150-PLA-0018

Date	Revision	Reason for Issue	Author	Checked	Approved
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Document review history

In accordance with consent condition D4, this document has been reviewed as follows:

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Acronyms and abbreviations

Acronym	Description
µg/L	micrograms per litre
AHD	Australian height datum
AEP	annual exceedance probability
ANZECC	Australia and New Zealand Environment and Conservation Council
APGA	Australian Pipelines and Gas Association
ARI	average recurrence interval
AS/NZS	Australian Standard/New Zealand Standard
$CaCO_3$	calcium carbonate
$CaSO_4$	calcium sulfate (gypsum)
cm	centimetre
CoC	Conditions of consent for the NGP SSD 6456
CQA	construction quality assurance
CSG	coal seam gas
DO	dissolved oxygen
DoI	The former NSW Department of Industry
DPE	NSW Department of Planning and Environment
DPE Water	The Water Group within DPE
DPI	The former NSW Department of Primary Industries
DPIE	The former NSW Department of Planning, Industry and Environment
DTIRIS	The former Department of Trade and Investment, Regional Infrastructure and Services
dS	deciSiemens
dS/m	deciSiemens per metre
EC	electrical conductivity
EIS	environmental impact statement
EMP	environmental management plan
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EP&A Regulation	Environmental Planning and Assessment Regulation 2021
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPL	environment protection licence under the POEO Act
ERL	Emergency Reporting Level
EQuIS	Environmental Quality Information System
FSL	Full Supply Level
ha	hectare
IEA	Independent Environmental Audit
HDPE	high density polyethylene

Acronym	Description
IMP	Irrigation Management Plan
L	litre
LNG	liquefied natural gas
m	metre
m/s	metres per second
m^2	square metre
m^3	cubic metre
ML	megalitre
ML/day	megalitre per day
ML/y	megalitre per year
mm	millimetre
MOL	Maximum Operating Level
NRAR	Natural Resources Access Regulator
PAL	petroleum assessment lease under the PO Act
PEL	petroleum exploration licence under the PO Act
PO Act	*Petroleum (Onshore) Act 1991* (NSW)
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
POEO Regulation	Protection of the Environment Operations (General) Regulation 2022
POP	Petroleum Operations Plan
PPL	petroleum production lease under the PO Act
PSBRDS	Produced Salt Beneficial Reuse and Disposal Study
PWMP	Produced Water Management Plan (this document)
RO	reverse osmosis
RREO	resource recovery exemption and order
SMS	Santos Management System
TARP	trigger action response plan
TDS	total dissolved solids
WBTP	water and brine treatment plant
WTAG	Water Technical Advisory Group

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1. Introduction

1.1 Narrabri Gas Project

1.1.1 Background

Resource exploration has been occurring in the north-western area of NSW since the 1960s; initially for oil, but more recently for coal and gas. Santos NSW Pty Ltd began exploring for natural gas from coal seams in north-western NSW in 2008 and is currently conducting coal seam gas (**CSG**) exploration and appraisal activities within Petroleum Exploration Licence (**PEL**) 238, Petroleum Assessment Lease (**PAL**) 2 and Petroleum Production Lease (**PPL**) 3, located in the Gunnedah Basin about 20 kilometres (**km**) south-west of the town of Narrabri. Activities in PAL 2 have focussed on the Bibblewindi and Bohena CSG pilots, whilst recent activities in PEL 238 have focussed on the Dewhurst and Tintsfield CSG pilots.

The Narrabri Coal Seam Gas Utilisation Project (Wilga Park Power Station and associated infrastructure) operates under an existing Part 3A approval under the *Environmental Planning and Assessment Act 1979* (NSW) (**EP&A Act**). It was originally approved in 2008, with various modifications approved between 2011 and 2019. It encompasses a gas gathering system, a compressor and associated flare, a gas flow line from Bibblewindi to Wilga Park within a 10 metre (**m**) corridor with a riser at Leewood and an expansion of the existing Wilga Park Power Station from 12 to 40 megawatts.

1.1.2 Narrabri Gas Project

On 30 September 2020, Santos NSW (Eastern) Pty Ltd (**Santos**) obtained consent for State significant development (**SSD**) 6456 to develop the Narrabri Gas Project (**NGP**) (**the Project**). Approval EPBC 2014/7376 under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**EPBC Act**) was granted on 24 November 2020.

The Project includes the progressive installation of up to 850 new gas wells on up to 425 new well pads over approximately 20 years and the construction and operation of gas processing and water treatment facilities.

Four phases of development are defined under the consent, including:

- Phase 1 - exploration and appraisal;
- Phase 2 - construction activities for production wells and related infrastructure;
- Phase 3 - gas production operations; and
- Phase 4 - gas well and infrastructure decommissioning, rehabilitation and closure.

Phase 1 of the Project is defined in the consent as the phase of the development comprising ongoing exploration and appraisal activities in the Project area, including:

- seismic surveys;
- core and chip holes;
- construction and operation of pilot wells (up to 25 wells on up to 25 well pads across the project area); and
- pilot well ancillary infrastructure, including access tracks, gas and water gathering lines, water balance tanks, safety flaring infrastructure, utilities and services, and environmental monitoring equipment including groundwater monitoring bores.

Santos plans to continue exploration and appraisal of the resource in the near term until a final investment decision can be made. The exploration and appraisal activities will include continued operation of Santos' existing wells, infrastructure and facilities in PEL 238 and PAL 2, and construction and operation of new core holes, pilot wells and supporting infrastructure permitted under Phase 1.

Santos' existing exploration and appraisal activities in PEL 238 and PAL 2 include:

- Tintsfield Pilot;
- Bibblewindi East Pilot;
- Bibblewindi West Pilot;
- Dewhurst North Pilot;
- Dewhurst South Pilot;
- Dewhurst northern and southern flow lines;
- Leewood Water Management Facility including ponds, water and brine treatment plant (**WBTP**) and irrigation area;
- Bibblewindi Facility including gathering system, water balance tank, compressor and flare; and
- Bibblewindi to Leewood buried gas pipeline.

These exploration and appraisal activities will continue as part of the NGP. The initial, new-appraisal Phase 1 scope is a relatively minor extension to these existing exploration and appraisal activities.

The Phase 1 scope is planned to include the construction and operation of:

- 4 coreholes;
- 6 pilot wells;
- 2 deep reservoir monitoring bores (converted coreholes);
- new shallow water monitoring bores;
- associated linear infrastructure;
- seismic surveys (length and location to be determined); and
- continued operation of Santos' existing exploration and appraisal activities, including workover activities.

The full definitions of the approved activities for Phases 2, 3 and 4 of the Project are provided in the consent. Santos is not prevented from carrying out any or all of the phases concurrently, subject to the conditions of this consent.

Further details regarding the NGP, including a full overview of the regulatory framework and statutory provisions of the NGP and the current approvals, leases and licences related to the management of water, are provided in the overarching Water Management Plan. Details regarding the staging of the works and the exact scope for each phase are as per the approved Field Development Plan.

1.2 Purpose and scope of the PWMP - Phase 1

This Produced Water Management Plan (**PWMP**) has been developed in accordance with the requirements of compliance conditions of PEL 238; PAL 2, PPL 3, Environment Protection Licence (**EPL**) 20350, the SSD 6456 conditions of consent (**CoC**) and the *Exploration Code of Practice Produced Water Management, Storage and Transfer* (DPE, 2017) (**Produced Water Code**). It details how Santos manages produced water resulting from the operation of its CSG activities in the Narrabri area during Phase 1 of the Project only. As such, requirements and obligations applicable to subsequent phases of the Project are not considered in this Plan. Santos will implement all reasonable and feasible measures to prevent, and if prevention is not reasonable and feasible, minimise any harm to the environment that may result from the management of produced water.

This PWMP supersedes the previous PWMP dated November 2018, which was approved by the then NSW Department of Planning, Industry and Environment (**DPIE**), Division of Resources and Geoscience on 15 March 2019. That plan was prepared to satisfy the conditions of PEL 238, PAL 2 and PPL 3 and provided information how Santos managed produced water resulting from its exploration, appraisal and production activities.

This Plan forms part of a suite of documents prepared as part of the Water Management Plan under Condition B41(d), which includes the following:

(i) An Erosion and Sediment Control Plan, prepared in accordance with the Blue Book[1] and identifying details including but not limited to activities that could cause soil erosion, generate sediment or affect flooding; the location, function, and capacity of erosion and sediment control structures and flood management structures; and measures to manage any effects of soil erosion, sediment transport and flooding;

(ii) A Site Water Balance, which includes but is not limited to details of the inflows and outflows in the Project area; sources and security of water supply for the life of the Project; water storage and treatment capacity; water use and management, including sharing and transfers; licenced discharge points; and reporting procedures, including the annual preparation of an updated site water balance;

(iii) A Surface Water Management Plan, which includes but is not limited to specific details on baseline data on surface water flows and quality of watercourses; the surface water management system; detailed plans, design objectives and performance criteria for water infrastructure; performance criteria; a program and procedures for monitoring, evaluation and reporting; and plan to respond to any exceedances of the performance measures or performance criteria, and repair, mitigate and/or offset any adverse surface water impacts of the development;

(iv) A Groundwater Management Plan, which provides details including but not limited to baseline data of hydrogeology and groundwater levels, formation parameters and quality for groundwater resources; a description of the groundwater management and monitoring system; performance criteria, trigger and response levels; a program and procedures for monitoring, evaluation and reporting; and a plan to respond to any exceedances of the groundwater performance criteria, and repair, mitigate and/or offset any adverse groundwater impacts of the Project;

(v) A Produced Water Management Plan (this document);

(vi) An Irrigation Management Plan for managing beneficial reuse of treated water for crop irrigation and stock watering, that includes but is not limited to details regarding site selection and assessment; agreements with third parties; baseline soil and groundwater conditions and

[1] *Managing Urban Stormwater: Soils and Construction - Volume 1* (Landcom 2004), more commonly known as the 'Blue Book'.

quality; a protocol for operation of the irrigation management system; and measures to manage any effects on soils structure, erosion, groundwater quality and maintain a water balance;

(vii) A Dust Suppression Protocol for managing beneficial reuse of treated water for dust suppression and construction activities including but not limited to details of site selection and assessment; baseline soil and groundwater conditions and quality; a protocol for operation of the dust suppression system; and measures to manage any effects on soils structure, erosion, surface water runoff, groundwater quality and groundwater levels;

(viii) A Managed Release Protocol for managing disposal of treated water to Bohena Creek, that includes but is not limited to details of water flows, quality and health; predicted plume dispersal; a protocol and detailed procedures for managed release; and measures to manage any effects of water quality, stream and riparian health, erosion and sedimentation and downstream flooding. There will be no managed release to Bohena Creek during Phase 1 of the Project and as such this protocol will be developed for Phase 2 of the Project. A summary of the managed release is provided in section 6 of this PWMP;

(ix) A Salt Management Plan, which includes but is not limited to details of salt and other waste volumes and composition generated by the produced water management system; a program for investigating and implementing beneficial reuse options for the salt product; and a protocol and procedures for the full-cycle management of salt and salt-related waste products. There will be no salt produced during Phase 1 of the Project (only brine will be produced) and there is adequate storage in the existing facilities to manage this brine for Phase 1. Section 7 of this PWMP describes this proposed approach to salt management for the Project. A full Salt Management Plan will be developed prior to Phase 2 of the Project, based on the findings of the Produced Salt Beneficial Reuse and Disposal Study (**PSBRDS**) prepared in accordance with condition B69;

(x) A Pollution Incident Response Management Plan, prepared in accordance with *the Protection of the Environment Operations (General) Regulation 2009* (POEO Regulation) and which includes detailed procedures for responding to incidents, spills and leaks associated with the produced water management system; and a Dam Safety Emergency Plan for managing potential incidents and emergencies associated with produced water storages, and

(xi) A protocol to report on the measures, monitoring results and performance criteria identified above, in the Annual Review referred to in consent condition D8.

A list of the key conditions applicable to the PWMP is presented in section 3.1.4. A copy of the consent conditions relevant to each of the other sub-plans and protocols listed above is provided in each of the respective documents.

As required by CoC B42, Santos will implement the latest revision of the WMP (including this PWMP) once approved by the Planning Secretary.

1.3 Objectives

The objectives of this PWMP are to provide the following:

- details of the relevant statutory requirements (including any relevant approval, licence or lease conditions);
- details of any relevant commitments or recommendations identified in the Environmental Impact Statement (**EIS**) for the Project;
- a description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria;
- detailed baseline data on produced water yield and quality;

- detailed description of the produced water management system;
- detailed performance criteria, including trigger levels for identifying and investigating any potentially adverse impacts;
- a contingency plan to manage any unpredicted impacts and their consequences;
- a program to monitor, evaluate and report on compliance with the requirements, obligations and performance measures and criteria; and
- a program to investigate and implement ways to improve the environmental performance of the produced water management system over time.

1.4 Performance measures

In accordance with consent condition B37 Table 7, Santos will ensure that the Project complies with the following water management performance measures related to produced water:

- implement all reasonable and feasible measures to minimise risk of leaks and spills;
- design, install and maintain leak detection systems and fail-safe measures on the produced water management system;
- design, install and maintain all produced water storage ponds to provide sufficient freeboard to accommodate a 72-hour 1 in 100-year ARI flood event;
- all produced water to be treated to meet the treated water quality criteria in Appendix 6 [of the CoC[2]], unless otherwise authorised in an EPL;
- design, install and maintain produced water infrastructure in accordance with the *Exploration Code of Practice: Produced Water Management, Storage and Transfer* (DPE, 2017); and
- drawdown and water take to be generally consistent with the 'base case' predictions and produced water profile in the EIS.

1.5 Consultation

Extensive consultation with government agencies was undertaken during the preparation and approval of each of the previous versions of a PWMP for the existing operations (refer section 1.2).

For Phase 1, this PWMP has been prepared by a suitably qualified and experienced person in consultation with the Water group within the NSW Department of Planning and Environment (**DPE**) (generally referred to as **DPE Water**), the NSW Environment Protection Authority (**EPA**) and the Water Technical Advisory Group (**WTAG**).

The comment received from the Natural Resources Access Regulator (**NRAR**) [on behalf of DPE Water] on the draft PWMP (Revision C) and the attachments referred to the predicted Phase 1 produced water take. The comments received from the EPA on the draft PWMP generally centred around the use of treated water for dust suppression not being acceptable and not consistent with the consent, and that the definition for 'treated water' in the consent should be corrected. It is to be noted that only bore water is proposed to be used for dust suppression during Phase 1, and the use of treated water for dust suppression (rather than amended treated water) was never contemplated during Phase 1.

[2] Appendix 6 of the CoC has been reproduced as Appendix D of this PWMP.

Very few comments were provided by the WTAG, which identified a number of discrepancies and opportunities for improvement.

All consultation correspondence and the responses to comments are provided in Appendix A.

1.6 Structure of this Plan

Together with the suite of documents listed in section 1.2, this Plan is a supporting management plan (sub-plan) to the Water Management Plan. The Water Management Plan sets out the overall details how the documents are related and where information or details are located in the event of any overlap or commonality. The structure of this Plan is as follows:

Sections

Section 1	Provides an introduction to the Project and the context, scope, purpose and objectives of this Plan. It further provides the performance measures related to produced water
Section 2	Defines the roles and responsibilities of personnel involved with the management of produced water generated through NGP activities, including staff, consultants, contractors and service providers
Section 3	Outlines the statutory provisions relevant to the management of produced water generated by development of the NGP
Section 4	Describes the characteristics of produced water, including details about the sources, quantity and quantity
Section 5	Provides details how produced water from exploration, appraisal and production activities is managed through a network of gathering, storage and treatment infrastructure
Section 6	States that there will be no managed release to Bohena Creek during Phase 1.
Section 7	Provides an overview of the proposed approach to salt management for the Project, as no salt will be produced during phase 1
Section 8	Details the risk assessment of potential impacts and a description of measures to be implemented to avoid, minimise, mitigate, offset, manage and/or monitor the potential impacts of produced water
Section 9	Outlines the infrastructure monitoring program implemented across the produced water and brine storage facilities and gathering and transfer infrastructure.
Section 10	Describes the trigger, action and response plan developed to assess and respond to abnormal conditions and to manage risks to operations, personnel and the environment
Section 11	Provides details on the process that is implemented to manage data and records in a consistent, efficient and effective manner
Section 12	Details the actions required for incidents and non-compliances related to produced water management and storage
Section 13	Describes the reporting, evaluation and review process of this PWMP, including the annual review, independent audits and environmental improvement measures
Section 14	References
Section 15	Glossary

Appendices

Appendix A	Provides copies of the consultation records and responses to all comments
Appendix B	Consent conditions relevant to PWMP
Appendix C	Compliance with the Produced Water Code
Appendix D	Treated water quality
Appendix E	Key produced water management assets

1.7 Distribution

A copy of the approved PWMP is available to all Santos personnel via the Santos intranet. In accordance with consent condition D13, the latest copy of the Plan including all associated appendices, audits and reports, and summaries of all monitoring data (where relevant), can also be found on the Project website, once these have been approved by the Planning Secretary. This information will be kept up to date.

In accordance with specific licence, approval and/or code of practice conditions, a copy of this PWMP is available at the Santos Operations Centre located at 300 Yarrie Lake Road in Narrabri. This is where operational and field staff commence and finish each workday.

Note that any printed copies of the PWMP are uncontrolled.

2. Roles and responsibilities

All Santos employees and contractors involved in the Narrabri Gas Project are responsible for the environmental performance of their activities and for complying with all legal requirements and obligations. Project personnel will be required to comply with approval requirements of the activities they undertake and potential environmental impacts from all activities will be managed in accordance with the Project's relevant management plan(s).

In accordance with consent condition D1, the Environmental Management Strategy (**EMS**) sets out the role, responsibility, authority and accountability of all key personnel involved in the environmental management of the Project, including the requirements and obligations in this PWMP. All roles, responsibilities and accountabilities have been assigned in accordance with Santos Management System *SMS-MS_14 People Management Standard*.

3. Regulatory requirements

The Project is permissible with development consent under the *State Environmental Planning Policy (Resources and Energy) 2021*, and is identified as a 'State significant development' under Section 4.38 of the EP&A Act and the *State Environmental Planning Policy (Planning Systems) 2021*.

The Project was subject to the State significant development assessment and approval provisions of Division 4.1 of Part 4 of the EP&A Act and was approved as a State significant development under the EP&A Act and the EPBC Act.

The Project will be carried out in accordance with the:

- relevant existing development consents and activity approvals;
- the conditions of relevant tenements including PEL 238, PAL 2, PPL 3, the provisions of the *Petroleum (Onshore) Act 1991* (NSW) (**PO Act**) and relevant codes of practice;
- requirements of the *Dams Safety Act 2015* (NSW);
- EPL 20350 issued by the EPA and the provisions of the *Protection of the Environment Operations Act 1997* (**POEO Act**); and the
- conditions of consent for the NGP SSD 6456.

Further details regarding the NGP, including a full overview of the regulatory framework and statutory provisions of the NGP and the current approvals, leases and licences are provided in the Water Management Plan.

3.1 Compliance conditions

Compliance conditions associated with the following licence(s), lease(s) and consent(s) are relevant to this PWMP:

- PEL 238, granted on 1 September 1980 and most recently renewed on 12 April 2022;
- PAL 2, granted on 30 October 2007;
- PPL 3, granted on 15 December 2003;
- PPLs 13, 14, 15 and 16, once issued;
- EPL 20350; and
- SSD 6456.

3.1.1 PEL 238

There are no specific conditions or obligations in PEL 238 related to this PWMP.

3.1.2 PAL 2 and PPL 3

Lease condition 2 of PAL 2 and PPL 3 state that activities must only be carried out in accordance with a Petroleum Operations Plan (**POP**) which has been approved by the then Director-General of the Department of Primary Industries. Further, the POP must (i) identify how operations will be carried out on site in order to prevent and or minimise harm to the environment; and (ii) reflect conditions of approval under the EP&A Act, the POEO Act, and any other approvals relevant to PAL 2 and PPL 3.

This PWMP supports the POP and satisfies condition 2 of PAL 2 and PPL 3 by providing information about how Santos manages produced water resulting from its activities within PAL 2 and PPL 3.

3.1.3 EPL 20350

'Petroleum exploration, assessment and production' is a scheduled activity listed in Schedule 1 of the POEO Act. Under Section 48 of this Act, all scheduled activities are required to hold an environment protection licence. EPL 20350 is held for CSG activities in PEL 238, PAL 2 and PPL 3.

Monitoring of amended treated water from the 5 ML tank at Leewood (sample point 77, LWWTPDM1) is conducted in accordance with condition M2.2, M2.3, M 2.7 and M2.11 of EPL 20350, to be completed prior to irrigation and yearly thereafter. These conditions are detailed extensively in the Irrigation Management Plan.

3.1.4 Development Consent SSD 6456

There are a number of SSD 6456 consent conditions directly relevant to this Protocol for Phase 1, with the key conditions CoC B37 and B41(d)(v) provided below. Table B1 in Appendix B specifies where each of the requirements of all the relevant SSD 6456 consent conditions are addressed in this Plan.

Consent condition B37 states that Santos must ensure that the development complies with the following management performance measures related to produced water:

- implement all reasonable and feasible measures to minimise risk of leaks and spills;
- design, install and maintain leak detection systems and fail-safe measures on the produced water management system;
- design, install and maintain all produced water storage ponds to provide sufficient freeboard to accommodate a 72-hour 1 in 100-year ARI flood event;
- all produced water to be treated to meet the treated water quality criteria in Table D1 in Appendix D, unless otherwise authorised in an EPL;
- design, install and maintain produced water infrastructure in accordance with the *Exploration Code of Practice: Produced Water Management, Storage and Transfer* (DPE, 2017).

Consent condition B41 states that prior to the commencement of Phase 1, Santos must prepare a Water Management Plan for the NGP to the satisfaction of the Planning Secretary and that this plan must include an:

(v) Produced Water Management Plan, that includes:

- detailed baseline data on produced water yield and quality;
- a detailed description of the produced water management system, including details of:
  - produced water collection, transfer, storage, treatment, beneficial usage and/or disposal infrastructure;
  - fail-safe, redundancy and contingency measures;
  - capacity of water storages, large ponds and dams, including during plant outages and extreme weather events;
  - provision for continuous logging of produced water and treated water volumes;
  - leak detection and spill response;

    - preferential beneficial water use options;
- detailed performance criteria, including trigger levels for identifying and investigating any potentially adverse impacts associated with:
    - produced water yield and quality;
    - treated water yield and quality;
    - leaks and spills;
    - treated water irrigation and other beneficial reuse application;
    - discharge of excess treated water to Bohena Creek;
    - salt yield and quality;
- a program to monitor, evaluate and report on:
    - compliance with the relevant performance measures listed in Table 7 [of the CoC], and the performance criteria established above;
    - produced water yield and quality, including chemicals of potential concern;
    - treated water yield and quality, including chemicals of potential concern;
    - leaks and spills;
    - soil, surface water and groundwater quality in irrigation and other beneficial reuse application areas;
    - Bohena Creek discharges, flows and water quality;
    - salt and other waste products yield and quality; and
    - the effectiveness of the produced water management system.

3.2 Relevant codes, standards, policies and guidelines

3.2.1 Produced Water Code

As required by consent condition B37, the produced water infrastructure will be designed, installed and maintained in accordance with the Produced Water Code.

The Produced Water Code sets out mandatory requirements and provides title holders with related guidance about the expected performance for the management, storage and transfer of produced water. It serves three purposes. It:

- provides upfront information to industry and the community;
- facilitates the assessment of exploration activities consistent with Part 5 of the EP&A Act;
- sets out enforceable mandatory requirements related to produced water management, storage and transfer.

Further, it enables industry to:

- adopt a risk-based approach to ensure compliance with mandatory requirements related to produced water;
- commit to measurable performance;
- monitor performance and take corrective action if outcomes are not being achieved; and
- keep and maintain relevant records of activities and/or actions.

Table C1 in Appendix C set out the key mandatory requirements of the Produced Water Code and specify where these are addressed in this Plan. Although the Produced Water Code is applied as a term of consent condition B37, it only took effect in 2015 and as such the mandatory requirements do not apply to any existing infrastructure that was constructed and commissioned prior to 2015. This is expressly stated in Part A of the Code.

Note however that EPL 20350 expressly states in Condition E1 (as part of the Special Conditions) that the Tintsfield Water Management Facility must not receive produced water until the following measures have been prepared and implemented:

1. a revised Produced Water Management Plan;
2. any pond receiving produced water has been upgraded to comply with the *Exploration Code of Practice Produced Water Management, Storage and Transfer* which is subject to amendment from time to time; and
3. installation of double lining with sumps and real time leak detection on any pond receiving produced water.

3.2.2 Well Integrity Code

The *Code of Practice for Coal Seam Gas: Well Integrity* (DTIRIS, 2012) (**Well Integrity Code**) is an industry guideline administered by the NSW Government and enforced under the PO Act. The Well Integrity Code and practice defines the standards for well design and construction to prevent environmental harm, particularly to groundwater resources.

Wells constructed as part of the Project would comply with the code. With regard to produced water, the Code states that wells must be designed '*to ensure all fluids produced from the well travel directly from the production zone to the surface without contaminating groundwater*'.

3.3 EIS commitments

In the EIS Chapter 31, and updated in Appendix B of the Response to Submissions, Santos has committed to implement a number of measures pending Project approval and a final investment decision. The EIS commitments relevant to produced water management have been reproduced below in Table 3.1, in accordance with consent condition D3(c) which states that Santos must ensure that (where relevant) the management plans include any relevant commitments or recommendations identified in the EIS. Note that in some instances a commitment may be no longer relevant or correct due to the management plan structure required by the SSD 6456 consent conditions, rather than the environmental management plan structure proposed in the EIS.

Table 3.1 - EIS commitments relevant to produced water management

Number	EIS Commitment relevant to Produced Water Management
3.1	Irrigation of treated water during production will be undertaken in accordance with an irrigation framework, included under the Produced Water Management Plan [Note: Irrigation of treated water is fully described in the Irrigation Management Plan]
5.6	Irrigation of treated water during production will be undertaken in accordance with an irrigation framework, included under the Produced Water Management Plan [Note: Irrigation of treated water is fully described in the Irrigation Management Plan]

As described in section 13 of this Plan and section 8 of the EMS, this Plan will be subject to regular evaluation and review. This will include the EIS commitments to ensure they remain current, applicable, and generally improve the environmental performance of the Project.

4. Characterisation of produced water

4.1 Produced water source

CSG development will primarily target gas reserves associated with Early and Late Permian coal seams of the Maules Creek Formation, located at depth in the northern portion of the Gunnedah Basin.

The primary target seams (Bohena, Parkes, Namoi and Rutley seams) of the early Permian Maules Creek Formation occupy the basal part of the Bohena Trough within the northern part of the Gunnedah Basin. The Later Permian Blackjack Group (Hoskissons coal seams) are also development targets. However, these units are not utilised for water supply due to the depth and presence of the alluvium and Pilliga Sandstone closer to the ground surface. The coal seams are typically characterised by poor (saline) water quality.

Overlying the target seams are approximately 600-800 metres (**m**) of Permian and Triassic strata. Jurassic-age strata belonging to the Surat Basin, a south-eastern extension of the Great Artesian Basin, overly the Permo-Triassic strata and are themselves overlain in part by more recent consolidated and unconsolidated alluvial sediments.

Gas trapped in coal is adsorbed onto the coal surface in cleats and joints or micro pores and held in place by reservoir and water pressures. To extract the gas, it is necessary to reduce the pressure by first removing water (known as produced water). Typically, water production is higher earlier in the life of a CSG field and declines as gas production increases.

4.2 Produced water quantity

The estimated quantity of produced water associated with the Phase 1 activities, including the operation of the existing pilots for exploration and appraisal activities in PEL 238 and PAL 2 is up to approximately 1.26 ML/day.

The volume of water generated during the production phase is determined by the properties of the coal and the depressurisation targets that must be achieved to facilitate gas production.

Figure 4.1 presents the predicted produced water production volumes over time for Phase 1, showing the predicted contribution of each pilot to water production for a period of 10 years from the start of Phase 1. It is to be noted that final water production may vary depending on a range of factors, such as well operation, coal properties and Project scheduling.

The monitoring of the volume of produced water is addressed in section 9.1.

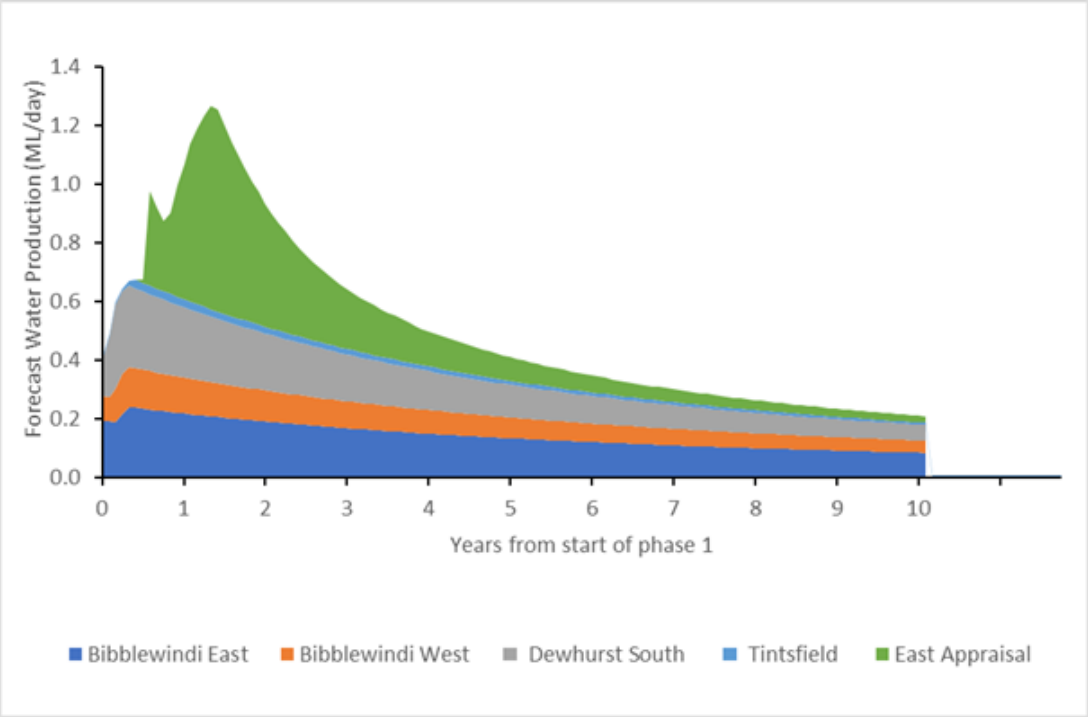


Figure 4.1 - Predicted existing and produced water production in Phase 1

Further details are provided in the Site Water Balance, as attachment 2 to the WMP and the Groundwater Modelling Plan, as appended to the Groundwater Management Plan (attachment 4 to the WMP).

4.3 Produced water quality

The quality of water extracted from a coal seam, like many forms of groundwater, can vary depending on a range of factors including age, depth and the type of geological formation. The average salinity of produced water generated during exploration and appraisal activities within the Project area to date from the Maules Creek Formation and Blackjack Group is around 19,000 µS/cm.

The quality of produced water is primarily dependent upon the geology of the area in which CSG wells are located and consequently, variability between wells can be high. Evidence suggests that the produced water quality from a single well is generally within a consistent range with fluctuations in the order of 20 % (+/-) over the lifetime of a well.

Table 4.1 provides the average produced water quality at the well head and has been derived from over 300 samples from around 50 wells throughout PAL 2 and PEL 238 over a period of 16 years. Considering the spatial extent and the extended period over which samples were taken, Table 4.1 is considered to be representative of the conditions which could be encountered in the field. It has been reproduced from Table A1 in Appendix A to the Supplementary Response to Submissions.

Table 4.1 - Produced water quality at well head

Parameter	Units	LOR*	Number of analyses	Average	16th %-ile	84th %-ile
Physicochemical						
pH			321	8.0	7.3	8.6
Electrical Conductivity	µS/cm		319	14836	11284	18653
Solids (Dissolved)	mg/L	2	252	9765	7083	13000
Solids (Dissolved) @180ºC	mg/L	2	82	11675	7971	14815
Dissolved anions						
Carbonate alkalinity as $CaCO_3$	mg/L	1	227	378	1	779
Bicarbonate alkalinity as $CaCO_3$	mg/L	1	335	8518	5157	11800
Bromide	mg/L	0.005	41	4.44	3.04	5.51
Chloride	mg/L	2	335	1396	1000	1673
Fluoride	mg/L	0.05	75	4.86	2.51	6.00
Sulphur as SO4	mg/L	0.1	258	45	1	34
Dissolved cations						
Calcium (Total)	mg/L	0.1	284	19	5	31
Magnesium (Total)	mg/L	0.01	166	6	3	7
Potassium (Total)	mg/L	0.2	331	213	41	156
Sodium (Total)	mg/L	1	334	4360	2858	5955
Hardness (Total)	mg/L	1	105	88	26	147
Nutrients						
Ammonia-Nitrogen	mg/L	10	57	10	4	16
Nitrate-Nitrogen	mg/L	0.1	167	2.56	0.05	3.00
Nitrite-Nitrogen	mg/L	0.01	75	0.04	0.01	0.02
Nitrogen (TKN)	mg/L	1	54	25.6	6.0	33.6
Nitrogen (Total)	mg/L	1	60	23.6	4.9	30.8
Ortho-Phosphorus	mg/L	0.18	34	<0.18	<0.18	<0.18
Phosphorus (Total)	mg/L	0.02	58	0.28	0.04	0.22
Total metals & trace elements						
Aluminium (Total)	mg/L	0.01	60	3.35	0.02	2.73
Antimony (Total)	mg/L	0.0001	59	0.0008	<0.0001	0.0011
Arsenic (Total)	mg/L	0.0001	57	0.0106	0.0047	0.0126
Barium (Ba)	mg/L	1	60	8.5	4.2	14.4
Beryllium (Total)	mg/L	0.001	55	<0.001	<0.001	<0.001
Boron (Total)	mg/L	0.2	60	0.6	<0.2	1.2
Cadmium (Total)	mg/L	0.0001	60	0.0107	<0.0001	0.0204
Chromium (Total)	mg/L	0.0005	60	0.0116	0.0008	0.0201
Cobalt (Total)	mg/L	0.0001	56	0.0017	<0.0001	0.0027
Copper (Total)	mg/L	0.0005	60	0.0503	0.0046	0.0438
Iron (Total)	mg/L	0.01	106	17.17	0.26	6.00
Lead (Total)	mg/L	0.0005	17	0.0199	<0.0005	0.0252
Lithium (Total)	mg/L	0.1	17	1.7	1.3	2.0
Manganese (Total)	mg/L	0.001	61	0.266	0.003	0.062
Mercury (Total)	mg/L	0.0001	58	0.0005	<0.0001	0.0005
Molybdenum (Total)	mg/L	0.0001	59	0.0047	0.0001	0.0043
Nickel (Total)	mg/L	0.0001	60	0.0065	<0.0001	0.0125

Parameter	Units	LOR*	Number of analyses	Average	16th %-ile	84th %-ile
Selenium (Total)	mg/L	0.0005	58	0.0206	0.0039	0.0413
Strontium (Total)	mg/L	0.001	86	2.521	0.603	4.361
Tin (Total)	mg/L	0.0005	17	0.0018	<0.0005	0.0027
Uranium	mg/L	0.0001	58	0.0004	<0.0001	0.0005
Vanadium (Total)	mg/L	0.005	53	0.009	<0.005	0.012
Zinc (Total)	mg/L	0.0005	60	0.0531	0.0041	0.0575

*LOR - limit of reporting

5. Produced water management

5.1 Water management facilities

Santos' main water management facilities are located at the Leewood property on the Newell Highway, approximately 24 km south-west of Narrabri, within PAL 2. Leewood hosts the following infrastructure to manage produced water and brine from Santos' exploration and appraisal activities:

- two HDPE double-lined produced water and brine storage ponds, each pond with two cells;
- a water treatment facility to treat produced water from exploration and appraisal activities;
- a managed irrigation system; and
- a storage and utilities area, staff amenities and car parking.

Additional water management infrastructure is located at the Bibblewindi facility, on Garlands Road within the Bibblewindi State Forest, in PEL 238. This includes a 5 ML (4 ML full supply level) water balance tank used to manage produced water flows between the gas field and the water treatment plant at Leewood, a recently commissioned small capacity gas compression station, a safety flare, storage and utility areas, staff amenities and car parking. The facility also has two disused ponds, Bibblewindi Pond 2 and Pond 3.

Two additional produced water ponds, known as Tintsfield Pond 1 and Pond 2, are located approximately 10 km south-west of Narrabri, within PEL 238. The ponds currently do not hold any produced water. Tintsfield Pond 1 will be upgraded to the standard of the Leewood Ponds before any produced water from the Tintsfield Pilot is received. There are no current plans for Tintsfield Pond 2 to receive and store produced water. Table E1 in Appendix E summarises the field's key produced water assets and facilities, their status and relevant activity approvals. Figure 5.1 identifies the location of key assets and infrastructure, and the indicative Phase 1 footprint.

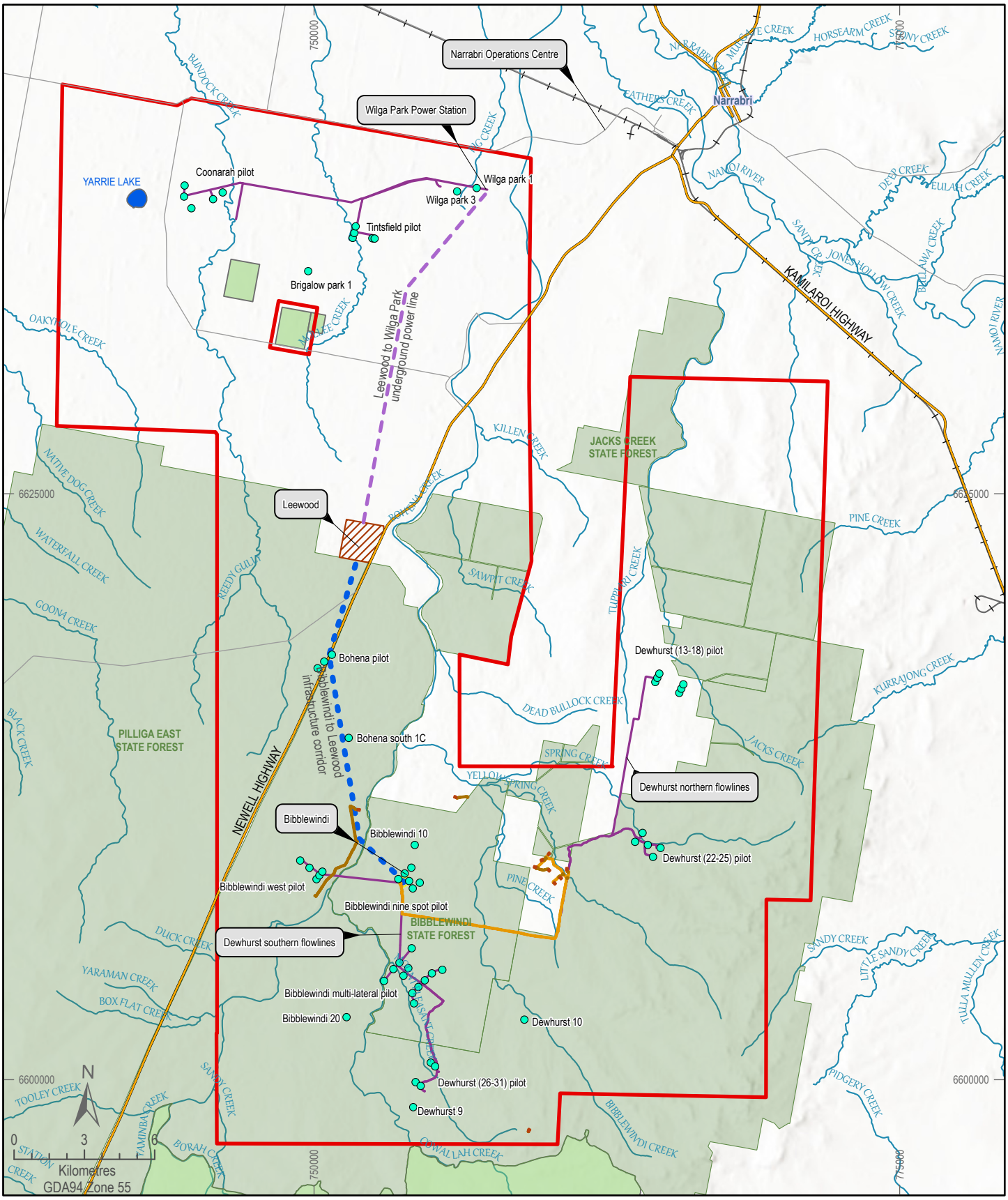
There are other approved pilots that are not included in Table E1 in Appendix E which are currently not producing water or gas. These pilots are the Bibblewindi 9 Spot pilot, the Coonarah wells in PPL 3 and the Bohena Pilot. They will not be producing water during Phase 1.

Produced water from exploration and appraisal activities within PEL 238 and PAL 2 is managed through a network of existing gathering, storage and treatment infrastructure. This infrastructure has been developed after extensive environmental impact assessment and approval and is operated in accordance with the relevant conditions and commitments identified in section 3.

The produced water management infrastructure and processes are described in the sections below. Further details of each aspect of the network can be found in the relevant Review of Environmental Factors documents, all available on the DPE DiGS website or EIS documents available on the DPE Major Projects website.

5.2 Produced water gathering and transfer

At each pilot, produced water is pumped from through local water gathering lines to a centralised balance tank for that pilot (where installed). Produced water is then pumped from the balance tank (or directly from the pilot well where no balance tank is installed) via flowlines to the Bibblewindi facility balance tank and onto Leewood via the Leewood Water Pipeline. The only exception is produced water from the Tintsfield Pilot, which is transferred via flowlines to the Tintsfield Ponds.



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ONWARD CONSULTING

LEGEND

- NGP boundary
- Leewood
- Bibblewindi
- Existing wells
- Existing flowlines
- Phase 1 access roads
- Phase 1 flowlines
- Phase 1 well pads
- Leewood to Wilga Park infrastructure corridor
- Bibblewindi to Leewood infrastructure corridor
- Highway
- Major roads
- Watercourse
- Railway
- State Forest
- Parks and reserves
- Lakes and dams

NARRABRI GAS PROJECT

Figure 5.1

Key Assets and Infrastructure
Phase 1

The existing water pipeline and flowline network includes:

- the Leewood Water Pipeline between the Bibblewindi facility and the Leewood Water Management Facility;
- the Dewhurst Northern Flowline between Dewhurst 22-25 Pilot and the Bibblewindi facility;
- the Dewhurst Southern Flowline between Dewhurst 26-29 Pilot and the Bibblewindi facility;
- water flowlines from Bibblewindi West Pilot to Bibblewindi facility;
- water flowlines from Bibblewindi East Pilot (also known as the Multi-lateral Pilot) to the Bibblewindi facility; and
- water flowlines from the Tintsfield Pilot to Tintsfield ponds.

As provided in section 1.1.2, the Phase 1 scope is planned to include the construction and operation of:

- 4 coreholes;
- 6 pilot wells;
- 2 deep reservoir monitoring bores (converted coreholes);
- new shallow water monitoring bores;
- associated linear infrastructure; and
- seismic surveys (length and location to be determined).

In addition, there is a buried gas pipeline between the Bibblewindi facility and Wilga Park Power Station that has an offtake at Leewood. This pipeline can be used to transfer water between Bibblewindi, Leewood and Tintsfield, if required.

The design, construction and operation of the high-density polyethylene (**HDPE**) flowlines is undertaken in accordance with the Australian Pipelines and Gas Association's *Code of Practice for Upstream Polyethylene Gathering Networks – CSG Industry* (August 2019). This includes detailed quality control measure requirements to ensure the integrity during the construction process. After construction and prior to commissioning, the entire flowline is required to be pressure tested and once operating, ongoing pressure monitoring using remote telemetry occurs.

The process of managing the integrity of pipeline systems, including rigid and flexible risers, is fully detailed in the Pipeline Integrity Management System.

5.3 Produced water storage facilities

A summary of the current produced water storage facilities is presented in Table 5.1. The table includes information on storage volumes of each facility and controls to prevent and minimise pollution including pond liners and monitoring equipment installed. It does not include tanks within the Leewood Water Treatment Facility.

Table 5.1 - Summary of approved produced water storage facilities

Storage name	Full supply level volume (ML)	Maximum operating level volume (ML)	Design Life	Lining and leak detection system	Facility monitoring		
					Monitoring aspect	Frequency	Monitoring at facility
Bibblewindi Transfer Tank (produced water)	4	3.75	25 years	Galvanised steel panel tank with internal polypropylene bladder. Tank is also contained within an earthen bund underlain with a HDPE liner	Water level	Continuous sensors and remote monitoring. Tank is equipped with level instrumentation, alarms and trips, to ensure the tank does not over fill.	Network of 13 monitoring bores installed at the facility at varying depths located up-gradient, down-gradient and cross hydraulic gradient of the water infrastructure. These monitoring points were installed when there were three produced water storage ponds at Bibblewindi and pre-dated the construction of the Transfer Tank. The bores are designed to both monitor groundwater (chemical, physical and hydraulic) and intercept groundwater where this is found to be present. Additional perched water layers are monitored at a number of locations to assess any vertical migration of groundwater.
					Inflow and outflow	Continuous flow meters and remote monitoring.	
Leewood Pond 1 Leewood Pond 2	411.4 438.4	346.1 364.5	25 years	Primary polyethylene geomembrane liner underlain by leak detection system underlain by a secondary liner. The secondary liner will be underlain by 300 mm of smooth clayey subgrade. The leak collection system transfers any produced water collected below the liner directly back into the pond. The operation of the sump pumps and sump levels is checked based on an alarm feedback loop and data recorded. Ponds designed by a suitably qualified engineer and constructed on stable sub-base with each liner weld tested and associated QA Documentation developed. The ponds also have a fauna proof fence installed to prevent terrestrial fauna from entering the pond area.	Water level	Continuous sensors and remote monitoring	Network of 7 seepage detection bores (50mm diameter) installed around the Leewood ponds to a depth of 10 metres, with screening from 7 to 10 m below ground level. Seepage detection bores are monitored biannually. Ten groundwater monitoring bores of varying depths are installed across the Leewood property. The monitoring bores are screened at a number of shallow perched water layers below the surface. Sampling of standard groundwater parameters is undertaken quarterly, and results reviewed for any unexpected changes to physical and chemical water quality parameters and water levels.
					Inflow and outflow	Continuous flow meters and remote monitoring	
					Embankment seepage	Monthly	
					Embankment erosion	Quarterly	
					Pond crest integrity and capping	Quarterly	
					Hydraulic structures	Quarterly	
					Pipework and valves	Weekly to fortnightly	
					Pond water quality	Quarterly for pH, DO, redox potential and EC. Six-monthly grab sample for laboratory analysis in accordance with EPL 20350	
					Rainfall and evaporation	Continuous (from the weather station)	
					Pond liner condition	Monthly	
					Embankment deformation	Monthly	
					Vegetation growth	Quarterly	
					Wildlife management systems (fences etc)	Quarterly	

Storage name	Full supply level volume (ML)	Maximum operating level volume (ML)	Design Life	Lining and leak detection system	Facility monitoring		
					Monitoring aspect	Frequency	Monitoring at facility
Tintsfield Pond 1 (not currently operational)	22.9	15.3	25 years	Ponds not currently holding produced water or in use. Prior to being brough back into commission Pond 1 will be upgraded to the Exploration Code of Practice Produced Water Management, Storage and Transfer	Water level	Continuous sensors and remote monitoring	Network of 20 monitoring bores of monitoring bores installed at the facility at varying depths located up-gradient, down-gradient and cross hydraulic gradient of the water infrastructure. The monitoring bores are screened at a number of shallow perched water layers below the surface. Sampling of standard groundwater parameters is undertaken quarterly, and results reviewed for any unexpected changes to physical and chemical water quality parameters and water levels
					Inflow and outflow	Continuous flow meters and remote monitoring	
					Embankment seepage	Monthly	
					Pond crest integrity and capping	Quarterly	
					Hydraulic structures	Quarterly	
					Pipework and valves	Weekly	
Tintsfield Pond 2 (not currently operational)	92.0	72.6			Pond water quality	Quarterly for pH, DO, redox potential and EC. Six-monthly grab sample for laboratory analysis in accordance with EPL 20350	
					Rainfall and evaporation	Weekly	
					Pond liner condition	Monthly	
					Embankment deformation	Monthly	
					Vegetation growth	Quarterly	
					Wildlife management systems (fences etc)	Quarterly	

5.4 Produced water and brine treatment

The treatment and beneficial reuse of treated water from exploration and appraisal activities has previously been assessed and approved under Part 5 of the EP&A Act and the PO Act. When operational, the current WBTP has the capacity to treat approximately 1.5 ML/day of produced water to produce approximately 1 ML/day of amended treated water.

Treatment processes include:

- **pre-treatment** to enable the removal of solids and/or scale-causing compounds from the water. To remove solids and/or scale causing compounds, produced water first undergoes membrane filtration to remove solids between 0.01 - 0.1 microns within the feed water. The final pre-treatment process involves using a biocide for bio-fouling control. This step controls the growth of microorganisms, both in the microfiltration/ultrafiltration and reverse osmosis (**RO**) stages;
- **treatment by RO** where the produced water is pumped through a semi-permeable membrane, separating treated water into one stream and salts into another stream known as rejected concentrate or 'brine'. Feed water is pumped at high pressure through the membranes, typically separating over 99 % of the total dissolved solids from the water;
- **post-treatment** which involves a series of steps in order to chemically balance the treated water prior to beneficial reuse (particularly for irrigation). This includes:
  - dechlorination by sodium bisulphate addition (this is dosed prior to the RO to protect the RO membranes from oxidation by chlorine);
  - addition of calcium and magnesium to lower the sodium adsorption ratio; and
  - adjustment of pH by acid or caustic addition, if required.

Brine from the reverse osmosis plant is sent to the brine treatment plant to further recover treated water and concentrated brine beyond the limit of the water treatment plant. A membrane brine concentrator within the brine treatment plant uses a high-pressure membrane process to concentrate dissolved solids in solution by using reverse osmosis and recovering additional treated water. The main output from the membrane brine concentrator is concentrated brine which is then transferred to a brine storage cell, or recirculated into one of the ponds.

All treated produced water will meet the treated water quality criteria in Table D1 in Appendix D [reproduced from Appendix 6 of the CoC] prior to beneficial reuse.

5.5 Preferential beneficial water use options

Amended treated water from the plant is stored in the 5 ML storage tank prior to its beneficial reuse. Monitoring of treated water from this tank is conducted in accordance with the conditions of EPL 20350 prior to beneficial reuse for irrigation, construction and drilling and completions (**D&C**) (refer to section 3.1.3). As specified in Table 7 [of the CoC], under the 'Irrigation and beneficial reuse management' feature, only amended treated water from the plant is approved to be used for reuse activities (except for firefighting).

In summary, the beneficial reuse hierarchy that will apply during Phase 1 for the various water types is provided in Table 5.2.

Table 5.2 - Preferential reuse options

Water type	Beneficial reuse						
	Dust suppression and rehabilitation	Construction	D&C	Irrigation at Leewood	Managed release	Stock watering	Firefighting
Bore water	✓	✓	✓	✓			✓
Treated water	There will be no treated water produced, stored and/or used during Phase 1. Only amended treated water will be produced, stored and/or used during Phase 1.						
Amended treated water		✓ (preferred)	✓ (preferred)	✓ (preferred)			✓ (preferred)
Potable water	For personal use / ablutions only						

The use of amended treated water for the various beneficial reuse options is described in detail in section 5 of the Site Water Balance, provided as attachment 2 to the WMP.

The specific use of amended treated water for irrigation is fully addressed in the Irrigation Management Plan (as attachment 6 to the WMP).

The use of bore water for dust suppression is detailed in the Dust Suppression Protocol (as attachment 7 to the WMP).

The hierarchy of preferential uses may change for Phase 2 and subsequent phases, depending on the volumes of treated effluent available and any RREOs obtained.

6. Managed Release Protocol

In accordance with CoC B41(d)(viii), this section provides the Managed Release Protocol as a sub-plan to the WMP, specifically for managing disposal of treated water to Bohena Creek and that includes:

- details of baseline creek water flows, quality and stream health;
- details of predicted plume dispersal for all potential pollutants, based on updated mixing zone assessment and modelling;
- a protocol and detailed procedures for managed release, in accordance with the water management performance measures in Table 7 [of the CoC];
- measures to:
  - upgrade and maintain applicable infrastructure, including a stream flow gauging and monitoring station/s;
  - maintain water quality and stream and riparian health;
  - minimise erosion and sedimentation, or changes to channel stability; and
  - minimise downstream flooding;

There will be no managed release of treated water to Bohena Creek during Phase 1.

This Protocol will be reviewed, and where relevant, updated for Phase 2.

7. Salt Management Plan

In accordance with CoC B41(d)(ix), this section provides the Salt Management Plan as a sub-plan of the Water Management Plan, that includes details of:

- salt and other waste volumes and composition generated by the produced water management system, including chemicals of potential concern;
- a program for investigating and implementing beneficial reuse options for the salt product, in accordance with the Produced Salt Beneficial Reuse and Disposal Study (**PSBRDS**);
- a protocol and procedures for collection, storage, waste classification, transport and disposal of salt and other waste products;
- measures to:
  - ensure all salt and other waste product is stored within a weather-proof structure while on site; and
  - ensure all salt and other waste product is disposed to an appropriately licenced off-site waste facility, if not able to be beneficially reused, in accordance with the Produced Salt Beneficial Reuse and Disposal Study.

As detailed in the PSBRDS, no salt will be produced during Phase 1 and Phase 2 of the Project. It is expected that there will be adequate capacity in the ponds at the existing Leewood Water Management Facility to store produced water and brine during Phase 1 and 2, as detailed in section 7 of the Site Water Balance.

The PSBRDS, prepared in accordance with CoC B69, provides further details required to manage salt during Phase 3. It will be reviewed and, where relevant, updated, prior to the commencement of Phase 2.

This Salt Management Plan will also be reviewed and, where relevant, updated prior to the commencement of Phase 2, based on the information obtained through the PSBRDS.

8. Risk assessment and mitigation

The potential risks associated with the Phase 1 activities covered by this Plan were assessed, and mitigation measures described, in the various review of environmental factors documents listed in Table E1 in Appendix E. Further risk assessment has been carried out during the implementation of these activities in accordance with Santos Management System *SMS-MS_1 Risk Management Standard*. A summary of the key risks associated with produced water management, and measures to manage these risks, are provided in Table 8.1. The operational risk matrix used to determine the risk levels is provided in Table 8.2.

A full description of the risk assessment and mitigation process is provided in section 4 of the WMP.

Table 8.1- Risk assessment and mitigation

Risk	Potential causes	Inherent design standards and operational practices	Initial risk			Site/activity specific mitigation measures/ management plans to reduce risk	Residual risk		
			L	C	R		L	C	R
Loss of containment of produced water from wellhead.	Equipment failure, operational error, tampering, impact from livestock.	Wells are designed and constructed in accordance with the NSW Government *Code of Practice for Coal Seam Gas - Well Integrity*. Well leases are fenced.	C	IV	3	Pressure gauges are fitted to wellhead equipment and monitored remotely through a Supervisory Control and Data Acquisition (SCADA) system. Any change in pressure is investigated immediately and in the event of a leak, the well shut in. Well head inspections are carried out on a regular basis for operational wells and quarterly for shut-in and suspended wells, in accordance with the NGP Well Integrity Control Plan. Well integrity is monitored through a leak detection and repair program (LDAR) in accordance with the NGP Well Integrity Control Plan, as required by EPL 20350.	B	IV	2
Loss of containment of produced water from flowlines, pipelines and from low point drains	Excavation, overpressure, equipment failure.	Pipelines are designed and constructed in accordance with APGA's *Code of Practice for Upstream Polyethylene Gathering Networks - CSG Industry* and pressure tested prior to commissioning.	D	IV	4	Differential pressure flowmeters are used to determine if there are any losses of produced water along the pipeline network. In the event that a loss is detected, wellheads are able to be shut-in remotely. Refer to the Pipeline Integrity Management System for details. The response to spills associated with loss of containment from flowlines, pipelines and from low point drains is detailed in the Pollution Incident Response Management Plan (PIRMP).	C	IV	3
Loss of containment of produced water from storage tanks	Faulty valve, operator error, tank failure or overflow.	All produced water storage tanks are bunded to 110% capacity.	C	IV	3	Inflow and outflow of the Bibblewindi Transfer Tank and balance tanks is monitored continuously. Continuous level measurement of the Bibblewindi Transfer Tank is carried out in accordance with section 9.1. Balance tanks are inspected on a monthly basis.	B	III	2
Loss of containment of produced water or brine from ponds due to lining, pipe or wall failure, or overtopping	Improper design, construction or maintenance. Operation outside design limits	All ponds are designed and operated according to appropriate engineering standards. The Leewood ponds have: • a spillway capacity designed to pass 0.01% Annual Exceedance Probability (AEP) flows • wet season design storage allowance (the volume between the MOL and FSL /spillway level) sized to provide storage for a volume equivalent to the 1:100 AEP and a storm event containment of 1:100 AEP 72-hour duration • double lining and leak detection	C	V	4	Continuous pond level measurement is carried out in accordance with section 9.1. Monitoring of other aspects of the ponds, such as embankment and liner condition, is carried out in accordance with Table 5.1. Level instrumentation and pond level forecasting is carried out. Trigger action response plans have been developed for water level management and leakage management for the Leewood Ponds (refer to section 10).	B	V	3
Loss of containment of produced water or chemicals from WBTP.	Improper design, overpressure, operator error, equipment failure	The plant is designed and operated according to appropriate engineering standards.	C	IV	3	The plant is operated in accordance with the approved Leewood Water Treatment Plan, as required under EPL 20350 condition M 2.7. The plant is situated on a bunded area.	B	III	2

Table 8.2- Risk assessment and mitigation

Santos Risk Matrix

Santos

Consequence							
	Safety	**Negligible Harm** + No bodily damage or minimal harm or impairment (hours to days)	**Minor Harm** + Short term impairment (days to weeks)	**Moderate Harm** + Temporary disablement or medium term impairment (weeks to months)	**Severe Harm** + Long term/life altering disablement or impairment	**Single Fatality OR Critical Life Threatening Injuries**	**Multiple Fatalities**
	Environment	+ No impact to Environmental Value (EV).	+ Small-scale impact to EV(s) of conservation significance + Potential surface or groundwater impact.	+ Moderate-scale impact to EV(s) of conservation significance + Localised surface or groundwater impact.	+ Large-scale impact to EV(s) of conservation significance + Moderate-scale surface water impact; + Localised impact to groundwater with potential or known beneficial use.	+ Extensive population or community scale impact to EV(s) of conservation significance + Extensive impact to other EV(s).	+ Irreversible impact to EV(s).
	Community & Reputation	+ No actual or potential community criticism + Details remain within Santos sites and/or offices	+ Minor level local community criticism (< week) + No reputation impact	+ Local community criticism (> week) or one-day community protest + Local company reputation impacted	+ State-level community criticism or protest over multiple days/locations + State-based company reputation impacted + Very short-term share price impact (< week)	+ National community criticism or large scale protest + Company reputation and approvals impacted + Shareholder intervention or short-term share price impact (< month)	+ Sustained national community criticism or widespread protest + Industry reputation and approvals impacted + Changes at executive/board level or long-term share price impact (> month)
	Financial (A$)	< $30k	$30k to $300k	$300k to $3m	$3m to $30m	$30m to $300m	> $300m
	Workforce	+ Will require some staff attention over several days. + No actual or potential impact to culture	+ Will require several days local management time. + Minor impact to employee engagement and limited staff turnover	+ Will require head office staff and take several weeks of site management time. + Moderate impact to employee engagement and staff turnover above industry average with some key roles	+ Will require several weeks of senior management time + Impact to employee engagement (< 6 months), moderate turnover of key roles and no succession	+ Will require several months of senior management time + Impact to employee engagement (< 18 months), high staff turnover and attraction issues	+ Will require more than a year of senior management involvement and operations severely disrupted + Impact to employee engagement (> 18 months), significant key role turnover and attraction issues
	Compliance	+ Non-conformance with legislation, instruments (e.g. tenure licence) or contract + No regulatory or punitive action	+ Minor breach of legislation, instruments or contract + Notification/report to; request for information by; and/or administrative/ warning notice from the regulator + LOCI Tier 3 or non-hydrocarbon releases notifiable to the regulator	+ Limited number of minor breaches of legislation, instruments or contract + Statutory notice from the regulator + LOCI Tier 2 or non-hydrocarbon releases immediately reportable to the regulator	+ Systemic minor breaches (or one moderate breach) of legislation, instruments or contract + Company charged with an offence with minor penalty/fine + LOCI Tier 1 or cumulative regulator notification of non-hydrocarbon releases	+ Systemic moderate breaches (OR single material breach) of legislation, instruments or contract + Company charged with an offence with moderate penalty/fine	+ Material breaches of legislation, instruments or contract + Company or officers charged with an offence with material penalty/fine, or loss of tenure/operatorship
		I	II	III	IV	V	VI
Likelihood	**ALMOST CERTAIN (< 4 monthly)** Occurs in almost all circumstances OR could occur *within days to weeks*	f	Low	Medium	High	Very High	Very High	Very High
	LIKELY (4 monthly - 1 yearly) Occurs in most circumstances OR could occur *within weeks to months*	e	Low	Medium	High	High	Very High	Very High
	OCCASIONAL (1 - 3 yearly) Has occurred before in Santos OR could occur *within months to years*	d	Low	Low	Medium	High	High	Very High
	POSSIBLE (3 - 10 yearly) Has occurred before in the industry OR could occur *within the next few years*	c	Very Low	Low	Low	Medium	High	Very High
	UNLIKELY (10 - 30 yearly) Has occurred elsewhere OR could occur *within decades*	b	Very Low	Very Low	Low	Low	Medium	High
	REMOTE (30 - 100 yearly) Requires exceptional circumstances and is unlikely even in the long term OR only occurs as a *"one in 100 year event"*	a	Very Low	Very Low	Very Low	Low	Medium	Medium

Operational Risk Assessment Requirements

Risk Level	Action	Governance Mechanism	Authority for Continued Tolerance of Risk	Control Development and Timeframe	Control Ownership
Very High	+ Following verification of the risk at 'Very High' activity must stop + Activity cannot recommence until controls are implemented to reduce risk to 'High' or lower + For incidents, a dedicated multi-disciplinary incident investigation team will be formed + Level 3 Manager or Excom member will be included in the investigation team	+ Controls will be governed at the Operations Committee meeting or equivalent forum + Sponsorship of incident investigation by EVP or Level 2 Manager	+ CEO	+ Intolerable Risk Level + Develop and implement controls urgently to reduce risk to 'High' or lower as soon as practicable	+ Level 2 Manager (e.g. Executive Vice President)
High	+ Assess risk to determine if it is reduced So Far As Is Reasonably Practicable (SFAIRP) + If SFAIRP, activities related to maintenance of controls will be prioritised and managed + If not SFAIRP, improve existing controls and/or implement new control(s) + For incidents, a dedicated multi-disciplinary incident investigation team will be formed	+ Controls will be governed at Divisional level meeting or equivalent forum + Sponsorship of incident investigation by Level 3 Manager	+ EVP or Level 2 Manager	+ Action to reduce risk level to 'Medium' or below	+ Level 3 Manager (e.g. General Manager)
Medium	+ Assess risk to determine if SFAIRP + If SFAIRP, activities related to maintenance of controls will be prioritised and managed + If not SFAIRP, improve existing controls and/or implement new control(s) + Incidents are assessed using Mining the Diamond and investigated relative to the incident potential	+ Controls will be governed at Area level meeting or equivalent forum + Sponsorship of incident investigation at Level 4 Manager	+ General Manager or Level 3 Manager	+ Manage and monitor risk efficiently in accordance with business management plans	+ Level 4 Manager (e.g. Asset or Functional Manager)
Low	+ Assess risk to determine if SFAIRP + If SFAIRP, activities related to maintenance of controls will be prioritised and managed + If not SFAIRP, improve existing controls and/or implement new control(s) + Incidents are assessed using Mining the Diamond and investigated relative to the incident potential	+ Controls will be governed at site level meeting or equivalent forum + Sponsorship for incident investigation at Level 5 Manager	+ Level 4 Manager	+ Manage and monitor risk efficiently in accordance with business management plans	+ Level 5 Manager (e.g. Area Manager, Team Leader, Superintendent or equivalent)
Very Low	+ Risk to be managed as stipulated by the related work processes	+ Governed if required	+ Level 5 Manager	+ Manage and monitor risk efficiently in accordance with business management plans	+ Any individual contributor

9. Monitoring program

An infrastructure monitoring program is implemented across the produced water and brine storage facilities and gathering and transfer infrastructure. A summary of the infrastructure monitoring measures and their frequency for each storage is included in Table 5.1. Additional monitoring is described in the sections below.

9.1 Produced water storages

Produced water storage facilities, including storage tanks, are monitored in accordance with Table 5.1 and in section 5.3. Water storage levels have been defined for each of the ponds for monitoring and management purposes. These definitions are based on the Queensland guidelines '*Manual for Assessing Hazard Categories and Hydraulic Performance of Dams*' (DES, 2016), and include:

- wet season containment (**Maximum Operating Level (MOL)**) - includes a minimum spare storage capacity (Design Storage Allowance) required at the nominal start of the wet season (1 November each year) to give the regulatory agency confidence that wet season inputs can be managed without loss of containment (i.e. spillway discharge).
- storm event containment (**Emergency Reporting Level (ERL)**) - the dam level at which loss of containment could potentially occur within a single storm event (72-hour duration event) triggering notifications and further action.
- spillway capacity (**Full Supply Level (FSL)**) - sufficient spillway capacity is required to ensure that the design flood event can be conveyed by the spillway without causing overtopping of the dam embankment which could lead to catastrophic failure of the dam structure. The FSL is the level at which the pond overtops.
- minimum inter-bund crest elevation (**MICE**) - the minimum elevation of the inter-bund separating the two cells in each of the ponds. This is the maximum level at which water can be stored in each cell before it overflows into the adjacent cell.
- suggested operating level (**SOL**) - represents the suggested maximum operation water level for each cell. This has been set to 300 mm below the MICE to provide a nominal containment freeboard in an effort to avoid inadvertent overtopping between adjacent cells in the event of relatively minor storm or wind events. The 300 mm freeboard allowance may be adjusted in response to operational requirements.

Produced water pond and cell operating levels are identified in Table 9.1 and Table 9.2 respectively. Note that the Tintsfield ponds do not currently store any produced water.

Table 9.1 - Defined pond operating levels

Produced water storage facility	Full Supply Level (FSL)		Emergency Reporting Level (ERL)		Maximum Operating Level (MOL)	
	RL (m AHD)	ML	RL (m AHD)	ML	RL (m AHD)	ML
Tintsfield Pond 1	225.8	22.9	225.5	20.6	224.6	15.1
Tintsfield Pond 2	225.8	90.9	225.5	84.9	224.9	70.6
Leewood Pond 1	250.4	438.4	249.9	394.7	249.6	364.5
Leewood Pond 2	249.85	411.4	249.4	377.2	249.0	346.1

Table 9.2 - Defined Leewood cell operating levels

Produced water storage facility	Suggested Operating Level (SOL)		Emergency Reporting Level (ERL)		Minimum crest elevation (MICE)	
	RL (m AHD)	ML	RL (m AHD)	ML	RL (m AHD)	ML
Leewood - Cell 1	249.2	168.6	As per the above values		249.5	181.7
Leewood - Cell 2	249.2	162.2			249.5	174.9
Leewood - Cell 3	248.7	169.2			249.0	181.0
Leewood - Cell 4	248.7	150.6			249.0	161.3

Monitoring of storage levels is undertaken with the use of pressure sensors that continuously measure and record storage depth, volume and surface area based on hydrostatic pressure. These automated meters are submersed in the pond to a depth as close to the base of the pond as reasonably practicable and are used in conjunction with surveyed data to determine the water level of the pond. Telemetry is used to allow for remote real-time monitoring of the pond levels, and this is used to monitor storage capacity in conjunction with other parameters such as upstream pilot or wellhead water production data.

Field operators monitor the pond level and volume in accordance with the trigger action response plan (**TARP**) for Produced Water Pond Level Management. Other operating markers/indicators may also be used in conjunction with the pressure sensor monitoring, such as volume and MOL indicator markers on storage facility walls. The level sensors system used in the existing ponds are subject to regular functionality assessment, and recalibration occurs as per the manufacturer's requirements in order to ensure the accuracy of readings.

In addition to monitoring, a six-monthly review of predicted water production will be undertaken to identify the potential for elevated levels as early as possible to allow strategies to be implemented to minimise the potential for pond levels to exceed the MOL. Refer also to section 8.4 of the GMP.

In the event that the water level of a pond exceeds the MOL, appropriate plans will be put in pace to rectify and reduce the level back below the MOL. Such examples could include reducing / stopping field water production, transfer of water to other water storage facilities (if available) via truck, pipeline or other suitable means, introduction of small portable reverse osmosis plants and other technologies available, or trucking to appropriate water treatment plants or approved waste treatment facilities.

9.2 Dam safety

In addition to the monitoring outlined for the Leewood Water Management Facility, the Leewood ponds are subject to the surveillance requirements for prescribed dams, including the preparation of a Surveillance Report. This report requires inspection and reporting of the condition of the ponds including embankment slopes, crest and spillway, presence of any erosion, vegetation, seepage and monitoring instrumentation.

A Dam Safety Emergency Plan has been provided to the Dams Safety NSW in accordance with the requirements of the *Dams Safety Act 2015* (NSW). The plan provides emergency response procedures for the management of the Leewood ponds in the event of an imminent or actual uncontrolled release from the ponds. The Dam Safety Emergency Plan forms part of the NSW Operations - Narrabri Gas Pollution Incident Response Plan (**PIRMP**), provided as attachment 8 to the WMP.

9.3 Flowline and pipeline monitoring

Pipeline integrity management procedures are maintained to ensure flowline infrastructure remains fit for purpose at all times by implementing a systematic approach to operation, maintenance, testing and inspection activities. Periodic inspections are carried out to identify actual or potential problems that could affect the integrity of the pipeline and any maintenance required is carried out in a timely manner. The process of managing the integrity of pipeline systems, including rigid and flexible risers, is fully detailed in the Pipeline Integrity Management System.

9.4 Groundwater monitoring

Santos also undertakes an extensive regional groundwater monitoring program to monitor groundwater in the region of its operations. The Groundwater Management Plan and its appendices, as a sub-plan to the Water Management Plan, provides a detailed description of the groundwater management and monitoring system. Specifically, section 4 of the Groundwater Monitoring Plan details the groundwater monitoring network, comprising monitoring points owned and operated by both Santos and DPE Water.

9.5 Treated water monitoring

All treated produced water will meet the treated water quality criteria in Table C in Appendix C prior to beneficial reuse.

Monitoring of treated water from the Leewood storage tank is conducted in accordance with condition M2.2, M2.3, M2.7 and M2.11 of EPL 20350. As required by condition M 2.7, the monitoring frequency specified for monitoring point 77 (LWWTPDM1) commenced upon the completion of the commissioning stage for the Water and Brine Treatment Plant as outlined in document titled "*Energy NSW - Leewood Phase 2 - Water Treatment Plan*" dated 19 November 2015.

Further details are provided in section 3.1.2 of the Irrigation Management Plan.

9.6 Leakage rate monitoring

Leakage rates are defined as follows:

- Action Leakage Rate (**ALR**) - the Action Leakage Rate is the leakage rate of two holes per square hectare each having a diameter no greater than 2 mm. The Action Leakage Rate is commonly accepted in international jurisdictions as the amount of leakage that could occur through primary containment geomembrane line that was constructed with good construction quality assurance.
- Normal Operating Leakage Rate (**NOLR**) (LR <0.5 ALR) - **t**he Normal Operating Leakage Rate is a leakage rate of half the ALR or less. This flow rate from the leak detection system is not considered abnormal.
- Abnormal Operating Leakage Rate (**AOLR**) (0.5ALR<LR<ALR) - **t**he Abnormal Operating Leakage Rate is a leakage rate greater than half of the ALR but less than the ALR. This flow rate from the leak detection system is greater than normal and warrants further investigation and increased frequency of monitoring.

Table 9.3 presents the Action Leakage Rates for corresponding pond operating levels.

Table 9.3 - Calculated leakage rates between primary and secondary liner

Pond	Leakage rate (L/d)	Water depth (m)						
		1	2	3	4	5	6	7
Leewood Cell 1	AOLR	1,825	3,163	4,310	5,417	6,530	7,669	8,847
	ALR	3,649	6,325	8,619	10,834	13,060	15,338	17,693
Leewood Cell 2	AOLR	1,629	3,051	4,162	5,236	6,318	7,427	8,575
	ALR	3,257	6,101	8,323	10,472	12,635	14,854	17,149
Leewood Cell 3	AOLR	1,461	2,705	3,688	4,648	5,623	6,628	7,674
	ALR	2,921	5,410	7,375	9,296	11,245	13,256	15,348
Leewood Cell 4	AOLR	1,431	2,422	3,306	4,177	5,068	5,991	6,957
	ALR	2,862	4,844	6,611	8,354	10,135	11,982	13,913

Source: Fabtech (2015).

Each of the Leewood ponds contains a total of 4 leakage collection sumps (2 in each cell) and 2 under-liner depressurisation collection sumps (1 in each cell). The leakage collection sumps collect leakage that flows via a continuous drainage network, whilst the depressurisation collection sumps collect seepage that flows via the depressurisation network below the secondary liner.

The leakage collection sumps and depressurisation sumps are lined with a membrane, and are filled with drainage aggregate which is overlain by a textile and the primary membrane. Seepage collected in the leakage collection sumps is removed via a submersible pump that is located in a riser pipe installed between the primary and secondary liners. The riser pipe penetrates the primary liner near the crest of the embankment at the edge of the anchor trench.

The secondary liner is continuous below all the leakage collection sumps, pipes and collection layers. Seepage is pumped from the riser pipe via the submersible pump to each respective pond via a return pipe that has an isolating valve and a flow meter. The flow meter also has a low flow alarm which stops the submersible pump.

The water level in each leakage collection sump and depressurisation sumps is monitored via a level transmitter with the level sensors each contained within a riser. The level transmitters are used to provide:

- on/off level control which start or stop the submersible pump when the level reaches the high or low setpoint respectively; and
- high-high level alarms which stop the submersible pump.

Each leakage collection sump riser also includes a separate adjacent smaller diameter pipe for the installation and extraction of monitoring instrumentation for the ponds and pumps. This allows the pumps and instruments to be managed separately without interference to the ponds.

In the event that the leakage rate of a pond is verified as exceeding the ALR, appropriate plans will be put in pace to rectify and reduce the leakage rate below the ALR. Strategies to reduce the leakage rate will revolve around reducing the pond operating level and therefore static head on the liner. These are listed in section 9.1.

10. Trigger action response plans

TARPs are developed to identify, assess and respond to abnormal conditions and are implemented to manage risk to operations, personnel and the environment. Two TARP documents have been developed to address the requirements of the Produced Water Code of Practice:

- Produced Water Pond Level Management provides the actions to be taken if defined pond management levels are reached, and
- Leewood Pond Leakage Management provides actions to be taken if defined leakage rates are reached.

The pond level principal response flowchart is presented in Figure 10.1. This describes the pre-determined process of decision making to be applied with respect to taking corrective actions.

Detailed information on the pond water level TARP is provided in Table 10.1.

Figure 10.2 shows the principal response flowchart for pond leakage rates. This describes the pre-determined process of decision making to be applied with respect to taking corrective actions.

Detailed information on the pond leakage rate TARP is provided in Table 10.2.

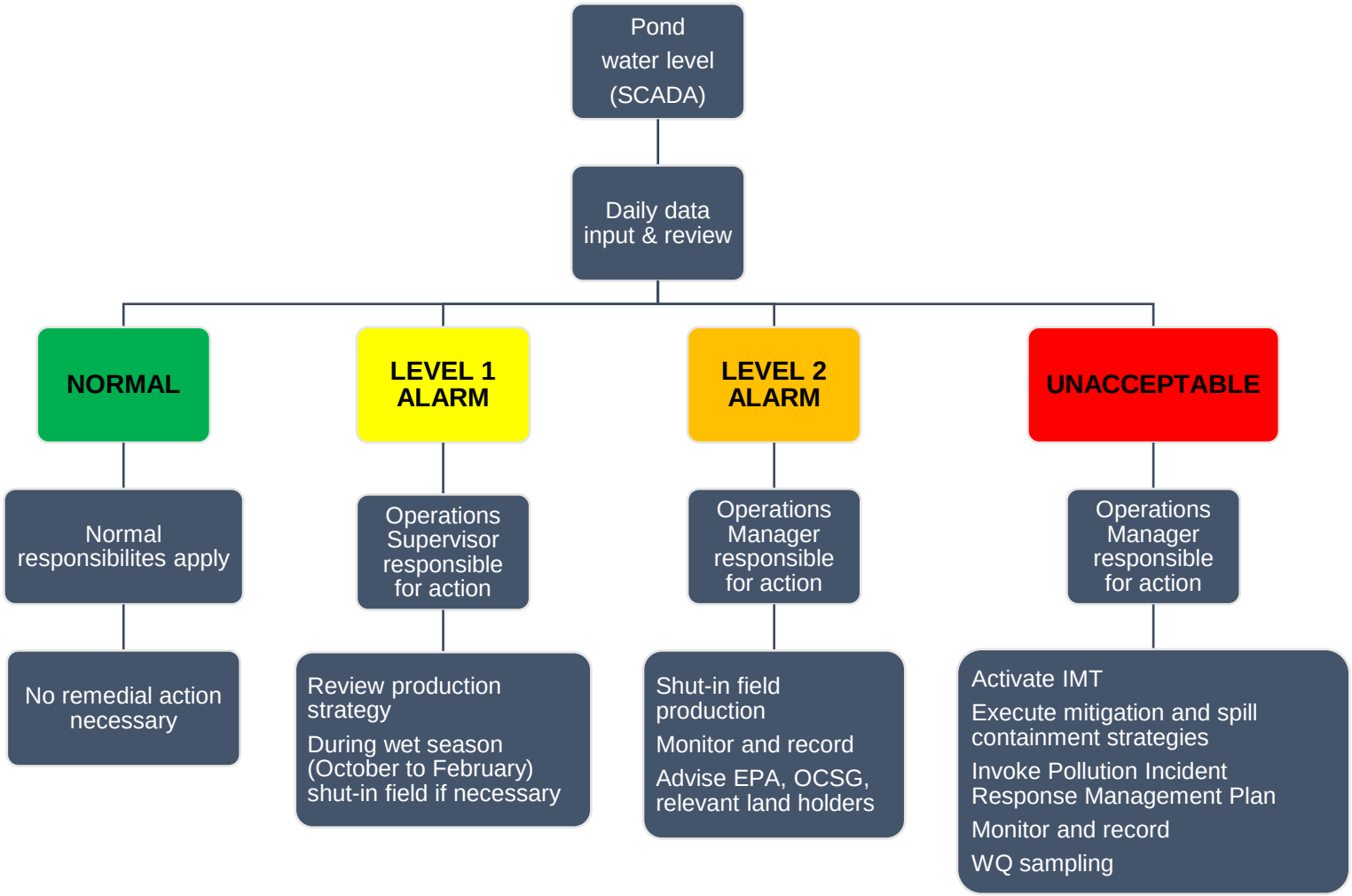

Figure 10.1 - Pond level principal response flowchart

Table 10.1 - Pond level trigger action response plan

Trigger level	Characteristics of level	Possible reasons	Actions	Action by	Notification
NORMAL	≤ 95% of MOL water level Water is contained within the pond.	N/A	• No remedial action necessary • Monthly review meeting	No special action required	No notification required
	95% of MOL	• Heavy rainfall • Increased field PW production • Nearing capacity for containment	• Review field production strategy • Develop water reduction strategies • Weekly review meeting	Field Supervisor / Operations Engineering	• Water Management Review Team • Site operators • Field production team
LEVEL 1	> MOL to ≤ ERL water level	• Heavy rainfall • Increased field PW production • Nearing capacity for containment	• Review field production strategy • Stop the flow of PW into pond/cell • During wet season (October to February) shut-in field if necessary • Activate additional pumping capacity as required • Develop an appropriate remedial solution or other water reduction strategies. • Increase WQ sampling to weekly • Weekly review meeting	Field Supervisor	• Water Management Review Team • Site operators • Field production team

Trigger level	Characteristics of level	Possible reasons	Actions	Action by	Notification
LEVEL 2	> ERL to ≤ FSL	• Heavy rainfall • Reached capacity for containment	• Shut-in field PW production / stop the flow of water into the pond/cell • Area Manager notification • Finalise and implement water reduction strategy as per Level 1 • Apply pumping strategy and review ongoing capability • Advise EPA and DRE • Daily water quality sampling and reporting • Increase review meeting frequency to daily	Operations Manager	• Water Management Review Team • Site Operators • Field Production Team • Area Manager • EPA, DPE & relevant land holders
UNACCEPTABLE	> FSL Water is being released to the environment.	• Heavy rainfall • Reached capacity for containment	• Activate IMT • Execute mitigation and spill containment strategies as appropriate • Adopt contingency measures from Level 2 • Daily water quality sampling (including receiving environment) and reporting • Implement Pollution Incident Response Management Plan • Daily review meeting	Operations Manager	• Water Management Review Team • Site Operators • Field Production Team • IMT • Area Manager • EPA, DPE and other agencies as required under the PIRMP, plus relevant landholders

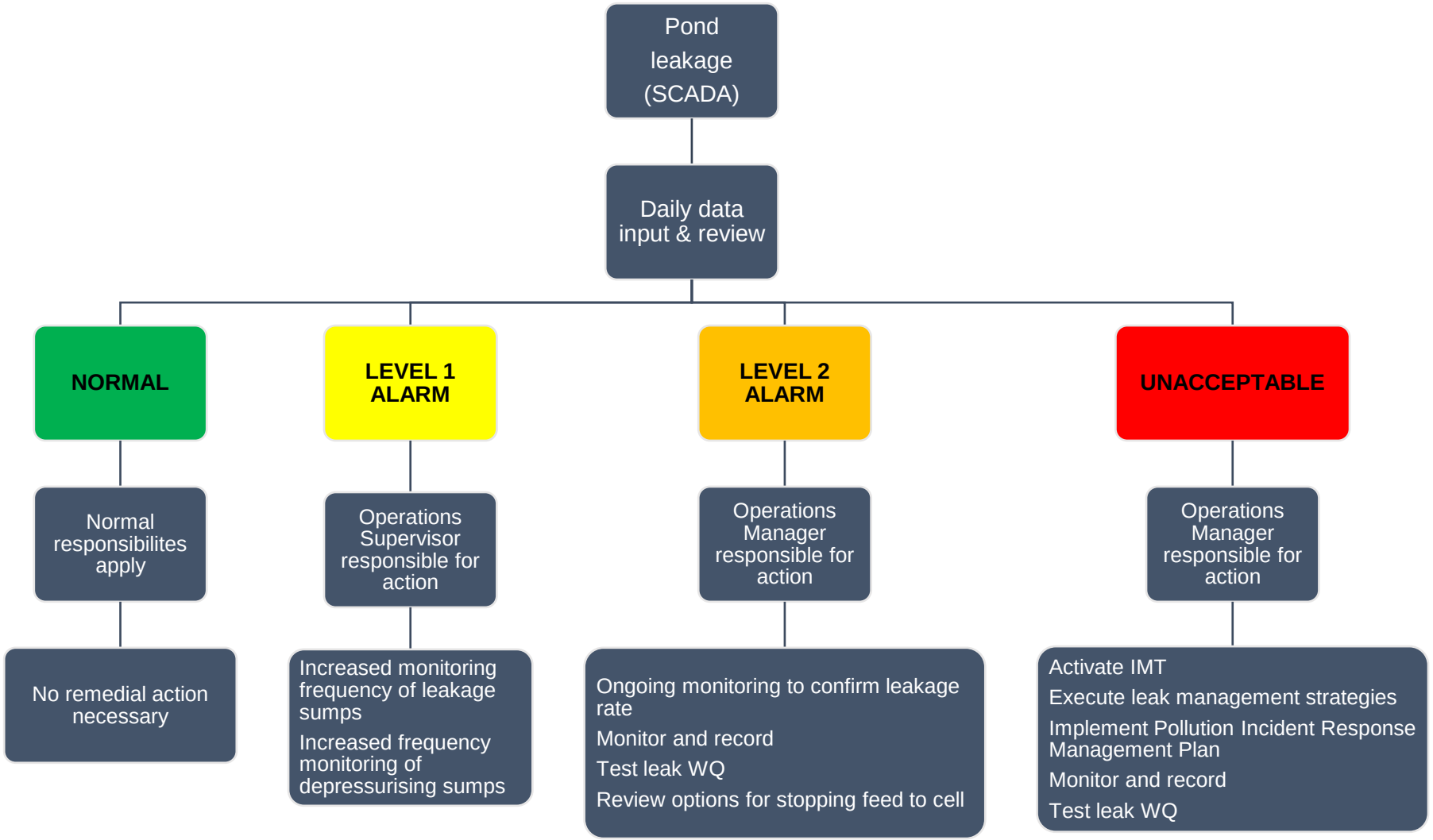

Figure 10.2 - Pond leakage principal response flowchart

Table 10.2 - Pond leakage rate trigger action response plan

Trigger level	Characteristics of leakage rate	Possible reasons	Actions	Action by	Notification
NORMAL	Leakage rate ≤ Abnormal Operating Leakage Rate	N/A	• No remedial action necessary • Monthly review meeting	No special action required	No notification required
LEVEL 1	Abnormal Operating Leakage Rate < Leakage rate < Action Leakage Rate	• Heavy rainfall • Liner leak	• Increase water quality monitoring to weekly • Weekly review meeting • Investigate and confirm possible location	Field Supervisor	• Water Management Review Team • Site Operators
LEVEL 2	Confirmed Leakage Rate > Action Leakage Rate	• Heavy rainfall • Liner leak	• Cease putting water into cell • Notify Team Leader Narrabri Operations • Implement water reduction strategy • Apply transfer pumping strategy and review ongoing capability • Increase water quality monitoring and reporting frequency • Increase review meeting frequency	Team Leader Narrabri Operations	• Water Management Review Team • Site Operators • Field Production Team • Area Manager

Trigger level	Characteristics of leakage rate	Possible reasons	Actions	Action by	Notification
UNACCEPTABLE	Confirmed Leakage Rate > Action Leakage Rate + Leakage rate observed from depressurisation sump	• Primary liner leak • Secondary liner leak	• Shut-in field production wells production if there is insufficient space in other cells for water transfer • Activate IMT (refer to PIRMP) • Execute mitigation strategies as appropriate • Daily water quality monitoring (including receiving environment) and reporting frequency • Should the leakage be confirmed through monitoring bores, invoke Pollution Incident Response Management Plan • Weekly water quality monitoring from depressurising sumps. • Daily review meeting	Team Leader Narrabri Operations	• Water Management Review Team • Site Operators • Field Production Team • Area Manager • IMT • EPA, DPE and other agencies as required under the PIRMP, plus relevant land holders

11. Record keeping

Santos has a data management plan for the NGP that outlines the policies and procedures that will be implemented to ensure that data is managed in a consistent, efficient and effective manner in order to provide accurate records of activity operations and enhance the value of the data collected. An overview of Santos' data management plan is presented in Figure C1 of Appendix C of the Water Management Plan, in the form of a data-management flow chart.

Santos uses a number of systems and platforms to manage the documentation and data associated with the activities under this Plan. These include Sharepoint for management plans, procedures and laboratory reports; Santos' EHS Toolbox for capturing inspections and field assessments; and EquIS[3], an advanced environmental data management and decision support system, for capturing all data and any laboratory results.

Key records associated with this PWMP that are stored and managed include:

- inspection and monitoring records for facilities and dams (including leak detection monitoring);
- records of construction quality assurance program, including details of person(s) who prepared the program and records to demonstrate their certification by Engineers Australia;
- records of pond design (including location) and installation;
- records of standards and quality control testing used for seam joining of geomembrane liners;
- records of groundwater levels or underdrainage measures;
- name of standard or code that is utilised for construction of pipeline and records of field pressure testing;
- record of pipeline leak detection testing;
- records of any review of this PWMP;
- operational monitoring and performance data for treatment systems;
- water sampling and laboratory analytical reports;
- calibration records for field instruments and continuous water quality monitoring systems;
- waste transportation and disposal certificates; and
- annual inspection reports and/or certifications of storages.

Monitoring data is subject to quality assurance and quality control protocols and procedures that ensure that data is accurate and usable. Data is subjected to consistent validation and verification procedures.

The records required to be kept and maintained according to the Produced Water Code should be kept from the time the Code applies as a term imposed on an activity approval. Records are to be kept in a legible form for production to any inspector for a period of four years following the expiry or termination of a prospecting title (sections 97D and 97E of the PO Act).

[3] EQuIS (Environmental Quality Information System) is a proprietary software application.

12. Incidents, non-compliances and complaints

12.1 Incidents and non-compliances

Reporting of any incident, non-compliance or exceedance will be in accordance with CoC D6 and D7 respectively, as described in section 6 of the EMS. Santos will notify the DPE and any other relevant agency via the Major Projects Portal immediately after becoming aware of an incident.

Within 7 days of becoming aware of a non-compliance with the CoC, Santos will notify the Department of the non-compliance via the Major Projects Portal. This notice will set out the non-compliance, the reasons for the non-compliance (if known) and what actions have been taken, or will be taken, to address the non-compliance. A non-compliance which has been notified as an incident will not be notified as a non-compliance.

Where incidents or non-compliances associated with this PWMP are identified, Santos will:

- take all reasonable and feasible steps to ensure that the incident or non-compliance ceases and does not reoccur;
- consider all reasonable and feasible options for remediation (where relevant) and submit a report to the relevant department(s) describing options and any preferred remediation measures or other courses of action; and
- implement remediation measures as directed by the relevant department(s).

The response to spills and the associated agency notification are addressed in the Pollution Incident Response Management Plan (PIRMP), as part of the Water Management Plan.

12.2 Unpredicted impact protocol

It is considered unlikely that the activities during Phase 1 will result in any unpredicted or unforeseen impacts in relation to the management of produced water, both before and after treatment. However, in accordance with CoC D3(f), the following strategy outlined in Table 12.1 will be adopted in the event where the estimated production volumes or capacity of the infrastructure is not in accordance with the Water Balance.

Table 12.1 - Unpredicted impact protocol

Step	Strategy
1	Implement immediate corrective actions to minimise the unpredicted effect or impact
2	Review the unpredicted effect or impact and consider the following: • current activities that may have triggered this event; and • activities that may not have been considered in the PWMP in causing the effect or impact; and • relevant monitoring data.
3	Notify the relevant agencies and departments
4	If appropriate, commission an investigation by an appropriate specialist
5	Based on the results of the investigation, develop the appropriate amendment and amelioration methods to return to normal operations

Step	Strategy
6	Implement the information from the investigation to review, and if necessary, update this PWMP which will include any or all of the following: • a review and where required, revision of the monitoring scope detailed in section 9; • a review and where required, amendment to the water storage and treatment facilities and capacities (section 5); • a review of any actions that may have been taken prior to event or unpredicted impact; • a review and update of the risk register in section 8 (and section 4 of the WMP); and • implement any relevant infrastructure or training based on the findings of the investigation to avoid any recurrence of the unpredicted effect or impact.

12.3 Complaint management

Santos has a documented *Complaint Management Procedure* that is communicated to all relevant staff members. Complaints can be directed to Santos via phone or email 24 hours a day, 7 days a week. Contact details are publicly available on the Project website and are presented in Appendix D of the EMS.

All complaints are logged on a complaint form which includes the following details:

- date and time of the complaint;
- complainant details;
- details of the issue or complaint;
- actions taken to remediate the issue, if any;
- follow up actions required, if any;
- details of further liaison with complainant, if any; and
- closure date and time of the issue.

As per CoC D13, Santos maintains a complaint register which is updated as required and available on the Project website.

13. Reporting, evaluation and review

13.1 Annual Review

In accordance with condition D8 and as further described in section 6 of the EMS, Santos will review the performance of its produced water management for the previous calendar year and report the relevant results within the Annual Review, to the satisfaction of the Planning Secretary. The Annual Review will be submitted to the DPE via the Major Projects Portal by the end of March each year, and will at a minimum report the following information regarding:

- the effectiveness of the management measures to prevent, and if prevention is not reasonable and feasible, to minimise any impact from the management of produced water;
- produced water yield against predicted volumes and the overall produced water profile in the EIS;
- produced water quality, including chemicals of potential concern;
- amended treated water yield and quality, including chemicals of potential concern;
- leaks and spills;
- soil, surface water and groundwater quality in irrigation and other beneficial reuse application areas;
- Bohena Creek discharges, flows and water quality (clearly stating that this is not applicable to Phase 1);
- salt and other waste products yield and quality (clearly stating that this is not applicable to Phase 1); and
- any incidents or non-compliances associated with the handling and management of produced water or amended treated water.

Further, the annual review under consent condition D8 requires a number of items to be reviewed or assessed. In summary these are:

- monitoring results and complaints;
- non-compliances and incidents;
- compliance with performance measures;
- discrepancies between predicted and actual impacts; and
- measures to be implemented to improve environmental performance.

The Annual Review may also make recommendations for any additions, changes or improvements to the produced water management strategy and processes.

13.2 Independent environmental audits

Within one year of commencement of Phase 1 and every three years thereafter, Santos will commission an Independent Environmental Audit (**IEA**) of the operation, to be conducted in accordance with CoC D9. The audit team will be led by a suitably qualified auditor and include experts in groundwater, well integrity, hazards, and any other fields specified by the Planning Secretary.

The IEA process is further described in section 8.3 of the EMS.

13.3 Management Plan review and evaluation

In compliance with Section 4 of Part B (Mandatory Requirements) of the Produced Water Code, this PWMP will be reviewed and updated in at least the following circumstances:

(a) in accordance with any direction from the NSW EPA or the Minister administering the PO Act;

(b) if changes to the way in which produced water is managed under the relevant authority or prospecting title requires additional assessment under the EP&A Act;

(c) before making any significant change to the design or operation of the produced water storage or transfer facility. If there is ambiguity in relation to whether there is a significant change, Santos must consult with the Secretary to determine whether the PWMP must be reviewed;

(d) in the event that a relevant TARP trigger level 2 is activated (notification to regulator); and

(e) otherwise at intervals of no longer than one year, to reflect any developments in the management of produced water[4].

In accordance with section 4 of Part B (Mandatory Requirements) of the Produced Water Code, a copy of any updated PWMP will be provided to the Secretary [of the Department of Regional NSW]:

- if there is a significant change to the design or operation of the produced water storage or transfer facility, no later than 14 days prior to commencing operation of the changed facility; or
- if the PWMP is revised for any other reason, no later than 14 days after that revision is complete.

As required by CoC D4, Santos will review the suitability of existing strategies, plans and programs required under this consent, within two months of:

(a) the submission of an incident report;

(b) the submission of an Annual Review;

(c) the submission of an Independent Environmental Audit;

(d) the submission of a Field Development Plan;

(e) the submission of a Groundwater Model Update; or

(f) the approval of any modification of the conditions of SSD 6456.

This is to ensure the PWMP is updated on a regular basis and to incorporate any recommended measures to improve the environmental performance of the Project.

The review history table in the front of this Plan provides the details of each review, conducted in accordance with condition D4.

As required by CoC D5, if the review under condition D4 determines that the PWMP requires revision – to either improve the environmental performance of the development, cater for a modification or comply with a direction – then Santos will submit the revised document to the Planning Secretary for approval within 6 weeks of the review. Note also the submission requirements detailed above under the Produced Water Code.

Further details on the reporting, evaluation and review of the PWMP is provided in section 8 of the EMS.

[4] This means that if a review was triggered by items (a) to (d), the PWMP should be reviewed and updated (as required) no later than one year after that review

13.4 Improvement measures

Santos will conduct a program to investigate and implement ways to improve the environmental performance associated with produced water over time, and implement a protocol for the periodic review of the PWMP, in accordance with CoC D3(g) and (i) respectively.

This program to improve the environmental performance of the Project that will be implemented following review and evaluation include the following:

- an informal internal audit of the produced water management system or part thereof, to be completed prior to the second and subsequent IEA;
- modifications to the PWMP to reflect changing site or water treatment conditions; and
- a review of the monitoring regime and monthly site inspections.

The protocol for review is set out by consent conditions D8, D4 and D5, which have been addressed in sections 13.1 and 13.3 above.

In accordance with CoC D13 and as described in section 6 of the EMS, all relevant monitoring data and associated reports will be made available on the Project website, for the duration of the Project. This information will be kept up to date.

14. References

DES (2016). *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* QLD Department of Environment and Science.

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DTIRIS (2012). *Code of Practice for Coal Seam Gas: Well Integrity*. NSW Department of Trade and Investment, Regional Infrastructure and Services.

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GHD (2017). *Narrabri Gas Project Environmental Impact Statement*. Prepared for Santos Ltd.

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Landcom (2004) *Managing Urban Stormwater – Soils and Construction: Volume 1*.

15. Glossary

Term	Definition[5]
Amended treated water	Produced water that has undergone treatment and amendment, as generally described in the EIS, to enable it to be used for beneficial reuse purposes including irrigation, stock watering, drilling[6], construction and dust suppression
Alluvial	Sediments deposited following a decrease in velocity of flowing water
Alluvium	General term for unconsolidated fluvio-lacustrine deposits of inorganic materials (clay, silt, sand, gravel, and boulders) deposited following a decrease in velocity of flowing water
Alluvium aquifer	An aquifer formed within alluvium. See Alluvium.
Aquifer	A saturated permeable geologic unit that can transmit useful quantities of water
Beneficial use	Beneficial use refers to the use of waters, including produced water from an oil or gas well, for a secondary purpose that has a positive value. Potential beneficial use options for produced water include domestic and livestock supply, industrial supply, irrigation supply, dust suppression and recreation.
Brine	Saline water with a total dissolved solid concentration of greater than 40,000 milligrams per litre. May be a wastewater produced by the desalination of coal seam water (e.g. by reverse osmosis)
Bund (or bunding)	Wall of a secondary containment system, usually in the form of an embankment, used to prevent sediment and liquids from entering the environment
Department	NSW Department of Planning and Environment (DPE)
Depressurisation	The extraction of coal seam water to facilitate gas production causes depressurisation of the target coal seams, which has the potential to propagate into surrounding formations.
Drilling fluid	A fluid (sometimes referred to as a mud) made up of 70 to 80 per cent water that is pumped into wells during drilling to cool and lubricate the drill bit and carry drill cuttings to the surface
EIS	The Environmental Impact Statement titled Narrabri Gas Project Environmental Impact Statement, dated 31 January 2017, submitted with the development application, including the Applicant's response to submissions and supplementary response to submissions, and the additional information provided by the Applicant to the Department in support of the application
Exploration well	A petroleum well that is drilled to: a) explore for the presence of petroleum or natural underground reservoirs suitable for storing petroleum, or b) obtain stratigraphic information for the purpose of exploring for petroleum. For clarity, an exploration well is not a production well
Feasible	Means what is possible and practical in the circumstances
Gas compression facility	A facility that houses multiple compressor units, either nodal or hub compressors or a mixture of both used to increase the pressure of gas for the purpose of transmission; may be collocated with a gas treatment facility and/or water management facility
Gas field infrastructure	All Project-related infrastructure, excluding the Leewood facility, Bibblewindi

[5] The majority of the definitions are as provided in the Development Consent for SSD 6456.

[6] Note that when 'drilling' is stated in consent conditions, where relevant this has been interpreted to mean 'drilling and completions'.

Term	Definition[5]
	facility and the road upgrades required under SSD 6456
Gas well	Pilot wells and production wells
Gathering lines	Pipelines used to transfer gas and produced water from wells
Groundwater	Water contained in the interconnected pore spaces and voids of the saturated zone of sediments and rocks.
Incident	An occurrence or set of circumstances that causes or threatens to cause material harm and which may or may not be or cause a non-compliance
Linear infrastructure	Project related infrastructure of a linear nature including gas and water gathering lines, gas and water pipelines, access tracks, power lines, communication lines and other service lines
Major facilities	Leewood facility and Bibblewindi facility
Managed release scheme	The managed release of treated water into Bohena Creek as one of the beneficial uses of produced water (not part of Phase 1)
Material harm	Material harm to the environment is defined in Section 147 of the POEO Act
Minimise	Implement all reasonable and feasible mitigation measures to reduce the impacts of the Project
Mitigation	Activities associated with reducing the impacts of the development
Non-compliance	An occurrence, set of circumstances or development that is a breach of the SSD 6456 consent
Petroleum Assessment Lease 2 (PAL 2)	A PAL is required to hold the exclusive right to prospect for petroleum and to assess any petroleum deposit over a specified area of land in NSW. A lease allows the holder to maintain a title over a potential area, without having to commit to further exploration. The holder can, however, continue prospecting operations and to recover petroleum in the course of assessing the viability of commercial mining. PAL 2 is held by Santos NSW Pty Ltd.
Petroleum Exploration Licence 238 (PEL 238)	Before exploring for minerals or petroleum in NSW, an explorer must first obtain a Petroleum Exploration Licence (PEL) under the Petroleum (Onshore) Act 1991. An exploration licence gives the licence holder exclusive rights to explore for petroleum or specific minerals within a designated area but it does not permit mining, nor does it guarantee a mining or production lease will be granted. PEL 238 is held by Santos NSW Pty Ltd.
Petroleum Production Lease 3 (PPL 3)	A petroleum production lease gives the holder the exclusive right to extract petroleum within the production lease area during the term of the lease. PPL 3 is held by the following titleholders: • Santos QNT Pty Ltd; • Santos NSW (Hillgrove) Pty Ltd; and • Santos NSW (Eastern) Pty Ltd.
Petroleum production lease application (PPLA)	A petroleum production lease gives the holder the exclusive right to extract petroleum within the production lease area during the term of the lease. Development consent under the Environmental Planning and Assessment Act 1979 must be in place before a petroleum production lease can be granted. Santos, on behalf of its joint venture partner lodged four petroleum production lease applications under the PO Act in May 2014 for the Project area, being PPLAs 13, 14, 15 and 16. The ownership of the application is now held by Santos NSW Pty Ltd.
Pilot well	A well for gas and water extraction, for the purpose of exploration, appraisal and assessment of the gas field potential

Term	Definition[5]
Planning Secretary	Planning Secretary under the EP&A Act, or nominee
Produced water	Any form of groundwater that is actively extracted from a borehole, well or excavation, excluding incidental groundwater mixed with drilling fluids
Production well	A well for gas and water extraction, for the purpose of commercial gas production and/or use
Project area	The area of approximately 95,000 hectares that encompasses the Project
Project footprint	The area of surface expression being about 1,000 hectares occupied by the infrastructure components of the Narrabri Gas Project
Project-related infrastructure	All infrastructure and other structures associated with the development. This includes linear infrastructure and non-linear infrastructure, surface infrastructure and subsurface infrastructure, major facilities, wells and well pads and other gas field infrastructure
Reasonable	Means applying judgement in arriving at a decision, considering mitigation benefits, cost of mitigation versus benefits provided, community views and the nature and extent of potential improvements
Treated water	Produced water that has undergone treatment to enable it to be used for beneficial reuse purposes including irrigation, stock watering, drilling[7], construction and dust suppression, and/or for managed release to Bohena Creek[8]
Well	Pilot wells and production wells
Well pad	An area of up to 1 hectare in size upon which the gas wells are to be located, with the area decreasing to no more than 0.25 hectares following rehabilitation[9], or other area as may be approved in the Field Development Plan

[7] Note that when 'drilling' is stated in consent conditions, where relevant this has been interpreted to mean 'drilling and completions'.

[8] Note that there will be no discharge to Bohena Creek during Phase 1.

[9] Workover activities will be contained within the operational area of the well pad area of around 0.2 ha, with an additional laydown area that could be approximately 0.2 ha in size.

Appendix A - Consultation records

NSW GOVERNMENT | Natural Resources Access Regulator

Contact: Tim Baker
Phone: 0428 162 097
Email : Tim.Baker@nrar.nsw.gov.au

Our ref: V15/3875-5#53
File No:
Your Ref:

27 September 2021

Dave Gornall
Santos Limited
email: David.Gornall@santos.com

Dear Dave

Re: Narrabri Gas Project - Water Management Plans second batch

Thank you for the opportunity to provide comment on the second set of plans under the Water Management Plan requirement for Phase 1 of the Narrabri Gas Project. It is understood this consultation is in accordance with the Condition B41 of Project Approval SSD 6456. The plans reviewed include the Water Management Plan, Erosion and Sediment Control Plan, Produced Water Management Plan, Irrigation Management Plan and the Pollution Incident Response Management Plan. NRAR is satisfied the consultation requirements have been met in respect to the plan preparation and provides the following comments.

- It is recommended the Water Management Plan include a map that depicts the location of the existing and proposed infrastructure for the Phase 1 activities.
- In Section 4.2 of the Produced Water Management Plan it is noted 1.26ML/d of produced water is predicted from operation of the existing and proposed pilot wells. It is recommended a reference be included to how this water take is to be accounted for by inclusion of relevant Water Access Licence numbers and entitlement, and relevant linked Work Approval/Miscellaneous Work numbers.
- The Erosion and Sediment Control Plan refers to water needed for dust suppression, but no details are provided on the volumes/water source and any relevant water license details. It is recommended this information be included in this plan or the separate Dust Suppression Protocol.
- It is recommended Section 5.9 of the Erosion and Sediment Control Plan include a reference to the need to design works in watercourses in accordance with the *"Guidelines for Controlled Activities on Waterfront Land* (NRAR 2018)". It is also recommended that these guidelines are reviewed against the proposed design for works within waterfront land such as Appendix D and E. The guidelines are accessible at the following link: https://www.nrar.nsw.gov.au/how-to-apply/controlled-activities/guidelines-for-controlled-activities

For further information please contact Tim Baker, Senior Water Regulation Officer on 0428162097 or **e:** Tim.Baker@nrar.nsw.gov.au

Yours sincerely

Tim Baker
for
Shavaun Tasker
A/Manager Licensing and Approvals – Water Regulatory Operations - West
Natural Resources Access Regulator
Department of Planning, Industry and Environment

Santos

Management Plan Consultation Feedback Form

DOCUMENT TITLE:	**Produced Water Management Plan (including Managed Release Protocol and Salt Management Plan)**
STAKEHOLDER:	NSW Environment Protection Authority
CONSULTATION RELEASE DATE:	**3 August 2021**
COMMENTS DUE DATE:	**11 October 2021**

Key Issues	**Dust suppression in forests** Section 5.5, page 21, states that: "Treated water used for dust suppression within the State Forest areas will be of a quality consistent with that of the managed release to Bohena Creek (refer to section 6), while amended treated water used for dust suppression within agricultural areas will be of a quality consistent with irrigation water. Treated, and amended treated water quality 'target' criteria are presented in Table C1 in Appendix C." The management plans do not specify water quality criteria that is "consistent with that of the managed release to Bohena Creek". This should be clarified in the Plans. The Plans refer to treated effluent quality (unamended) and it is assumed that this is the quality consistent with that of the managed release to Bohena Creek. Unamended effluent for reuse as dust suppression in forested areas is not acceptable and is not consistent with the Consent. Consent condition B37 states that Santos must ensure that the development complies with a range of management performance measures. Irrigation performance measures include: • Only amended treated water to be used for reuse activities (except for firefighting), unless other use of treated water has been approved as part of the Water Management Plan (IMP Section 5.2) • No irrigation in forested area, apart from dust suppression and construction activities on operational areas and access roads (IMP Section 5.4) A key risk in unamended effluent is elevated sodium adsorption ratio (SAR) where it is reused for dust suppression. The EPA submission on the EIS highlighted that the use of treated water for dust suppression in forested areas could potentially increase dust emissions as soil may dissolve into finer particles. The EPA considered the high SAR effluent risks of sodicity including reduced soil hydraulic conductivity, dispersion and destruction of structural aggregates, and increased erosion risks, especially on the sandy sodic duplex soils. The proponent's response to submissions (RTS) stated that the results of treated water quality from the operation of the Leewood Water and Brine Treatment Plant provide that the maximum SAR reported for treated water (unamended effluent) of 29. Table C1 in Appendix C of the PWMP provides the irrigation criteria of SAR above 15 being unacceptable for irrigation. The RTS also stated that, based on the treated water quality results, dust suppression activities would only use amended treated water. The Consent condition is based on this commitment in the RTS. There has been no further assessment of SAR risk for unamended effluent for use in dust suppression in the PWMP (or Dust Suppression Protocol, see below). Table C1 of the PWMP, under Treated water/Operational results, states that SAR is "n/a" (not analysed). There is concern that there is an unsupported proposal for dust suppression activities with unamended effluent and a key analyte for assessing risk for dust suppression is not analysed.

Santos

Management Plan Consultation Feedback Form

	The Glossary for treated water "Treated water" in each Plan and Sub-plan refers to treated water being suitable for a range of activities not consistent with the Consent such as irrigation, stock water and dust suppression. This definition should be corrected to state that only amended effluent should be used for those activities. Note that a proposed "Dust Suppression Protocol" (DSP) has been submitted but is in the next batch of sub-plans which are due for review at a later date, however, this Protocol will need to address the inconsistencies with the Consent requirements as discussed above. An initial scan of the DSP indicates that it does not address the risk to forest road soils from high sodium adsorption ratio and only salinity is considered. Note also that the DSP states that a TARP for dust suppression is not required for Phase 1 as it is expected that only bore water from the Bibblewindi bores will be used for dust suppression.
Suggestions for improvement	It is recommended, consistent with the Conditions of Consent relating to dust suppression, that only amended treated water is to be used for reuse activities (except for firefighting) unless there is an appropriate assessment and mitigation of risk including approval through an amended PWMP.

Section	**Type**	**Specific Feedback** *Detail specific issues with certain sections in the document*
eg Section 2	*Legislative + Regulatory reqs./ Readability / Usability /*	*Further detail is required about when a report is required and how the report is to be submitted.*

Produced Water Management Plan – NRAR comments received on Revision C (draft)

Item	Section #	Section heading	Existing text	Comment	Final response
1	4.2	Produced water quantity	The estimated quantity of produced water associated with the Phase 1 activities, including the operation of the existing pilots for exploration and appraisal activities in PEL 238 and PAL 2 is up to approximately 1.26 ML/day. Further details are provided in the Site Water Balance	It is noted 1.26ML/d of produced water is predicted from operation of the existing and proposed pilot wells. It is recommended a reference be included to how this water take is to be accounted for by inclusion of relevant Water Access Licence numbers and entitlement, and relevant linked Work Approval / Miscellaneous Work numbers	Section 4 of the Site Water Balance provides full details on the water access licences and water supply works for direct and indirect water take.

Note:
The numbering of the sections and appendices between the draft and final version of the document may have changed.

Produced Water Management Plan – EPA comments received on Revision C (draft)

Item	Section #	Section heading	Existing text	Comment	Final response
1	5.5	Beneficial use of treated water and brine	Treated water used for dust suppression within the State Forest areas will be of a quality consistent with that of the managed release to Bohena Creek (refer to section 6), while amended treated water used for dust suppression within agricultural areas will be of a quality consistent with irrigation water. Treated, and amended treated water quality 'target' criteria are presented in Table C1 in Appendix C.	The management plans do not specify water quality criteria that is "consistent with that of the managed release to Bohena Creek". This should be clarified in the Plans. The Plans refer to treated effluent quality (unamended) and it is assumed that this is the quality consistent with that of the managed release to Bohena Creek.	Full details of both treated water and amended treated water quality is presented in Table C1 in Appendix C. Although there will be no release of treated water to surface waters during Phase 1, the quality if the treated water would be the same as that used for dust suppression within the State Forest. Note that only bore water will be used for dust suppression during Phase 1.
2				Unamended effluent for reuse as dust suppression in forested areas is not acceptable and is not consistent with the Consent. Consent condition B37 states that Santos must ensure that the development complies with a range of management performance measures. Irrigation performance measures include: • Only amended treated water to be used for reuse activities (except for firefighting), unless other use of treated water has been approved as part of the Water Management Plan (IMP Section 5.2) • No irrigation in forested area, apart from dust suppression and construction activities on operational areas and access roads (IMP Section 5.4)	Amended treated water is defined in the consent as: *Produced water that has undergone treatment and amendment, as generally described in the EIS, to enable it to be used for beneficial reuse purposes including irrigation, stock watering, drilling, construction and dust suppression*. Treated water is defined in the consent as: *Produced water that has undergone treatment to enable it to be used for beneficial reuse purposes including irrigation, stock watering, drilling, construction and dust suppression, and/or for managed release to Bohena Creek*. As such, both amended treated water and treated water can be used for dust suppression. However, only bore water will be used for dust suppression during Phase 1.
3				A key risk in unamended effluent is elevated sodium adsorption ratio (SAR) where it is reused for dust suppression. The EPA submission on the EIS highlighted that the use of treated water for dust suppression in forested areas could potentially increase dust emissions as soil may dissolve into finer particles. The EPA considered the high SAR effluent risks of sodicity including reduced soil hydraulic conductivity, dispersion and destruction of structural aggregates, and increased erosion risks, especially on the sandy sodic duplex soils.	Only bore water will be used for dust suppression during Phase 1.
4				The proponent's response to submissions (RTS) stated that the results of treated water quality from the operation of the Leewood Water and Brine Treatment Plant provide that the maximum SAR reported for treated water (unamended effluent) of 29. Table C1 in Appendix C of the PWMP provides the irrigation criteria of SAR above 15 being unacceptable for irrigation. The RTS also stated that, based on the treated water quality results, dust suppression activities would only use amended treated water. The Consent condition is based on this commitment in the RTS.	Only bore water will be used for dust suppression during Phase 1.
5				There has been no further assessment of SAR risk for unamended effluent for use in dust suppression in the PWMP (or Dust Suppression Protocol, see below). Table C1 of the PWMP, under Treated water/Operational results, states that SAR is "n/a" (not analysed). There is concern that there is an unsupported proposal for dust suppression activities with unamended effluent and a key analyte for assessing risk for dust suppression is not analysed.	Only bore water will be used for dust suppression during Phase 1.
6	N/A	General	No specific reference	The Glossary for treated water "Treated water" in each Plan and Sub-plan refers to treated water being suitable for a range of activities not consistent with the Consent such as irrigation, stock water and dust suppression. This definition should be corrected to state that only amended effluent should be used for those activities.	Noted. Treated water is defined in the consent as: *Produced water that has undergone treatment to enable it to be used for beneficial reuse purposes including irrigation, stock watering, drilling, construction and dust suppression, and/or for managed release to Bohena Creek*. The EPA is advised to contact the DPE to correct the definition.

Item	Section #	Section heading	Existing text	Comment	Final response
7	N/A	General	No specific reference	Note that a proposed “Dust Suppression Protocol” (DSP) has been submitted but is in the next batch of sub-plans which are due for review at a later date, however, this Protocol will need to address the inconsistencies with the Consent requirements as discussed above. An initial scan of the DSP indicates that it does not address the risk to forest road soils from high sodium adsorption ratio and only salinity is considered. Note also that the DSP states that a TARP for dust suppression is not required for Phase 1 as it is expected that only bore water from the Bibblewindi bores will be used for dust suppression.	Correct. Only bore water will be used for dust suppression during Phase 1. If, for any reason, insufficient bore water is available for dust suppression, only amended treated water would be considered for this purpose, as approved.
8	N/A	General	No specific reference	It is recommended, consistent with the Conditions of Consent relating to dust suppression, that only amended treated water is to be used for reuse activities (except for firefighting) unless there is an appropriate assessment and mitigation of risk including approval through an amended PWMP.	As previously noted, there is an inconsistency in the definitions in the consent. Only bore water will be used for dust suppression during Phase 1. If, for any reason, insufficient bore water is available for dust suppression, only amended treated water would be considered for this purpose, as approved.

Note:
The numbering of the sections and appendices between the draft and final version of the document may have changed.

Produced Water Management Plan – WTAG comments received on Revision C (draft)

Comments received from Randall Cox, Jack Warnock and Michael Williams

Item	Section #	Section heading	Existing text	Comment	Final response
1	5.4	Produced water and brine treatment	The main output from the membrane brine concentrator is concentrated brine which is then transferred to the brine storage cell.	**[Michael Williams]** A reference to where details (location, storage capacity, salinity range et al) can be found would be helpful	Water quality target criteria are provided in Appendix C. Full details of the water management and storage facilities are provided in the Site Water Balance. The text has been amended to include the following reference: *Full details of the water management and storage facilities are provided in section 6 of the Site Water Balance.*
2	5.5	Beneficial use of treated water and brine	Apart from assessing all opportunities to maximise water recycling, beneficial reuse and sharing, Santos is exploring opportunities to beneficially reuse brine from its water treatment operations	**[Jack Warnock]** Page 22: Could "sharing" in respect to "assessing all opportunities to maximise …" be explained please.	Condition B37 Table 7 lists '*Maximise water recycling, reuse and sharing opportunities*' as a general water management performance measure. As such, sharing of treated and amended treated water for beneficial reuse purposes is an option that continues to be considered. Condition B41(d)(ii) requires the Site Water Balance to include details of '…. *sharing with neighbouring water users*'. Making treated effluent water available for use by established irrigators is an option that has been under serious consideration for some time, and would be subject to approval from the EPA. This paragraph has been moved to section 5.2.1 of the Site Water Balance.
3	7	Salt management	The PSBRDS required by condition B65 (a) to (c) will provide further details required to manage salt during Phase 2	**[Jack Warnock]** Page 26: The PSBRDS required by condition B65 (a) to (c) refers to VISUAL Operating Conditions – visual and lighting conditions. Is this the correct reference? Should this be "Condition B67 (a) to (c)"? This reference is also made in 7.2 Salt Product investigation program Page 27: first paragraph.	Correction has been made. This should be Condition B69(a) to (c). The text has been amended at both locations as follows: *The PSBRDS required by condition B69 (a) to (c) will provide further details required to manage salt during Phase 2.*
4	8.1		Table 8.1 and 8.2	**[Randall Cox]** Table 8.1 and 8.2 relate to risk. Table 8.1 gives the likelihood, consequence and risk rating before and after treatment of risk. The likelihood and consequence assessments relate to the assessment classification lines in Table 8.2. However, this relationship is not clear. Would help if the classification lines on the Table 8.2 (e.g. 'minor harm' is classified as 'ii', and 'likely' is classified as 'e') were more prominent, as these faint lines are the starting point for understanding likelihood and consequence in Table 8.1.	The risk matrix does provide a considerable amount of information and its use can be somewhat confusing at first. It is recommended to use a separate (hard)copy of the matrix as a guide while considering the initial and residual risks in the assessment tables to minimise scrolling through the management plan.
5	10	TARP	No specific text reference	**[Michael Williams]** The TARP developed are limited to two specific activities. It is assumed that the TARP that relate to CSG production will be developed after Phase 1 is completed?	Correct. Any production TARPs that may be required will be developed for Phase 3, which is the phase of development comprising ongoing operation of the gas production wells and related infrastructure.
6	11	Record keeping	These include Sharepoint for management plans, procedures and laboratory reports; Santos' EHS Toolbox for capturing inspections and field assessments; and EQuIS, an advanced environmental data management and decision support system, for capturing all data and any laboratory results.	**[Jack Warnock]** Page 36: Second paragraph: As observed elsewhere, could **"EQuIS"** be explained or listed in the Acronyms and abbreviations table?	EQuIS (Environmental Quality Information System) is a proprietary software application. A footnote with this information has been added to the text, and the abbreviation has been added to the Acronyms and abbreviations table.

Note:
The numbering of the sections and appendices between the draft and final version of the document may have changed.

Appendix B - Consent conditions relevant to the PWMP

Table B1 - SSD 6456 consent conditions directly relevant to this PWMP

SSD 6456 consent conditions directly relevant to this PWMP	Section reference
Consent condition A1 In meeting the conditions of this consent, the Applicant must implement all reasonable and feasible measures to prevent and, if prevention is not reasonable and feasible, minimise any material harm to the environment that may result from the construction, operation or rehabilitation of the development.	Section 1.2
Consent condition A5 The Applicant may only undertake the development in the following stages:	Section 1.1.2 Section 1.2
a) Phase 1, comprising ongoing exploration and appraisal activities;	
b) Phase 2, comprising construction activities for production wells and related infrastructure;	
c) Phase 3, comprising gas production operations; and	
d) Phase 4, comprising gas well and infrastructure decommissioning, rehabilitation and mine closure.	
Consent condition A23 With the approval of the Planning Secretary, the Applicant may:	
a) prepare and submit any strategy, plan or program required by this consent on a staged basis (if a clear description is provided as to the specific stage and scope of the development to which the strategy, plan or program applies, the relationship of the stage to any future stages and the trigger for updating the strategy, plan or program	Section 1.2
b) combine any strategy, plan or program required by this consent (if a clear relationship is demonstrated between the strategies, plans or programs that are proposed to be combined);	Section 6 Section 7 The Managed Release Protocol and Salt Management Plan are included as part of this PWMP
c) update any strategy, plan or program required by this consent (to ensure the strategies, plans and programs required under this consent are updated on a regular basis and incorporate additional measures or amendments to improve the environmental performance of the development); and	Section 1.2 Section 13.4
d) combine any strategy, plan or program required by this consent with any similar strategy, plan or program required by a consent	Section 6 Section 7 The Managed Release Protocol and Salt Management Plan are included as part of this PWMP
Consent condition B1 The Applicant must ensure that petroleum mining operations in the project area comply with the locational criteria in Table 1 [of the CoC]:	

SSD 6456 consent conditions directly relevant to this PWMP	Section reference
• No large ponds and dams, or any ponds and dams used for storage of produced water or brine, within the 1% AEP flood extent, as identified in Appendix 5 (apart from approved ponds and dams in major facilities constructed above the 1% AEP flood extent)	Refer to the Dam Safety Emergency Plan. And sections 4.2 and 4.2 of the Surface Water Management Plan.
Consent condition B37 The Applicant must ensure that the development complies with the water management performance measures in Table 7 [of the CoC]:	
• Water management – General	
▪ Maximise beneficial re-use of treated water	Section 5.5
▪ Minimise the need for discharge of treated water to Bohena Creek	Section 6
• Gunnedah Oxley Basin aquifers	
▪ Drawdown and water take to be generally consistent with the 'base case' predictions and produced water profile in the EIS;	Section 9.1 and 13.1 Also refer to the GMP section 8.4
• Produced water management	
▪ implement all reasonable and feasible measures to minimise risk of leaks and spills;	Section 8 Table 8.1 Section 9 Also refer to the PIRMP
▪ design, install and maintain leak detection systems and fail-safe measures on the produced water management system;	Section 8 Table 8.1
▪ design, install and maintain all produced water storage ponds to provide sufficient freeboard to accommodate a 72-hour 1 in 100-year ARI flood event;	Section 8 Table 8.1
▪ all produced water to be treated to meet the treated water quality criteria in Appendix 6 [of the CoC], unless otherwise authorised in an EPL;	Sections 1.4 and 5.4
▪ design, install and maintain produced water infrastructure in accordance with the *Exploration Code of Practice: Produced Water Management, Storage and Transfer* (DPE, 2017).	Section 3.2
Consent condition B41 Prior to the commencement of Phase 1, the Applicant must prepare a Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must:	
(d) include a	
(v) Produced Water Management Plan, that includes	
• detailed baseline data on produced water yield and quality;	Section 4.2 and 4.3
• a detailed description of the produced water management system, including details of:	Section 5
▪ produced water collection, transfer, storage, treatment, beneficial usage and/or disposal infrastructure;	Section 5.2

SSD 6456 consent conditions directly relevant to this PWMP	Section reference
▪ fail-safe, redundancy and contingency measures;	Table 5.1 Sections 5.2 and 9.3
▪ capacity of water storages, large ponds and dams, including during plant outages and extreme weather events;	Table 5.1 Table 8.1 Sections 9.1 and 9.2
▪ provision for continuous logging of produced water and treated water volumes;	Section 9.1 Table 5.1
▪ leak detection and spill response;	Table 5.1
▪ preferential beneficial water use options;	Section 5.5
• detailed performance criteria, including trigger levels for identifying and investigating any potentially adverse impacts associated with	
▪ produced water yield and quality;	Section 4.2 Section 9.1
▪ treated water yield and quality;	Section 4.2 Section 9.1
▪ leaks and spills;	Appendix C Table C2
▪ treated water irrigation and other beneficial reuse application;	Section 5.5
▪ discharge of excess treated water to Bohena Creek;	Section 6
▪ salt yield and quality;	Section 7
• a program to monitor, evaluate and report on:	Section 9 Section 13.1
▪ compliance with the relevant performance measures listed in Table 7 [of the CoC], and the performance criteria established above;	
▪ produced water yield and quality, including chemicals of potential concern;	
▪ treated water yield and quality, including chemicals of potential concern;	
▪ leaks and spills;	
▪ soil, surface water and groundwater quality in irrigation and other beneficial reuse application areas;	Section 5.5 Section 9.5 Section 13.1 Also refer to the IMP
▪ Bohena Creek discharges, flows and water quality;	Section 6
▪ salt and other waste products yield and quality; and	Section 7
▪ the effectiveness of the produced water management system.	Section 13.1
Consent condition D42 The Applicant must implement the approved Water Management Plan.	Section 1.2
Consent condition D3 The Applicant must ensure that (where relevant) the management plans required under this consent include:	

SSD 6456 consent conditions directly relevant to this PWMP	Section reference
a) summary of relevant background or baseline data;	Section 4.2
b) details of:	
(i) the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 3.1
(ii) any relevant limits or performance measures and criteria; and	Section 1.4
(iii) the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;	Section 9 Appendix D Table D1
c) any relevant commitments or recommendations identified in the documents that together comprise the NGP EIS;	Section 3.3
d) a description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria;	Section 8 Table 8.1 Table 5.1 Section 5.4
e) a program to monitor and report on the:	
(i) impacts and environmental performance of the development; and	Section 9 Section 13.1
(ii) effectiveness of the management measures set out pursuant to paragraph (d);	Sections 13.1 and 13.4
f) a contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	Section 12.2
g) a program to investigate and implement ways to improve the environmental performance of the development over time	Section 13.4
h) a protocol for managing and reporting any:	
(i) incident, non-compliance or exceedance of any impact assessment criterion and performance criterion	Section 12.1
(ii) complaint; or	Section 12.3
(iii) failure to comply with other statutory requirements; and	Section 12.1
i) a protocol for periodic review of the plan.	Sections 13.1 and 13.4
Consent condition D4 Within 2 months of: (a) the submission of an incident report; (b) the submission of an Annual Review; (c) the submission of an Independent Environmental Audit; (d) the submission of a Field Development Plan; (e) the submission of a Groundwater Model Update; or (f) the approval of any modification of the conditions of this consent, the Applicant must review the suitability of existing strategies, plans and programs required under this consent.:	Section 13.3

SSD 6456 consent conditions directly relevant to this PWMP	Section reference
Consent condition D5 If the review determines that the strategies, plans and programs required under this consent require revision – to either improve the environmental performance of the development, cater for a modification or comply with a direction - then the Applicant must submit the revised document to the Secretary for approval within 6 weeks of the review. **Note**: *This is to ensure strategies, plans and programs are updated on a regular basis and to incorporate any recommended measures to improve the environmental performance of the development.*	Section 13.3
Consent condition D6 The Applicant must notify the Department and any other relevant agencies via the Major Projects Portal immediately after it becomes aware of the incident. This notice must describe the location and nature of the incident.	Section 12.1
Consent condition D7 Within 7 days of becoming aware of a non-compliance with the conditions of this consent, the Applicant must notify the Department of the non-compliance via the Major Projects Portal. This notice must set out the non-compliance, the reasons for the non-compliance (if known) and what actions have been taken, or will be taken, to address the non-compliance. **Note**: *A non-compliance which has been notified as an incident does not need to also be notified as a non-compliance*	Section 12.1
Consent condition D8 By the end of March each year, unless the Planning Secretary agrees otherwise, the Applicant must submit an Annual Review of the environmental performance of the development to the Department via the Major Projects Portal.	Section 13.1
Consent condition D9 Within one year of commencement of Phase 1 and every 3 years thereafter, unless the Planning Secretary directs otherwise, the Applicant must commission and pay the full cost of an Independent Environmental Audit of the development.	Section 13.2
Consent condition D13 From the commencement of Phase 1, until the completion of all rehabilitation required under this consent, the Applicant must:	

SSD 6456 consent conditions directly relevant to this PWMP	Section reference
a) make copies of the following information publicly available on its website: (i) the document/s listed in condition A2©; (ii) current statutory approvals for the development; (iii) approved strategies, plans and programs; (iv) detailed plans for the Phases of the development; (v) minutes of CCC and Advisory Group meetings; (vi) regular reporting on the environmental performance of the development in accordance with the reporting requirements in any plans or programs approved under the conditions of this consent; (vii) a comprehensive summary of the monitoring results of the development, reported in accordance with the specifications in any conditions of this consent, or any approved plans and programs; (viii) a summary of the current phase/s and progress of the development; (ix) contact details to enquire about the development or to make a complaint; (x) a complaint register, updated monthly; (xi) a record of all incidents and non-compliances; (xii) the Annual Reviews of the development; (xiii) audit reports prepared as part of any Independent Environmental Audit of the development and the Applicant's response to the recommendations in any audit report; and (xiv) any other matter required by the Planning Secretary; and	Section 1.7
b) keep such information up to date.	Section 1.7

Appendix C - Compliance with the Produced Water Code

Table C1 - Mandatory requirements of the Produced Water Code

No	Produced Water Code mandatory requirements	Section reference
1	Preparation of a Produced Water Management Plan	This Plan
1.1	The title holder must prepare a Produced Water Management Plan (PWMP) prior to commencing (i) petroleum exploration which requires the management of produced water, or (ii) activities which require produced water to be stored on site (excluding the management of incidental groundwater mixed with drilling fluids that can be temporarily contained in drilling sumps or above ground tanks) The PWMP must:	
	a) set out a description of the activities associated with produced water to be carried out by the title holder.	Section 1
	▪ set out a description of management controls for those activities which are reasonable to prevent (or where that is not practicable mitigate so far as practicable) the risks associated with produced water activities, and	Table 5.1, Table 8.1 Section 5
	▪ set out measures which demonstrate compliance with the mandatory requirements of this Code and the requirements of any other relevant legislation.	Section 8
1.2	The title holder **must** implement and comply with the PWMP, as revised from time to time in accordance with this Code.	Section 3.2.1 Section 13
1.3	The PWMP **must** set out how identified risks will be managed and mitigated, including the characterisation, consideration of beneficial reuse and the fate of the produced water	Section 8
1.4	The PWMP **must** set out a site-specific water balance to be maintained during activities. When multiple produced water activities are conducted under a single prospecting title, or as part of a broader exploration Project area (under more than one prospecting title), the PWMP **must** provide a water balance model showing how these activities interrelate.	Sections 4.2 and 5.5 Reference to section 3.5 of the Site Water Balance
1.5	The title holder **must** provide a copy of the PWMP to the Secretary [of the Department of Regional NSW] no later than 14 days prior to conducting activities set out in the PWMP.	Section 13.3
1.6	The PWMP **must** be made available at the site of the produced water activities to all persons involved in those activities.	Section 1.7
2	Produced water storage requirements.	Table C2 in Appendix C
3	Trigger Action Response Plan	Section 10
4	Review of the Plan	Section 13
5	Record keeping	Section 11

Table C2 - Produced water storage requirements

No.	Produced Water Storage Requirements (section 2 of the Produced Water Code)	Compliance	Comment
2.1	Evaporation ponds **must** not be used to manage produced water in connection with activities carried out under a prospecting title for petroleum.	Yes	No evaporation ponds are used. Produced water is stored in ponds prior to treatment at Leewood.
2.2	If the produced water being stored may have an adverse impact on the environment if released:		
	(a) the produced water storage containment **must**:		
	(i) not have its structural integrity compromised by the chemistry of the produced water being stored;	Yes	Refer to Table E1 for pond and tank liner systems assessment and approval documents. Note that the current (pre-Phase 1) PWMP has been approved on the basis that the lining system is fit for purpose.
	(ii) not absorb the produced water being stored, and	Yes	Refer to Table E1 for pond and tank liner systems. Polypropylene and HDPE do not absorb water. Note that the current (pre-Phase 1) PWMP has been approved on the basis that the lining system is fit for purpose.
	(iii) incorporate measures to prevent any overfilling or draining to the environment of the produced water being stored.	Yes	Refer to Table 5.1 for pond and tank liner systems and measures to prevent overfilling.
	(b) the title holder must not operate a produced water storage facility beyond its intended design life without prior approval from the Secretary. Materials utilised in the construction must have performance characteristics that exceed the anticipated conditions and length of time that the facility is intended to be in operation.	Yes	Refer to Table E1 for date each produced water storage facility was approved and Table 5.1 for design life of each produced water storage facility.
	(c) produced water storage facilities with the capacity to store more than five (5) cubic metres (m^3) of produced water must have a secondary containment, and	Partial (exempt)*	The Leewood ponds are double lined. The Tintsfield Pond 1 will be upgraded to the same standard prior to being brought back into operation.

No.	Produced Water Storage Requirements (section 2 of the Produced Water Code)	Compliance	Comment
	(d) the produced water storage facility must have the capability to detect leaks of produced water through the primary containment (such as a tank or liner material) within one (1) month of the compromising event occurring. (e) Note: Any detection of a leak will trigger the requirements to implement the Trigger Action Response Plan (clause 3.3 of the Code)	Partial (exempt)*	The Leewood ponds are designed and constructed to capture leaks of produced water through the primary containment. Sumps are monitored weekly.
2.3	If ponds are used or upgraded to store produced water:		
	(a) the design and installation of the pond must comply with the requirements specified in a Construction Quality Assurance (CQA) program. The CQA program must be prepared by a person certified by Engineers Australia to provide those services, or such other organisation approved by the Secretary;	Yes	Engineering design and construction QA program completed by certified engineer through Golders Associates
	(b) the pond must maintain an environmental containment freeboard capable of containing inflow from events up to and including a 1 in 100-year Annual Exceedance Probability (AEP) 72 hour rainfall event, without discharge, unless the operation of a freeboard for that pond is authorised by an EPL;	Partial (exempt)*	The Leewood ponds have an environmental containment freeboard capable of containing events greater than the 1:100-year AEP 72-hour rainfall event. Refer to Table 8.1.
	(c) the ponds must be located and designed to be structurally stable in all events up to and including the probable maximum flood;	Partial (exempt)*	Flood study completed by Golder Associates as part of the Engineering design for the Leewood Ponds with both the 1:50-year and 1:100-year flood events considered. Refer to the Dam Safety Emergency Plan.
	(d) the ponds must not be located in any area that will increase flood risk to surrounding area land unless controls are implemented to effectively mitigate that risk;	Partial (exempt)*	Flood study completed by Golder Associates as part of the engineering design for the Leewood Ponds with both the 1:50-year and 1:100-year flood events considered. Refer to the Dam Safety Emergency Plan.
	(e) the ponds must have spillway or overflow levels located above the 1 in 100-year Annual Recurrence Interval (ARI) flood level;	Partial (exempt)*	The Leewood ponds have a spillway level above the 1:100-year ARI flood level. Refer to Table 8.1.
	(f) if geomembrane liners are used in the construction of the pond:		

No.	Produced Water Storage Requirements (section 2 of the Produced Water Code)	Compliance	Comment
	(i) liner seams and joins **must** be watertight and seamed over their full length in accordance with the manufacturer's standard procedures and any site-specific recommendations by a person certified by Engineers Australia to provide these services, or such other organisation approved by the Secretary;	Partial (exempt)*	For both the Leewood and Tintsfield ponds, engineering design and construction QA program was completed by certified engineer through Golders Associates and Aquatech Consulting respectively
	(ii) quality control testing must be conducted over the full length of seams and joins prior to storing any produced water in the pond;	Yes	All seams have been tested and associated QA documentation completed for all welds.
	(iii) liners **must** be installed on a stable soil sub-base, free of protrusions that have the potential to compromise the liner. The underside of the lowest liner (secondary containment) **must** be at least two (2) metres above the highest seasonal groundwater level, unless effective under-drainage measures are installed to prevent upward water pressure on the liner, and	Yes	Both the Leewood and Tintsfield ponds have been constructed on a stable sub-base.
	(iv) controls **must** be implemented to limit as far as practicable the entry of terrestrial fauna that have the potential to damage the liner from entering the pond.	Yes	Both the Leewood and Tintsfield ponds are fully fenced to limit as far as practicable the entry of terrestrial fauna and subsequently damaging the liner.
2.4	If pipelines are used to convey produced water:		
	a) the pipelines must be constructed and installed in accordance with *AS2885, AS/NZS2566* or the APGA's *Code of Practice for* Upstream *Polyethylene Gathering Networks - CSG Industry.* The licence holder **must** carry out field pressure testing to verify pipe integrity prior to commissioning the pipe, and	Yes	All pipelines are constructed in accordance with the APGA's *Code of Practice for Upstream Polyethylene Gathering Networks - CSG Industry* and pressure tested prior to commissioning. Refer to section 5.2.
	b) computational pipeline monitoring (or some other leak detection system that provides equivalent or better leak detection than computational pipeline monitoring) **must** be implemented for any pipeline which conveys produced water at flow rates greater than one (1) ML per day.	Yes (exempt)*	Flowlines/pipelines do not convey produced water at flow rates greater than 1 ML/day. Refer to section 9.3, and the referenced Pipeline Integrity Management System for details on the leak detection system.

Note:
Although the Produced Water Code is applied as a term of consent condition B37, it only took effect in 2015 and as such the mandatory requirements do not apply to any existing infrastructure that was constructed and commissioned prior to 2015. This is expressly stated in Part A (Introduction) of the Code.

Appendix D - Treated water quality

Table D1 - Treated water quality

Parameter	Australian Drinking Water and Recreational Guidelines (NHMRC, NRMMC 2008; 2011, 2017)	ANZECC / ARMCANZ (2000) Irrigation Guidelines (long term > 20 years)	ANZECC / ARMCANZ (2000) Stock watering	Treated water [a]	Treated and amended water [b]	Treated water [c] (Leewood WBTP)	Treated and amended water [d] (Leewood WBTP)	RO brine [e] (Leewood WBTP)
	(mg/L)			Target (mg/L)			Actual (mg/L)	
pH (pH units)	6.5 – 8.5	6.0 -9.0	Not referenced	7.1	7.1	7.9	7.1	(Lab) 9.3
Electrical conductivity (laboratory) (µS/cm)	Not referenced	Crop specific -Lucerne (2,700 in loamy soils)	Not referenced	357	566	n/a	107	76,000
Total dissolved solids	Health: Not referenced Aesthetic as follows: <600 good quality 600-900 fair quality 900-1200 poor quality >1,200 Unacceptable	Crop specific – Lucerne (1,273 - 3,015)	No adverse effects to: Beef cattle, pigs and horses 4,000 Sheep 5,000	232	368	56	71	N/A
Sodium Adsorption Ratio	Not referenced	<1 excellent 1-2 Good 2-4 Fair 4-8 Poor 8-15 Very poor >15 Unacceptable	Not referenced	130	3.3	29	3.7	1,046
Sodium (filtered)	Health: Not referenced Aesthetic: 180	Crop specific - Lucerne (230 - 460)	Not referenced	77	77	17	18	41,600
Magnesium (filtered	Not referenced	Not referenced	Not referenced	<0.01	<0.01	<1	<1	55
Aluminium	Health: Not ref Aesthetics: 2	5	5	<0.001	<0.001	<0.01	<0.01	<0.05
Silica (SiO2) (µg/L)	80	Not referenced	Not referenced	23	0.15	<0.1	<0.1	135
Potassium (filtered)	Not referenced	Not referenced	Not referenced	0.8	0.8	<1	<1	387
Calcium (filtered)	Health: Not referenced Aesthetic as follows: <60 Soft 60-200 Good quality >200 Increased scaling	Not referenced	1,000	0.01	40.01	<1	6	28
Chromium (III+VI)	0.05	0.1 (Cr^{IV})	1	<0.001	<0.001	<0.001 (Cr^{IV})	<0.001 (Cr^{IV})	<0.01
Manganese	0.5	0.2	Not sufficiently toxic	<0.001	<0.001	<0.001	<0.001	0.014
Iron	<1	0.2	Not sufficiently toxic	<0.001	<0.001	<0.05	<0.05	0.27
Boron	4	Crop specific: 0.5 (sensitive) to 15 (very tolerant)	5	0.12	0.12	0.11	0.09	5.57
Cobalt	Not referenced	0.05	1	<0.001	<0.001	<0.001	<0.001	<0.005
Nickel	0.02	0.2	1	<0.001	<0.001	<0.001	<0.001	<0.005
Copper	2	0.2	0.4 (sheep) 1 (cattle) 5 (pigs)	<0.001	<0.001	<0.001	<0.001	<0.005

Parameter	Australian Drinking Water and Recreational Guidelines (NHMRC, NRMMC 2008; 2011, 2017)	ANZECC / ARMCANZ (2000) Irrigation Guidelines (long term > 20 years)	ANZECC / ARMCANZ (2000) Stock watering	Treated water [a]	Treated and amended water [b]	Treated water [c] (Leewood WBTP)	Treated and amended water [d] (Leewood WBTP)	RO brine [e] (Leewood WBTP)
	(mg/L)			Target (mg/L)		Actual (mg/L)		
Zinc	Health: Not referenced Aesthetic: 3	2	20	<0.001	<0.001	<0.005	<0.005	<0.025
Arsenic	0.01	0.1	0.5 – 5	<0.001	<0.001	<0.001	<0.001	0.018
Selenium	0.01	0.02	0.02	<0.001	<0.001	<0.01	<0.01	<0.05
Molybdenum	0.05	0.01	0.15	<0.001	<0.001	<0.001	<0.001	0.006
Cadmium	0.002	0.01	0.01	<0.001	<0.001	<0.0001	<0.0001	0.0012
Barium	2	Not referenced	Not referenced	<0.001	<0.001	<0.001	<0.001	12.3
Mercury	0.001	0.002	0.002	0.0000067	<0.001	<0.0001	<0.0001	<0.0005
Lead	0.017	2	0.1	<0.001	<0.001	<0.001	<0.001	<0.005
Uranium	0.017	0.01	0.2	<0.0028	<0.0028	<0.001	<0.001	<0.005
Alkalinity (total as CaCO3)	Not referenced	Not referenced	Not referenced	139	139	34	28	73,500
Ammonia (as N)	Health: Not referenced Aesthetic: 0.5	Crop specific as N (25 - 125)	Not referenced	0.005	0.005	0.25	0.24	N/A
Nitrate (as N)	50	Crop specific as N (25 - 125)	400	0.005	0.005	0.04	0.25	N/A
Total N	Not referenced	25 - 125	Not referenced	0.005	0.005	0.23	0.42	N/A
Sulfate	500	Not referenced	1,000	0.003	95.9	<1	<1	58
Chloride	Health: Not referenced Aesthetics: 250	Crop specific –Lucerne (350 –700)	Not referenced	15	15	10	19	7030
Fluoride	0.5	1	2 (1 if livestock feed contains fluoride)	0.08	0.08	<0.1	<0.1	47
Total phosphorous	Not referenced	0.05 [g]	Not referenced	0.01	0.01	<0.01	<0.01	N/A

N/A - not analysed.
a - Theoretical composition based on manufacturers' specifications.
b - Calculated composition based on theoretical treated water and amendment with 1 mol gypsum.
c - All values reported as maximum recorded values, except pH reported as average.
d - Treated water amended with calcium chloride.
e - Laboratory limits raised due to high salinity.
f - To minimise blocking of irrigation equipment only.

Appendix E - Key produced water management assets

Table E1 - Key produced water management assets within PEL 238, PAL 2 and PPL 3

Asset / facility	Tenure	Type	Status	Relevant assessment documents	Approval reference and date	Approval period expiry date
Bibblewindi West Pilot	PAL 2	Appraisal Pilot	Operating - dewatering	• Review of Environmental Factors (REF) Narrabri Coal seam Gas Project Bibblewindi West Lateral Production Pilot, January 2009 • The Narrabri Coal Seam Gas Project REF Bibblewindi West Lateral Gas Pilot and Water Gathering System, March 2009	• PAL 2: Approval to conduct Narrabri Coal Seam Gas Project Bibblewindi West Lateral Production Pilot. Department of Primary Industries, 30 April 2009 • PAL 2: Approval to conduct Narrabri Coal Seam Gas Project Bibblewindi West Lateral Pilot Gas and Water Gathering System (File 09/3009). Department of Primary Industries, 29 May 2009	None specified
Bibblewindi East Pilot	PAL 2	Appraisal Pilot	Operating - dewatering	• REF 2008 Narrabri Coal Seam Gas Lateral Program Lateral Production Pilot A • 2009 Narrabri Coal Seam Gas Project Bibblewindi Lateral Pilot Supplementary REF Bibblewindi Shield Laterals, July 2009 • The Narrabri Coal Seam Gas Project Operations and Water Management Plan, September 2008 • Supplementary REF - 2009 Narrabri Coal Seam Gas Project - Bibblewindi Lateral Pilot - ESP Installation & Extension of GGS to BW28H & 21H, May 2010	• PAL 2: Approval to conduct the Narrabri Coal Seam Gas Lateral Program, Lateral Production Pilot A, involving coal seam methane exploration well(s) Bibblewindi 18H, 12, 13, 14, 19H, 15, 16, 17. Department of Primary Industries, 12 August 2008 • PAL 2: Approval to conduct Narrabri Coal Seam Gas Project Bibblewindi Lateral Pilot – Shield Laterals Supplementary (File 09/4500). Department of Primary Industries, 20 July 2009 • PAL 2: Approval to conduct 2009 Narrabri Coal Seam Gas Project: Bibblewindi Lateral Pilot: ESP Installation & Extension of GGS to BW28H & 21H (File 09/4500). Department of Industry & Investment, 24 March 2011	None specified
Leewood Water Management Facility (ponds)	PAL 2	Ponds	Operational	• Leewood Produced Water & Brine Management Ponds REF, December 2012	• PAL 2 Approval to construct and operate Leewood produced water and brine management ponds (INT13/23812). Department of Resources & Energy, 19 March 2013	None specified
Leewood Produced Water Treatment and Beneficial Use Project	PAL 2	Plant, treated water storage tank and irrigation infra-structure	Suspended until September 2019	• Leewood Produced Water Treatment and Beneficial Reuse Project REF, June 2015	• PAL 2 Approval to undertake Leewood Produced Water Treatment and Beneficial Reuse Project (MCV15/245#3, OUT15/16630). Division of Resources and Energy, 18 August 2015	18 August 2020; rehabilitation by 18 August 2023
Bibblewindi 5 ML tank	PAL 2	Tank	Operational	• Leewood Produced Water & Brine Management Ponds REF, December 2012	• PAL 2 Approval to construct and operate Leewood produced water and brine management ponds (INT13/23812). Department of Resources & Energy, 19 March 2013	None specified
Bibblewindi to Leewood water flow line	PAL 2	Water flow line	Operational	• Leewood Produced Water & Brine Management Ponds REF, December 2012	• PAL 2 Approval to construct and operate Leewood produced water and brine management ponds (INT13/23812). Department of Resources & Energy, 19 March 2013	None specified
Bibblewindi to Wilga Park GRE gas flowline	PAL 2	Gas flow line	Operational. Can be used to transfer produced water if required.	• Narrabri Coal Seam Gas Utilisation Project Part 3A Environmental Assessment (Project Application 07_0023) • Narrabri Coal Seam Gas Utilisation Project (MP 07_0023) Modification 3	• Project Approval for MP07_0023 (S07/00277). Minister for Planning, 2 December 2008. • Notice of Modification to Project Approval (07_0023). Planning Assessment Commission, 18 July 2014.	None applicable as works are complete
Dewhurst Northern Water and Gas Flow Lines	PAL 2 / PEL 238	Water and gas flow lines	Water flow line installed	• Dewhurst Northern Water and Gas Flow Lines REF, June 2013	• PEL 238 and PAL 2, Approval to undertake Dewhurst Northern Water and Gas Flow Lines construction program (MCV13/369, OUT 13/25591). Office of CSG, 18 September 2013	No specified end date in amended approval
Dewhurst Southern Water and Gas Flow Lines	PAL 2 / PEL 238	Water and gas flow lines	Water flow line installed; gas flow line under construction	• Dewhurst Southern Water and Gas Flow Lines REF, June 2013	• PEL 238 and PAL 2, Approval to undertake Dewhurst Southern Water and Gas Flow Lines construction program (MCV13/370, OUT13/25677). Office of CSG, 18 September 2013	No specified end date in amended approval.

Asset / facility	Tenure	Type	Status	Relevant assessment documents	Approval reference and date	Approval period expiry date
Tintsfield 2-7 Pilot	PEL 238	Appraisal Pilot	Operating – currently dewatering	• Recommencement of Tintsfield Pilot and flare PEL 238 and PPL 3, Gunnedah Basin NSW, Supplementary REF, August 2013	• PEL 238 and PPL 3, Approval to recommence Tintsfield Pilot and construct and operate associated flare (MCV13/588, OUT13/32001). Office of CSG, 25 October 2013	No specified end date in amended approval
Dewhurst 13-18H Pilot	PEL 238	Appraisal Pilot	Shut in	• REF Dewhurst-8 Lateral Production Pilot, June 2009	• PEL 238: Approval to conduct Narrabri Coal Seam Gas Project Dewhurst – 8 Lateral Production Pilot (09/4409). Department of Primary Industries, 21 July 2009	None specified
				• EIS Dewhurst Gas Exploration Pilot Expansion SSD 6038	• SSD – 6038 Dewhurst Gas Exploration Pilot Expansion Planning Assessment Commission,18 July 2014	18 July 2017
Dewhurst 22-25 Pilot	PEL 238	Appraisal Pilot	Shut in	• REF Dewhurst 22-25 Pilot Wells, March 2013	• PEL 238 Approval to undertake Dewhurst 22-25 Pilot Wells exploration program (MCV13/204, OUT13/23530). Office of CSG, 16 August 2013	No specified end date in amended approval
Dewhurst 26-29	PEL 238	Appraisal Pilot	Operating – currently dewatering	• Dewhurst 26-29 petroleum wells REF, March 2013	• PEL 238 Approval to undertake Dewhurst 26-29 Pilot Wells exploration program (MCV13/205, OUT13/23533). Office of CSG, 16 August 2013	No specified end date in amended approval
				• EIS Dewhurst Gas Exploration Pilot Expansion SSD 6038	• SSD – 6038 Dewhurst Gas Exploration Pilot Expansion Planning Assessment Commission, 18 July 2014	18 July 2017
Tintsfield pond 1 and 2	PEL 238	Ponds	Operational – not currently in use	• Tintsfield Water Management Plan, Narrabri Coal Seam Gas Project, February 2010	• PEL 238: 2009 Narrabri Coal Seam Gas Program, Approval of Tintsfield CSG Pilot Water Management Plan (OUT10/7377). Department of Industry and Investment, 25 May 2010	No specified end date in amended approval for Tintsfield 2-7 pilot (which identified use of Tintsfield ponds to manage water)

Note:
There are other approved pilots that are not included in Table E1 above which are currently not producing water or gas. These pilots are the Bibblewindi 9 Spot pilot, the Coonarah wells in PPL 3 and the Bohena Pilot. They will not be producing water during Phase 1.