9.1 Introduction

This chapter presents an assessment of the impacts to soils, geology and groundwater for the proposed Facilities and associated infrastructure including transmission lines, access road and gas pipeline.

9.2 Methodology

Desktop Assessment

A desktop assessment was conducted, which involved analysis of geological and soil maps for the area.

Field Work

Preliminary geotechnical investigations were carried out at the Site to assess typical depths and geotechnical characteristics of the overburden soils and underlying bedrock, and obtain soil and rock samples for laboratory testing. Five boreholes were augered to assess the soil profile on the Marulan Site. Selected rock and core samples were submitted for testing.

9.3 Existing Environment

9.3.1 Soils and Geology

Topography

The Site comprises approximately 116 ha of pasture land and woodland. The Site consists of a cleared area approximately 300 m wide, bordering a tree covered area which continues on high ground to the east of the Wollondilly River. Generally the Site slopes gently west from 626 m AHD to the Wollondilly River corridor at around 590 m AHD.

The exact location of the gas pipeline will be finalised at the detailed design stage and, subject to the Minister's determination, will be subject to a future, separate project application with appropriate environmental assessment of the key impacts. However, investigations of the area surrounding the Site indicate that the proposed Gas Pipeline Corridor consists of lands that have been previously cleared for agricultural purposes. Consequently, clearing has resulted in the removal of most of the naturally occurring vegetation. There are scattered areas of paddock trees that occur within the proposed Gas Pipeline Corridor, as well as small patches of native woodland or forest. The land ranges in height from 590 m AHD to 670 m AHD and is bordered on the east by Paddy's River. Uringalla Creek also runs through the south-eastern part of the proposed Gas Pipeline Corridor. Tributaries for both of these waterways traverse the proposed Gas Pipeline Corridor.

Geology

The 1:250,000 Wollongong geological map shows the general area (including the land proposed for the Site and the Gas Pipeline Corridor) to be underlain by granite, granodionite or porphyry of Devonian age. Observations on Site during preliminary investigations supported this general geological setting:

- granite rock cuttings were present in the excavated spoil from nearby transmission tower footings;
- granite outcrops and granite-derived soils were observed in the watercourse;
- there were large granite boulders on the surface in some locations;
- extensive granite cobbles and small boulders were scattered on the surface in some locations; and
- "decomposed granite" surface soils were exposed at numerous locations in the open woodland on the higher parts of the Site, and in the excavation for a farm dam.

The depth to the top of the granite bedrock was found in preliminary investigations to vary across the Site, but was generally in the range of 1.5 to 5.5 m, being shallower to the east of the Site (typically 1.5 to 2.5 m). The granite is typically medium to coarse grained, and was found to be of extremely low strength within the upper weathered profile, progressively grading to high strength with depth.

Soils

The Site and the proposed Gas Pipeline Corridor fall within the Marulan Soil Landscape (Hazelton and Tille, 1990). The soils within this landscape are dominated by colluvial processes. Mass movement is the principal agent of parent material accumulation. Cliffs, scarps, and steep slopes are dominant features in upper parts of the landscapes with undulating hills and broad benches in lower catchment areas. Alluvial processes are likely to dominate in downslope areas adjacent to the Wollondilly River.

Red Podzolic Soils occur on hillcrests and upper slopes, grading into Yellow Podzolic soils on the lower slopes. Gleyed Podzolic soils are found in drainage depressions (Hazelton and Tille, 1990).

The preliminary investigations encountered granite derived colluvium / slopewash and residual soils overlying granite bedrock across the investigation areas.

Preliminary investigations identified three main geological units characterising differing geotechnical properties. The typical units found are summarised in **Table 9-1**.

Table 9-1 Summary Description of Geotechnical Units

Geotechnical Unit	Approximate Depth Range (metres below ground level)	Summary Description
Unit I	0 – 1.5 m	Stiff to hard sandy clay (colluvium)
Unit II	1.5 - 5.5 m	Dense to very dense silty sand (decomposed granite)
Unit III	Below 1.5 – 5.5 m	Weathered granite bedrock grading to fresh rock with depth

The Australian Soil Research Information System Map of the Marulan Site and surrounding area indicates that the Site is not an area of Potential Acid Sulphate Soils.

9.3.2 Groundwater

The geology of the Site is complex, as the area is located approximately at the boundary between granites of Devonian age and slate, quartzite and phillite of Ordovician age, the granites having intruded the Ordovician sediments.

The presence of groundwater supply in these rocks is uncertain, their storage depending entirely on the amount of fracturing and interconnection between fractures.

The possibility exists for fractured ground to be present at the contact between the granite and the Ordovician rocks, due to the intrusive nature of the contact. Establishment of the conditions of the rocks would require further geological evaluation. The need for further work to determine the shallow groundwater conditions at the Site would depend on the level of excavation required. This would be confirmed during the pre-tender phase by directly assessing the presence of groundwater and, if necessary in the future, its quality in relation to construction issues.

Groundwater was not encountered during preliminary investigations in any of the boreholes to the depth limit of investigation (5.5 m).

No investigations have been progressed within the proposed Gas Pipeline Corridor so it is unknown whether groundwater occurs in that area. It is anticipated that this will be further investigated once an exact route for the pipeline has been confirmed.

9.3.3 General Foundation Conditions

Granite-derived soils are typically very good materials for use in engineered fills as they usually have significant proportions of fine gravel and sand, with sufficient silty / clayey fines to provide good compaction characteristics. In these soil types, the clay content is usually such that shrink / swell moisture reactivity is unlikely to be a significant issue. The weathered granite underlying the surface soils will also be a good construction material for engineered fills.

9.4 Assessment of Potential Impacts - Common Shared Works

The Facilities, common infrastructure and Laydown Area footprint is up to approximately 34 ha. This footprint area may be refined during detailed design. In order to avoid the potential for flood impact on risk-averse property, the level of the Facilities pad would be set at approximately 605 m AHD (refer to **Chapter 14** for further detail). The actual level of the Facility pad may be further refined through detailed design.

Bulk earthworks for the Site would require clearing of approximately the areas identified in **Table 9-2**.

Table 9-2 Extent of Vegetation Clearing

Component	Approximate Area (ha)
Total Area within the Marulan Site	116
Footprint	
Delta Electricity Facility	7.8
Energy Australia Facility	7.8
Proposed Laydown Area	4.3
Common infrastructure	14.3
Combined Construction Footprint	***34.2***
Approximate Area Remaining at the Site	81.8

The undulating terrain at the Site means that the preparation of nominally level platforms for Facility areas is likely to require substantial cut / fill earthworks. The preliminary Site investigations confirmed that, with the exception of the immediate topsoil, the vast majority of cut material should be suitable for use as engineered fill, and it is considered that these materials compacted to at least 98 % of standard dry density can be expected to have geotechnical characteristics similar to the in-situ overburden present at the Site.

9.4.1 Construction Phase

Excavation

Bulk earthworks for the Site would be undertaken for the two Facilities, either in a staged manner or at the same time. During detailed design, the Facility pad level will be refined and the sites may be benched (i.e., different parts of the Site at different levels) to create the optimum earthworks scenario.

For the purposes of this assessment, the worst case scenario has been assumed, that being that the earthworks are conducted in a single stage creating a single level, balanced cut and fill with the level of the pad approximately 605 m AHD. On this basis approximately 127,500 m^3 of material from 0 to 3 m depth would be excavated and compacted. Approximately 24,500 m^3 of material from greater than 3 m depth would be excavated and compacted. It has been assumed for the purposes of this assessment that the earthworks would be a balanced cut and fill and would not require import of significant quantities of fill.

Erosion of Disturbed Areas

During the construction period, approximately 30 % of the total Site would be disturbed in order to construct the Facilities pad, access roads and transmission lines and gas pipeline within the Site. Rainfall on these disturbed areas may cause soil erosion and runoff may contain high levels of sediments which could then enter the natural drainage system. Soils at the Site are likely to have a high percentage of fines, and may or may not be dispersible.

As the Site is located adjacent to the Wollondilly River, there is potential for sediment laden runoff to reach the river.

Groundwater

Groundwater was not encountered in any of the boreholes to the depth limit of investigation (5.5 m). This would be confirmed during the detailed design stage by directly assessing the presence of groundwater and, if necessary in the future, its quality and management requirements in relation to construction issues.

Moisture Reactivity

Shrink / swell potential is the relative change in volume to be expected with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. The design of buried services and structures on shallow footings needs to take into account the moisture reactivity of the near-surface soils.

The granitic residual soils should not undergo significant shrink / swell movements due to changes in moisture content. The Unit 1 colluvium, present on the lower parts of the Site, may have sufficient clay content to show some reaction to moisture changes, but if this is the case it will be practicable to design the subfoundation of the gas turbine foundation to suit these conditions.

Liquefaction Potential

Liquefaction can occur in soils below the water table when an increase in pore pressure (typically related to an earthquake) results in a decrease in the effective stress (strength) within a soil. When the pore pressure is equal to the effective stress, the material loses its strength and liquefies. This phenomena is typical of sands, especially loose compacted ones.

As no groundwater was encountered during the preliminary investigations, and given the high density and significant clay and silt content of the soils, it is considered that there is negligible likelihood of liquefaction at the Site.

Soil Contamination

A Phase 1 investigation, (URS, 2007) as undertaken for the Site and concluded based on the scope of the investigation that there were no potential sources of soil or groundwater contamination identified on the Site.

9.4.2 Operation Phase

This section addresses the operation of the access road and transmission line areas. The ‘operation’ of the areas of bulk earthworks is not relevant as further construction of the Facilities would take place on the pad created by the earthworks.

Rainfall runoff from the access road and transmission line may potentially be contaminated with material such as oil and dust. In addition, where flows are concentrated soil erosion may occur. The impacts of surface water flows are addressed in **Chapter 14**.

9.5 Assessment of Potential Impacts – Facilities

9.5.1 Construction

Preliminary geotechnical investigations indicate that in-situ overburden soils and engineered fill, using site-derived materials, should provide suitable foundation conditions for gas turbine generating units, without the need for piled footings extending through the underlying bedrock.

Corestone boulders are a common feature in the weathering profile of granitic terrain, and these usually have to be separated from the remainder of the spoil during excavation if the spoil is being used for engineered fills. It is anticipated that these corestones may be encountered even within the top 3 m below the existing surface anywhere on the Site.

Where earthworks result in weathered or fresh granite being the foundation bearing stratum, it would be suitable for the loadings applied by a gas turbine foundation.

The granitic residual soils (Unit II) should not undergo significant shrink / swell movements due to changes in moisture content. The Unit I colluvium, present on the lower parts of the Site, may have sufficient clay content to show some reaction to moisture changes, but if this is the case the subfoundation will be designed to suit these conditions.

9.5.2 Operation

Normal engineering practice is to implement regular inspection and maintenance of all operation areas to ensure proper performance of the Facilities in accordance with their engineering design.

There is potential for contamination at the Site during operation from spills of fuel, oil or chemicals.

Surface water from the Site that may potentially be contaminated could include:

- rainfall runoff from operational areas of the Site; and
- accumulated water within bunds.

In addition where flows are concentrated soil erosion may occur. The impacts of surface water flows are addressed in **Chapter 14**.

Stormwater and Wastewater Ponds

Stormwater and wastewater ponds would be lined with an appropriate impermeable liner to minimise the risk of water escaping into the natural groundwater system. When required, the accumulated sediments / waste sludge collected in the storage ponds would be disposed of by a licensed contractor.

Further discussion of the water management measures onsite for the Facilities is provided in **Chapter 14**.

9.6 Assessment of Potential Impacts – Gas Pipeline

9.6.1 Construction

To connect to the Moomba to Sydney Gas Pipeline a gas easement would be required for the installation of the pipeline infrastructure.

Rainfall on these disturbed sites may cause soil erosion and runoff may contain high levels of sediments, which could then enter the natural drainage system.

It is anticipated that the infrastructure for the pipeline will need to cross drainage lines and tributaries for watercourses in the area.

9.6.2 Operation

There is potential that if infrastructure alignments are not revegetated, flows may be concentrated on these flow paths and concentrated soil erosion may occur.

9.7 Mitigation Measures

9.7.1 Construction

A Construction Soil and Water Management Plan would be developed and implemented for the construction works to ensure effective management of potential soil erosion issues. Construction would be planned to minimise the time that disturbed land is exposed. Disturbed sites would be quickly revegetated or covered with a non-erodable surface following construction. Should excavation be phased, then interim soil stabilisation and erosion control measures would be implemented. During the construction period water may be required for dust suppression.

Should the bulk earthworks be progressed at the same time for both Facilities and there is a time lag between further construction, then appropriate longer term erosion control measures will be implemented on the vacant pad area until further work for construction of that Facility commences.

The Construction Soil and Water Management Plan will be prepared to beneficially reuse all suitable spoil, effectively reducing the volumes of spoil disposed to landfill and traffic associated with construction works.

Depending on the final gas pipeline alignment defined during subsequent Project Approval, this infrastructure may need to cross waterways. Prior to construction, further assessment would be undertaken of the most appropriate method for watercourse crossings.

9.7.2 Operation

Management of surface water flow from the Site is described in detail in **Chapter 14**. The outlet of the Facilities' stormwater system would be designed to maximise the dispersion of these high flows and thereby minimise their potential to cause soil erosion downstream. There would be zero discharge from the Site except for natural surface flows.

Appropriately bunded areas would be included for storage of fuels, oils and chemicals according to the relevant Australian standards.

Areas within the Facility would be appropriately drained so that surface runoff would be prevented from infiltrating directly onto the ground and reaching the groundwater.

9.7.3 Summary

The mitigation measures and safeguards would ensure that soils and groundwater are satisfactorily managed using suitable design, construction and management. Accordingly any impacts on soils resulting from the construction and operation of the Facilities at the Marulan Site are not likely to be significant.

Table 9-3 presents the mitigation measures to address the soil and geological issues for the proposed Facilities. The phase of implementation is indicated in the table by *Cons* – Construction *Ops* – Operation and *Design.*

Table 9-3 Summary of Mitigation Measures

Mitigation Measures	Implementation of mitigation measure		
	Common Shared Works	Facilities	Gas Pipeline
Soil Erosion			
A Construction Soil and Water Management Plan would be developed and implemented for the construction works to ensure effective management of potential soil erosion issues.	✓ (Cons.)	✓ (Cons.)	✓ (Cons.)
All construction works would be undertaken in a manner to minimise the potential for soil erosion and sedimentation and managed through a Soil and Erosion Control Plan. These measures would be incorporated into the CEMP.	✓ (Cons.)	✓ (Cons.)	✓ (Cons.)
At a minimum the measures outlined in the *Managing Urban Stormwater – Vol 1 Soils and Construction* would be implemented. Measures may include: • limiting slope length; • installation of sediment filters; and • the construction of a sedimentation basin downstream of the disturbed areas.	✓ (Cons.)	✓ (Cons.)	✓ (Cons.)
Soil erosion and sedimentation devices would remain in place until the surface is restored. These devices would also capture any gross pollutants.	✓ (Cons.)	✓ (Cons.)	✓ (Cons.)
Where practicable, disturbed areas would be quickly revegetated or covered with a non-erodable surface following construction.	✓ (Cons.)	✓ (Cons.)	✓ (Cons.)
Should the earthworks be progressed at the same time for both Facilities and there is a time lag between further construction, then appropriate longer term erosion control measures would be implemented on that vacant pad area until further work for construction of the Facility commences.	✓ (Cons.)	✓ (Cons.)	
Subject to design requirements, where excavation work extends into bedrock, suitable material may be reused as engineering fill on the Site.	✓ (Design)	✓ (Design)	
Assess need for groundwater control and collection system during further geotechnical investigations.	✓ (Design)	✓ (Design)	
Depending on engineering design requirements for the fill, material excavated from the Site (except for up to 150 mm of topsoil and root-affected material) may be used as engineered fill in any cut / fill operations.	✓ (Cons.)	✓ (Cons.)	
Construction would be planned to minimise the time that disturbed land is exposed.	✓ (Cons.)	✓ (Cons.)	✓ (Cons.)
Water required for dust suppression would be sourced from the existing dams on the Site where available and practicable or imported if required.	✓ (Cons.)	✓ (Cons.)	✓ (Cons.)
Appropriately bunded areas would be included for storage of fuels, oils and chemicals.	✓ (Cons.)	✓ (Cons. & Ops)	✓ (Cons.)

Mitigation Measures	Implementation of mitigation measure		
	Common Shared Works	Facilities	Gas Pipeline
Areas within the Facility area would be appropriately drained so that surface runoff would be prevented from infiltrating directly onto the ground and from reaching the groundwater.	✓ (Cons. & Ops.)	✓ (Cons. & Ops.)	
All possible pollutant materials would be stored well clear of Site boundaries and stormwater drainage lines and stored in a designated covered area.		✓ (Ops.)	
Waste disposal and collection would be properly undertaken.	✓ (Cons. & Ops.)	✓ (Cons. & Ops.)	
All major vehicle maintenance would be undertaken offsite.	✓ (Cons. & Ops.)	✓ (Cons. & Ops.)	
Stormwater and wastewater ponds would be lined with an appropriate impermeable liner to minimise the risk of water escaping into the natural groundwater system.		✓ (Design & Ops.)	