9 GEOLOGY, MINERAL RESOURCES, OVERBURDEN AND SOILS

9.1 INTRODUCTION

This chapter outlines the geology and soil characteristics of the southern coal seam methane (CSM) water supply pipeline (the proposed pipeline) corridor and details the rehabilitation requirements of the site. A detailed geology, mineral resources, overburden and soils technical report is presented in TR 9-1-V2.5 Geology, Mineral Resources, Overburden and Soils Impact Assessment. Note that figures/documents with numbering ending in V2.3, for example, refer to figures/documents contained in Volume 2, Book 3 of the EIS.

9.2 METHODOLOGY OF ASSESSMENT

The assessment was conducted as a desktop soils and land suitability assessment.

9.2.1 EXISTING INFORMATION

Previous investigations that provided information for this report regarding soil and landscape characteristics (topography and geomorphology) include:

- Gray, H.J and Macnish, S.E (1985) Land Management Field Manual Wandoan District
- Forster, B.A (1985). Evaluation of Agricultural Land in Taroom Shire
- Maher, J.M. (1996) Understanding and Managing Soils in the Murilla, Tara and Chinchilla Shires.

9.2.2 OVERBURDEN

No overburden assessment was conducted for this study as no mining activity is proposed within the proposed pipeline corridor.

9.2.3 SOILS

The soils and land suitability assessment comprised a desktop review of available published data to:

- identify anticipated soil types along the corridor
- characterise soil types
- assess land suitability classes
- assess available topsoil types and suggested stripping depths
- assess erosion potential of the topsoil and subsoil materials.

The soil investigation comprised a review of existing geotechnical, geological, topographic, aerial photograph and soil data. The investigation was conducted in accordance with The Planning Guidelines: the Identification of Good Quality Agricultural Land (Department of Primary Industries and Department of Housing, Local Government and Planning 1993).

Soil classification system

The adopted soil classification system is the Australian Soil Classification System (Isbell 1996). Where soil descriptions correlate with soil types in the resources listed in Section 9.2.1, soil names from these resources have been adopted.

9.2.4 LAND SUITABILITY ASSESSMENT

A land suitability assessment was carried out over the proposed pipeline study area based on the methodology of Attachment 2 of the Land Suitability Assessment Techniques (Department of Mines and Energy 1995a). The land in the proposed pipeline corridor was assessed for its suitability for dry-land cropping and cattle grazing on improved pasture.

The findings of the land suitability assessment were then assessed against the Good Quality Agricultural Land (GQAL) mapping under the former Taroom Shire Council Planning Scheme. (Taroom Shire Council, 2006) and Murilla Shire Council Planning Scheme (Murilla Shire Council 2006) to assess the accuracy of the GQAL mapping.

GQAL is defined under State Planning Policy 1/92 Development and conservation of agricultural land. State planning policy 1/92 is based on the principle that land suitable for agricultural purposes is limited in Queensland, and that suitable “good quality” land should be protected for agricultural uses, however the policy makes allowances for developments on high quality agricultural land where the project provides an overriding public benefit and there are no other suitable sites for the purpose.

9.3 EXISTING ENVIRONMENT

9.3.1 TOPOGRAPHY AND GEOMORPHOLOGY

Topography

The topography of the proposed pipeline study area is shown on Figure 9-1-V2.3. Three main landscape units were identified in the proposed pipeline study area:

- low undulating hills north of the Great Dividing Range, with surface levels (RL) between 280 m and 420 m Australian height datum (AHD). Surface elevation and relief generally increases to the south. The proposed pipeline corridor approximately follows the 320 m contour through this landscape. This area is generally cleared of vegetation and used for cattle grazing or fodder cropping
- undulating hills of the GDR and south of the range. The GDR has a maximum height of about 460 m AHD, and the pipeline corridor crosses the GDR at approximate RL 380 m. South of the GDR the topography is gently undulating with decreasing altitude to the south. The southern portion of the study area, south of Dalwogon, has RLs between about 320 m and 380 m AHD. This portion of the corridor, the vegetation has not generally been cleared
- alluvial floodplains of Nine Mile Creek, Eleven Mile Creek, Wallan Creek, Dogwood Creek and associated streams. The study area follows the upper edge of the Eleven Mile Creek floodplain south from approximately Kowguran. The Eleven Mile Creek floodplain is up to about 3 km wide, with a number of smaller streams joining the main creek, each having floodplains of approximately 1 km width. These floodplains have generally been cleared of vegetation and used for cattle grazing or fodder cropping.

9.3.2 GEOLOGY

Regional geology

The summary of geology, underlying the proposed pipeline corridor has been referenced to:

- detailed studies of the geology of the Wandoan region including photogeological interpretation (Snodin, 2004)
- Roma and Chinchilla sheets of the Geological Survey of Queensland's 1:250,000 series.

The geologic units in the region occur in generally west-north-west to east-south-east trending bands, which have been dissected by generally north or south trending creeks draining the GDR. Soils and the underlying rock of the proposed pipeline corridor are from the following main geological units:

- Quaternary age alluvium (Qa) consisting of sand, silt, mud and gravel along creeks and drainage lines. In the vicinity of Condamine Power Station Site this alluvium becomes sandy alluvium of the Condamine River
- Quaternary age sand plains (Czs) sourced from eroded Kumbarilla beds, south of the Great Dividing Range including the floodplain of Wallan Creek and the upper floodplain of Eleven Mile Creek
- Jurassic to Lower Cretaceous age Kumbarilla beds (Jsk) on the southern slopes of the Great Dividing Range and southern undulating landform, consisting of clayey labile to quartzose sandstone, siltstone, mudstone and polymictic conglomerate. Much of the profile is deeply weathered, containing younger ferruginous material
- Middle to Upper Jurassic age Orallo Formation (Jso) on the topographically higher ground including the GDR, consisting clayey lithic sandstone, siltstone, mudstone, claystone, minor bentonite and polymictic conglomerate
- Middle to Upper Jurassic age Gubberamunda Sandstone (Jsg) on topographically higher ground the northern slopes of the GDR, consisting of quatrzose to sublabile sandstone, conglomerate and siltstone
- Middle to Upper Jurassic age Injune Creek Group (Jsi) on the undulating landform north of the GDR, comprising sandstone and mudstone with coal. This unit is anticipated to comprise the Juandah Coal Measures, Springbok Sandstone and Westbourne Formation.

A map illustrating the geology of the proposed pipeline study area is shown on Figure 9-2-V2.3.

9.3.3 GEOMORPHOLOGY

The GDR forms a topographic high in the region, despite being highly weathered and displaying low relief, being up to about 460 m AHD. Drainage over the study area is generally towards the north and south from the GDR, with sediment from the GDR in the centre of the study area slowly transported by the creeks via the floodplains towards the Dawson River, located to the north of the study area and the Condamine River in the south-east of the study area.

The narrow floodplains, gentle slopes and confined meanders of drainage lines suggest that the landscape is geologically young north of the GDR. The ephemeral creeks are slowly cutting into and eroding the undulating hills, with lateral erosion of the valleys being the main large-scale landscape altering activity. Temporary deposition of eroded material occurs on the narrow floodplains. Erosion rates are anticipated to be low due to the relatively dry climate and low topographic gradient. Most erosion will occur during infrequent high rainfall events.

South of the GDR the topographic highs of the undulating terrain drain towards the south trending Eleven Mile Creek, Dogwood Creek and eventually the Condamine River. North of Miles Eleven Mile Creek and Dogwood Creek form a wide floodplain with mixed granular and clayey sediments, mainly sourced from coarse grained sedimentary rocks. Adjacent to the floodplain, extensive sand sheets have developed on Mesozoic sedimentary rocks.

East of Dogwood Creek the drainage is mainly east-west trending, draining the topographic high areas that are commonly associated with lateritised portions of sedimentary rocks.

Due to the relatively low relief and dry climate, the erosion rates in the topographic high areas and on the floodplains are anticipated to be low. Gullyhead erosion and intermittent transport of alluvial sediments appear to be the dominant geomorphic process operating in the area.

9.3.4 MINERAL RESOURCES

According to the Department of Energy and Mine's Interactive Resource and Tenure online maps (http://www.webgis.dem.qld.gov.au accessed on 15 August 2008), a number of petroleum leases (PL), and exploration permit for petroleum (EPP) exist over the proposed pipeline study area (refer Figure 9-3-V2.3). The petroleum leases include the leases from which the CSM water is being sourced. These PL and EPP are summarised below:

- PL216 (application) held by Origin Energy SCG Limited
- PL171 (granted) held by Roma Petroleum NL
- PL247 (application) held by Queensland Gas Company Limited
- PL267 (application) held by Origin Energy CSG Limited
- EPP747 (application), help by Arrow Energy Ltd
- EPP810 (granted) held by Arrow Energy Ltd
- EPP574 (granted) held by Victoria Petroleum NL
- EPP632 (granted) held by Queensland Gas Company Ltd
- EPP610 (granted) held by Queensland Gas Company Limited
- EPP702 (granted) held by Origin Energy CSG Limited
- EPP692 (granted) held by Origin Energy SCG Limited.

A number of exploration permits for Coal also exist along the proposed pipeline corridor.

- EPC1165 (granted), held by Metrocoal Limited
- EPC1134 (application), held by Surat Coal Pty Limited
- ECP1251 (application), held by Metrocoal Limited
- EPC1278 (application), held by Surat Coal Pty Ltd

- EPC787 (granted) held by Xstrata Coal Queensland
- EPC792 (granted) held by Xstrata Coal Queensland
- EPC 1118 (granted) held by Cougar Energy UCG Pty Ltd.

The proposed pipeline study area passes in close proximity to a number of small mining leases near Gurulmundi. These are:

- ML5907 (Ausben No. 2), held by Unimin Australia Limited
- ML5909 (Ausben No. 1), held by Unimin Australia Limited
- ML50058 (Ausben No. 3), held by Unimin Australia Limited
- ML5902 (Claymundi), held by Unimin Australia Limited
- ML5905 (Benton No. 1), held by Unimin Australia Limited
- ML5898 (Slippery), held by Unimin Australia Limited
- ML5906 (Benton No. 2), held by Unimin Australia Limited.

9.3.5 OVERBURDEN

Overburden is not relevant to this assessment.

9.3.6 SOILS

Land resource areas

Land resource areas (LRAs) are reoccurring landscape units with similar geology, landforms, soils and vegetation associations. They are used to simplify and aid quick field identification of land resource unit mapping and subsequent management. The LRAs of the proposed pipeline corridor are shown in Figure 9-4-V2.3.

The LRAs of the proposed pipeline study area are identified and described in the Wandoan District Land Management Field Manual (Gray and Macnish 1985), Evaluation of Agricultural Land in Taroom Shire (Forster 1985) and Understanding and Managing Soils in the Murilla, Tara and Chinchilla Shires (Maher 1996). These studies identified seven LRAs, which generally relate to the landscape units described in Section 9.3.1, and shown below:

- **Brigalow uplands.** Undulating plains with broad ridges and low hills, on sandstones and shales, with natural vegetation of Brigalow scrub
- **Glenhaughton forests.** Undulating plains, broad ridges and dissected hills on sandstones and shales, with natural vegetation of narrow-leaved ironbark forest
- **Poplar box flat plains.** Gently undulating to flat plains
- **Cypress pine sands.** Flat to gently undulating sandy plains
- **Brigalow plains.** Flat clay plains
- **Light forests.** Plateaus and low sandstone hills to undulating plains
- **Ironbark/bull oak forest.** Flat to gently undulating plains derived from weathered sandstone.

Soil types and descriptions

A number of soils have been identified as occurring within the LRAs of the proposed pipeline study area. These soils are anticipated to occur along the proposed pipeline corridor and are described below.

Brigalow uplands soils

Brigalow upland soils consist of cracking and non cracking clays and occur on the gently undulating topography. Surface soils are neutral to slightly alkaline, with low salinity and non-dispersive. Subsoils are generally moderately to strongly alkaline and are considered dispersive. Soils that occur within the Brigalow Uplands LRA and are anticipated to occur in the Pipeline corridor are:

- **Cheshire.** These soils occur on steeper gradient upper slopes (up to 3%). The topsoil consists of dark sandy clay to light clay, which tends to be dispersive in the lower topsoil. The subsoil is strongly alkaline, highly saline and dispersive. Under the Australian Soil Classification, this soil is a brown dermosol
- **Downfall.** These soils occur on mid to lower slopes on areas of sediment/slopewash accumulation. The topsoil is shallow brown-grey clay. Lower subsoils are strongly alkaline, dispersive grey and/or yellow-brown heavy clays. Under the Australian Soil Classification this soil is a brown vertosol
- **Kinnoul.** These soils occur on ridgetops and upper slopes, and are commonly covered by Brigalow regrowth. The topsoil consists of dark sandy clay or light clay with well developed blocky structure. Kinnoul is a shallower version of Cheshire, and often grades into Cheshire on upper slopes. The yellow-brown subsoil encountered in Cheshire is generally absent in Kinnoul. Under the Australian Soil Classification this soil is a brown dermosol
- **Rolleston.** These soils occur on mid and lower slopes. The topsoil is dark brown-grey heavy clay with blocky peds. Subsoils are dispersive, and lower sub-soils are strongly acidic or strongly alkaline. Under the Australian Soil Classification this soil is a brown dermosol
- **Rugby.** These soils manly occur on ridgetops. The topsoil is a yellow-brown sandy loam to clay loam. The soil has a shallow profile with weathered sedimentary rock generally encountered at less than 0.5 m depth. Under the Australian Soil Classification this soil is a dermosol
- **Teviot.** These soils occur on gently inclined midslopes. The topsoil is a brown-grey to dark brown-grey clay. Subsoils are grey-yellow-brown clays and are moderately alkaline, moderately saline and dispersive, tending to strongly dispersive with depth. Under the Australian Soil Classification this soil is a brown vertosol.

Glenhaughton Forest

Glenhaugton Forest soils have not been used widely for agricultural purposes, and as such limited soil characterisation information is available on the area. Occurrences of this soil in the proposed pipeline corridor are anticipated near Gurulmundi, and can be described as:

- **Texture contrast soils.** These soils occur throughout the Glenhaughton Forest LRA on a variety of landforms and slope positions. The soils are texture contrast, with a brown hard setting sandy loam surface soil over medium to heavy clays. Soil properties are variable, but generally have sodic subsoil. Under the Australian Soil Classification this soil is a brown sodosol.

Poplar box flat plains

Poplar box flat plains LRA occur on the gently undulating plains above the floodplains, south of the GDR. These soils occur north of Kowguran where the proposed pipeline corridor departs the Leichhardt Highway to follow the railway corridor. Soils that occur with the poplar box flat plains LRA and have the potential to occur in the proposed pipeline corridor are:

- **Braemer.** These soils occur on mid to upper slopes in sandstone plains and rises. The soils are texture contrast, with a grey-brown sandy loam surface soil over light clay. The soils have low fertility, subsoils are strongly sodic and highly saline. Under the Australian Soil Classification this soil is a brown sodosol
- **Weranga.** These soils occur on slopes, rounded hilltops and undulating plains. The soils are texture contrast, with a brown loamy sand surface soil over light to medium clay. The soils have low fertility and sodic and saline subsoils. Under the Australian Soil Classification this soil is a brown sodosol.

Cypress pine sands

Cypress pine sands LRA occurs on the flat to gently undulating sandy alluvial plains south of the GDR. Within the proposed pipeline corridor, these soils occur in the floodplains of various streams. Soils that occur with the cypress pine sands LRA and are anticipated to occur in the proposed pipeline corridor are:

- **Chinchilla.** These soils occur on terraces, sand ridges and alluvial plains of creek draining from weathered sandstone. The soils are texture contrast, with red-brown loose sandy loam surface over red loamy sand. The subsoils are non-sodic and non-saline. Under the Australian Soil Classification this soil is a rudosol
- **Davy.** These soils are mainly encountered on alluvial plains, terraces and creek banks draining from sandstone hills. The soils are uniform, with a brown, loose sand loam surface soil over sandy loam. The subsoils are non-sodic and non-saline. Under the Australian Soil Classification this soil is a rudosol
- **Combidiban.** These soils occur on sandy alluvial plains and terraces of small creeks, and on sandy plains above clay plains. The soils are texture contrast, with grey, loose, sandy loam topsoil over dark grey-brown medium clay. The subsoils are sodic. Under the Australian Soil Classification this soil is a grey chromosol
- **Bogandilla.** These soils occur on valley floors and floodplains associated with local drainage lines, and on the lower edge of brigalow clay plains. The soils are texture contrast, with a dark brown hardsetting clay loam surface soil over medium clay. Subsoils are strongly sodic and highly saline. Under the Australian Soil Classification this soil is a black sodosol.

Brigalow plains

Brigalow plains LRA occurs on the flat clay plains south of the GDR. One soil type from this LRA is anticipated to occur in the proposed pipeline corridor adjacent to the floodplain near Kowguran:

- **Tara.** These soils occur on flat to gently undulating plains and footslopes associated with elevated plains. The soils are uniform cracking clays, with brown, loose light clay surface over heavy clay. Subsoils are sodic, saline and alkaline. Under the Australian Soil Classification this soil is a grey vertosol.

Light forests

Light forests LRA occurs on plateaus and low sandstone hills and undulating plains. Within the proposed pipeline corridor, this LRA comprises most of the undulating hills south of the GDR. Soils that occur with the light forests LRA and are anticipated to occur in the proposed pipeline corridor are:

- **Minnabilla.** These soils occur on eroded ridgetops, scapes and slopes on laterised sandstone. The soils are uniform non-cracking sandy clay loams with weathered sandstone fragments from 0.1 m depth. The subsoils are non-saline and non-sodic. Under the Australian Soil Classification this soil is a rudosol
- **Binkey.** These soils occur on upper slopes on laterised sandstone. The soils are texture contrast, with brown sandy loam topsoil over medium heavy clay. The soils are strongly acid throughout, with low nutrient content, and strongly sodic subsoils. Under the Australian Soil Classification this soil is a brown kurosol.

Ironbark/bull oak forest

Ironbark/bull oak forest LRA occurs on flat to gently undulating plains derived from sandstone. Within the proposed pipeline corridor these soils occur adjacent the floodplains near Miles. Soils that occur with the ironbark/bull oak forest LRA and are anticipated to occur in the Pipeline corridor are:

- **Braemar.** As per the description of Braemar under ‘poplar box flat plains’
- **Cutthroat.** These texture contrast soils occur on flat to gently undulating plains and have dark brown loamy sand topsoil over sandy clay subsoil. The soils are non-saline, with low nutrient content and sodic lower subsoils. Under the Australian Soil Classification this soil is a brown sodosol
- **Channing.** These soils occur on flat to gently undulating plains derived from outwash from laterised sandstone. The soils are texture contrast soils, with brown-grey sandy loam to loam surface over red-brown clay. The soils are acid to strongly acid throughout, with strongly sodic and extremely saline subsoils. Under the Australian Soil Classification this soil is a red kurosol.

9.3.7 LAND SUITABILITY AND AGRICULTURAL LANDS

Land suitability

The land use suitability assessment was based on the Land Suitability Classification for Cropping and Grazing in the Semi-arid Sub-tropics of Queensland (Department of Mines and Energy, 1995). This classification system evaluates whether an area of land can sustain potential agricultural uses regardless of its current use.

All land within the proposed pipeline study area was within one of the following land use classes for either dryland cropping or beef cattle grazing:

- Class 1 – suitable land with negligible limitations and is highly productive requiring only simple management practices
- Class 2 – suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use
- Class 3 – suitable land with moderate limitations – land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use
- Class 4 – marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long-term
- Class 5 – unsuitable land with extreme limitations that preclude its use.

Distribution of land suitability classes for rain-fed cropping is provided in Figure 9-5-V2.3, and land suitability for beef cattle grazing is provided in Figure 9-6-V2.3.

Soils of the Brigalow Uplands LRA are a combination of Class 3 and Class 4 for dry land cropping. The mapping on Figure 9-5-V2.3 presents this LRA as Class 3, although some soils on steeper upper slopes (Cheshire and Kinnoul) will be Class 4 due to high erosion potential by surface runoff and the presence of alkaline subsoils that results in low nutrient availability; and some soils on lower slopes (Downfall and Rolleston) will be Class 4 due to high alkalinity within 0.6 m of the soil surface resulting in nutrient deficiency.

Cropping currently occurs within this Class 4 land, however, long term sustainability is limited due to low nutrient and high alkalinity conditions, shallow rooting depth, and the requirement for heavy application of fertilisers.

Glenhaughton Forests and all soils south of the GDR rated Class 4 and 5 for dry land cropping due to limited soil water holding capacity. Grazing and fodder cropping currently occurs within the Cypress Pine Sands LRA. This LRA was classed as Class 4 and 5 for dry land cropping as a result of the extremely low water holding capacity of the sandy soils. Agriculture on this land will require significant input to manage water.

North of the GDR, most of the study area is classed as Class 2 for beef cattle grazing. South of the GDR the study area is classed Class 3 to 5 for beef cattle grazing due to low soil water holding capacity.

Good quality agricultural land

In accordance with Section 2 and Attachment 2 of 'The Planning Guidelines: The Identification of Good Quality Agricultural Land' (Department of Primary Industries and Department of Housing, Local Government and Planning Queensland 1993), agricultural land classes A, B and C are considered GQAL in the area formally known as Taroom Shire and classes A and B are considered GQAL in the area formally known as Murilla Shire.

Agricultural land classes A, B and C are respectively be defined as:

- Class A: Crop land – land that is suitable for current and potential cropping with limitations to production which range from none to moderate level
- Class B: Limited crop land – land that is marginal for current and potential cropping due to severe limitations, and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered for cropping

- Class C: Pasture land – Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production, but some areas may tolerate a short period of ground disturbance for pasture establishment.

Under the Taroom and Murilla Planning Schemes most land within the proposed pipeline study area north of the GDR is classified as Class A agricultural land, while most land on and south of the Great Dividing Range is not GQAL, with the exception of the floodplain of Eleven Mile Creek, as shown in Figure 9-7-V2.3. However, the findings of this land suitability assessment presented in Section 3.8 of TR 9-1-V2.5 Geology, Mineral Resources, Overburden and Soils Impact Assessment indicate greater than 'moderate' limitations to dryland cropping for areas on the floodplains south of the GDR and over the lower slopes of the Brigalow Upland Soils. Consequently, the findings of this assessment suggest a different distribution of GQAL than the Taroom and Murilla Planning Schemes, with Class B agricultural land as a more appropriate classification for the lower slopes north of the GDR, and Class D land for the floodplains south of the GDR. This classification is mainly governed by the very low water holding capacity of soils in these areas.

9.3.8 SOIL CONSERVATION PLANS

No properties in the proposed pipeline study area are covered by soil conservation plans registered with the Department of Natural Resources and Water.

9.4 DESCRIPTION OF PROPOSED DEVELOPMENT

The proposed pipeline involves the construction and operation of a water pipeline from the Condamine Power Station near Miles, to the Wandoan Coal Project (the Project) Mining Lease Application (MLA) area.

The proposed pipeline will be approximately 93 km long and have a nominal diameter of 600 mm. The pipeline will be buried with approximately 0.6 m to 1.0 m cover and will be constructed using a section trench and backfill method.

The width of the proposed construction corridor will be about 20 m. Pre-construction works will include clearing of vegetation (where required), stripping of topsoil and formation of construction access tracks. Trenching would be used to construct the majority of the proposed pipeline and will be prepared ahead of construction. It is expected that a wheel trencher and excavator would be used to dig the trench for the majority of the route, being approximately 1.2 m-1.6 m deep and 0.9 m wide. In some areas, harder rock may be encountered and hydraulic rock breaking equipment may be required. Following placement of the pipeline, the trench will be backfilled, compacted and topsoiled.

All construction activities will be undertaken within the proposed construction corridor.

9.5 POTENTIAL IMPACTS

9.5.1 TOPOGRAPHY AND GEOMORPHOLOGY

The proposed pipeline will have negligible impact on topography as the trench will be fully backfilled and rehabilitated to the original ground surface and landform.

9.5.2 OVERBURDEN

Overburden is not relevant to this assessment.

9.5.3 SOILS

Alkalinity, sodicity and dispersivity

Most soils within the study area (with the exception of Kinnoul, Chinchilla, Davy and Minnabilla) have either sodic or alkaline subsoils. Brigalow Upland soils (with the exception of Kinnoul), are strongly sodic from about 0.3 m depth, and are also alkaline. Binkey subsoils are strongly sodic and acidic. The subsoils of Cheshire, Rolleston and Teviot, Binkey, Bogandilla, Weranga are anticipated to be strongly dispersive.

Alkaline and sodic soils are generally dispersive, and have high erosion potential if exposed. Sodic, alkaline and/or acidic subsoils are also poor plant growth mediums due to unfavourable growth conditions and low nutrient availability, and should not be used in rehabilitation of disturbed areas as surficial soils. The topsoil portion of these soils is considered suitable for use in rehabilitation.

Erosion

All soils in the proposed pipeline study area will be subject to erosion if vegetation is removed and the ground is disturbed.

Soils most susceptible to wind erosion are soils with sandy or loamy topsoils, which include the soils of Glenhaughton Forest, Poplar Box Flats, Cypress Pine Sands, Light Forests and Ironbark/Bull Oak Forest. If groundcover is disturbed, these soils will also be highly susceptible to water erosion including sheet erosion and gully erosion.

Soils with dispersive (sodic) topsoil or upper subsoil as discussed in 'Alkalinity, sodicity and dispersivity' above are also susceptible to erosion by water. Soils on steep and moderate upper slopes, as occur on undulating terrain, have higher risk from erosion by water than soils on gentle slopes and floodplain.

Exposure of dispersive subsoils has the potential to cause gullyhead erosion, even if only small areas of subsoil are exposed. After initiation, this erosion is anticipated to continue upslope and expose more dispersive soils.

Soils of Teviot and Braemar, and those within the Glenhaughton Forest LRA are potentially susceptible to tunnel erosion. Tunnel erosion forms when water infiltrates into dispersive subsoils and flows through cracks and channels. Dispersive clays are then suspended in the water, until the opening in the soil is enlarged and extended to form an outlet. Once a tunnel is initiated, free flowing water can enlarge it further.

Salinity

Soil salinity in the proposed pipeline study area is of limited extent and is not considered a high risk. However, some upper and mid slope soils within the Brigalow Uplands LRA (Cheshire and Teviot), Poplar Box Flat Plains and soils on the edge of alluvial plains (Bogandilla and Tara) have moderately to highly saline subsoils, and changes to the soil moisture regime due to vegetation removal or other impact may increase near surface soil salinity.

9.5.4 GEOLOGY AND FOSSILS

Uncovering fossil material

Fossil material is not expected to be uncovered during this work.

9.5.5 POST-CONSTRUCTION LAND SUITABILITY AND AGRICULTURAL LANDS

The proposed pipeline is proposed to be buried, and no reduction in land suitability class is expected as a result. Once construction has been completed, existing agricultural land uses will generally be able to continue over the corridor. Limitations to the siting of infrastructure such as sheds or irrigation equipment, and to practices that require excavation or disturbance of the soil may result from installation of the proposed pipeline.

9.6 MITIGATION MEASURES

The following section generally contains mitigation measures related to the construction and operation proposed pipeline. Mitigation measures related to the decommissioning of the proposed pipeline are covered in Chapter 25 Rehabilitation and Decommissioning.

9.6.1 TOPOGRAPHY

The proposed pipeline will have negligible impact on topography, and as such, mitigation measures are not required.

9.6.2 OVERBURDEN

Overburden is not relevant to this assessment.

9.6.3 SOILS

Dispersion and erosion

All soils will have high erosion potential if vegetation is removed and rehabilitation is not undertaken within an appropriate timeframe. Generally wind and water erosion control measures are proposed to be applied to all soils in the proposed pipeline study area, which include:

Site preparation and planning

- An erosion and sediment control plan will be prepared and implemented prior to the commencement of construction, specifying the locations and types of sediment and erosion control measures to be used.
- Vegetation clearing (including grass cover) will be limited to the minimal amount required for Project works.
- Site drainage, erosion and sediment controls will be implemented and in place prior to, or as soon as possible, following the removal of vegetation.
- Traffic will be confined to defined roads and access tracks to minimise soil disturbance.
- Infrastructure, parking and laydown areas will be located at sites with minimal slope grade.
- Hardstands will be constructed using erosion resistant material.

Managing water erosion

The following measures are proposed to be implemented to manage water erosion where appropriate:

- Erosion and sediment control measures will be installed on disturbed slopes to minimise erosion and sediment released into waterways. This is especially important for soils with sandy topsoil or dispersive subsoils.
- Water runoff will be directed around or away from disturbed areas using diversion bunds and catch drains as appropriate.
- Run-off from disturbed areas will be directed to sedimentation basins.
- Exposed soils will be revegetated as soon as practical after works have been completed. Soils on Light Forests LRA and Cypress Pine LRA will need to be revegetated with low water tolerant plants, or have soil amelioration measures to increase the water holding capacity of the soil.
- Disturbed and rehabilitated land will be retained with a rough surface (as opposed to a smooth surface) to slow overland water flow.
- The reinstated landsurface will be shaped to ensure that rain water is not channelised, but is allowed to disperse over a large area.
- All soil stockpiles will be bunded. Short term stockpiles may be bunded by sediment fencing, while long term stockpiles should have measures such as earthen bunds. Drainage works installed to divert overland flow from upslope of the longterm stockpile areas away from and around the stockpiles. Sediment traps or similar features will need to be installed downslope of stockpiles to present eroded sediment entering waterways.
- Erosion will be remediated as soon as practicable. This may include levelling the eroded area, capping with non-dispersive topsoil, application of seed and applying erosion control measures to prevent water impacting the site. The longer erosion is allowed to develop, the more costly and difficult it is to remediate.
- Any soil conservation measures, such as contour banks, that are disturbed during works will be reinstated following construction.

Managing wind erosion

The following measures are proposed to be implemented to manage wind erosion:

- Watering trucks will be used during windy conditions for dust suppression.
- vegetation clearing (including grass cover) will be limited to the minimal amount required for proposed pipeline works.
- Where appropriate, long-term (greater than 3 months) stockpiles of topsoil will be planted with vegetation to minimise entrainment of soil particles into the air and minimise erosion through raindrop impact.
- Exposed soils will be revegetated as soon as practical after works have been completed.

Managing dispersive soils

The following measures are proposed to be implemented to manage wind erosion:

- exposure of alkaline or sodic subsoils (e.g. all soils other than Kinnoul, Chinchilla, Davy and Minnabilla) should be avoided where possible, and should be limited to the minimal amount of time practicable
- alkaline or sodic subsoils should not be left exposed on the surface, and should be covered with topsoil or other material.

Tunnel erosion control

The following measures are proposed to be implemented to manage tunnel erosion:

- fill around the proposed pipeline will be compacted to at least the density of the surrounding soil material, and the filled trench left slightly higher than the natural land surface to minimise ponding or infiltration around the pipe
- all dispersive soils along the corridor will be fully capped with at least 0.2 m of topsoil with low erosion potential. Deeper topsoil depths have the potential to store rainwater and reduce infiltration into dispersive subsoils
- the geometry of the final landsurface will be managed to prevent the ponding of water on Teviot soils, to reduce the potential for infiltration into subsoils.

Monitoring

- regular (e.g. weekly or fortnightly) monitoring for erosion will be conducted during construction, including the trench and water management infrastructure
- erosion monitoring will continue until the vegetation cover has become fully established
- monitoring for the development of tunnel erosion will be undertaken quarterly for 12 months following the completion of construction.

Salinity

The following measures are proposed to be implemented in relation to soil salinity:

- the topsoil of Teviot is saline and generally will not be used as a topsoil layer in rehabilitation. Where suitable supply of other topsoil is available, this should be used in preference to Teviot, or Teviot soil mixed with this soil. Salt tolerant vegetation species may be required for rehabilitation on Teviot topsoils
- the subsoils of Cheshire, Teviot, Poplar Box Flat Plains soils, Bogandilla and Tara are saline and where practicable will be buried below the rooting depth plants and crops (i.e. below about 0.6 m depth).

Compaction

The following measures are proposed to be implemented in relation to compaction:

- soils that will be trafficked or compacted during construction will have water control and sediment containment measures installed to minimise potential erosion and sediment entering into waterways

- previously compacted areas that are to be rehabilitated will, where practicable, be remediated by ripping the top layer of soil. Ripping the top layer of soil breaks down the soil structure, and as a result protection of these areas from re-compaction (i.e. vehicles or grazing animals) after ripping is required to allow the soil structure to reform
- compaction of topsoil can be reduced by selection of appropriate earthmoving machinery for these soils (i.e. light weight vehicles with large wheel/track size).

Topsoil reuse

Suggested stripping depths and identified constraints for various encountered soil types are provided in Table 9-1. Topsoil is proposed to be managed as follows:

- stripped separately to subsoil and stockpiled during clearing for reuse in site rehabilitation
- stored in stockpiles no more than 3 m high to retain seed germination potential
- stored for the shortest period practicable, and where possible reused within 6 months of stripping to maximise the retention of the seed bank in the soil
- reused in the general area from which it was stripped
- during site rehabilitation works topsoil should be spread to a depth of not less than 0.2 m
- control measures such as fencing should be installed on newly topsoiled areas to exclude vehicle or stock access until a vegetation cover has established. Watering may need to be provided in the germination or early development stages of vegetation, together with appropriate seasonal timing of the revegetation works.

Table 9-1: Topsoil stripping depths and potential constraints for reuse

Soil type	Surface soil composition	Topsoil stripping depth (m)	Potential constraints
Brigalow Uplands LRA			
Cheshire	light clay	0.4	▪ highly alkaline and saline subsoil ▪ dispersive subsoil
Downfall	clay	0.15	▪ shallow topsoil depth ▪ dispersive subsoil
Kinnoul	clay	0.3	▪ low nutrient availability in topsoil ▪ dispersive subsoil ▪ shallow soil depth
Rolleston	clay	0.2	▪ alkaline ▪ topsoil may be dispersive ▪ dispersive subsoil
Teviot	clay	0.2	▪ dispersive subsoil ▪ moderately alkaline and saline
Rugby	loam	0.4	▪ sodic lower subsoil
Glenhaughton Forest			
Texture contrast soils	sandy loam	—	▪ stone and gravel ▪ very low pore available water capacity (soil water storage capacity)

Soil type	Surface soil composition	Topsoil stripping depth (m)	Potential constraints
			▪ low nutrient availability ▪ susceptible to wind erosion following disturbance
Poplar Box Flat Plains			
Braemar	sandy loam	0.15	▪ very low pore available water capacity (soil water storage capacity)
Weranga	loamy sand	0.05	▪ very low pore available water capacity (soil water storage capacity) ▪ sodic and dispersive subsoils ▪ highly saline lower subsoils ▪ impermeable subsoil ▪ low nutrient availability
Cypress Pine Sands			
Chinchilla	sandy loam	0.3	▪ low pore available water capacity (soil water storage capacity) ▪ susceptible to wind erosion following disturbance
Davy	sandy loam	0.4	▪ low pore available water capacity (soil water storage capacity) ▪ low nutrient availability ▪ susceptible to wind erosion following disturbance
Combidiban	sandy loam	0.3	▪ very low pore available water capacity (soil water storage capacity) ▪ variable topsoil depth ▪ susceptible to wind erosion following disturbance
Bogandilla	clay loam	0.1	▪ strongly sodic and dispersive subsoil ▪ highly saline lower subsoil ▪ low pore available water capacity (soil water storage capacity)
Brigalow Plains			
Tara	light clay	0.4	▪ sodic subsoils ▪ low to medium pore available water capacity (soil water storage capacity) ▪ gilgai (stripping difficulties)
Light Forests			
Minnabilla	sandy clay loam	0.1	▪ very low pore available water capacity (soil water storage capacity) ▪ very shallow profile depth ▪ stone and gravel
Binkey	sandy loam	0.3	▪ very low pore available water capacity (soil water storage capacity) ▪ stone and gravel ▪ acidic throughout ▪ low nutrient availability ▪ strongly sodic and dispersive subsoil

Soil type	Surface soil composition	Topsoil stripping depth (m)	Potential constraints
Ironbark/bull oak forest			
Braemar	sandy loam	0.15	▪ very low pore available water capacity (soil water storage capacity)
Cutthroat	loamy sand	0.3	▪ sodic lower subsoil ▪ very low pore available water capacity (soil water storage capacity) ▪ low nutrient availability
Channing	sandy loam to loam	0.15	▪ acidic throughout ▪ sodic and saline subsoil ▪ low pore available water capacity (soil water storage capacity)

Soil conservation plans

Although no approved soil conservation plans are present in the proposed pipeline study area, the following measures should be applied to soil conservation measures:

- existing soil conservation measures will be retained and maintained where they currently exist
- any soil conservation measures, such as contour banks, that are disturbed during works will be reinstated following construction.

9.6.4 POST CONSTRUCTION LAND USE

To maintain the existing land use and land suitability class after construction, the following measures should be implemented:

- topsoil should be stripped prior to construction and respread over the corridor following construction
- where applicable, the land surface should be left in a smooth even grade suitable for surrounding land use
- sodic or acidic subsoils should not be left on the land surface and should be buried below the rooting depth of crops (i.e. below about 0.6 m depth).

9.7 RESIDUAL IMPACTS

Following mitigation, the residual impacts are anticipated to be as follows:

- a buried pipeline
- some limitations on land use at sites of auxiliary infrastructure elements such as valves and signs
- potential restriction on landuse over the pipeline for farm infrastructure (i.e. sheds or irrigation equipment, etc.) and to practices that require deep excavation or disturbance of the soil.

9.8 REFERENCES

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