Wandoan Coal Project
Geology, mineral resources, overburden and soils impact assessment
Western CSM Water Supply Pipeline

October, 2008

Wandoan Joint Venture

Parsons Brinckerhoff Australia Pty Limited ABN 80 078 004 798

Level 4, Northbank Plaza
69 Ann Street
Brisbane QLD 4000
GPO Box 2907
Brisbane QLD 4001
Australia
Telephone +61 7 3854 6200
Facsimile +61 7 3854 6500
Email brisbane@pb.com.au

NCSI Certified Quality System ISO 9001

2133006C-RPT033-A:ow

Author:	Olivia White — Environmental Scientist
Signed:	O White
Reviewer:	Josef Major — Senior Engineering Geologist;
Signed:	
Approved by:	Helen D'Arcy — Senior Environmental Engineer
Signed:	
Date:	October, 2008
Distribution:	Wandoan Joint Venture, PB File, PB Library

Contents

Contents (continued)

Page Number

List of tables

List of figures

List of attachments

Glossary

A horizon	See topsoil
Acid generating potential	Potential of spoil material to form acid conditions when oxidised (i.e. contact with air).
Action Plan	Internal document of a business centre or employee defining goals to be achieved in the budget period. Action items may also be referenced in an employee's job description.
Alluvium	Any stream laid sediment deposit found in a stream channel and in low parts of a stream valley subject to flooding.
Anthropogenic	Caused or influenced by humans.
Australian Height Datum (AHD)	A level datum, uniform throughout Australia, based on an origin determined from observations of mean sea level at tide gauge stations, located at more than 30 points along the Australian coastline.
Best Practice Environmental Management	Management of an activity to minimise environmental harm through cost-effective measures, assessed against measures currently used for the activity by the mining industry in Queensland.
Borehole	A hole produced in the ground by drilling or driving.
Bushland	A functional, multi layered, semi-natural plant community including a permanent tree layer, natural or established (e. g. on spoil). The area would be capable of sustaining flora and fauna habitats.
California bearing ratio (CBR)	A measure of the bearing capacity of a soil obtained from a standard soil penetration resistance test.
CHPP	Coal handling and preparation plant.
Chromosol	Soils with strong texture contrast between A horizons and B horizons, in which the B horizons are not strongly acid and are not sodic, as defined by Isbell (1998).
Clay	Particles with a diameter less than 0.002 mm (McDonald et al.1998).
Clean water	Rainfall runoff flowing off lease in compliance with licence conditions.
Competent rock	Rock that is considered suitable for the intended use.
Competent spoil	Non acid, non dispersive durable spoil with potential characteristics to resist erosion.
Controlled discharge	Release of lesser quality water from the mining lease into better quality receiving water under conditions that allow for measured dilution to a predetermined water quality standard.
Cover material	Soil or other suitable plant growth medium placed on reshaped spoil surfaces; typically non crusting and low salinity.

Dermosol	Soil with a structured B2 horizon and lacking strong texture contrast between the A and B horizons, as defined by Isbell (1998).
Diversions/diversion channels	Structures for the controlled re-direction of drainage lines and watercourses around open cut pits and infrastructure areas.
DTPA	Diethylene triamine pentaacetic acid. A chemical used for the extraction of metal ions during chemical analysis.
Dyke	Sheet-like igneous intrusion cross cutting bedding planes, commonly sub-vertical.
EC	Electrical conductivity, a measure of the dissolved salts in a substance.
Erosional stability	The ability of a rehabilitated area to resist the natural forces of soil erosion.
Exploration track	Temporary vehicle traffic route used for exploration or infrequent access from which topsoil has not been removed.
Externally drained	Rainfall runoff water that reports to the external environment of a structure via local drainage systems.
Feldspar	A group of abundant rock forming minerals of the general formula MAI (Al, Si)3O8, where M can be potassium (K), sodium (Na), calcium (Ca), barium (Ba), rubidium (Rb), steradian (Sr) or iron (Fe).
FoS	Factor of Safety.
Functional vegetation	Vegetation that consists of species able to survive and regenerate under specific conditions, providing soil erosion control and fauna habitat.
Geochemistry	The chemical characteristics of a soil or rock material.
Geomorphology	Study of the characteristics, origin and development of land forms and the processes that act on them.
Geotechnical stability	Resistance of a natural slope or earth structures to mass movement and erosion.
Gilgai	The phenomena of an irregular land surface with mounds and depressions formed due to clay horizons shrinking and swelling with alternate drying and wetting cycles.
Graded banks	Cross slope earthen banks constructed on reshaped spoil areas, typically at horizontal intervals of approximately 50 m and 1 to 1.5% longitudinal gradient, to reduce the effective slope length and control the runoff flow rate.
Holocene	The most recent epoch of geological time, spanning to 10,000 years before present.
Hostile spoil	Acid, sodic or saline spoil deleterious to seed emergence, geotechnical and geochemical stability of spoil.
Incident register	A database of environmental incidents, causes and remedial actions.

Internal drainage	Drainage of rainfall runoff from reshaped spoil areas confined and ponded within the spoil area.
Leaching profile	Vertical change in chemical concentrations down the soil profile due to leaching.
MLA	Mine Lease Application
NATA	National Association of Testing Authorities Australia
Overburden	The soil or other mineral matter which has to be removed to gain access to the underlying material.
PAWC	Plant available water capacity.
Plan	Set of actions required to ensure the achievement of a stated objective/program.
Plant growth medium	Material which is typically non crusting and has low salinity levels, in which plant seed will germinate and establish.
Policy	Stated commitment to achieving objectives.
Program	Management supported work commitment, budget and time frame to achieve a stated objective.
Quaternary	The geological period of time from the present to two million years ago.
Refuse dump	Site to be used for the permanent placement of waste.
Regional Ecosystems	A vegetation community, within a bioregion, that is consistently associated with a particular combination of geology, landform and soil, As defined by Sattler & Williams (1999) in The Conservation Status of Queensland's Bioregional Ecosystems.
Regulated waste	Non-domestic waste as defined in Schedule 7 of the Environment Protection (Waste) Regulation 1998, (whether treated or immobilised) and includes: a) for an element — any chemical compound containing the element b) anything that has contained the waste.
Rehabilitation	Reshaping of a disturbed area to a geotechnically and geochemically stable condition, followed by revegetation.
Revegetation	Establishment of suitable plant species to support the agreed post mining land use and control soil erosion to sustainable levels.
Rock mulch	Durable or competent rock purposely placed on an area under rehabilitation to provide additional resistance to erosion.
Saline	Presence of salts, in water or spoil, generally undrinkable or in sufficient concentration to impair plant growth.
Sand	Natural mineral particles with a diameter between 0.02 mm to 2.0 mm (McDonald et al.1998).

Sediment dams	Large impoundment structures used to retain rainfall runoff to allow settlement of suspended particles, prior to discharge.
Sill	Sheet-like igneous intrusion within coal seams or along bedding plane partings.
Silt	Mineral particles with a diameter between 0.002 mm to 0.02 mm (McDonald et al.1998).
Silt traps	Small impoundment structures built within a drainage line, which retard water flow and allow suspended solids to settle out.
Sodic	A soil is considered sodic when the exchangeable sodium percent (ESP) is greater than 6. Sodic conditions usually result in clay dispersion and surface crust formation.
Sodosol	Soils with a strong texture contrast between A horizons and sodic B horizons which are not strongly acid, as defined by Isbell (1998).
Soil	That part of the upper weathered layer of the earth's crust which can support plant growth.
Soil horizons	Soil horizons as defined by McDonald et al. (1998) are: O — surface layer dominated by organic material in varying stages of decomposition A — one or more surface mineral horizons with some organic accumulation A1 — mineral horizon at or near the surface with some accumulation of humified organic matter. It is usually darker than underlying horizons A2 — mineral horizon having less organic matter, sesquioxides and/or silicate clay than immediately adjacent horizons. It is usually paler in colour than the A1 or B horizon. A3 — transition horizon between the A and B horizons, which is similar to the A horizon B — one or more mineral soil layers characterised by a concentration of silicate clay, iron, aluminium and/or organic material; and/or a differing structure, consistence or colour of the A horizon. B1 — transitional horizon between the A and B horizon which is similar to the B horizon B2 — horizon dominated by an illuvial, residual or other concentration of silicate clay, iron, aluminium and/or humus, and/or maximum development of pedological organisation. B3 — transitional horizon between the B and C horizon which is similar to the B horizon C — consolidated and unconsolidated material below the A and B horizon. Usually partially weathered and little affected by pedological processes.
Spoil area	Area where overburden has been dumped.

Subsoil	The B horizon within the soil profile which lies immediately below the topsoil or A horizon. The subsoil is not enriched with organic material as is the topsoil. It may also be subject to clay and/or salt accumulation.
Suitably qualified person	A person whose professional training or experience is relevant to the matter being considered (EPA, 2007).
Sump	Temporary excavation for the storage of water.
Sump	Temporary excavation for the storage of water.
t	tonne
Tension cracks	Cracks at the ground surface which occur due to tensional forces in the soil or rock mass, behind the crest of a slope.
Test pit	An excavation for examination of subsurface soil conditions.
Topsoil	The uppermost horizon (or A horizon) of the soil profile which usually contains the organic matter, biota and a concentration of the nutrients.
Vertosol	Clay soil with high shrink-swell properties as defined by Isbell (1998).
Waters	River, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, bed and bank of any waters, dams, non-tidal or tidal waters or any part-thereof.
Wetland	Area where natural flow has been permanently interrupted and will remain as a feature of the landform after mining.
WJV	Wandoan Joint Venture

Executive summary

This geology, mineral resources, and soils assessment was undertaken to assess and define the existing land-related site characteristics that may impact on or be impacted by the proposed Western CSM Water Supply Pipeline (the proposed pipeline) associated with the Wandoan Coal Project, to assess the soil and requirements and reuse potential.

The soils and land suitability assessment comprised a review of available published data, classification and mapping of soils, and a land suitability assessment.

The proposed pipeline study area is located in an area mainly underlain by the Jurassic age Injune Creek Group rocks with Quaternary age alluvium along existing streams. The study area consists of three land resource areas (LRA), Brigalow Uplands, Poplar Box Alluvia and Belmont. The Brigalow Uplands and Belmont LRA consists of undulating hills at a surface elevation (RL) of approximately 250 m to 295 m Australian height datum (AHD) with slope gradients generally less than 4%. The Poplar Box Alluvia LRA consists of alluvial floodplains of the various creeks that traverse the Pipeline study area, with an RL of approximately 230 m to 250 m and a typical floodplain width of between 500 m and 2 km.

Fourteen different soil types are anticipated to occur within the proposed pipeline study area, including cracking and non-cracking clays on the undulating hills, and uniform and texture contrast soils on the floodplains. Subsoils over much of the proposed pipeline study area are alkaline, sodic and dispersive and will require specific management techniques such as minimising exposure to prevent erosion, including tunnel erosion. Soils identified as most susceptible to erosion include Cheshire, Woleebee, Teviot, Pamaroo and Nimitybelle.

Based on the former Taroom Shire Council Planning Scheme (2006) and Bungil Shire Council Planning Scheme (2006), all of the proposed pipeline study area is classed as good quality agricultural land (GQAL).

A land suitability assessment for dry land cropping, and beef cattle grazing was carried out for the proposed pipeline study area, which generally supported the GQAL mapping, but found the area to be Class B GQAL rather than Class A. The proposed pipeline is not expected to impact the land suitability classification of land within the study area, but will limit the potential for some agricultural practices or infrastructure to be sited on the land.

1. Introduction

1.1 Project background

The Wandoan Coal Project (the Project) comprises the development of thermal coal resources situated immediately west of the Wandoan township, located in the Dalby Regional Council. The Project is located approximately 350 km north-west of Brisbane and 60 km south of Taroom as shown in Figure 1-1. The Project will be developed by the Wandoan Joint Venture. The joint venture partners are Xstrata Coal Queensland Pty Ltd (XCQ), ICRA RPW Pty Ltd and Sumisho Coal Australia Pty Ltd.

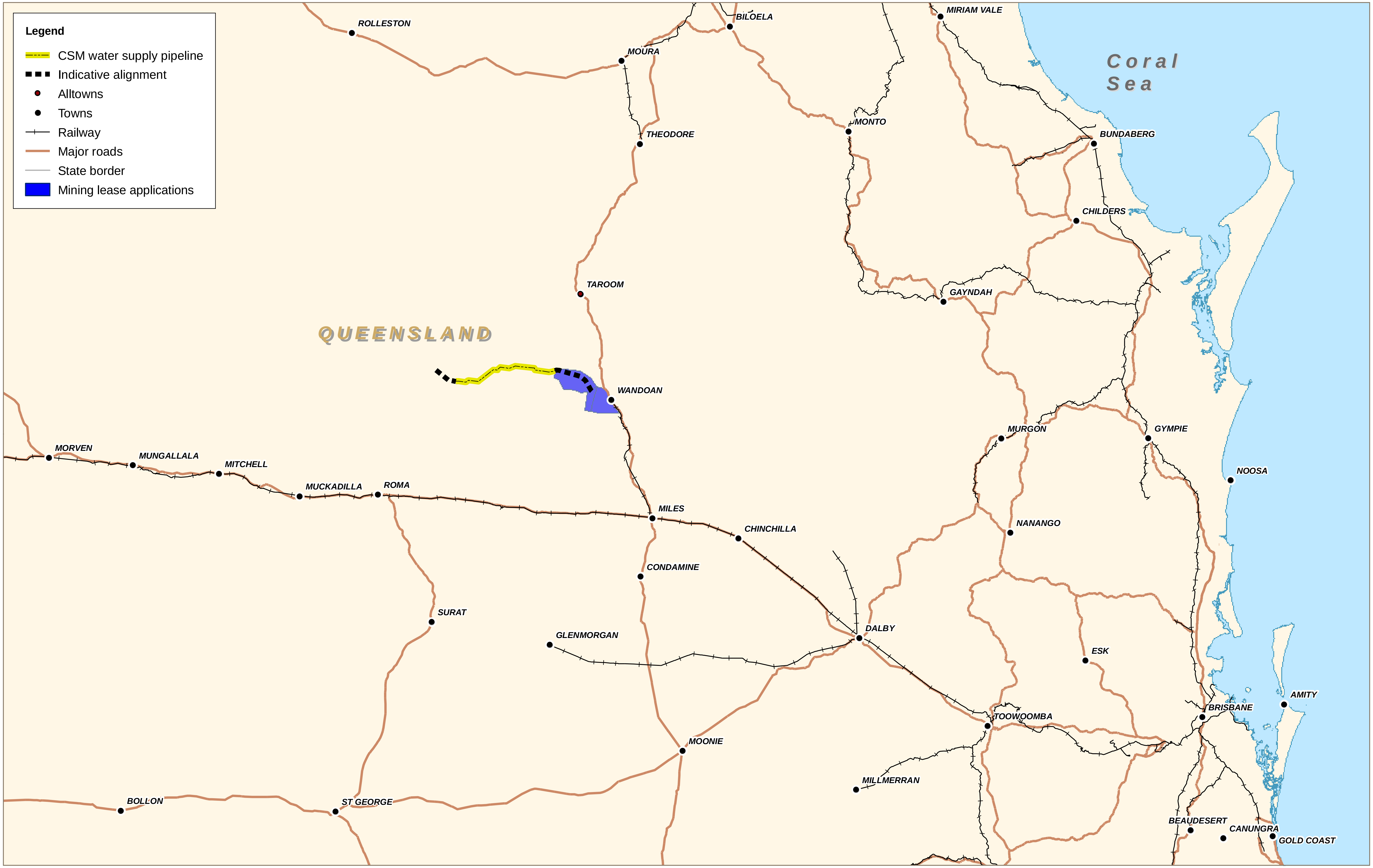
The Project will include on-site coal handling and processing which will require a constant and reliable water supply, which is anticipated to peak at approximately 9,100 ML/a. A potential water resource to help satisfy this demand has been identified at the Origin Energy and Santos coal seam methane extraction wells located at Spring Gully and Fairview, approximately 100 km west of the Wandoan Coal Project site.

This technical report covers a proposed water pipeline corridor to transfer coal seam methane (CSM) by-product water resulting from the extraction of CSM from wells at Spring Gully and Fairview, to the Wandoan Coal Project. The portion of the Project covered by this technical report will be referred to as the Western CSM Water Supply Pipeline (the proposed pipeline).

1.2 Description of study area

The study area for this geology, mineral resources, overburden and soils assessment comprises a 91 km corridor from the Spring Gully Reverse Osmosis (RO) Plant to the mining lease application (MLA) areas of the Wandoan Coal Project. (refer Figure 1-2).

The study area is located in a landscape that has been highly modified by past land uses including agriculture (i.e. grazing and cropping). Vegetation in the local area is therefore highly fragmented and relictual (i.e. <10% retained). The hydrology in the proposed pipeline study area is dominated by a number of north flowing ephemeral creeks.



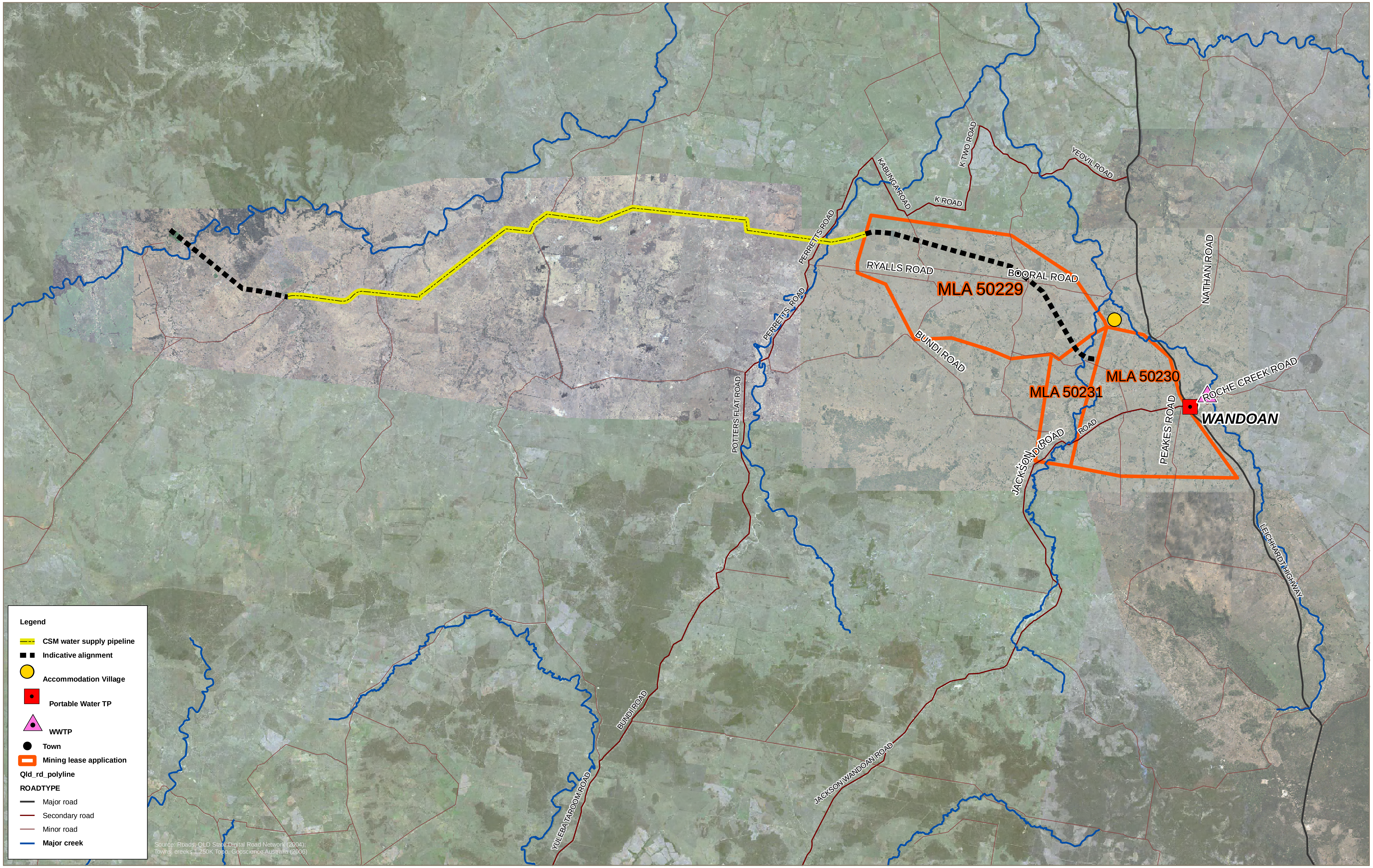
J:\A442-ENG\PROJ\2133006C__Wandoan_prefea\10_GIS\Projects\Env\Technical Report\Figure 1-1 Project Location.mxd

Source: Roads, QLD State Digital Road Network (2004); Towns, Coastline , boundaries, 1:250K Topo, Geoscience Australia (2006)

PARSONS BRINCKERHOFF

0 25 50 75 100 125
Kilometers

Figure 1-1
Project Location



PARSONS BRINCKERHOFF

0 5 10 15 20 25

Kilometres

Figure 1-2

Proposed pipeline area

2. Methodology of assessment

2.1 Relevant legislation and guidelines

2.1.1 State planning policy 1/92 Development and conservation of agricultural land, 1992

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.

The State Planning 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.

The State Planning Policy 1/92 is largely implemented at the local government level, and requires local governments to include maps of good quality agricultural land (GQAL) in their planning schemes.

2.1.2 Planning guidelines: The identification of good quality agricultural land, 1993

The Planning Guidelines assist the implementation of State Planning Policy 1/92, through the provision of a methodology for assessing and identifying agricultural land classes and subsequently GQAL.

Under the Planning Guidelines, land is classified into classes, ranging from Class A being cropping land with moderate to no production limitations, to Class D being land not suitable for agriculture due to extreme limitations. Which agricultural land classes are considered GQAL within each local government areas was established during the preparation of the planning guidelines in 1993, based on publicly available land resource mapping such as Department of Primary Industries manuals and CSIRO reports. The planning guidelines acknowledge that much of this mapping is at a broad scale, and that site-specific assessments may be needed to confirm the distribution of QGAL.

2.1.3 Environmental Protection (Water) Policy 1997

The Environmental Protection (Water) Policy (EPP (Water)) is a policy under the Environmental Protection Act 1994. The policy defines and protects environmental values of Queensland waterways.

Under Section 32 of the EPP (Water) it is an offence to allow sand, silt or mud to accumulate in a waterway or where it could wash into a waterway unless it is permitted by an Environmental Authority under the *Environmental Protection Act 1994*.

2.1.4 Land suitability classification for cropping and grazing in the semi-arid sub-tropics of Queensland

The land suitability classification system used in this assessment was produced by the Department of Mines and Energy in 1995, and provides a framework for the assessment of the suitability of land for cropping and grazing purposes, based on a range of soil and landscape characteristics (Grey and Macnish 1985). The guidelines were prepared for use in relation to mining and exploration projects for the assessment of pre-disturbance and post-disturbance land capability, but have now been widely adopted as a tool to assess land use potential relating to a range of infrastructure projects.

2.2 How the study was conducted and information obtained

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

- define potential soil types occurring along the corridor
- define anticipated lateral extent of various soils
- assess land suitability classes
- assess available topsoil types and suggested stripping depths
- assess erosion potential of the topsoil and subsoil materials.

2.2.1 Review of existing information

A number of previous studies have been conducted into soils and their properties at and around, the proposed pipeline. Previous investigations that provided information for this report regarding soil and landscape characteristics 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
- Macnish, S.E. (1987) Land Management Field Manual Roma District
- McNee, D.A.K. (1984) Cropping in the Maranoa and Warrego.

2.2.2 Field assessment

No field work was conducted for this assessment. However all previous studies had a field assessment component.

2.2.3 Laboratory testing

No laboratory testing was conducted for this assessment. Soil characteristics were derived from review of previous studies.

2.2.4 Soil mapping and classification

Classification of soils for the proposed pipeline study area was based on published soil classification data as listed in Section 2.2.1 of this report, and review of topography and aerial photography.

The adopted soil classification system is the Australian Soils Classification system (Isbell 1996). Where soil descriptions correlate with soil types in the references in Section 2.2.1, soil names from these references have been adopted.

2.2.5 Overburden assessment

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

2.2.6 Land suitability assessment

Land suitability assessments incorporating the proposed pipeline study area have previously been conducted by Grey and Macnish (1985), Forster (1985), Macnish (1987) and McNee (1984). The findings of these land suitability assessments were reviewed in relation to the proposed pipeline study area, and the land assessed for its suitability for dry-land cropping and cattle grazing on improved pasture. The criteria used for assessing the suitability of land for specific agricultural uses are included in Attachment A. The land was then classified into one of five land suitability classes for each potential land use assessed, relating to the land use limitations.

The land classes are shown below:

- 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.

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

2.3 Limitations

The assessment has been based on a desktop review of published land resource related reports. Soil in these reports have generally been mapped to the ‘land resource area’, with a description of the occurrence of soils within these land resource areas, and are mapped to 1:100,000 scale.

No field investigation or field confirmation of soil types or soil boundaries have been conducted with this assessment, although a review of topography and aerial photography has been carried out.

Soils are not discrete units, and variation of properties will occur within each of these soil types. The scale of mapping also will not identify small isolated occurrences of difference soils within each mapped unit.

3. Existing environment

3.1 Topography

The contours of the proposed pipeline study area is shown on Figure 3-1. Two main terrain elements are present in the proposed pipeline study area:

- alluvial floodplains of Eurombah, Slatehill, Barton, Kangaroo, Canal and Horse Creeks. These northerly flowing creeks are generally ephemeral and the floodplains vary in width from less than 500 m to about 2 km. The width of the floodplain generally increases from eastern creeks to the west. These landscapes occur at a reduced level (RL) of approximately 230 m to 250 m Australian height datum (AHD)
- low undulating hills, with an RL of between 250 m and 295 m AHD make up the majority of the Pipeline study area. The undulating hills are generally at a greater relief in the west of the study area than to the east.

As the creeks are generally north trending, the east-west trending proposed pipeline corridor is will cross the topographic low areas along the creeks and the corresponding north-south trending ridgelines between two adjacent creeks.

3.2 Vegetation

The majority of proposed pipeline study area consists of cleared or highly disturbed non-remnant vegetation and is generally represented by open pastoral expanses or degraded road reserves dominated by pastoral grasses.

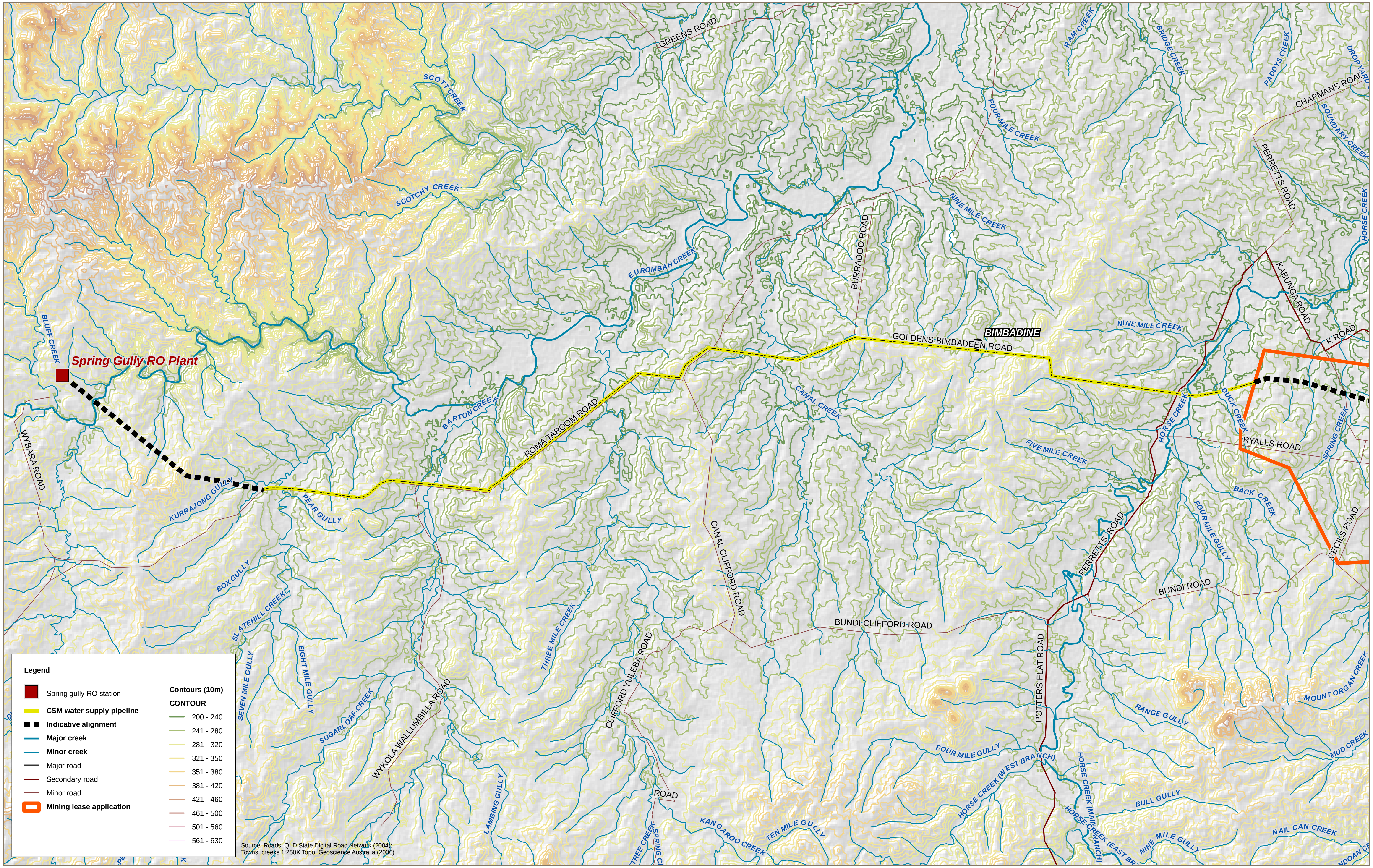
The majority of remnant vegetation in the proposed pipeline study area consists of *Eucalyptus tereticornis* (Queensland blue-gum) lining drainage lines and adjoining Eucalypt woodland dominated by *Eucalyptus populnea* (Poplar box), *Eucalyptus melanophloia* (Silver-leaved Ironbark) and occasional *Acacia harpophylla* (Brigalow) on the floodplain. A detailed description of the vegetation in the proposed pipeline study area is found in Chapter 17A Terrestrial Ecology and associated technical report.

3.3 Geology

3.3.1 Regional geology

The proposed pipeline study area is located with in the Surat Basin, an eastern lobe of the Great Artesian Basin. The Surat Basin contains up to 2,500 m depth of sediments comprised mainly of Jurassic clastic continental rocks and Early Cretaceous marine beds (Green and Chestnutt, 2007).

The geological history of the Wandoan-Taroom-Roma region is based on deposition of sedimentary material and subsequent erosion. During the Late Triassic, freshwater streams deposited sand over much of the region. This was followed by a period of widespread erosion in the Late Triassic, and then a cyclic period of fluvial sedimentation followed by erosion between the Early Jurassic and Early Cretaceous. Extensive coal deposits formed during Middle Jurassic time.



PARSONS BRINCKERHOFF

0 2 4 6 8 10
Kilometres

Figure 3-1:
Site Topography

Since the Late Jurassic the Surat Basin has been stable. A marine transgression in the Early Cretaceous was the last major sedimentary episode, after which the sea withdrew during the Late Cretaceous.

Deep weathering of the land surface occurred during the Tertiary, however subsequent erosion has since stripped this profile from the northern areas of the Surat Basin (Slater 1986). South of Wandoan large areas of deeply weathered material form plateaus along the Great Dividing Range, and mesa topography elsewhere.

3.3.2 Local geology

The geology underlying the proposed pipeline study area has been referenced from detailed studies of the geology of the Wandoan region including photogeological interpretation (Snodin 2004), and the Roma and Taroom sheets of the Geological Survey of Queensland's 1:250,000 series. The geologic units in the wider Wandoan region occur in generally west-north-west to east-south-east trending bands, which have been dissected by quaternary age creeks flowing north, away from the Great Dividing Range.(GDR). Soils and the underlying rock of the proposed pipeline are from the following main geological units:

- quaternary age alluvium (Qa) consisting of sand, silt, mud and gravel in the recent creeks and drainage lines
- 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 likely to consisting of the Westbourne Formation and Springbok Sandstone
- Lower Jurassic age Hutton Sandstone (Jshu) on the undulating terrain around Spring Gully, comprising quartzose sandstone minor carbonaceous siltstone and shale.

The geology of the proposed pipeline study area is shown on Figure 3-2.

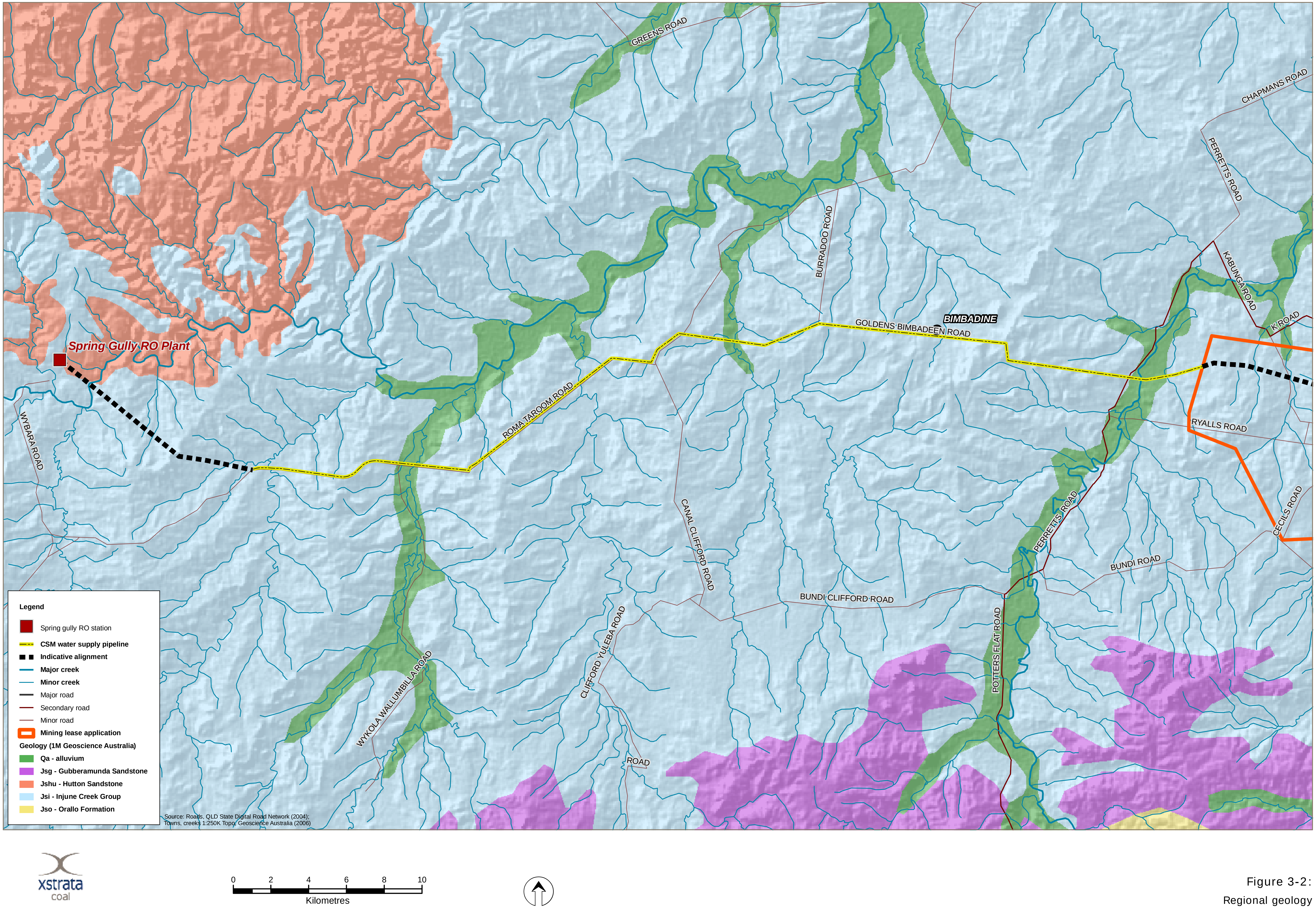
3.4 Mineral resources

According to the NRW's Interactive Resource and Tenure online maps (accessed on 15 August 2008), a number of petroleum leases (PL), and exploration permit for petroleum (EPP) exist over the Western CSM Water Supply Pipeline study area (refer Figure 3-3). The petroleum leases include the leases from which the CSM water is being sourced. These PL and EPP are summarised below:

- PL204 (granted) held by Origin Energy CSG marketing Pty Limited
- PL195 (granted) held by Origin Energy CSG Limited
- PL203 (granted) held by Origin Energy CSG Limited
- EPP852 (granted), held by Pure Energy Resources Limited
- EPP592 (granted), held by Origin Energy CSG Limited.

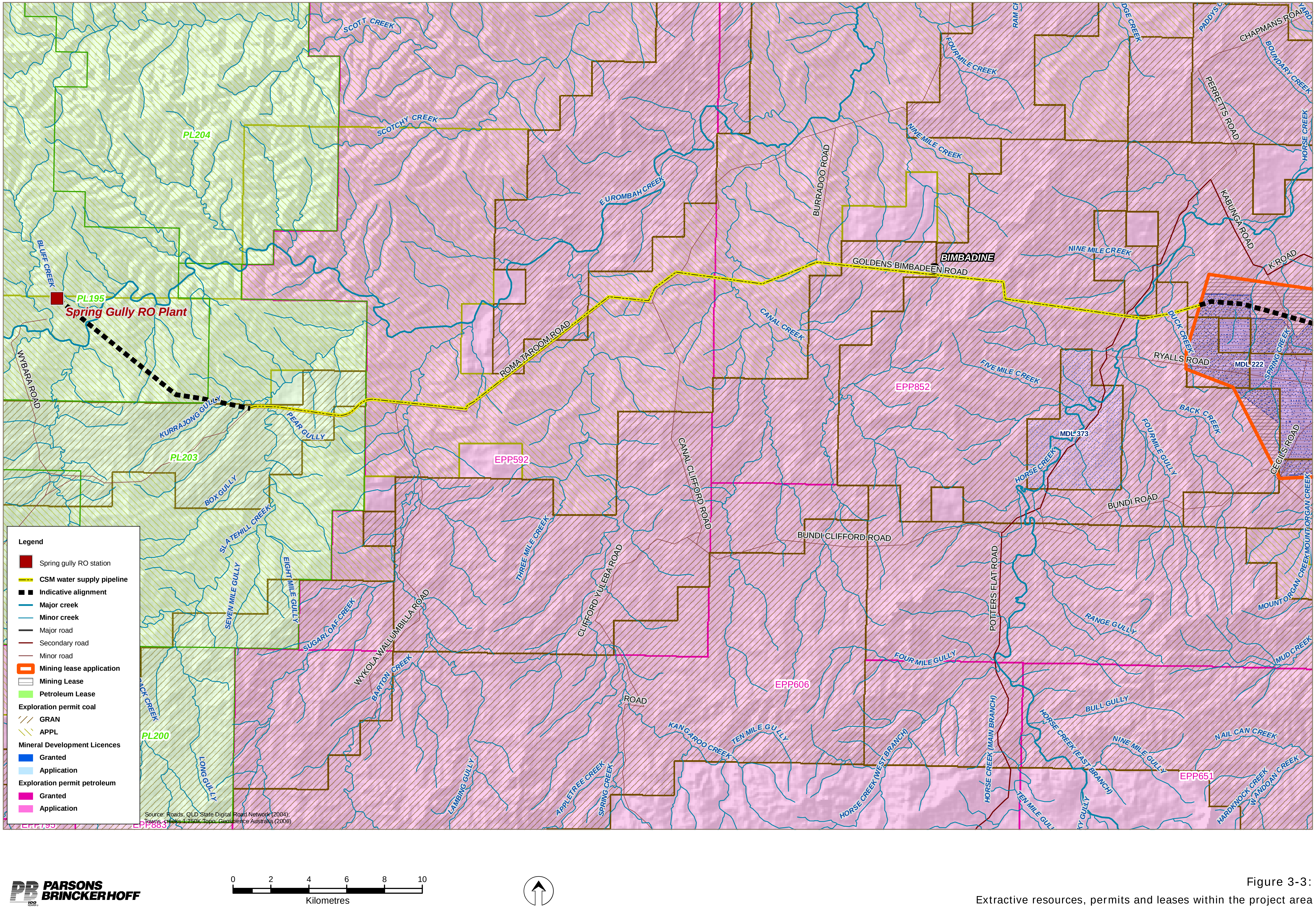
A number of exploration permits for Coal also exist along the pipeline corridor:

- EPC1164 (granted) held by Metrocoal Limited
- EPC1275 (application) held by Queensland Thermal Coal Pty Ltd



xstrata coal

Figure 3-2:
Regional geology



PARSONS BRINCKERHOFF

Figure 3-3:
Extractive resources, permits and leases within the project area

- EPC1274 (application) held by Queensland Thermal Coal Pty Ltd
- EPC859 (granted) held by Xstrata Coal Queensland Pty Ltd
- EPC1171 (granted) held by Taroom Coal Pty Ltd
- EPC791 (granted) held by Xstrata Coal Queensland Pty Ltd
- EPC787 (granted) held by Xstrata Coal Queensland Pty Ltd
- EPC 650 (granted) held by Taroom Coal Pty Ltd
- EPC789 (granted) held by Xstrata Coal Queensland Pty Ltd
- EPC1143 (granted), held by Xstrata Coal Queensland Pty Ltd.

A number of exploration bores and production bores exist at the western extent of the proposed pipeline, consisting of the Spring Gully gas fields from which the CSM water is being extracted as a by-product.

3.5 Geomorphology

Drainage over the proposed pipeline area is generally towards the north, with sediment from the GDR in the south slowly transported by the creeks via the floodplains towards the Dawson River, located to the north of the proposed pipeline.

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.

3.6 Overburden

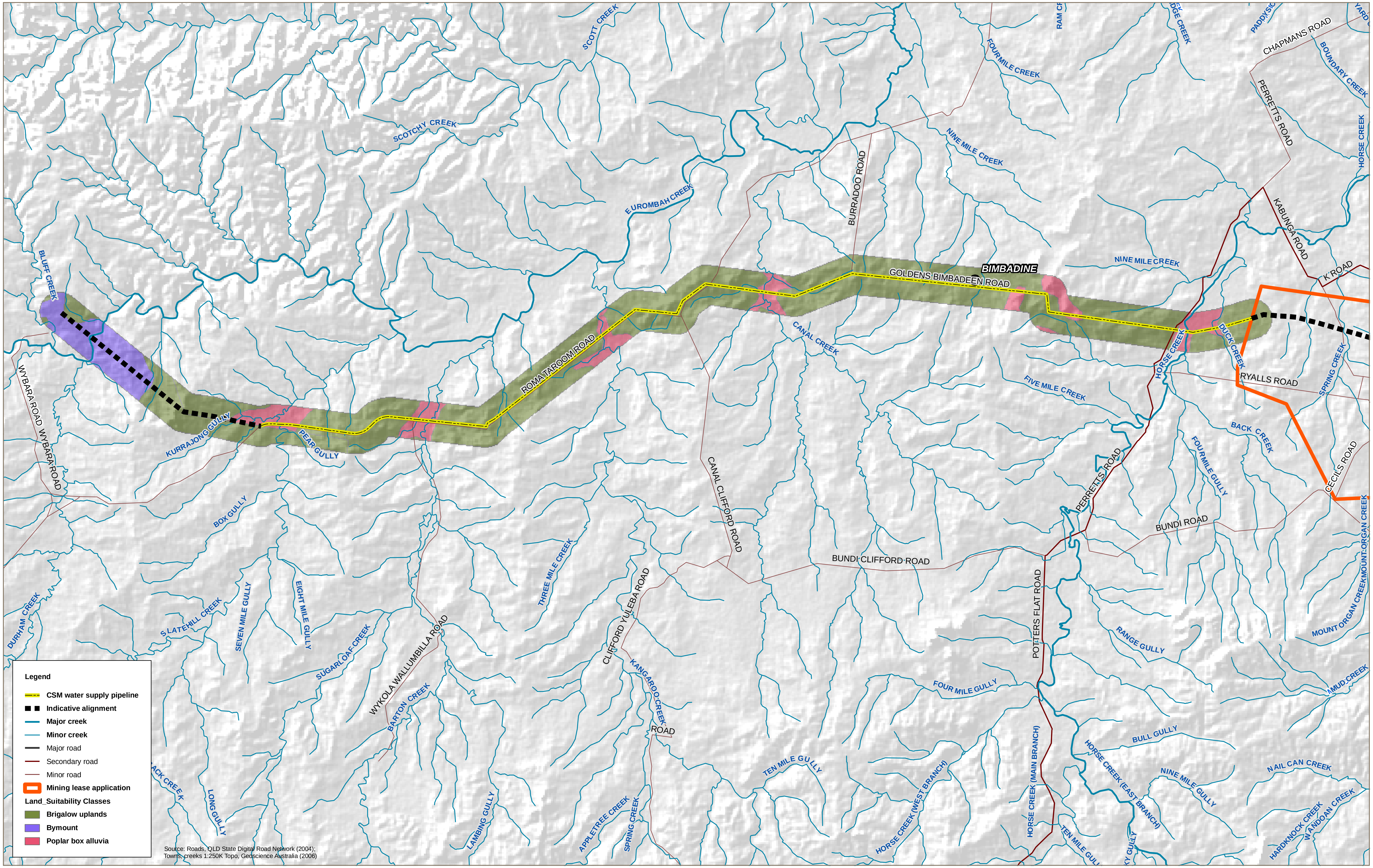
Overburden is not relevant to this assessment

3.7 Soils

3.7.1 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 LRA of the proposed pipeline corridor are presented in Figure 3-4.

The Wandoan District Land Management Field Manual (Gray and Macnish 1985) identified two LRAs in the proposed pipeline study area, and the *Roma District Land Management Field Manual* (Macnish 1987) identified a third LRA in the western portion of the corridor. These previously identified LRAs are shown in Table 3-1. *Evaluation of Agricultural Land in Taroom Shire* (Forster 1985), identified similar LRA, but named the LRA ‘Wandoan’ and ‘Juandah’, as opposed to Grey and Macnish’s ‘Brigalow Uplands’ and ‘Poplar Box Alluvia’ respectively. Cropping in the Maranoa and Warrego (McNee 1984), which covers a similar area to Macnish (1987), also identified similar LRA. These previously identified LRAs are shown in Table 3-1.



PARSONS BRINCKERHOFF

Figure 3-4:

Land resource areas in the pipeline study area

Table 3-1: Identified land resource areas

LRA	Landform	Soil type	Vegetation	Land use
Brigalow Uplands	Undulating plains with broad ridges and low hills, on sandstones and shales.	Grey and brown non-cracking and gilgaied cracking clays; shallow sandy and loamy soils on ridges and some texture contrast soils.	Brigalow open forest and softwood scrub. Brigalow open forest with either poplar box or belah or Dawson gum or bauhinia. Scattered wilga and softwood scrup species frequently occur.	Predominantly winter grain cropping with occasional summer cropping. Grazing of native and improved pastures.
Poplar Box Alluvia	Floodplains of generally narrower width than Coolibah LRA; often associated with active secondary stream channels; mixed and sandy alluvia.	Predominantly deep, cracking, grey clays and loams, texture contrast soils.	Predominantly poplar box grassy woodland. Scattered false sandalwood and softwood scrub species frequently occur.	Predominantly winter grain cropping and grazing of native and improved pastures. Summer cropping is difficult. Moderate flooding hazard.
Bymount	Gently undulating plains to undulating low hills (0-4%) developed predominantly on shales and mudstones, and minor sandstones.	Grey and brown non-cracking and cracking clays; minor texture contrast soils.	Silver leafed ironbark, poplar box open woodland with scattered sandalwood and softwood scrub species understorey. May occur in some areas associated with Brigalow.	Grazing, mainly of native pastures. Potential for winter cropping with a high level of conservation management. Suitable for pasture improvement.

Source: After Grey and Macnish 1985, Map 3, Macnich 1987, Map 3.

3.7.2 Soil description and mapping

A number of soils have been identified as occurring within the LRAs along the proposed pipeline study area. These soils are described in Table 3-2 and are anticipated to occur along the proposed pipeline corridor. A key to the location of soils within each LRA is provided in Figure 3-5.

Table 3-2: Soils of the Pipeline corridor

Soil name	Landscape position	Description	Chemical properties	Soil type
Brigalow uplands				
Cheshire	Occurs on steeper gradient upper slopes (up to 3%).	Shallow, non-cracking uniform clay. The topsoil is a dark sandy clay to light clay, underlaid by a brown to grey-brown medium clay subsoil.	Soils are strongly sodic below 0.3 m and with low to high salinity below 0.5 m. Subsoils are strongly alkaline and dispersive.	Dermosol
Downfall	Occurs on mid to lower slopes of approximately 2% grade in areas of sediment/slopewash accumulation.	Brown-grey cracking clay, with A horizon less than 0.3 m. Fine structured surface soils. The subsoil is grey or yellow-brown heavy clay.	Soils are strongly sodic below 0.3 m and with low to high salinity below 0.3 m. Subsoils are alkaline, and dispersive.	Vertosol
Eumamurrin	Occurs on most slope position on moderately undulating plains within the brigalow softwood scrub areas.	Brown to black medium to heavy cracking clay with grey to yellow-brown subsoil.	Soils are sodic to strongly sodic by 0.3 m.	Vertosol
Glenarden	Occurs on most slope position on moderately undulating plains within the brigalow softwood scrub areas.	Brown to grey-brown texture contrast soil, with a clay loam topsoil over heavy clay.	Soils are sodic to strongly sodic by 0.3 m with salinity in the lower A horizon. Dispersive subsoil.	Sodosol
Kinnoul	Occurs on ridgetops and upper slopes within the Brigalow Uplands, and is commonly covered by regrowth brigalow softwood scrub.	Brown to brown-black uniform non cracking light to medium clay. The soil has a shallow profile, generally less than 0.45 m to weathered sedimentary rock.		Dermosol
Limewood	Occurs on most slope positions on gently to moderately sloping plains.	Uniform to heavy cracking clay with brown-black topsoil over yellow-brown subsoil. The soil profile is less than 0.75 m deep.	Subsoils are sodic to strongly sodic below 0.3 m and with medium to high salinity below 0.5 m.	Vertosol
Rolleston	Occurs on mid and lower slopes.	Dark brown-grey heavy clay topsoil. Fine to medium structured surface. Pale yellow-brown to yellow-orange subsoil. Common land use is cropping.	Soils are sodic to strongly sodic below 0.3 m and with low to high salinity below 0.6 m.	Dermosol
Rugby	Occurs on ridges in Brigalow areas.	Brown non-cracking uniform soil with sandy loam to clay loam surface.	Soils are strongly sodic in the weathered zone.	Dermosol
Teviot	Occurs on gently inclined midslopes with a gradient of 1% to 3%.	Uniform cracking clay. The topsoil is a brown-grey to dark brown-grey clay. Coarse structured surface. Grey to yellow-brown subsoil. Common land use is cattle grazing.	Soils are sodic to strongly sodic below 0.3 m and with low to high salinity below 0.3 m.	Vertosol
Wondolin	Occurs on most slope positions on gently	Dark reddish brown to brownish black uniform	Soils are sodic to strongly sodic by	Vertosol

Soil name	Landscape position	Description	Chemical properties	Soil type
	undulating plains within areas of brigalow open forest.	heavy clay, with brown subsoil, and exists in both cracking and non-cracking forms. The soil profile is 1.0-1.5 m deep.	0.3 m, and with medium to high salinity below 0.2 m.	
Poplar box alluvia				
Juandah	Occurs on narrow valley floors, associated with poplar box open woodland.	Dark brown to black cracking clay. Coarse strongly structured, extremely hard (dry) consistence, subject to flooding. Commonly uncleared.	Soils are sodic to strongly sodic below 0.3 m and with low to high salinity below 0.6 m.	Vertosol
Retro	Occurs on gently undulating floodplains with slopes of less than 0.5%.	Dark brown texture contrast soil, with clay loam surface soil over red-brown heavy clay subsoil. Formed on mixed sand/clay alluvium and on weathered sediments. Common land use is cattle grazing.	Soils are sodic to strongly sodic below 0.3 m and with low to high salinity below 0.2 m. Subsoils are alkaline.	Chromosol
Bymont				
Nimitybelle	Occurs on most slope positions on moderately undulating plains.	Brown-grey heavy cracking clay with a yellow-brown subsoil.	Soils are sodic to strongly sodic by 0.5 m, and with medium salinity below 0.3 m.	Vertosol
Pamaroo	Occurs on most slope positions on moderately undulating plains in brigalow and poplar box areas.	Brown texture contract soil, with a sandy loam to medium clay topsoil over heavy clay.	Soils have a sodic B horizon.	Sodosol

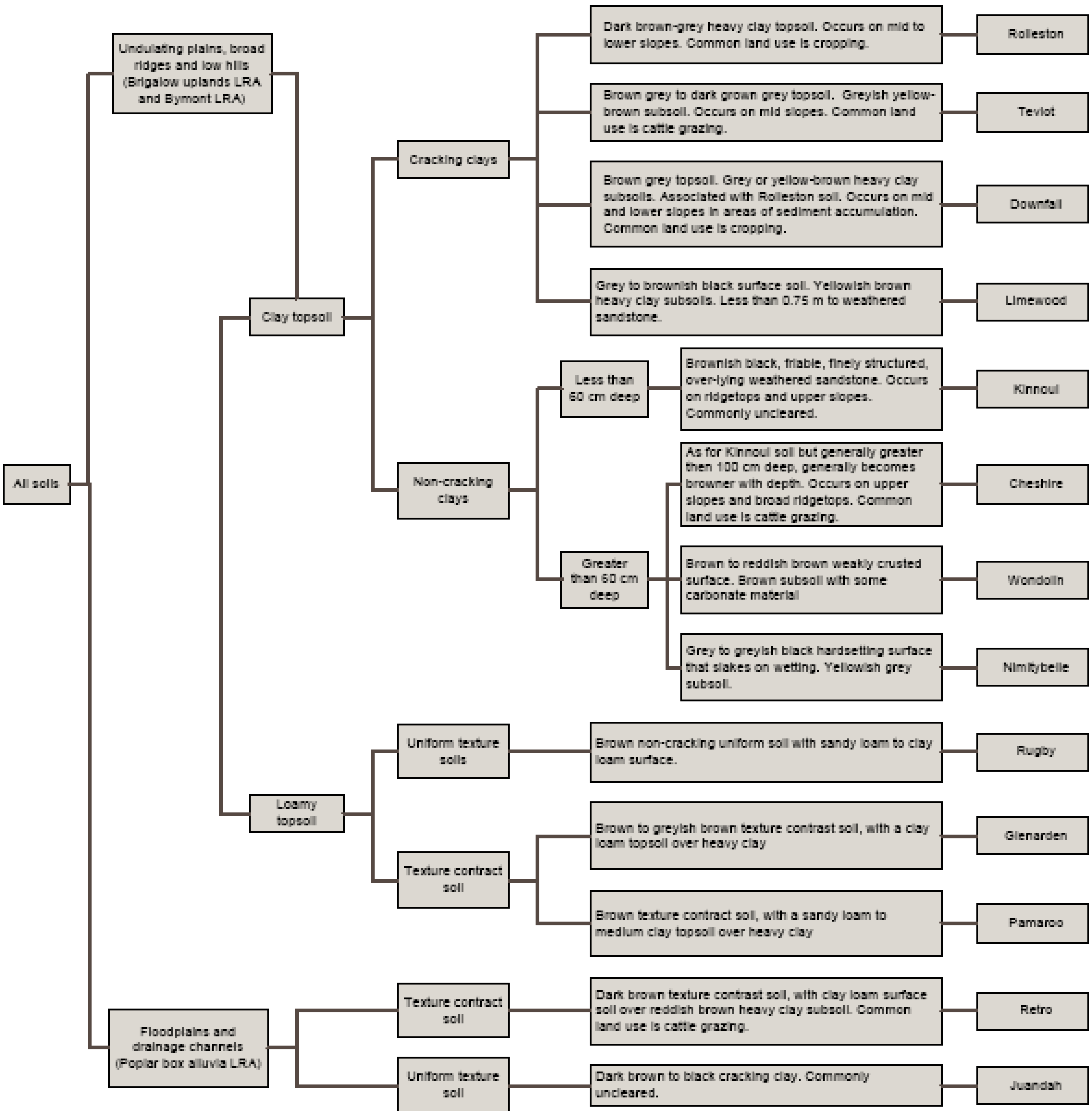


Figure 3-5: Key to soils in the proposed pipeline study area

3.8 Land suitability assessment

Land suitability and capability assessments for parts of the Wandoan-Taroom-Roma region has previously been conducted by Grey and Macnish (1985), Forster (1985), Macnish (1987) and McNee (1987). Forster's assessment was conducted at an LRA scale, and classed the Brigalow Upland soils (with a slope of up to 6%) as arable and the Poplar Box Alluvia soils as marginally arable land. Grey and Macnish (1985), and Macnish (1987) found the Brigalow Uplands LRA to generally be Class 3 to 4 land. Macnish (1987) found the Bymont LRA to consist of Class 4 land, while Grey and Macnish (1985) found the Poplar Box Alluvia to be Class 3 land. Limitations were mainly related to erosion, surface crusting and moisture availability. The above assessments were conducted prior to the release of Land Suitability Assessment Techniques (Department of Mines and Energy 1995), and do not meet the current requirements within this guideline.

The land suitability classes for the current assessment were derived from a combination of the identified soil types and geomorphic/topographic position4. Tables showing the classes assigned for each criteria are provided in Attachment A The land suitability class for a soil/landscape position relates to the highest (i.e. poorest) ranking criteria for the assessment.

Land suitability maps of the proposed pipeline study area for dry land cropping and beef cattle grazing are shown in Figures 3-6 and 3-7 respectively.

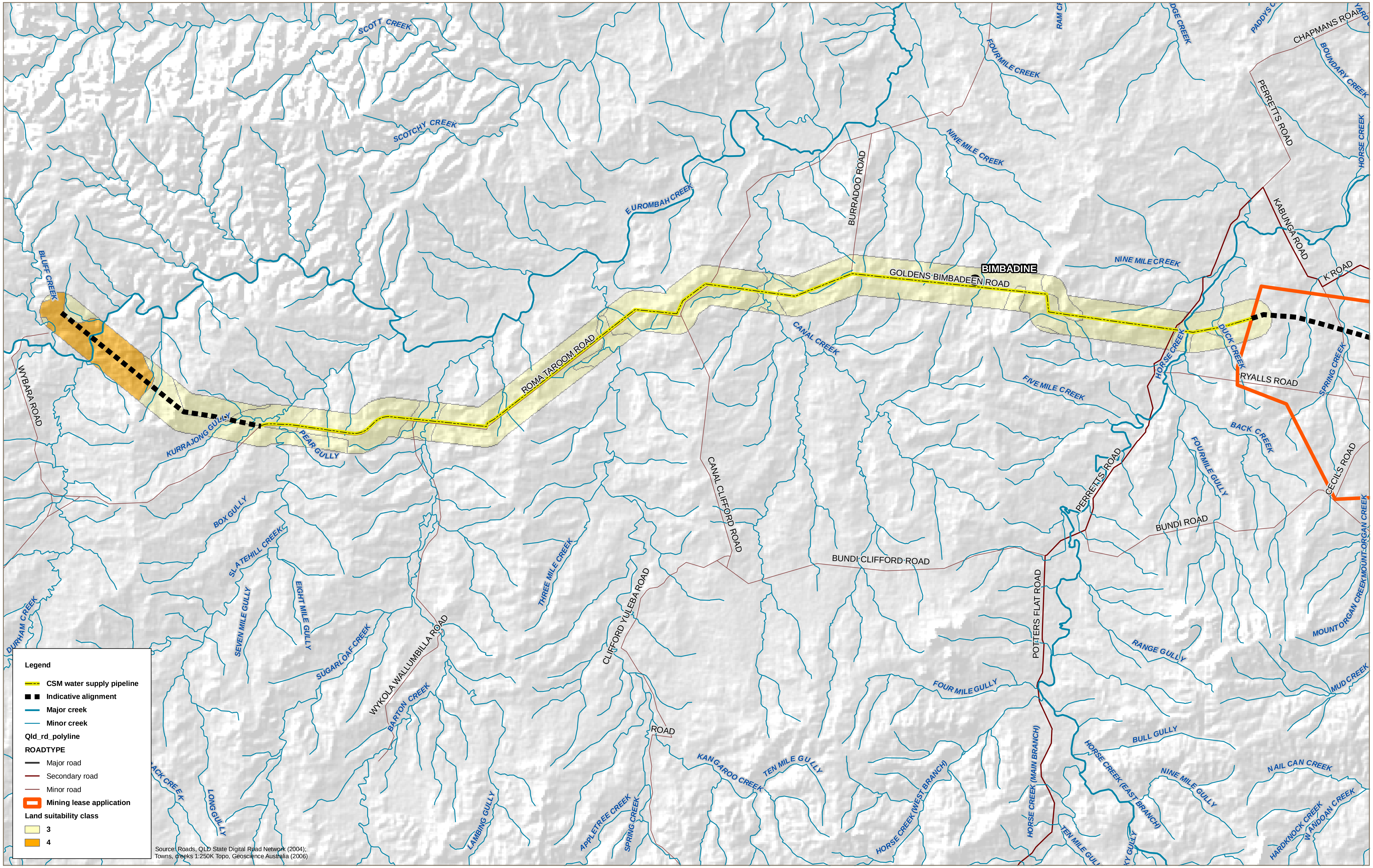
The findings of this assessment correlate well with the findings of Grey and Macnish (1985), Forster (1985), and Macnish (1987), with the Pipeline study area mainly classified as Class 3 and Class 4 for dry land cropping.

Soils of the Brigalow Uplands LRA are a combination of Class 3 and Class 4 for dry land cropping. The mapping on Figure 3-6 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 60 cm 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 heavy application of fertilisers.

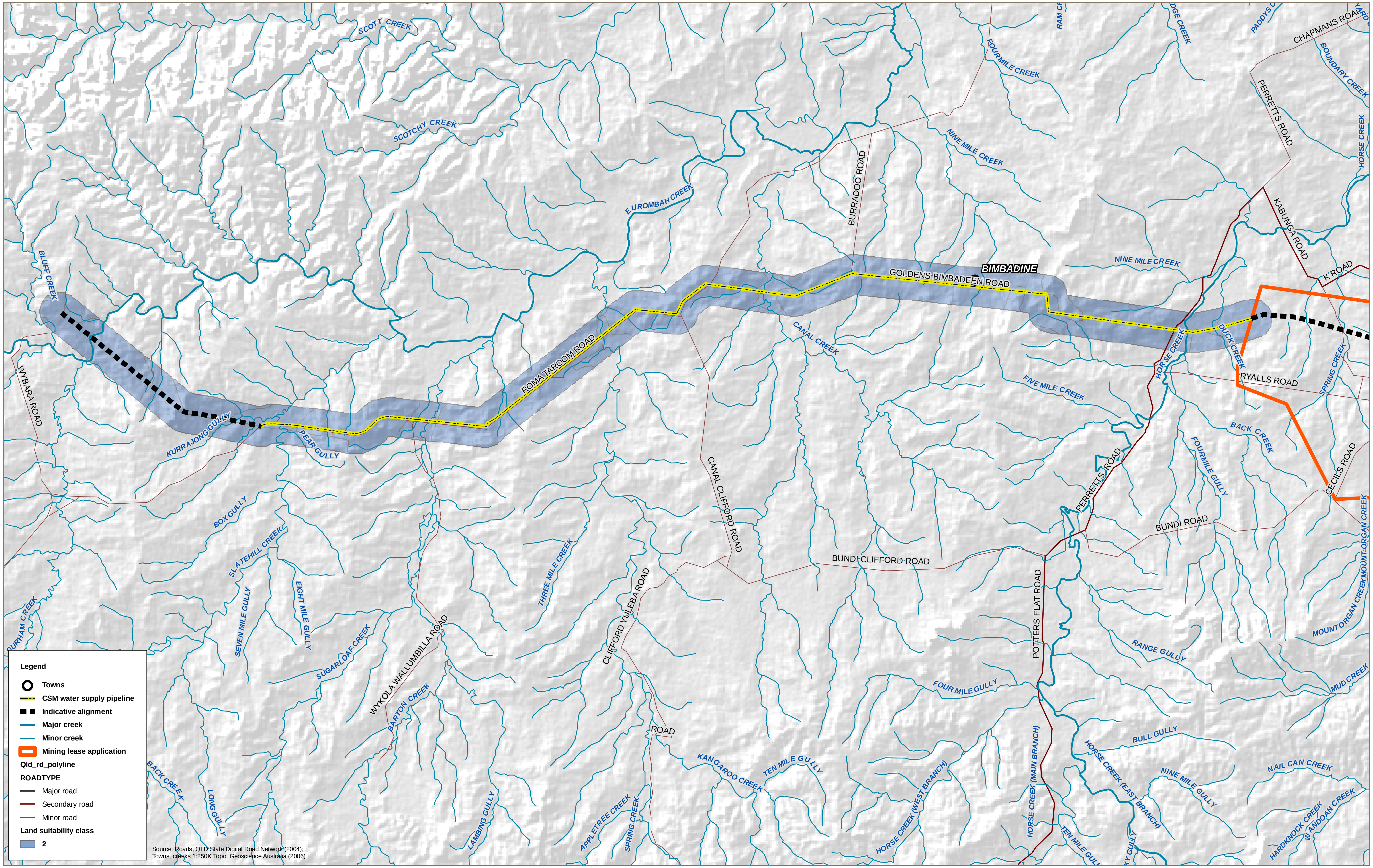
Soils of the Poplar Box Alluvia LRA were rated Class 3 for dry land cropping due to the potential of flooding. Small portions of land on the upper margins of the floodplains with alluvial soils, but impacted by flood to a lesser extent, may be Class 2 land for dryland cropping. Soils in the Bymont LRA were rated as Class 4 for dry land cropping due to their susceptibility to erosion.

All land in the proposed pipeline study area is considered Class 2 for beef cattle grazing.



0 2 4 6 8 10
Kilometres

Figure 3-6:
Land suitability for dry land cropping



PARSONS BRINCKERHOFF

0 2 4 6 8 10
Kilometres

Figure 3-7:
Land suitability classes for beef cattle grazing

3.9 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 the Taroom Shire, and area formally known as the Bungil 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.

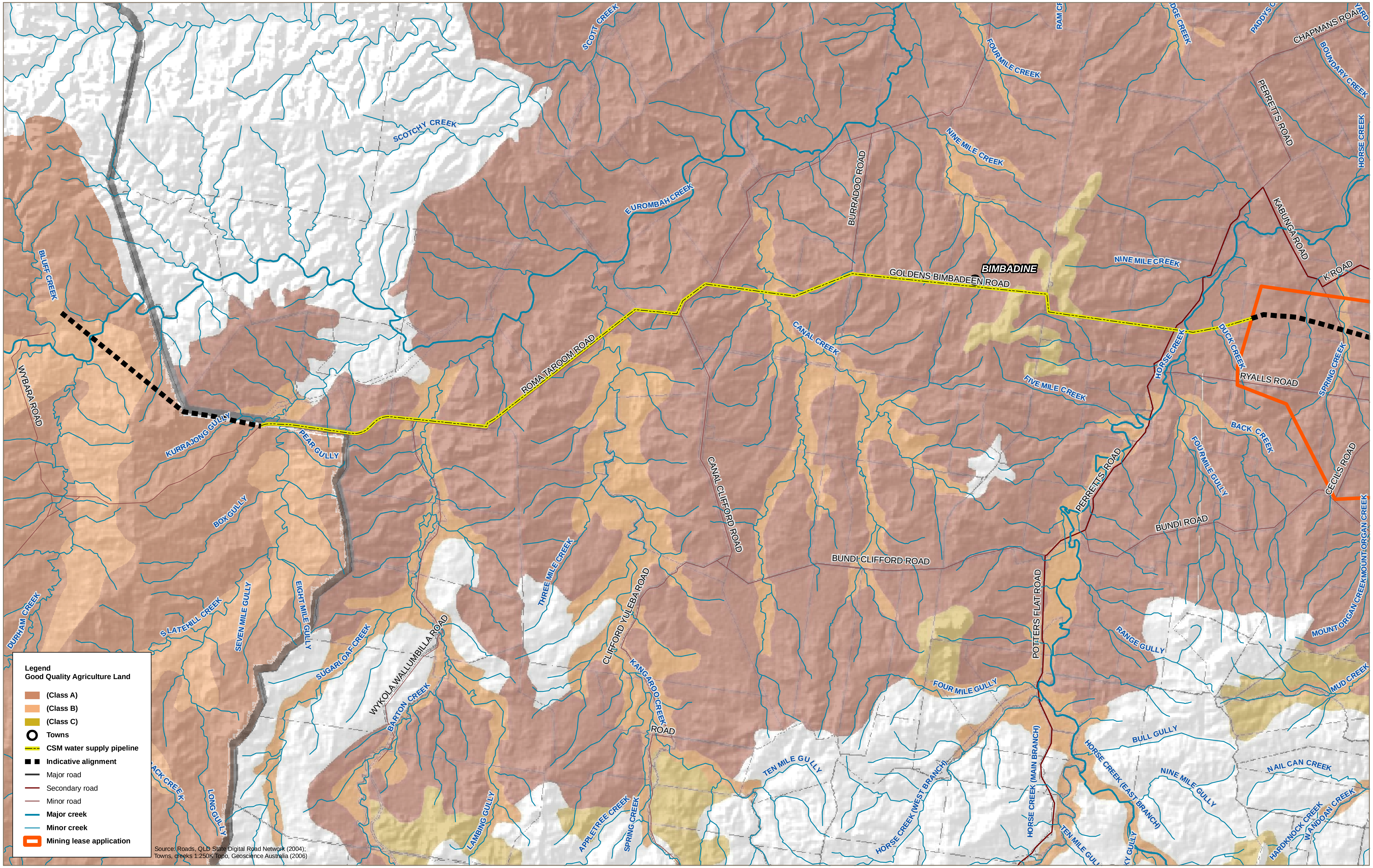
GQAL mapping of the proposed pipeline study area, in accordance with the Taroom Planning Scheme, is shown in Figure 3-8, and indicates that all the proposed pipeline study area occurs within the mapped GQAL area.

Under the Taroom Shire Council Planning Scheme and Bungil Shire Council Planning Scheme, almost all land within the proposed pipeline study area, other than along creek lines, is classified as Class A agricultural land. However, the findings of this land suitability assessment indicate greater than 'moderate' limitations to dryland cropping for areas over the lower slopes of the Brigalow Upland Soils. Consequently, the findings of this assessment suggest a different distribution of QGAL than the Taroom and Bungil planning schemes, with Class B agricultural land as a more appropriate classification for the proposed pipeline study area, as represented by Land Suitability Class 3 of Figure 3-6.

3.10 Soil conservation plans

Soil conservation plans can be developed by the Department of Natural Resources and Water for individual properties or a collection of neighbouring properties to manage water runoff flow. These plans are generally prepared at the request of landowners, and consist of a map and specification for soil conservation measures and practices to control erosion. Plans can also be approved under the *Soil Conservation Act 1986*.

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



PARSONS BRINCKERHOFF

Figure 3-8:
Good quality agricultural land

4. Description of proposed development

The proposed pipeline involves the construction and operation of a water supply pipeline from the Spring Gully Reserve Osmosis Plant to the Wandoan Coal Project MLAs, carrying coal seam methane by-product water.

The proposed pipeline will be approximately 91 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 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 route and would 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 construction of the proposed pipeline, the trench will be backfilled, compacted and topsoiled.

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

5. Potential impacts

5.1 Topography

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.

5.2 Overburden

Overburden is not relevant to this assessment

5.3 Uncovering fossil material

Proposed pipeline construction works will only impact the top one to two metres of soil, and as a result fossil material in not expected to be impacted.

5.4 Soils

5.4.1 Alkalinity, sodicity and dispersivity

Most soils within the study area (with the exception of Kinnoul) have either sodic or alkaline subsoils. Glenarden, Cheshire, Rolleston, Downfall, Teviot and Juandah, Nimitybelle and Pamaroo are strongly sodic from about 0.3 m depth. Glenarden, Cheshire, Woleebee, Rolleston and Teviot subsoils are anticipated to be strongly dispersive.

Alkaline and sodic soils are generally dispersive, and have high erosion potential if exposed. Sodic, alkaline 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.

5.4.2 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 on the edge of alluvial plains (Retro), and various soils on the undulating hill soils of (Glenarden, Rugby and Pamaroo).

Soils most susceptible to erosion by water are those with dispersive (sodic) topsoil or upper subsoil as discussed in Section 5.4.1 above. 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 as described in Section 9.5.3 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, Pamaroo and Limewood 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.

5.4.3 Salinity

Soil salinity in the 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, Teviot and Nimitybelle) and soils on the edge of alluvial plains (Retro) 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.

5.5 Land use suitability

The proposed water supply pipeline will to be buried, and no reduction in land suitability class is expected as a result of the proposed pipeline. 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 will result from the proposed pipeline.

6. Mitigation measures

6.1 Topography

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

6.2 Overburden

Overburden is not relevant to this assessment.

6.3 Uncovering fossil material

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

6.4 Soils

6.4.1 Dispersivity and erosion

As discussed in Section 5.4.2, almost all soils along the study corridor have sodic subsoils. These soils will be susceptible to erosion is exposed. Teviot, Pamaroo and Limewood are also susceptible to tunnel erosion. All soils will erode if vegetation is removed and rehabilitation is not undertaken within an appropriate timeframe. Generally wind and water erosion control measures will be applied to all soils in the proposed pipeline study area, which include:

Site preparation and planning

- An erosion and sediment control plan should 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) should be limited to the minimal amount required for Project works.
- Site drainage, sediment and erosion controls should be implemented and in place prior to, or as soon as possible, following the removal of vegetation.
- Traffic should be confined to defined roads and access tracks to minimise soil disturbance.
- Infrastructure, parking and laydown areas should be located at sites with minimal slope grade.
- Hardstands should be constructed out of erosion resistant material.

Managing water erosion

- Erosion and sediment control measures should be installed on disturbed slopes to minimise erosion and sediment released into waterways. This is especially important for soils with dispersive subsoils.

- Water runoff should be directed around or away from disturbed areas using diversion bunds and catch drains as appropriate.
- Run-off from exposed subsoil should be directed to sedimentation basins.
- Exposed soils should be revegetated as soon as practical after works have been completed.
- All soil stockpiles should 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 should 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 should be reinstated following construction.

Managing wind erosion

- Watering trucks should be used during windy conditions for dust suppression.
- Vegetation clearing (including grass cover) should be limited to the minimal amount required for Project works.
- Long-term (greater than three 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 should be revegetated as soon as practical after works have been completed.

Managing dispersive soils

- Exposure of alkaline or sodic subsoils (e.g. Cheshire, Woleebee, Rolleston, Teviot, Limewood, Wondolin, Eumamurrin, Glenarden, Retro, Nimitybelle) 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

- Fill around the proposed pipeline should 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 should be fully capped with at least 0.2 m of non-dispersive topsoil. Deeper topsoil depths have the potential to store rainwater and reduce infiltration into dispersive subsoils.
- The final land surface should be designed and managed to prevent the ponding of water on Teviot, Pamaroo or Limewood soils, to reduce the potential for infiltration into subsoils.

Monitoring

- Regular (e.g. weekly or fortnightly) monitoring for erosion should be conducted during construction, including the trench and water management infrastructure.
- Erosion monitoring should continue until the vegetation cover has become fully established.
- Monitoring for the development of tunnel erosion should be undertaken 3 monthly for 12 months following the completion of construction.

6.4.2 Salinity

As discussed in Section 5.4.3, high salinity levels are toxic to many plant species, and rehabilitation of saline soils can be difficult and costly. The following measures should be applied in relation to soil salinity:

- the topsoil of Teviot is saline and generally should 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 and Woleebee, Limewood, Wondolin, Glenarden and Pamaroo are saline and should be buried below the rooting depth plants and crops.

6.4.3 Compaction

The compaction of surface soil increases the potential for rainwater induced erosion, and reduces seed germination and root establishment of vegetation. The following measures should be applied in relation to compaction:

- soils that will be trafficked or compacted during construction should 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 should 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).

6.4.4 Topsoil reuse

As discussed in Section 3.9, all soils within the proposed pipeline study area are classed as Good Quality Agricultural Land. Suggested stripping depths and identified constraints for various encountered soil types are provided in Table 6-2. Topsoil should be managed as follows:

- stripped separately to lower soil 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 six 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 topsoil 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 6-1: 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
Eumanurrin	clay	0.3	▪ sodic subsoil
Glenarden	clay loam	0.3	▪ dispersive subsoil
Kinnoul	clay	0.3	▪ low nutrient availability in topsoil ▪ dispersive subsoil ▪ shallow soil depth
Limewood	clay	0.3	▪ sodic subsoil
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
Wondolin	clay	0.3	▪ sodic and saline subsoil
Poplar box alluvia			
Juandah	clay	0.1	▪ dispersive A2 horizon ▪ poor workability when wet
Retro	clay loam	0.15	▪ shallow topsoil depth ▪ poor workability when wet
Bymont			
Nimitybelle	clay	0.3	▪ strongly sodic subsoil ▪ hardsetting surface
Pamaroo	sandy loam		▪ sodic B horizon

6.4.5 Soil conservation plans

As discussed in Section 3.10, no approved soil conservation plans are present in the proposed pipeline study area. Existing soil conservation measures should be retained and or reinstated following construction works where they currently exist.

6.5 Construction materials

No significant earthworks or earth embankment structures are proposed for the proposed pipeline. Any catch drains or temporary sediment basins excavated for the proposed pipeline should be designed to minimise the potential for gullyhead erosion, such as limiting flow velocity, implementing trapezoidal design waterways, and avoiding perched waterways. Should there be any excess excavated material left after trench backfill, it should be shaped into stabile landform and topsoiled.

Most excavated material is anticipated to be suitable for use as trench backfill material. Weathered rock, forming particles larger than about 100 mm will be used in the upper portion of the backfill profile.

Bedding material and rip-rap is anticipated to be imported for the proposed pipeline but sourced within the region.

All temporary earthworks areas should be fully rehabilitated after the completion of the construction phase.

7. Residual impacts

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

- a buried pipeline
- some limitations on land use such as the siting of infrastructure such as sheds or irrigation equipment, and to practices that require excavation or disturbance of the soil.

8. Conclusions

This study has identified and mapped the broad soil types and characterised overburden material with the proposed pipeline study area. Based on existing literature and finding of the field assessment, the proposed pipeline contains a number of different soils derived from sedimentary or alluvial parent material.

Subsoils over much of the proposed pipeline study area are alkaline, sodic and dispersive, and will require specific management techniques, such as minimising exposure, to prevent erosion including tunnel erosion. Soils most susceptible to erosion include Cheshire, Woleebee, Rolleston and Teviot.

Based on the Taroom Shire Council Planning Scheme (2006) and Bungil Shire Council Planning Scheme (2006), the undulating hills within the proposed pipeline study area are classed as good quality agricultural land (GQAL).

A land suitability assessment for dry land cropping, and beef cattle grazing was carried out for the proposed pipeline study area. The proposed pipeline is not expected to impact land suitability classification of land within the study area, but will limit the potential for some agricultural practices or infrastructure to be sited on the land.

9. Summary of mitigation strategies

Recommended mitigation strategies to minimise potential impacts of the proposed pipeline to soils and land resources, as previously detailed in this geology, mineral resources, overburden and soils impact assessment, are summarised below:

- a sediment and erosion control plan should 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) should be limited to the minimal amount required for Project works
- site drainage, sediment and erosion controls should be implemented and in place prior to, or as soon as possible, following the removal of vegetation
- traffic should be confined to defined roads and access tracks to minimise soil disturbance
- infrastructure, parking and laydown areas should be located at sites with minimal slope grade
- hardstands should be constructed out of erosion resistant material
- erosion and sediment control measures should be installed on disturbed slopes to minimise erosion and sediment released into waterways. This is especially important for soils with dispersive subsoils
- water runoff should be directed around or away from disturbed areas using diversion bunds and catch drains as appropriate
- run-off from exposed subsoil should be directed to sedimentation basins
- exposed soils should be revegetated as soon as practical after works have been completed
- all soil stockpiles should 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 should 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
- any soil conservation measures, such as contour banks, that are disturbed during works should be reinstated following construction
- watering trucks should be used during windy conditions for dust suppression
- vegetation clearing (including grass cover) should be limited to the minimal amount required for Project works
- where appropriate long-term (greater than three 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 should be revegetated as soon as practical after works have been completed
- exposure of alkaline or sodic subsoils (e.g. Cheshire, Woleebee, Rolleston, Teviot, Limewood, Wondolin, Eumamurrin, Glenarden, Retro, Nimitybelle) 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
- fill around the proposed pipeline should be compacted to at least the density of the surrounding soil material, and the filled trench left slightly higher than the natural landsurface to minimising ponding or infiltration around the pipe
- all dispersive soils along the corridor should be fully capped with at least 0.2 m of non-dispersive topsoil. Deeper topsoil depths have the potential to store rainwater and reduce infiltration into dispersive subsoils
- the final landsurface should be managed to prevent the ponding of water on Teviot, Pamaroo or Limewood soils, to reduce the potential for infiltration into subsoils
- regular (e.g. weekly or fortnightly) monitoring for erosion should be conducted during construction, including the trench and water management infrastructure
- erosion monitoring should continue until the vegetation cover has become fully established
- Monitoring for the development of tunnel erosion should be undertaken 3 monthly for 12 months following the completion of construction
- the topsoil of Teviot is saline and generally should 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 and Woleebee, Limewood, Wondolin, Glenarden and Pamaroo are saline and should be buried below the rooting depth plants and crops
- soils that will be trafficked or compacted during construction should 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 should 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)
- existing soil conservation measures should be retained and or reinstated following construction works where they currently exist
- topsoil should be stripped separately to lower soil and stockpiled during clearing for reuse in site rehabilitation
- topsoil should be stored in stockpiles no more than 3 m high to retain seed germination potential

- topsoil should be stored for the shortest period practicable, and where possible reused within six months of stripping to maximise the retention of the seed bank in the soil
- topsoil should be reused in the general area from which it was stripped
- during site rehabilitation works topsoil should be spread to a depth of approximately 0.2 m
- control measures such as fencing should be installed on newly topsoil areas to exclude vehicle or stock access until a vegetation cover has established
- topsoil should be stripped to depth shown in Table 9-1.

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
Eumanurrin	clay	0.3	▪ sodic subsoil
Glenarden	clay loam	0.3	▪ dispersive subsoil
Kinnoul	clay	0.3	▪ low nutrient availability in topsoil ▪ dispersive subsoil ▪ shallow soil depth
Limewood	clay	0.3	▪ sodic subsoil
Rolleston	clay	0.2	▪ alkaline ▪ topsoil may be dispersive ▪ dispersive subsoil
Teviot	clay	0.2	▪ dispersive subsoil ▪ moderately alkaline and saline
Rugby	Clay loam	0.1	▪ low nutrient ▪ alkaline and saline subsoil
Wondolin	clay	0.3	▪ sodic subsoil
Poplar box alluvia			
Juandah	clay	0.1	▪ dispersive A2 horizon ▪ poor workability when wet
Retro	clay loam	0.15	▪ shallow topsoil depth ▪ poor workability when wet
Bymont			
Nimitybelle	clay	0.3	▪ strongly sodic subsoil ▪ hardsetting surface
Pamaroo	sandy loam	0.2	▪ sodic B horizon

10. References

Biggs, AJW and Coutts, AJ and Harris, PS 1999, *Central Darling Downs Land Management Manual*. Department of Natural Resources, Queensland. DNRQ990102.

Bungil Shire Council 2006, *Bungil Shire Council Planning Scheme*.

Department of Mines and Energy 1995, Land Suitability Assessment Techniques in *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland*.

Department of Primary Industries and Department of Housing, Local Government and Planning 1993, *Planning Guidelines: The Identification of Good Quality Agricultural Land*, Queensland.

EPA 2001, *Code of Environmental Compliance for Exploration and Mineral Development Projects*, Queensland Government.

Forster, B.A 1985*. Evaluation of Agricultural Land in Taroom Shire*, Department of Primary Industries Land Resources Branch, Project Report Series QO85032.

Geological Survey of Queensland 1971, Australia 1:250,000 Geological Series. *Sheet SG 55-12 Roma, Queensland*.

Geological Survey of Queensland 1967, Australia 1:250,000 Geological Series. *Sheet 55-8. Taroom, Queensland*.

Gray, H.J and Macnish, S.E 1985 *Land Management Field Manual Wandoan District,* Queensland Department of Primary Industries. Information Series QE85006.

Green D.R. and Chestnutt C., 2007, *Wandoan Project Pre Feasibility Study. Volume 2 – Geology.* Confidential Company Report.

Isbell, RF 1996, *The Australian soil classification*. CSIRO, Canberra.

Macnish, SE 1987, *Land Management Field Manual Roma District*, Department of Natural Resources and Mines. Information Series QE87001.

McDonald, RC, Isbell, RF, Speight, JG, Walker, J, and Hopkins, MS 1998, *Australian soil and land survey, field handbook* (2nd edition). CSIRO, Canberra.

McNee, DAK 1984, *Cropping in the Maranoa and Warrego*, Queensland Department of Primary Industries. Information Series QI84012

Slater, B 1986, Edaphic Properties of Soil and Overburden from a Potential Coal Mine near Wandoan, Queensland. University of Queensland Department of Agriculture.

Snodin, S. 2004. *Photogeological Interpretation of the Wandoan Area, Queensland*. Confidential unpublished company report, Xstrata Coal.

Sorby, P and Reid RE 2001, *Land Resources Bulletin: Soils and Agricultural suitability of the South Burnett Agricultural Lands, Queensland*, Department of Natural Resources and Mines QNRM01014.

Taroom Shire Council 2006, *Taroom Shire Council Planning Scheme*

Attachment A

Land suitability criteria

Attachment A – Land suitability criteria

Table A-1: Suitability criteria for rainfed broadacre cropping

Limitation	Land suitability class				
	1	2	3	4	5
Water availability	PAWC >150 mm	PAWC 125-150 mm	PAWC 100-125 mm	PAWC 75-100 mm	PAWC <75 mm
Nutrient deficiency	Bicarbonate P >10 ppm	Bicarbonate P 5-10 ppm and Exchangeable K >0.3 meq. %	Bicarbonate P 5-10 ppm and Exchangeable K ≤0.3 meq. % or pH <5 60-90 cm below surface or pH >9 60-90 cm below surface	Bicarbonate P <10 ppm and Exchangeable K ≤0.3 meq. %, and Exchangeable Ca <3 meq.%, or pH <5 30-60 cm below surface, or pH >9 30-60 cm below surface	pH <5 within 30 cm of surface or pH >9 within 30 cm of surface
Soil physical factors	Cracking clays with very fine self-mulch (peds <2 mm), or Rigid soils with a loose, soft or firm surface when dry	Cracking clays with fine self-mulch (peds 2-10 mm)	Cracking clays with coarse self-mulch (peds 10-20 mm) or Rigid soils with a hard setting surface when dry	Cracking clays with coarse peds at the surface (≥20 mm)	
Soil workability	Friable cracking clays (indicated by very fine self-mulch), or Rigid soils with a loose, soft or firm surface when dry	Firm cracking clays (indicated by fine self-mulch) or Rigid soils with a hard setting surface when dry	Stiff cracking clays (indicated by coarse self-mulch with peds>10 mm, crusting or hard setting surface)		
Salinity	Rootzone EC <0.15 mS/cm or Rootzone Cl <300 ppm	Rootzone EC 0.15 -0.3 mS/cm or Rootzone Cl 300-600 ppm	Rootzone EC 0.3-0.9 mS/cm or Rootzone Cl 600-900 ppm	Rootzone EC 0.9-1.2 mS/cm, or Rootzone Cl 900-1,500 ppm	Rootzone EC >1.2 mS/cm or Rootzone Cl ≥1,500 ppm
Rockiness	<10% coarse surface gravel (>6 cm diam.) and rock outcrop	10-20% coarse surface gravel and rock outcrop	20-50% surface cobble (6-20 cm diam.)and rock outcrop	50-90% surface cobble and rock outcrop, or	>90% surface cobble and rock outcrop, or

<table>
<tr><th rowspan="2">Limitation</th><th colspan="5">Land suitability class</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td></td><td></td><td></td><td></td><td>20-50% stone and boulders (>20 cm diam.)</td><td>>50% stone
and boulders and rock outcrop</td></tr>
<tr><td>Microrelief</td><td>No melonholes (semi-circular depressions <30 cm deep and usually surrounded by mounds)</td><td>Melonholes 30-60 cm deep cover <20% surface area
or
Melonholes >60 cm deep cover <10% surface area</td><td>Melonholes 30-60 cm deep cover 20-50% of surface area
or
Melonholes >60 cm deep cover 10-20% surface area</td><td>Melonholes 60-100 cm deep cover 50% surface area</td><td>Melonholes at least 100 cm deep cover 50% surface area</td></tr>
<tr><td>Wetness</td><td>Undulating terrain or
elevated plains</td><td>Low-lying level plains with melonholes covering <25% surface area,
or
Rigid soils with sodic subsoil (ESP 6-14) within 60 cm of the surface,
or
Non-sodic rigid soils with coarse pale grey and yellow mottles within 75 cm of the surface</td><td>Low-lying level plains with melonholes covering 25-50% surface area,
or
Rigid soils with strongly sodic subsoil (ESP≥15) within 60 cm of the surface,
or
Non-sodic rigid soils with coarse pale grey and yellow mottles within 50 cm of the surface</td><td>Seasonal swamps and lowlying run-on areas</td><td>Permanent swamps and lakes</td></tr>
<tr><td>Topography</td><td>No gully dissection</td><td>Occasional deep gullies impede cultivation slightly</td><td>Many deep gullies reduce arable area by <33% or require major changes to cultivation practices</td><td>Many deep gullies make the arable areas too small to cultivate</td><td>Abundant deep gullies prevent any practical cultivation</td></tr>
<tr><td>Water erosion</td><td>Slopes <0.5% on cracking clays without melonholes,
or
Slopes <1% on melonhole clays, or
Slopes <1% on nonsodic rigid soils, or
Slopes <0.5% on sodic rigid soils</td><td>Slopes 0.5-1% on cracking clays without melonholes
or
Slopes 1-3% on melonhole clays, or
Slopes 1-2% on non-sodic rigid soils, or
Slopes 0.5-1% on sodic rigid soils</td><td>Slopes 1-3% on cracking clays without melonholes
or
Slopes 2-4% on non-sodic rigid soils
or
Slopes 1-2% on sodic rigid soils</td><td>Slopes 3-5% on all cracking clays
or
Slopes 4-6% on non-sodic rigid soils
or
Slopes 2-3% on sodic rigid soils</td><td>Slopes >5% on all cracking clays
or
Slopes >6% on nonsodic
rigid soils
or
Slopes >3% on sodic
rigid soils</td></tr>
</table>

Limitation	Land suitability class				
	1	2	3	4	5
Flooding	No flooding	Rare flooding (only during abnormal 1 in 50 to 100 year events)	Infrequent flooding (inundation occurs <half the times that stream flow increases)	Occasional flooding (inundation occurs ≥half the times that stream flow increases)	Regular flooding (inundation occurs whenever stream flow increases)

Table A-2: Suitability criteria for beef cattle grazing

Limitation	Land suitability class				
	1	2	3	4	5
Water availability	PAWC >125 mm	PAWC 100-125 mm	PAWC 75-100 mm	PAWC 50-75 mm	PAWC ≤50 mm
Nutrient deficiency	Brigalow, gidgee, blackwood or softwood scrub soils and former scrub soils with Bicarbonate P >10 ppm	Eucalypt vegetation and downs with Bicarbonate P >10 ppm	Other soils with Bicarbonate P 5-10 ppm except Sands and loams at least 75 cm deep or overlying rock at shallow depth	Sands and loams at least 75 cm deep or overlying rock at shallow depth, with Bicarbonate P 5-10 ppm, or Bicarbonate P ≤4 ppm	
Soil physical factors	Cracking clays with very fine self-mulch (peds <2 mm), or Rigid soils with a loose, soft or firm surface when dry	Cracking clays with fine self-mulch (peds 2-10 mm), or Rigid soils with a hard setting surface when dry	Cracking clays with coarse peds (peds ≥10 mm) or crust on the surface		
Salinity	Rootzone EC < 0.15 mS/cm or Rootzone Cl <300 ppm	Rootzone EC 0.15-0.3 mS/cm or Rootzone Cl 300-600 ppm	Rootzone EC 0.3-0.9 mS/cm or Rootzone Cl 600-900 ppm	Rootzone EC 0.9-1.2 mS/cm or Rootzone Cl 900-1,500 ppm	Rootzone EC >1.2 mS/cm or Rootzone Cl ≥1,500 ppm
Rockiness	<20% coarse surface gravel (>6 cm diam.) and rock outcrop	20-50% coarse surface gravel and rock outcrop	50-90% surface cobble and rock outcrop	>90% surface cobble and rock outcrop	Rock outcrop and surface coarse fragments cover total area
Microrelief	Melonholes cover <20% surface area (semi-circular depressions at	Shallow melonholes (30-60 cm deep) cover 20-50%	Deep melonholes (>60 cm deep) cover 20-50% of		

Limitation	Land suitability class				
	1	2	3	4	5
	least 30 cm deep and usually surrounded by mounds)	surface area	surface area		
pH (1:5)	5.6-6.6	6.6-8.0 5.0-5.6	8.0-9.0 4.5-5.0	9.0-10.0 4.0-4.5	>10.0 < 4.0
ESP (10 cm)% Exchangable Sodium Percentage	<5.0	5-10	10-15	15-30	>30
Wetness	Undulating terrain or elevated plains	Low-lying level plains , or Rigid soils with strongly sodic subsoil (ESP≥15) within 60 cm of the surface, or Non-sodic rigid soils with coarse pale grey and yellow mottles within 50 cm of the surface	Shallow seasonal and permanent swamps		Permanent lakes and deep swamps
Topography				Many deep gullies make cultivation for sowing pastures impractical, or Slopes >15% make cultivation along contours impractical	Strongly dissected terrain over ≥75% of the area preventing adequate herd management
Water erosion	Slopes <1% on sodic rigid soils or Slopes <3% on all other soils	Slopes 1-3% on sodic rigid soils or Slopes 3-6% on cracking clays, or Slopes 3-12% on non-sodic rigid soils	Slopes 3-6% on sodic rigid soils or Slopes 6-9% on cracking clays, or Slopes 12-20% on nonsodic rigid soils	Slopes 6-12% on sodic rigid soils or Slopes 9-15% on cracking clays or Slopes 20-45% on non-sodic rigid soils	Slopes >45%

Limitation	Land suitability class				
	1	**2**	**3**	**4**	**5**
Flooding	No flooding	Periodic flooding (from once in 50 years to whenever stream flow increases)			
Vegetation regrowth (management limitation)	Softwood, brigalow, gidgee or blackwood scrub without melonholes , or Queensland bluegrass grasslands, or Mountain coolabah, bloodwood and ironbark open woodlands	Brigalow, gidgee or blackwood scrub with melonholes, or Box and ironbark woodlands without wattle understorey, or Coolabah woodlands on flooded country		Eucalypt woodlands with wattle understorey or Broad-leaved teatree woodlands	

Table A-3: Suitability assessment for beef cattle grazing

	Brigalow uplands						
	Cheshire	**Downfall**	**Eumanurrum**	**Glenarden**	**Kinnoul**	**Limewood**	**Rolleston**
Water availability	2	1	1	2	1	2	2
Nutrient deficiency	2	2	2	1	2	2	2
Soil physical factors	1	1	2	2	1	2	2
Salinity	1	1	1	2	1	2	1
Rockiness	2	1	1	1	2	1	1
Micro relief	1	1	1	1	1	1	1
Ph	2	2	2	2	2	2	2
Esp	2	1	2	2	1	2	1
Wetness	1	2	1	1	1	1	1
Topography	1	1	1	1	1	1	1
Water erosion	2	1	1	2	2	1	1
Flooding	1	2	1	1	1	1	1
Vegetation regrowth	1	1	1	1	1	1	1
Land suitability class	**2**	**2**	**2**	**2**	**2**	**2**	**2**

Table A-3: Suitability assessment for beef cattle grazing (continued)

	Brigalow uplands			Poplar box alluvia		Bymont	
	Teviot	**Rugby**	**Wondolin**	**Juandah**	**Retro**	**Nimitybelle**	**Pamaroo**
Water availability	2	2	2	1	1	2	2
Nutrient deficiency	2	1	1	2	2	2	2
Soil physical factors	2	2	2	1	1	2	1
Salinity	1	2	2	1	1	2	1
Rockiness	1	1	1	1	1	1	1
Micro relief	1	1	1	1	1	1	1
Ph	2	2	2	2	2	2	1
Esp	1	2	2	2	1	1	2
Wetness	1	1	1	2	2	1	1
Topography	1	1	1	1	1	1	1
Water erosion	1	1	1	1	1	1	2
Flooding	1	1	1	2	2	1	1
Vegetation regrowth	1	1	1	1	1	1	1
Land suitability class	**2**	**2**	**2**	**2**	**2**	**2**	**2**

Table A-4: Suitability assessment for dry land cropping

	Brigalow uplands						
	Cheshire	**Downfall**	**Eumanurrum**	**Glenarden**	**Kinnoul**	**Limewood**	**Rolleston**
Water availability	3	2	2	3	2	3	3
Nutrient deficiency	3	4	2	2	3	2	4
Soil physical factors	1	2	2	2	1	2	1
Workability	2	2	2	2	2	2	2
Salinity	1	1	2	2	1	1	1
Rockiness	2	1	1	1	2	1	2
Microrelief	1	1	1	1	1	1	1
Wetness	1	2	1	1	1	1	1
Topography	2	2	2	2	2	2	2
Water erosion	4	3	3	4	4	3	3
Flooding	1	2	1	1	1	1	1
Land suitability class	**4**	**4**	**3**	**4**	**4**	**3**	**4**

Table A-4: Suitability assessment for dry land cropping (continued)

	Brigalow uplands			Poplar box alluvia		Bymont	
	Teviot	**Rugby**	**Wondolin**	**Juandah**	**Retro**	**Nimitybelle**	**Pamaroo**
Water availability	3	3	3	2	2	3	3
Nutrient deficiency	3	2	2	2	2	2	2
Soil physical factors	2	3	2	2	2	2	1
Workability	2	2	2	1	1	2	1
Salinity	1	2	3	1	2	2	1
Rockiness	1	1	1	1	1	1	1
Microrelief	1	1	1	1	1	1	1
Wetness	1	1	1	3	3	1	1
Topography	2	2	2	1	1	2	2
Water erosion	3	3	3	2	2	4	4
Flooding	1	1	1	3	3	1	1
Land suitability class	**3**	**3**	**3**	**3**	**3**	**4**	**4**