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3.1 INTRODUCTION

This chapter provides an assessment of topography, geology, soils and landform for the rail component of the project. The assessment has been prepared in accordance with the EIS Terms of Reference (ToR).

This chapter describes the existing physical environment along the rail alignment and assesses the likely changes and potential impacts to soils, geology and landforms resulting from the Project. The chapter also describes the approach to be taken by Waratah Coal to minimise potential impacts.

3.2 LEGISLATIVE PLANNING AND FRAMEWORK

State Planning Policies (SPPs) are planning instruments implemented under the Sustainable Planning Act 2009 (SPA) that the Planning Minister (or any Minister in conjunction with the Planning Minister) can make to protect things that are of interest to the state.

This includes:

- agricultural land;
- separating agricultural land from residential land;
- development within close proximity to airport land; and
- protecting development from adverse effects of bushfire, floods and landslides.

The following SPPs are relevant to soils and geology aspects of the project and are further discussed within Volume 1, Chapter 2 Project Approvals.

- SPP 1/92 – Development and Conservation of Agricultural Land
- SPP 2/02 – Planning and Managing Development involving Acid Sulfate Soils

3.3 ASSESSMENT METHOD

3.3.1 DESKTOP ASSESSMENT

Desktop investigations and a review were undertaken of publicly available databases, digital resources including Geosciences Australia's Mapconnect and grey literature relevant to geology, soils and landforms in the Project area.

3.3.1.1 Topography

Topography and landscapes were reviewed with reference to CSIRO Australian Soil Resource Information System (ASRIS) datasets, Queensland Department of Employment, Economic Development and Innovation (DEEDI) –Department of Mines and Energy (DME) resource and tenure maps and Environment and Resource Management (DERM) records, Local Government mapping, cadastral data and SPP mapping.

3.3.1.2 Geology

Geology and landforms were identified using mapping sourced from ASRIS and Geological and Topographic mapping series sourced from Geosciences Australia.

The shear zones, faults and dykes have been identified as these areas may have increased geotechnical risks.

3.3.1.3 Soils

The occurrence and distribution of the major soil groups have been mapped for the project area. The typical soil profile characteristics of the main soil groups mapped have been compiled from field observations and various sources including:

- CSIRO ASRIS Mapping (CSIRO, 2006);
- CSIRO *Regional land systems and soils mapping* (1967, 1968, and 1974);
- Geosciences Australia 1:250,000 map series (1968); and
- Atlas of Australian Soils (Isbell *et al*,. 1967).

Data obtained from previous field investigations has also been reviewed including studies undertaken by AMEC (2009), Coffey Mining (2009) and the land resources digital atlas data sets including the CSIRO land research series.

3.3.1.4 Acid Sulfate Soils

Methods of assessment employed to assess Acid sulfate soils (ASS) within the project area consisted of the following studies:

- a review of the relevant legislation and guidelines applicable to ASS within the project area;
- a review of topography, geology and soils mapping and aerial photography available for the project area; and
- a review of previous ASS investigations relevant to the project area.

3.3.1.5 Landforms

Landforms were mapped using landscape units that provided a basis for the describing of the physical environment. The information reflects the distribution of geological areas, landforms and the associated soil types. Landscape units are a combination of several map units including:

- broad landform (slope and relief), geology and lithology;
- dominant soil orders;
- local climate, drainage networks and related soil profile classes;
- regolith materials; and
- similar geomorphological systems.

3.3.1.6 Good Quality Agricultural Land

An assessment of GQAL was undertaken, as required in the ToR and SPP 1/92, the assessment was based upon a four class system that is described in the DEEDI and Department of Housing and Local Government (DHLG) planning guidelines for the identification of GQAL. These guidelines describe land as one of the following:

- Class A: Crop land, being land suitable for current and potential crops with limitations to production which range from nil to moderate;
- Class B: Limited Crop Land, being land that is marginal for current and potential crops due to severe limitations, but is suitable for pastures. The land may require improvement before it is suitable for sustainable cropping / cultivation;
- Class C: Pasture Land, being land suitable for improved or native pastures due to limitations which preclude continuous cultivation for crop production. Some areas may tolerate short-term cultivation for improved pasture and forage crop establishment. Other areas are primarily suited to grazing of native pastures, with or without the addition of improved pasture species without ground disturbance. Elsewhere the land is suited to restricted light grazing of native pastures in accessible areas, otherwise very steep hilly lands more suited for forestry, conservation or catchment protection; or
- Class D: Non-agricultural land, being land not suitable for agricultural uses due to extreme limitations. This may comprise undisturbed land with significant habitat, conservation and / or catchment values, or land that may be unsuitable because of very steep slopes, shallow soils, rocky outcrops or poor drainage conditions.

Data sources used in the assessment of GQAL included:

- DERM Regional Compilation of Mapping (1:250 000) Central West Region –GQAL; and
- Local Government Planning documents including the Planning Schemes for Barcaldine, Isaac and Whitsunday Regional Councils.

The Local Government GQAL mapping from the various Planning Schemes was used to undertake the desktop review of GQAL. This information was supplemented with site specific sampling.

3.3.1.7 Contaminated Land Assessment

In order to adopt an appropriate ranking system to assess the large number of properties across the study area for contaminated land risk, a tiered / ranking approach was adopted to assess lots with moderate or high potential for contamination and to select lots with potential impacts to the project area for more detailed investigation. These lots were then selected for Preliminary Site Investigations (PSIs). The ranking order of lots across the study area was classified accordingly to a system of high, medium and low risk.

The following summarises the approach of the of the ranking risk assessment:

- a search of DERM's Queensland Valuation and Sales System (QVSS) was conducted to establish primary landuse activities to group into high, medium or low;
- lots ranked as a high risk included industrial land use, (e.g. transport terminals, transformers, airfields, extractive industry). Lots ranked as medium risk include cattle and stock agribusinesses (potential for stock / cattle dips) and contractors / builders yards. Lots ranked as low risk include parks, gardens and residential land as it is unlikely potentially contaminating activities would have been carried out on that land;
- all sites ranked as high risk were subject to a search on the Environmental Management Register (EMR) / Contaminated Land Register (CLR). Medium risk sites were subject to aerial imagery investigations; and
- EMR / CLR searches were not carried out on low risk sites as lots subject to residential land use were

considered the most sensitive land use in terms of public use and exposure. Therefore they would have a low probability of being impacted by contamination.

Further detail on the tiered ranking risk assessment is provided in the Contaminated Land Technical report at (Volume 5, Appendix 8).

3.3.2 FIELD INVESTIGATIONS

The dominant soil types intersected by the project were assessed. Desktop assessment of major soil types used dominant soils mapping to refine the scope of field investigations to ensure all of the major soils types within the project area were represented by the sampling. The field investigations included:

- characterisation of soil types;
- assessment of depth and quality of useable soils;
- assessment of dispersivity and erosion potential; and
- assessment for potential as a regrowth medium.

A soil survey of representative sites along the rail alignment was conducted with reference to the physical soil stability and the chemical properties of the materials that influence erosion potential, stormwater run-off quality, rehabilitation and agricultural productivity of the land. At the time of undertaking field-based soil mapping, detailed site layout design had not been finalised. As a result, the approach adopted during field work was to focus efforts within an 800 m wide buffer zone of the rail alignment.

Soil profiles were mapped by initially reviewing the aerial photography and regional mapping and assigning soil areas based upon common photo tones and topography. Representative samples were then collected from these areas for assessment.

An appraisal of the depth and quality of useable soil was undertaken by using a hand auger and test pitting to a maximum depth of approximately 2 m from the surface. Sample cores were split into two to three sub-samples depending on the number of soil horizons encountered at each site. Samples were selected for laboratory analysis in order to characterise all soil types within the study area.

Along the rail alignment 118 samples were collected from 43 locations with 43 samples selected for laboratory analysis.

3.3.2.1 Soil Observations

Visual observations of soil type and structure were undertaken at a number of the waterways that will be disturbed by construction works. These observations were carried out in order to discuss erosion potential at waterway crossings along the rail alignment. Characteristics noted on site included dominant soils type, stream morphology, bank vegetation and signs of existing erosion / disturbance. A total of 39 sites were observed along the rail alignment.

3.3.2.2 Laboratory Analysis

Samples were submitted to laboratories with National Association of Testing Authorities (NATA) accredited methods for the analyses. The laboratory analyses included:

- pH;
- Calcium (Ca) and Magnesium (Mg) Ratios;
- Chlorides (ppm);
- Electrical Conductivity (EC);
- Emerson Crumb Dispersive Analysis;
- Exchangeable Sodium Percentage (ESP); and
- Sodium Absorption Ratios (SAR).

A detailed description of the tests carried out can be found in the Geology, Soils and Landforms Technical report (Volume 5, Appendix 6).

3.3.2.3 Contaminated land

Sites with an identified potential for contaminantion were selected for field investigations. The field studies were conducted in November 2009 and April 2010. The following summarises the rationale and methodology for field investigations:

- selection was based upon the results of EMR searches of lots following the tiered risk assessment of land uses and the result of aerial and ground inspections;
- soil samples were collected from targeted locations based upon principals described in AS4482.1 - 2005: Guide to sampling and investigation of potentially contaminated soil (Part 1: Non volatile and semi volatile compounds) and AS4482.2-1999: Guide to sampling and investigation of potentially contaminated soil (Part 2: Volatile compounds);
- sampling was conducted with either a hand auger to a maximum depth of 0.9 m below ground level

(mgbl) or a hand trowel. Two types of samples were collected, either a surface sample (0.0 mgbl) or samples at depths of 0.3 mgbl, 0.6 mgbl and 0.9 mgbl respectively; and

- the toxicant parameters analysed for both rounds of soil sampling is as follows:
  - livestock dip or spray race operation included Orchnochlories (OC) and Organophosphate pesticides (OP); and
  - petroleum product or oil storage included Total Petroleum Hydrocarbons (TPH) C_6-C_9, TPH C_{10}-C_{36} and Poly Aromtaic Hydrocarbons (PAH).

3.4 EXISTING ENVIRONMENT

3.4.1 TOPOGRAPHY

The following sections described the topography of the rail alignment in the five areas of the 468 km.

Kilometer Point (KP) 5-KP25 – Coastal Plains

The topography of the coastal plain ranges from wetlands and residual clay plains to flat, weathered granite and granitic hills. The rail alignment tracks westward for 5.6 km from the coal terminal along relatively flat terrain between 5 m and 15 m Australian Height Datum (AHD) with some isolated areas below the 5 m AHD contour associated with creek crossings.

KP25-KP85 – Clarke Ranges

Elevations in this area range from around 100 m AHD to over 1,000 m AHD; however the rail alignment reaches maximum elevations of about 200 m. The topography includes the granite hills of Mt Abbot (1056 m), Mt Aberdeen (910 m), Mount MacKenzie (514 m), Pine Hill (624 m), and Highlanders Bonnet (487 m).

KP85-KP125 – Bowen River Valley

The topography of this area reflects the Bowen River Valley's erosional impact upon the underlying geology with the topography falling from 233 m AHD to 150 m AHD in the centre of the valley before climbing up to 350 m as the valley gives way to the Leichhardt Range.

KP125-KP190 – Leichhardt Range

The topography of the Leichardt Range inclines from 250 m to 516 m AHD and includes Bulgonunna Peak (516 m). The intrusive rock types form areas of higher relief with radial drainage to the Suttor Formation which surrounds them. The area is also dissected by tributaries of the Suttor River that eventually drain to the southwest, into the Belyando and subsequently the Burdekin catchment.

KP190-KP468 – Inland Plains

The topography comprises undulating plains crossing the Suttor River Valley at 190 m to 220 m, rising up to 250 m on areas of outcrop before dropping back to about 230 m on sandy cover. The topography then steadily rises to the west reaching about 250 m to 290 m across the Belyando River valley and rising to 300 m to 320 m adjacent to the Permian Sandstones. It finally reaches 330 m at the end of the rail alignment. The generally low undulating topography indicates a low potential for landslip in this area.

Topography along the rail alignment is shown in Figure 1 to Figure 4.

Figure 1. Topography – KP05 to KP85 (Map 1 of 4)

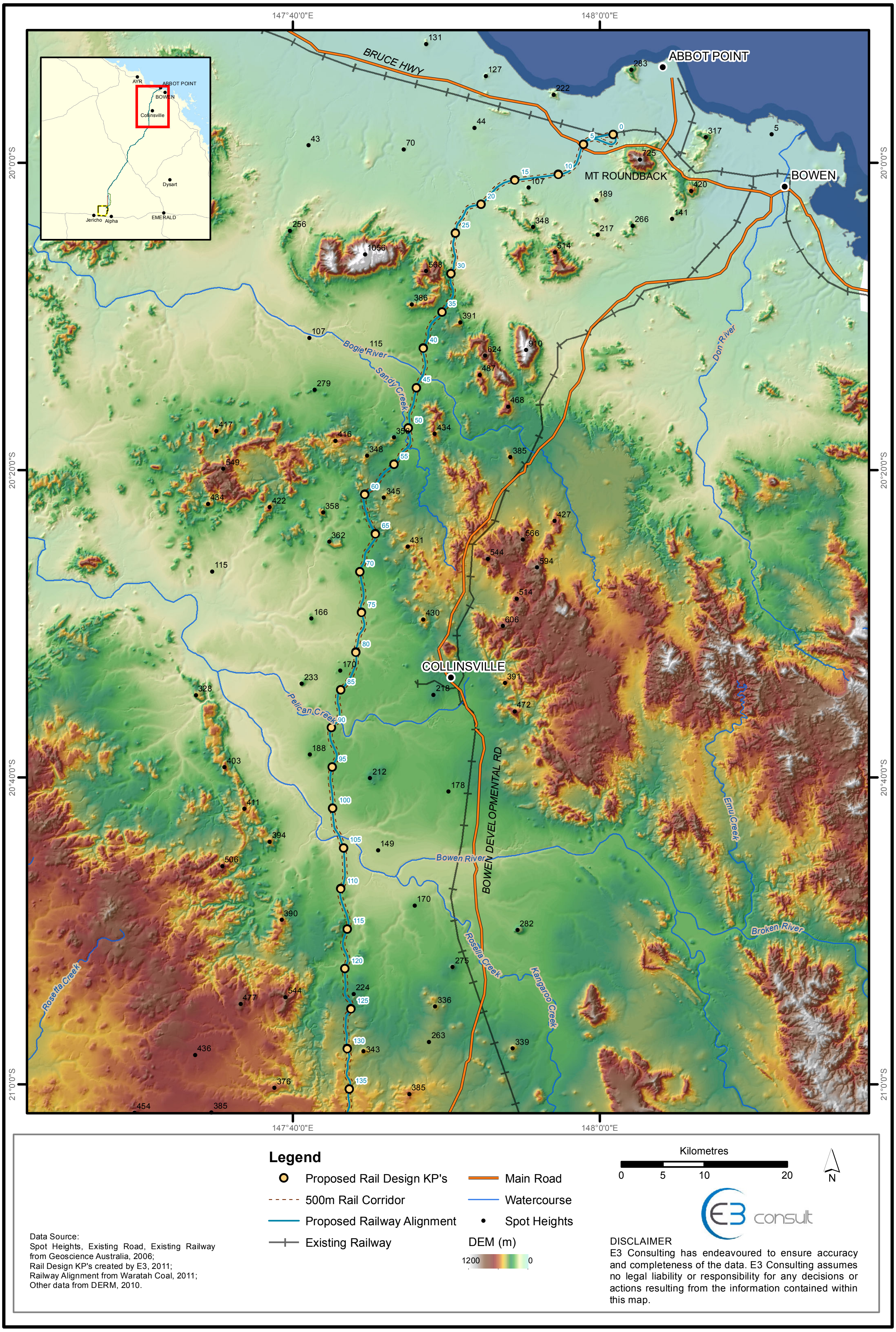
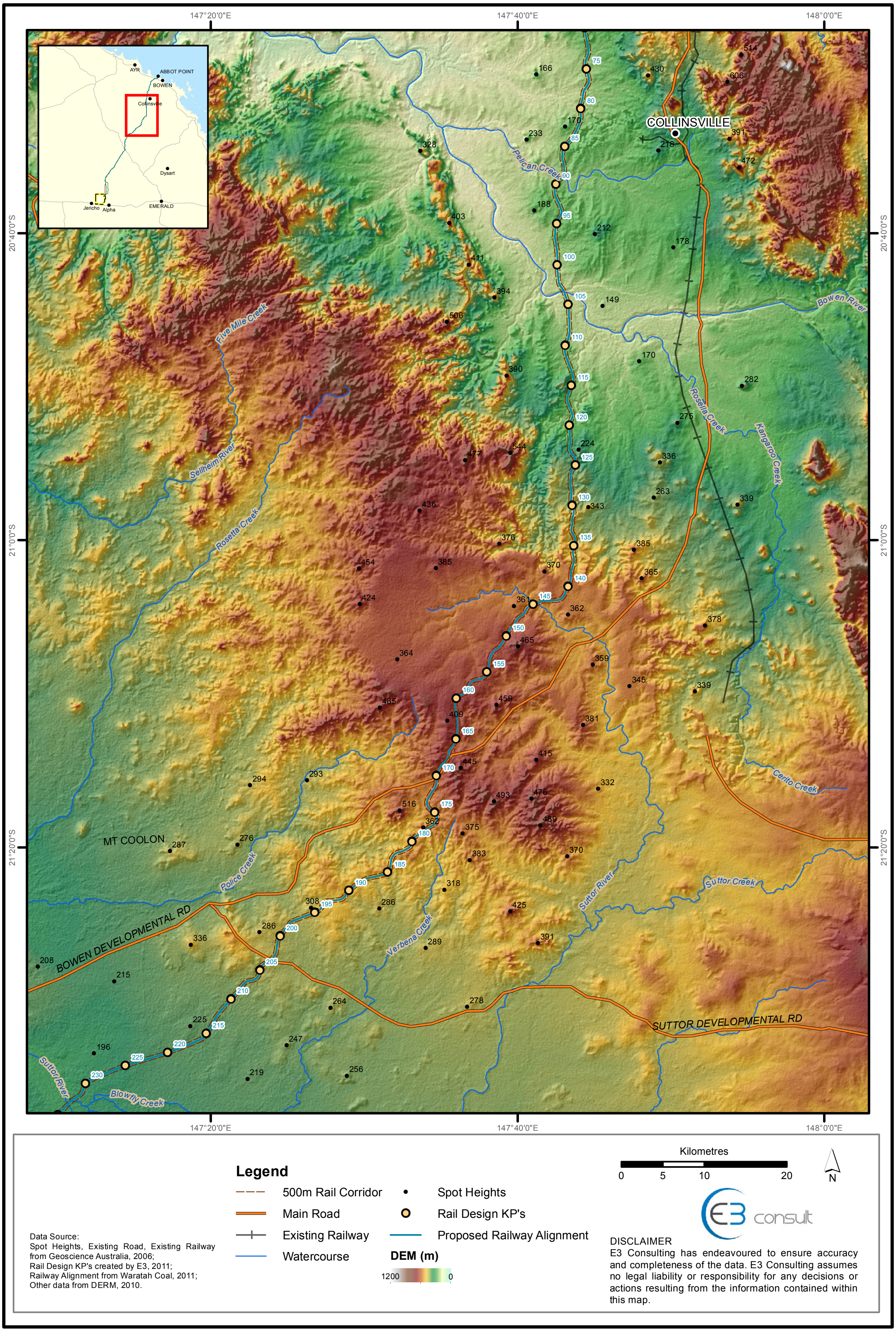


Figure 2. Topography – KP85 to KP235 (Map 2 of 4)



Data Source:
Spot Heights, Existing Road, Existing Railway from Geoscience Australia, 2006;
Rail Design KP's created by E3, 2011;
Railway Alignment from Waratah Coal, 2011;
Other data from DERM, 2010.

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Figure 3. Topography – KP235 to KP360 (Map 3 of 4)

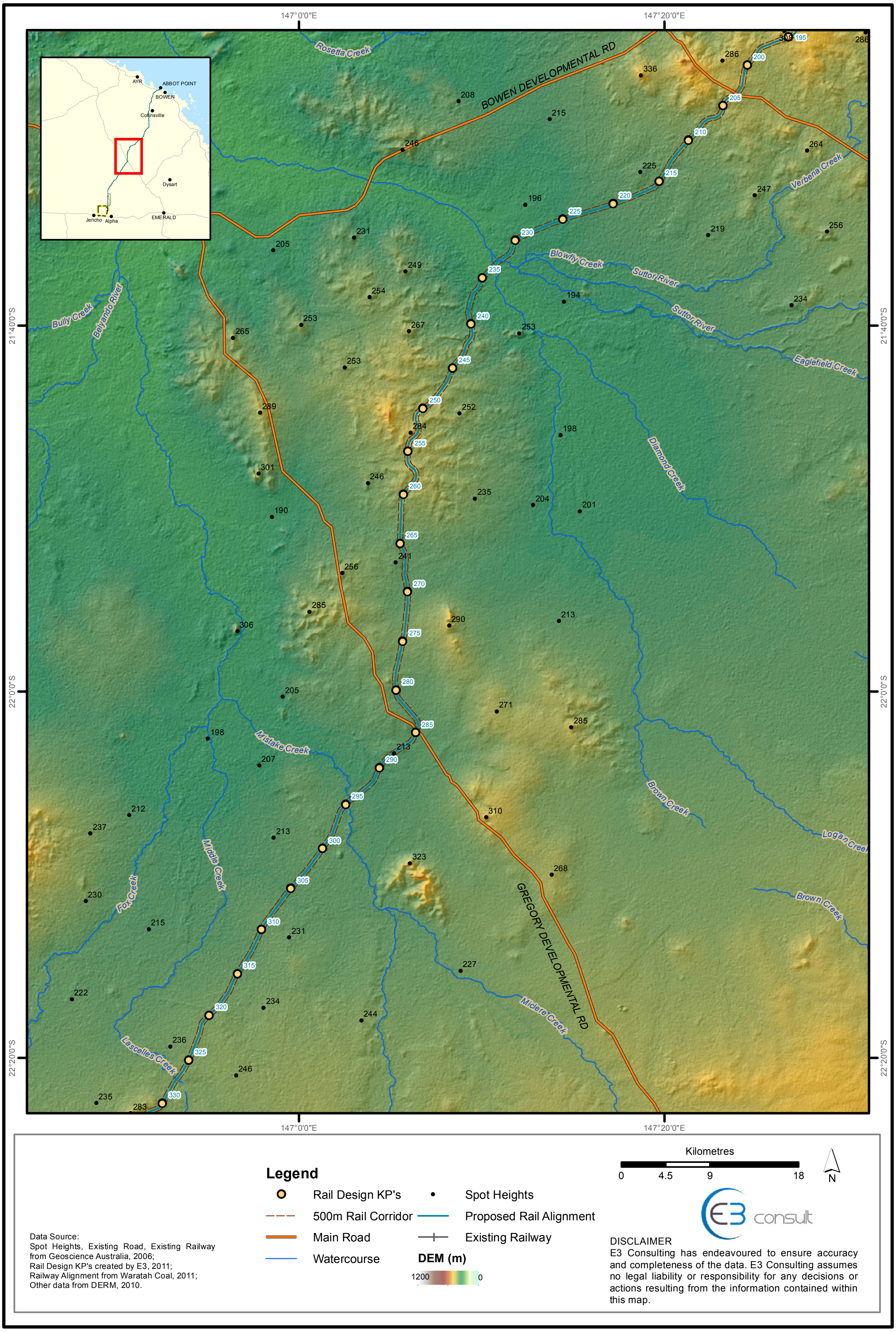
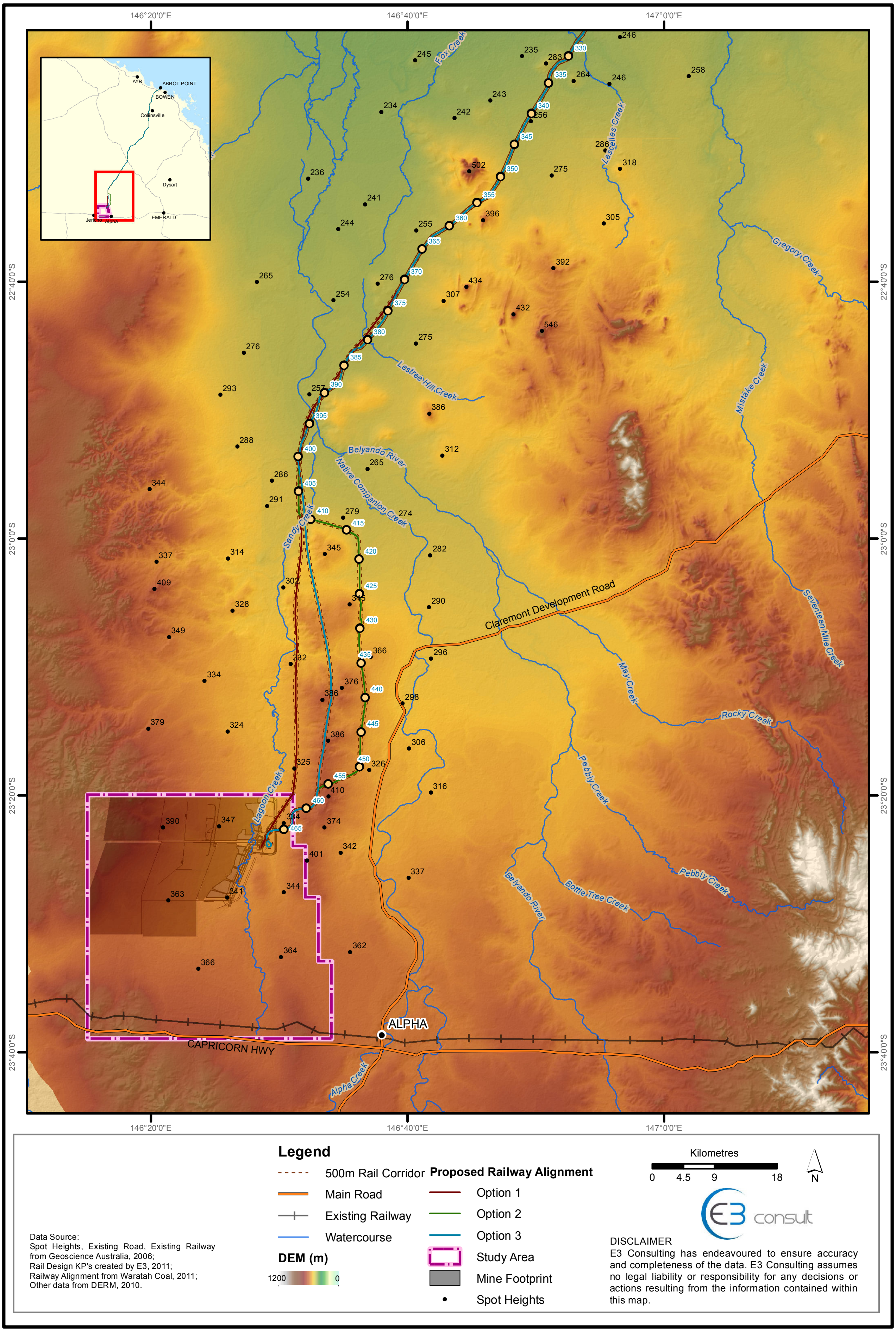


Figure 4. Topography – KP360 to KP468 (Map 4 of 4)



3.4.2 GEOLOGY

This section describes the geology of the rail alignment and the main structural features that may impact upon project construction such as fault zones and dykes following structural trends within the five regional zones.

KP5-KP25 – Coastal Plains

The coastal plain is dominated by intrusive / extrusive rock types and recent alluvial and erosional geology with a low potential for fossils. This includes the predominantly Palaeozoic granitoid terrain from which the Tenosols and sandy soils are derived and the Quaternary mudflats and alluvial valley floors from which the cracking clays are derived. Quaternary coastal sand dunes and talus outwash surround the granitoid intrusives along the coast.

KP25-KP85 – Clarke Ranges

The geology of the Clarke Range is comprised of granite, rhyolite, diorite and other igneous rocks ranging in origin from Carboniferous to Early Permian age (354 to 270 million years). The foothills of the range are generally low undulations before rising to very rugged and broken country.

The major structural faults and shears that occur in close proximity to and / or intersect the rail alignment include those in the Bulgonunna Volcanics region where the north-west trending fault sets dominate including the Glenore Shear zone. Further to the south-east of the rail alignment, the Millaroo Fault Zone extends through the Lizzie Creek Volcanics. It is highly unlike that fossil will be found in this area. There are numerous other faults and structures exploited by dykes that mirror the north-west trend of these zones. The combination of localised steep topography and greater prevalence of fault and fracture systems indicates a higher potential for landslip in these areas adjacent to the rail alignment. The presence of dykes indicates the potential for bars of hard ground requiring rock breaking or explosives in areas otherwise amenable to normal excavation / construction equipment.

KP85-KP125 – Bowen River Valley

The Bowen River Valley is cut into the Lizzie Creek Volcanics including basalts, andesites, tuffs and minor acid volcanic. Further south, the Blackwater and Back Creeks Group comprising sedimentary rocks including sandstones, siltstones, shales and coal. The Hecate granite intrudes these sediments at KP95. The major structures in the area include northwest trending faults in some intrusive and the easterly dip of the Blackwater and Back Creeks Group sedimentary rocks.

The Back Creek and Blenheim groups of the Collinsville coal measures and the Blackwater Group are described as having fossiliferous content. Recorded fossil finds in these units include marine invertebrates such as bivalves and brachiopods as well as aquatic plants.

KP125-KP190 – Leichhardt Range

The Leichhardt Range comprises sandstone, conglomerate and claystones of the Tertiary Suttor Formation to about KP155, after which the corridor intersects the Bulgonunna Volcanics until KP185. Here these are a group of Carboniferous intrusive volcanic including rhyolite and tuffs.

KP190 – KP468 Inland Plains

From KP190 to the mine, the alignment crosses sedimentary rocks of the Suttor Formation and alluvium of the Suttor River derived from these rock types until KP235. From KP235, the sandy alluvium derived from surrounding rock forms a sheet covering most of the landscape with outcrops of low grade metamorphic and acid igneous rocks. Tertiary sedimentary rocks and sandstones as well as siltstones of the Permian Colinlea Sandstone and sedimentary rocks of the Lower Carboniferous Drummond Group are also found in this area. The Permian and younger sedimentary rocks have fossiliferous potential; however, along the rail alignment, there is extensive Quaternary cover and therefore there is a low potential for fossiliferous geological units to occur at the surface.

The largest structure affecting the study area is the Anakie Inlier. The Post-Upper Devonian movement of the Anakie Inlier shaped the Devonian and Permian depositional basins. This controlled the major northwest trending fold axes in these basins. The adjacent basinal sediments in the southeast portion of the Project area are generally much less structurally disrupted with little faulting. These areas are characterised by very gently dipping sedimentary units. Geology along the rail alignment can be seen on Figure 5 to Figure 8. A detailed description of the geological units is provided in Table 1.

Table 1. Geological Key

GEOLOGICAL SYMBOL	ERA	PERIOD/EPOCH	FORMATION NAME	LITHOLOGICAL DESCRIPTION
Qa	Cainozoic	Quaternary undifferentiated	Coastal Mudflats	Fine to medium grained unconsolidated sand
	Cainozoic	Quaternary undifferentiated	Coastal Sand Dunes	-
Qrc	Cainozoic	Quaternary undifferentiated	Outwash and talus	-
Czs/Cza	Cainozoic	Undifferentiated	Alluvial and Deltaic deposits	Sand/sand and gravel, clayey sand, silty sand, clayey silt and silty/clayey sand.
Cgcx/Cggx	Palaeozoic	Upper Carboniferous – Early Permian	Un-named Intrusives	Adamellite, granite, some granodiorite, minor fine grained variants
Cgd	Palaeozoic	Upper Carboniferous – Early Permian	Un-named Intrusives	Diorite, Quartz diorite, tonalite, gabbro, norite, minor granodiorite, adamellite and granite.
Kg	Mesozoic	Lower Permian or Cretaceous		Leucogranite, microgranite, minor adamellite, diorite
Kga	Mesozoic	Lower Cretaceous	Mount Abbot Igneous Complex	Granodiorite, and Adamellite, late stage leucocratic phases
Pa	Palaeozoic	Lower Permian	Kurungle Volcanics	Andesite, andesite brecca, flow banded rhyolite, agglomerate, tuff
Czc	Cainozoic	Tertiary	Sedimentary Rocks	Sandstone and other sedimentary rocks
Czl	Palaeozoic	Upper Carboniferous	Bulgonunna Volcanics	Diorite, quartz diorite, tonalite, gabbro, granodiorite, rare adamelite, diorite, mononite, granite.
Pwlz	Palaeozoic	Lower Permian	Lizzie creek Volcanics	Basalt, andesite, agglomerate, lithic and tuffaceous sediments, minor acid volcanic
Pfmw	Palaeozoic	Upper Permian to Lower Triassic	Mount Wickham Rhyolite	Mainly flow banded porphyritic rhyolite, rhyolite brecca, subordinate trachyte, dacite, obsidian, agglomerate
Psb	Palaeozoic	Lower to Upper Permian	Back creek group – Collinsville coal measures	Quartzose sandstone, conglomerate, siltstone, calcareous sublabile sandstone, coal seams, carbonaceous shale, plant and marine fossils
Cglg	Mesozoic	Lower Cretaceous		Granodiorite, and Adamellite, late stage leucocratic phases
Pok	Palaeozoic	Upper Permian	Blackwater group	Cross bedded well sorted lithic sandstone, siltstone, quartose sandstone, carbonaceous shale with some coal seams, pebble and cobble conglomerate, dolomitic and calcareous sandstone, tuff plant fossils
Cgcx/Cf/Dfiv	Palaeozoic	Upper Devonian to lower Carboniferous and undifferentiated	Connors Volcanics	Andesite, rhyolite, and dacite lavas, agglomerate, volcanic brecca

Czcsu	Cainozoic	Tertiary	Suttor Formation	Coarse clayey sandstone, sandy claystone, polymictic pebble and cobble conglomerate, minor oil shale lateritised. Olivine basalt
Cfb	Palaeozoic	Devonian/ Carboniferous	Mt Rankin Beds	Sedimentary Rocks
Czl	Palaeozoic	Carboniferous	Bulgonunna Volcanics	Flow banded, porphyritic, rhyolite , quartz feldspar, porphyry, acid tuff and agglomerate, acid to intermediate stocks and bosses
Nya	Palaeozoic	Lower Palaeozoic	Anakie Metamorphic	Quartz-mica shist, mica schist, hornfels, slate, sandstone
Csry/Cwst	Palaeozoic	Devonian carboniferous	Drumond Group	Feldspathic quartz sandstone, buff siltstone and claystone, rhyolite flows and agglomerate, sublabile sandstone, siltstone fossiliferous
Czs	Cainozoic	Quaternary undifferentiated		Sand, sandy soil
Csdu/Csdl	Cainozoic	undifferentiated	Sedimentary Rocks	Sandstone / Siltstone
Psb	Palaeozoic	Lower Permian	Colinlea Sandstone	Labile and Quartz sandstone, minor siltstone and coal

Figure 5. Geology – KP05 to KP85 (Map 1 of 4)

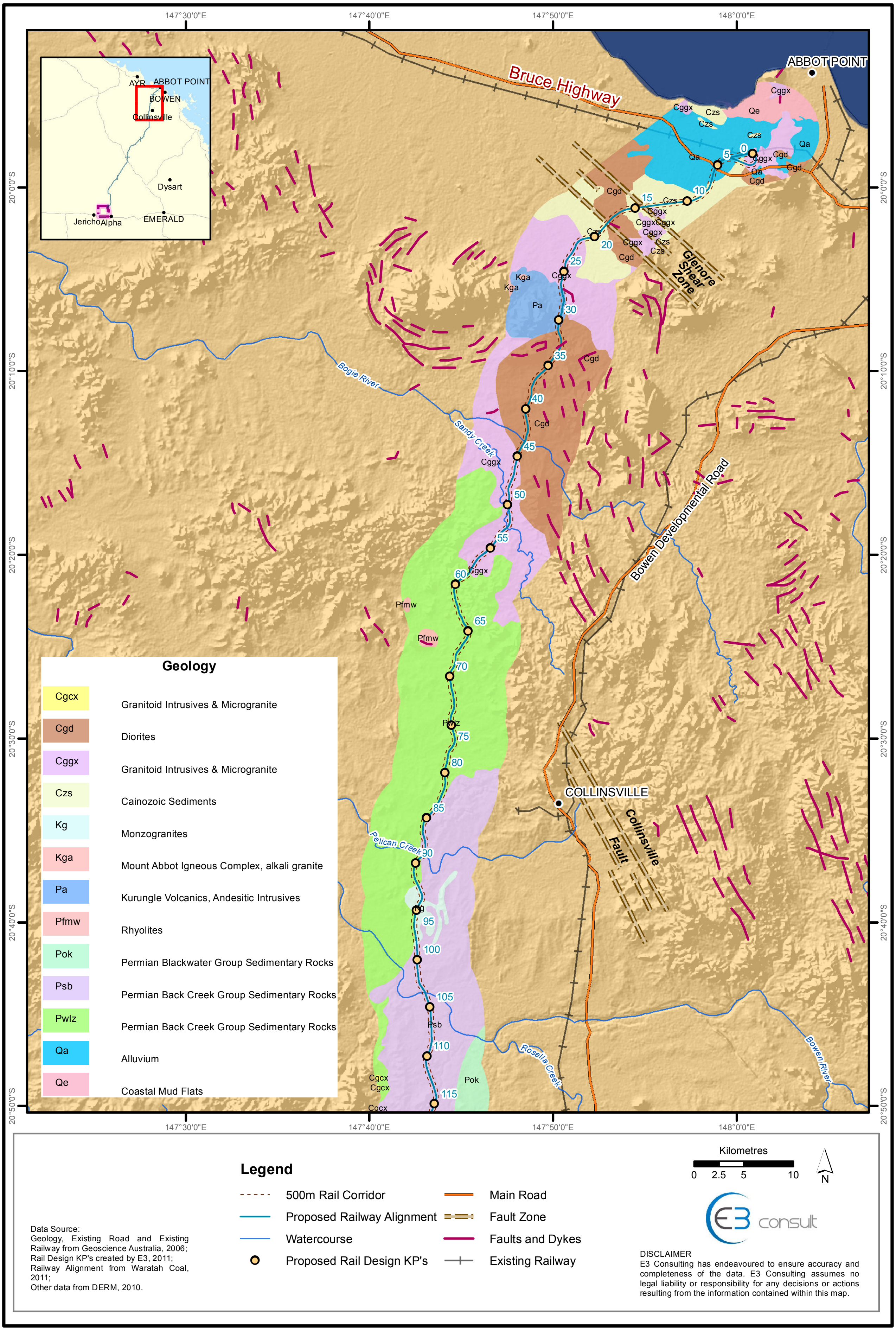


Figure 6. Geology – KP85 to KP235 (Map 2 of 4)

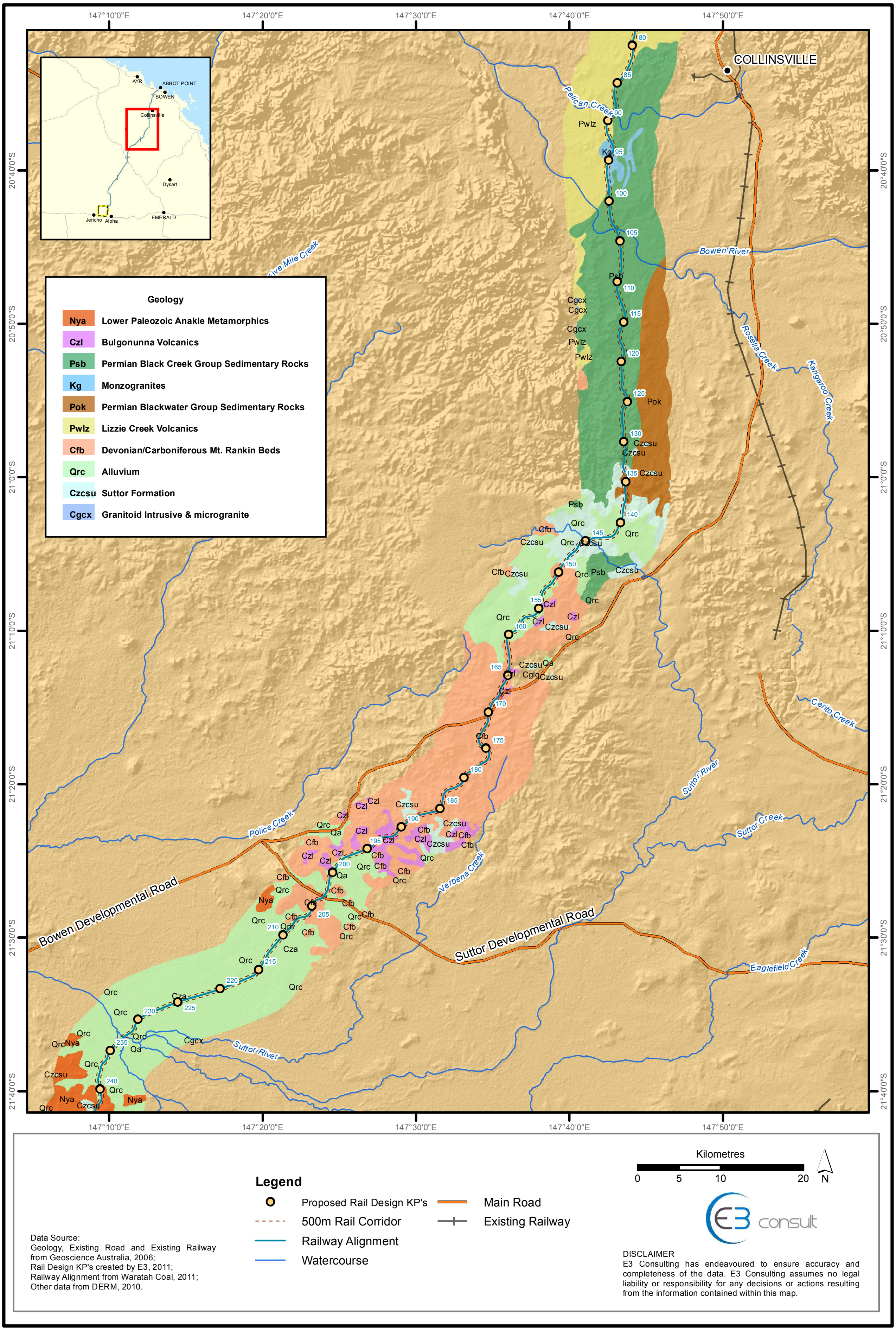
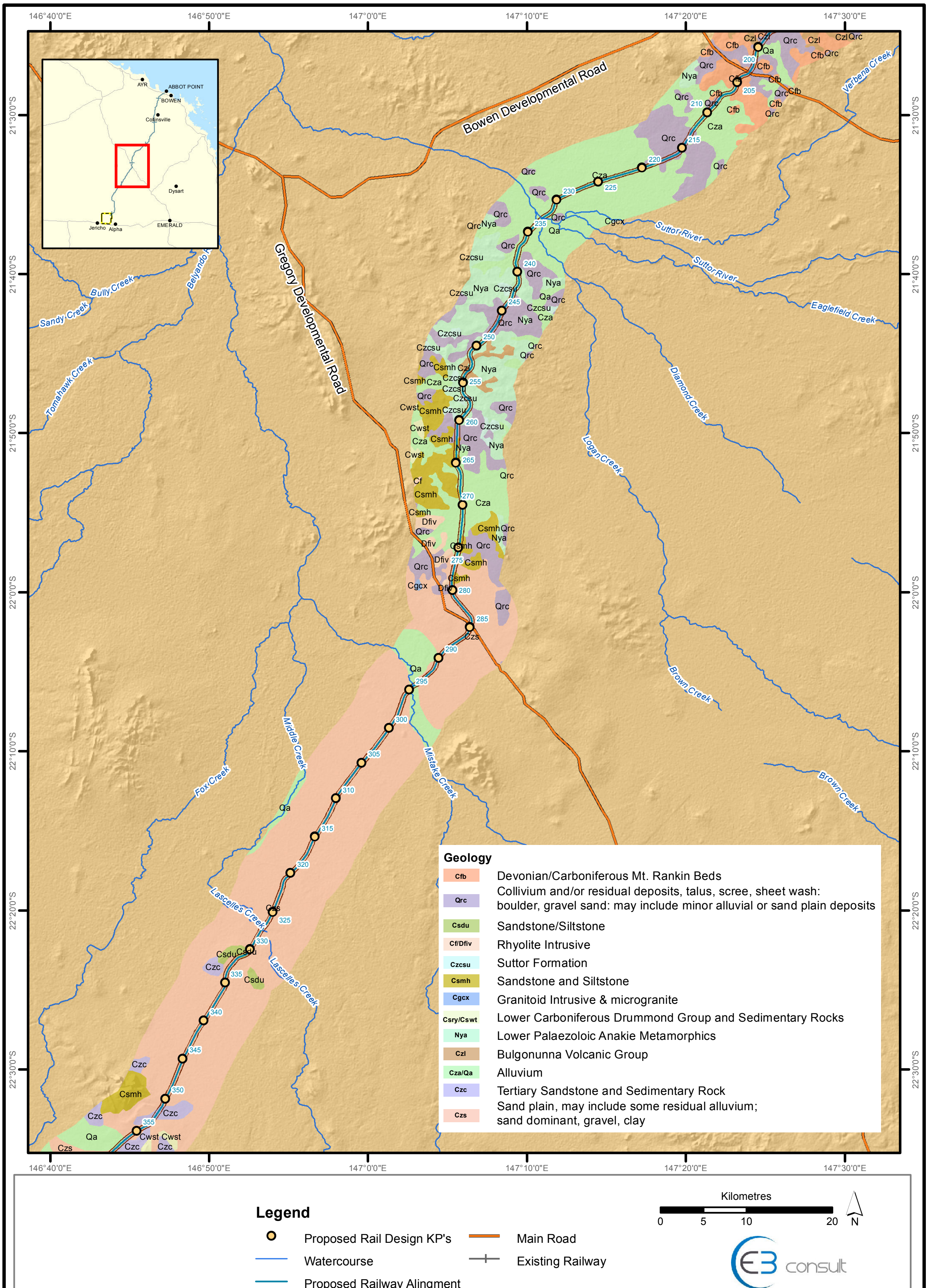


Figure 7. Geology – KP235 to KP360 (Map 3 of 4)



Data Source:
Geology, Existing Road and Existing Railway from Geoscience Australia, 2006;
Rail Design KP's created by E3, 2011;
Railway Alignment from Waratah Coal, 2011;
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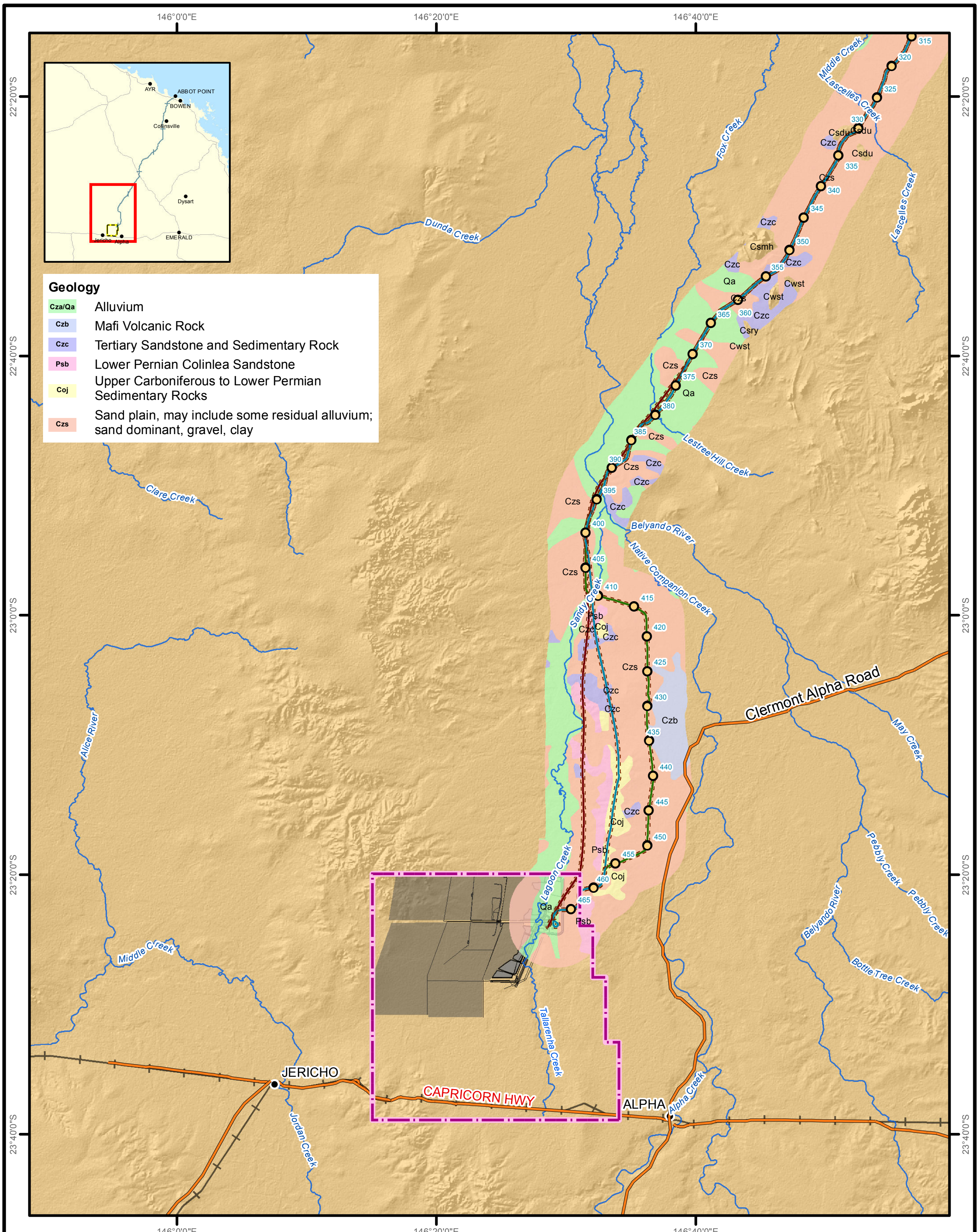
Figure 8. Geology – KP360 to KP468 (Map 4 of 4)



Data Source:
Geology, Existing Road and Existing Railway from Geoscience Australia, 2006;
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Other data from DERM, 2010.

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3.4.3 SOILS

The following section provides an overview of the soil types along the rail alignment split into the five specific regions.

KP5-KP25 – Coastal Plains

Soils in the coastal area are regionally mapped as Sodosols; however, site sampling in the APSDA indicates Vertosols and some Tenosols are present. Vertosols include clay soils with shrink-swell properties that exhibit strong cracking when dry and can be associated with gilgai landscape microrelief. They also form mounds and depressions in the landscape as a result of repeated shrinking and swelling of the clay blocks of subsoil. Tenosols comprise sandy to gravelly soils derived from granitoid outwash. Sodosols include sodic soils predominantly in areas subject to periodic inundation.

Soils sampled in the coastal plains included Tenosols and Vertosols on the coastal land above the inundated saline mudflats that have a pH of 5.9 to 8.6. More alkaline soils are generally associated with Vertosols and Sodosols. The soil fertility is indicated by Cation Exchange Capacity (CEC) which identifies the soil's ability to supply the plant nutrients Ca, Mg and K. The Tenosols generally have low CEC (i.e. SS01, 1.9 meq/100g) while the clay soils have generally higher CEC (SS05, 52.4 meq/100g). This is also reflected in the individual cation analyses. Saline soils with salt scalds are apparent on periodically inundated lands adjacent to the wetlands. Salinity as indicated by the chloride and EC suggests that Tenosols generally have low salinity while the Vertosols have moderate salinities.

The topsoil availability is likely to limited in the range of <0.1 m in the area of the shallow Tenosols, while the Sodosols may produce topsoils up to 0.3 m thick. Cracking clays are present at several locations (SS03, 06 and 08) throughout this area, generally in very low flat plains and / or near creeks and floodplains.

The soil sodicity and / or Emerson Crumb dispersivity analyses of samples SS02 and SS06 reported high potential for erosion and indicate that soils in these areas tend to be sodic in nature and prone to dispersion and erosion.

The variable rainfall and relatively flat topography of this area can result in localised flooding occurring over the rail alignment during rain events >200 mm over a 48 hr period. Flooding generally occurs during summer months as a result of heavy monsoon rainfalls caused by tropical lows and rain depressions generated from cyclones crossing the north eastern Queensland coastline. This can contribute to scour and tunnel erosion in soils in this area.

Six sites were visually assessed to determine their potential for erosion. Four of the six sites (Sites SO2, SO3, SO6 and SO8) were assessed as having a high potential for erosion. The four sites were deemed to have a high potential either due to evidence of existing erosion or were considered to be susceptible to erosion due to sandy substrates with no vegetative cover. The remaining two sites were assessed as having a low potential due to minimal erosion or comprising heavily vegetated banks.

Acid Sulphate Soil (ASS)

As a portion of the land proposed for the rail alignment (up to KP5.6) is below 5 m AHD, ASS have the potential to be encountered. Investigations are required to be undertaken prior to the commencement of construction activities associated with the rail alignment to assess the possible presence of ASS in accordance with SPP2/02.

KP25-KP85 – Clarke Ranges

Dominant Chromosol, Sodosol and Vertosols soils within this area include loamy red duplex soils from KP25 to KP57, shallow stony, loamy red duplex soils from KP58 to KP63 and hard alkaline yellow soils from KP63 to KP74. The hilly areas have very shallow stony duplex soils, while valley floors have occasional small areas of dark clays and / or red-brown clays, hard alkaline yellow and crusty loamy soils that are generally consistent with the area being mapped as Chromosol soils with some cracking clays in valleys. However, the dominant soils are loamy red duplex soils of shallow to moderate depth (up to 0.3 m). In some areas yellow loamy duplex soils are locally dominant, although these are often closely associated, particularly on lower slopes with mottled yellow duplex soils.

Between approximately KP75 and KP85, the alignment traverses an area bordering Sodosol / Vertosol soil areas. The landform in this section of the alignment includes moderate to strongly undulating lands with some hills. Dominant soils are described as grey loamy and standard loamy duplex soils associated with alluvial plains which are more consistent with Sodosol soils. From approximately KP82 to KP84, the dominant soils are shallow sands, sandy or loamy duplex soils which are more consistent with the Sodosol or Tenosol soils (weakly developed soils). Based upon the mapped soil types and observations from soil sampling, topsoil is expected to be in the range of 0.1 m to 0.3 m.

The area dominated by Chromosol soils are generally low salinity but often also low fertility soils as indicated by CEC results of 4.6 (SS09) to 8.6 (SS13) in most samples from this area. Though some clays around river valleys have high CEC and greater potential for agriculture (SS15), they also have low Mg content.

From approximately KP25 to KP85, the Chromosols in areas of higher relief are likely to have low to high erosion potential. While these soils generally contain high organic matter and lower proportions of sand / silts, the higher relief increases the potential for erosion in some areas. In the lowland portions of this area, the erosion potential will generally be lower, except where creeks with periodic high flows which can scour the soil profile. Where sampled, Emerson Crumb tests identified Chromosols as having moderate erodibility on the surface and at depth and are anticipated to have lower potential for erosion than other areas.

The Sodosols had near neutral pH and low salinity. Some (SS15) had low Exchangeable Sodium Percentage (ESP) and are considered to be generally less prone to erosion than the Chromosols. Topsoil depths are anticipated to be in the order of 0.1 to 0.3 m in Chromosol areas and up to 0.6 m deep in Sodosol areas.

Six sites were visually assessed to determine their potential for erosion. Five of the six sites (Sites SO10 to SO15) were described as having a low potential for erosion due to a combination of predominantly clayey substrates, vegetative cover and low energy stream flows. Site SO9 would likely have a high potential for erosion due to sandy banks and a rocky stream bed indicating the potential for high energy flows capable of severe scouring.

KP85-KP125 – Bowen River Valley

Sodosols mapped in the area includes loamy duplex soils with mottled yellow-brown subsoils. These were present in the undulating lands on tributaries while small alluvial areas have grey loamy duplex soils. Tenosols are present as thin soils on sandstone ridges. Dominant soils in the valley floor include dark clays of moderate depth, with older terraces and levees having deep sandy or sandy loam with 0.3 m to 0.6 m A horizons with a clear change to reddish brown clay or sandy clay. Gilgai microrelief is present on the deep clays. On the southern undulating slopes that rise to the south, more thin loamy duplex soils are present. This area is usually strongly dissected by many small streams and nearly all soils have a gravel-strewn surface and are often eroded.

From approximately KP85, the rail alignment traverses Sodosol mapped areas until it reaches about KP125 where the alignment traverses an area bordering Tenosol / Sodosol / Kandosol soil mapped areas.

Soils are described as sandy to loamy duplex soils and some shallow sands on the moderately undulating lands consistent with the Sodosol and Tenosol mapped areas with deep sandy or sandy loams on the alluvial flood plains more consistent with Kandosol soils (soils which lack a strong texture contrast and have a weakly structured B horizon).

Soils in these areas generally have a pH from 6.9 to 7.9, with low CEC indicating generally low fertility. The deep clays in the river valleys have higher CEC. The soils are generally low salinity soils with low Electrical Conductivity (EC) and low to medium ESP. However, the clay soils at SS20 (Rosella Creek a tributary of the Bowen River) were saline with a high ESP indicating some salinity is present in soils in the valley floors. These valley floor clay soils can also be sodic and therefore susceptible to dispersion, as indicated by high ESP and / or low Ca:Mg ratios.

Some clay soils (SS18) had high Emerson Crum results indicating low potential for erosion, while others (SS19) had lower results. This indicates that while clays are widespread throughout the valley floors, the erosion potential of these soils will vary over their extent in the alignment.

From a review of aerial photography and on-site observations, areas around creek lines appear to be subject to erosion. However, the erosion potential can vary along the alignment within individual soil types. The most susceptible soils for erosion are sodic or dispersive clays and loamy soils. Topsoil availability in areas is not subject to excess salinity or sodicity and is generally considered to be between 0.1 m to 0.2 m; however, some sandy loams on alluvial terraces may have topsoils up to 0.6 m deep.

Three sites (SO16, SO17 and SO18) were visually assessed for their erosion potential. One site (SO16) was assessed as having a low erosion potential due to the observed heavily vegetated clayey banks comprising a stepped formation, rather than steep incline, and moderate flow. Sites SO17 and SO18 were identified as having a high erosion potential attributable to silty / sandy banks with little vegetative cover.

KP125-KP190 – Leichhardt Range

The rail alignment traverses mainly Tenosol with small areas of Kandosol. The landscape varies throughout this portion of the alignment from level plains to strongly undulating elevated land. Dominant soils on the level plains are loamy yellow earths with areas of loamy red earths and cracking clays. Dominant soils on the strongly undulating elevated areas may include shallow stony gritty leached sands or sandy loams more consistent with Tenosols.

Soils in this area include acidic soils with very low CEC and ESP (SS24, 25, 26, 27 and 30). Several samples (SS25, 27, 29 and 30) had very low exchangeable calcium and low Mg, indicating low fertility soils. This was further enforced by poor growth on stony soils. The soils are generally low salinity soils with EC of <150 μs/cm, low chloride and low to very low ESP with the exception of Sodosols where soils (SS30) recorded a very high EC of 2240 μs/cm, chloride of 3020 mg/kg and very high ESP of 54.2.

Kandosols in the generally low relief areas between KP130 and KP190 are considered to have generally low to moderate erosion potential. The higher erosion potentials are expected locally in alluvial areas with higher sand or silt contents. Emerson Crumb results indicate that some soils in the valley floors have moderate dispersion potential and will be susceptible to erosion after disturbance, while others are generally stable.

Tenosols from KP165 to KP190 are generally shallow soils in areas of moderate to high relief and are anticipated to have moderate to high erosion potential. The Tenosols were non-dispersive; however, the stoniness of these soils combined with the shallow bedrock would be unsuitable for stripping and susceptible to erosion. The Tenosols encountered in sampling had nil to minimal (0.05 m) topsoil.

Five waterway sites (SO20 to SO24) were visually assessed for their erosion potential. Three of the five sites (SO20, SO21 and SO24) were assessed as likely having a high erosion potential. Evidence of erosion was observed at Sites SO20 and SO24, while Site SO21 was described as sandy banks with moderate flow. The remaining two sites (SO22 and SO23) were assessed as having a moderate to high erosion potential comprising sandy substrates with high proportions of vegetation likely to reduce the potential for erosion.

KP190-KP468 – Inland Plains

From approximately KP190 to KP220, the alignment traverses areas mapped as Sodosols. The landscape varies from the gently undulating to low hilly lands from about KP190 to KP200 to level or gently undulating plains from approximately KP202 to KP225. Dominant soils on the hilly land are shallow stony gritty leached sands or sandy loams more consistent with Tenosol soils. The soils of the sloping plains consist of loamy duplex soils more consistent with Sodosol soils to loamy yellow, red and grey earths and cracking clays on the lower areas associated with Vertosol soils (from approximately KP215 to KP305). Landforms include level to gently undulating alluvial plains from approximately KP220 to KP230, KP257 to KP274 and KP282 to KP361 with more strongly undulating lands from KP231 to KP256.

Soils described on the more strongly undulating slopes are dominated by sand and gravelly loamy duplex soils and sandy red earths more consistent with Sodosol or Kandosol soils. Dominant soils within the more level or gently undulating land include deep grey clays and cracking clays consistent with Vertosol soils and loamy duplex soils, sandy red and yellow earths more consistent with Sodosol or Kandosol soils.

From approximately KP305 to KP420, the alignment traverses areas predominantly soils mapped as Kandosols with a section of Vertosols from KP365 to KP375. The landform in this section of the alignment varies from level plains to undulating lands with the exception of some strongly undulating land from approximately about KP410 to KP412.

Dominant soils on the level plains to undulating lands include sandy and loamy red and yellow earths, loamy duplex soils consistent with Kandosol, Chromosol or Sodosol soils and grey deep clays consistent with Vertosol soils. The dominant soils on the strongly undulating land are shallow stony loams with small areas of stony red earths consistent more consistent with Rudosol soils.

From approximately KP420 to KP468, the soils are mapped as Kandosol soils. Land forms consist of very gently to level undulating plains. Dominant soils are sandy or loamy red and yellow earths with some areas of sandy surfaced duplex soils, associated with deep red sands that form low dunes. This is consistent with the mapped Kandosol soil description. These soils are generally neutral or near neutral pH with low salinity. The soils mostly have low CEC and ESP indicating lower fertility with the exception of some areas in the alluvial valleys. Sodicity as indicated by ESP is generally low although some clays soils have elevated sodicity.

The Emerson Crumb results (SS48) suggest that the soils have the potential for erosion through dispersion. They also generally have low Ca:Mg ratios. However, the generally lower topography results in overall lower potential erosion impact from rainfall runoff.

Topsoil depth varies along this area of the rail alignment. Deeper topsoils of 0.25-0.6 m thickness were observed although, generally they are approximately 0.3 m thickness which are expected in areas of heavy clay soils, while the sandy soils exhibit shallower topsoil depth of up to 0.15 m.

Nineteen sites were visually assessed for their erosion potential. Of the 19 sites:

- 12 sites (SO25 to SO30, SO32 to SO34 and Sites SO37, SO38 and SO41) were assessed as having a low erosion potential;
- two sites (SO31 and SO40) were assessed as having moderate erosion potential;
- four sites (SO35, SO36, SO42 and SO43) were assessed as having a moderate to high erosion potential; and
- SO39 was assessed as having a high erosion potential.

SO39 was categorised as having a high erosion potential due to loose silty soil observed on the steep and already eroded banks, compared to predominantly clayey substrates with greater proportions of vegetation at the remaining locations.

Dominant soils along the rail alignment are shown on Figure 9 to Figure 12.

Figure 9. Dominant Soils – KP05 to KP85 (Map 1 of 4)

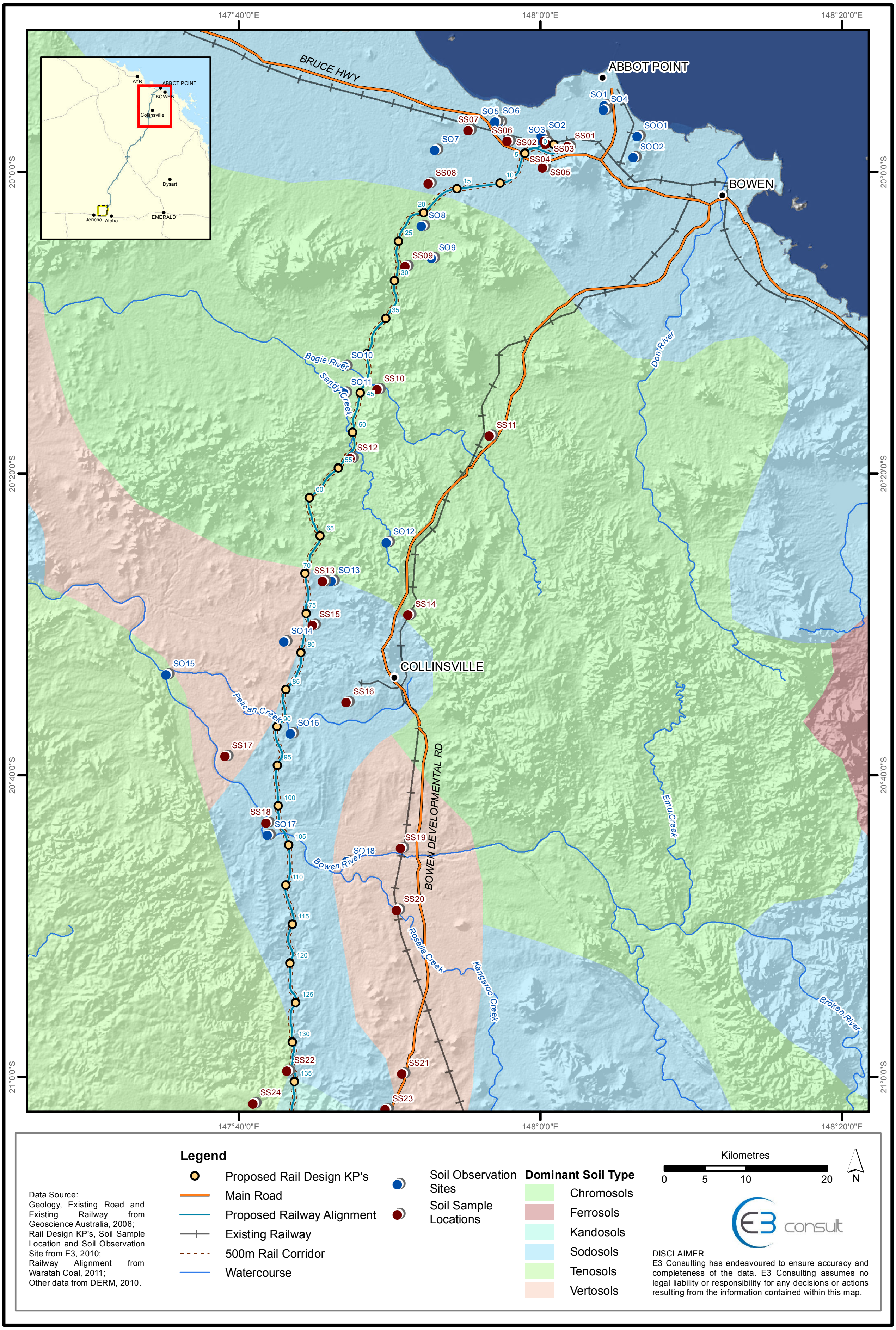


Figure 10. Dominant Soils – KP85 to KP235 (Map 2 of 4)

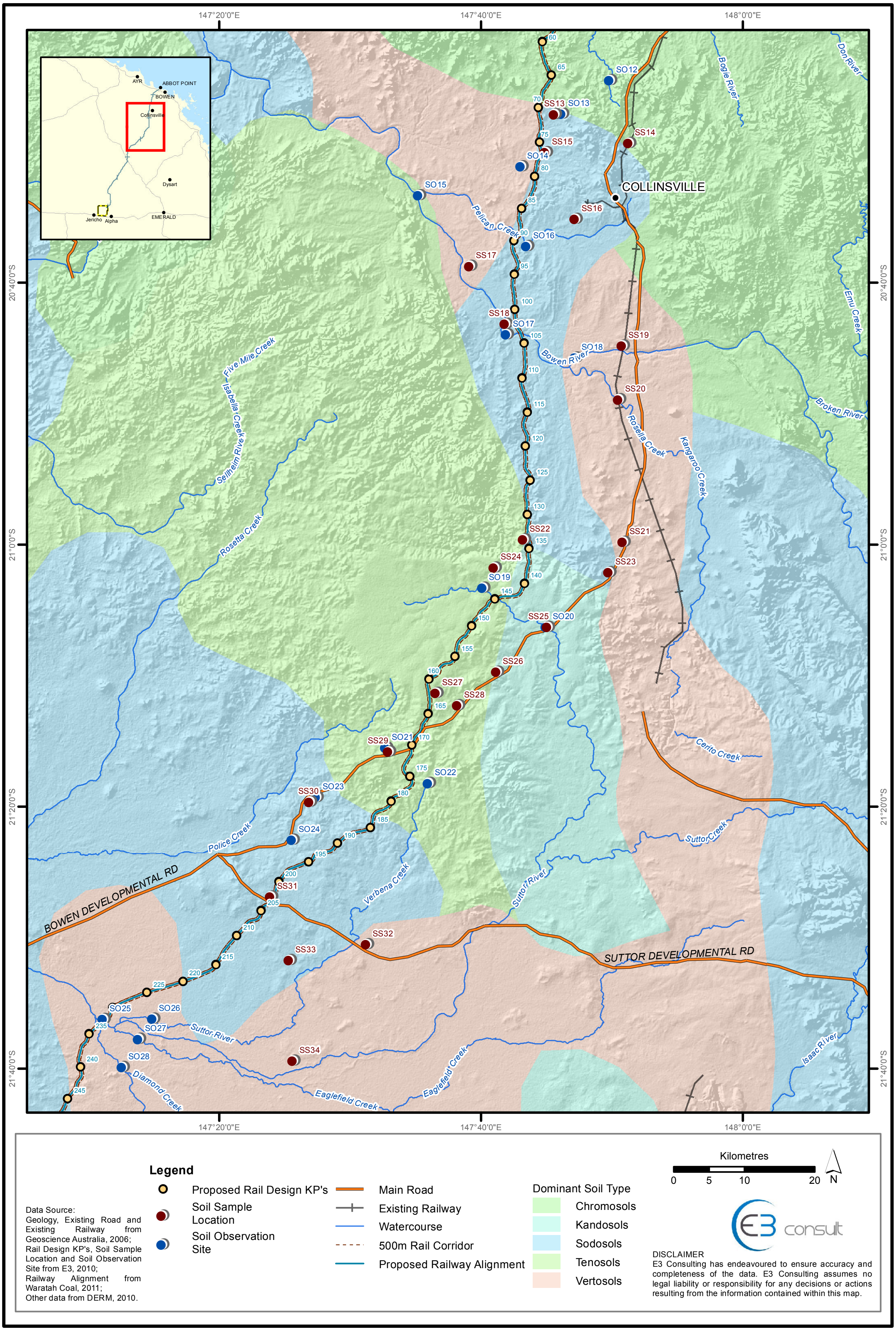


Figure 11. Dominant Soils – KP235 to KP360 (Map 3 of 4)

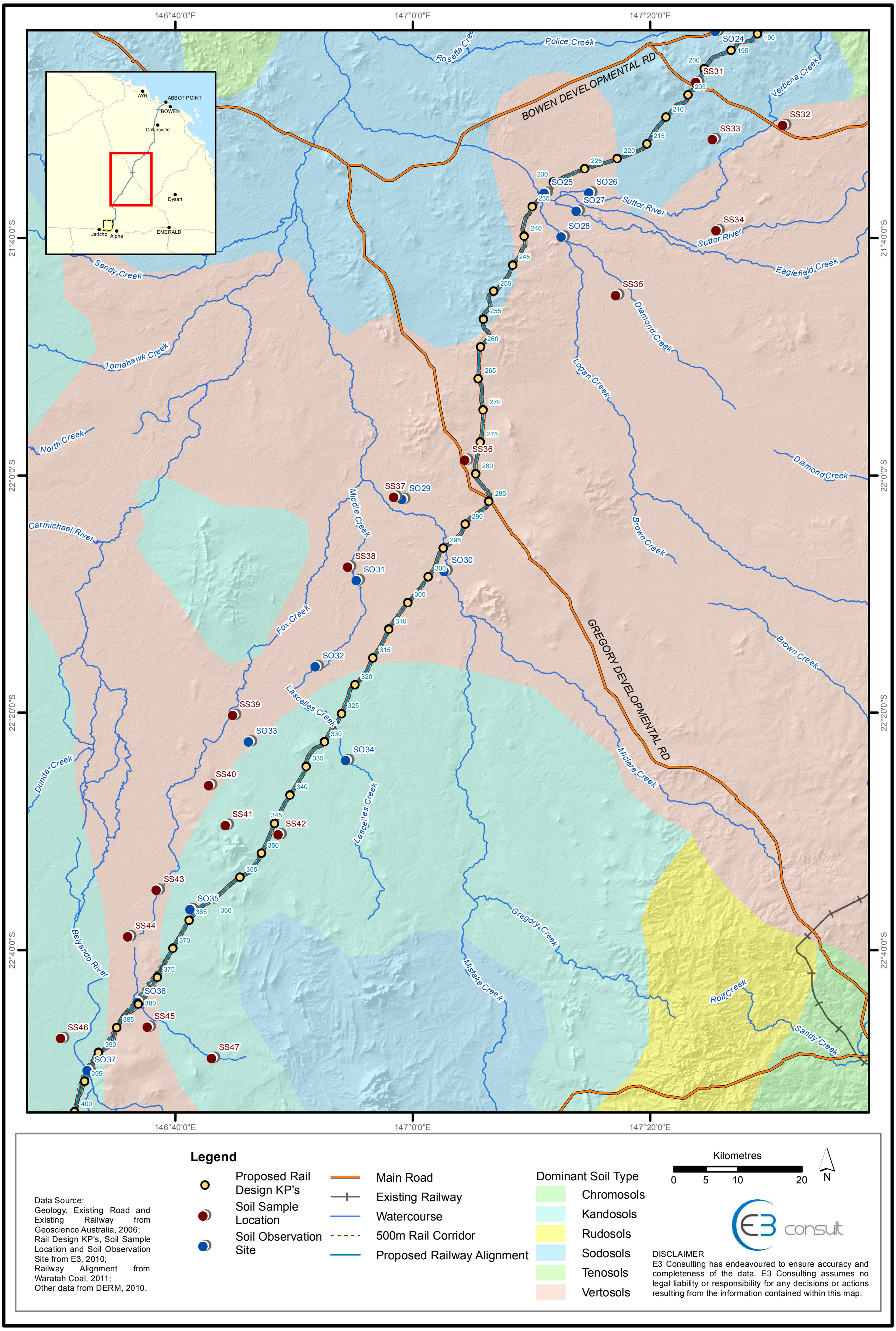
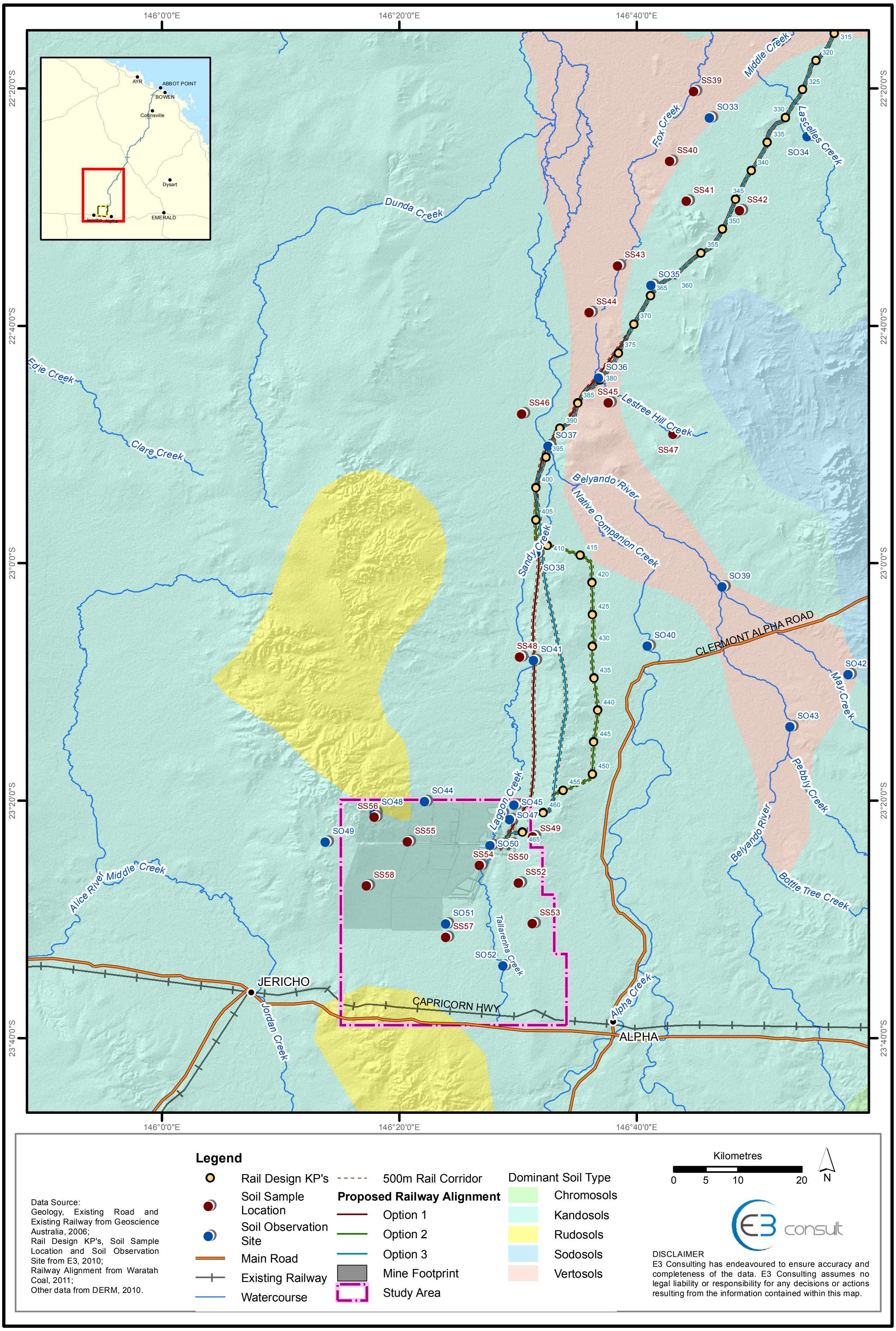


Figure 12. Dominant Soils – KP360 to KP468 (Map 4 of 4)



3.4.4 LANDFORMS

The following section provides an overview of the landforms along the rail alignment within the five identified regions.

KP5-KP25 Coastal Plains

The landform of this section of the alignment is characterised by level plains and gently undulating lands to KP18. At KP18, the slope of the land increases to moderately / strongly undulating lands in which the soils are dominated by sandy or loamy duplex soils consistent with Sodosol soils. In contrast, from KP02 to KP05, deep dark cracking clays are observed which are consistent with Vertosols with slight gilgai microrelief.

KP25-KP85 Clarke Ranges

The dominant landforms in the Clarke Range are moderately and / or less commonly, strongly undulating lands with occasional isolated hills surrounded by strongly dissected steep slopes with limited rock outcrop and some valley plains.

KP85-KP125 Bowen River Valley

The landforms include moderate to strongly undulating lands with occasional high strike ridges with sandstone outcrop on the south facing valleys slope, changing to undulating land with gently sloping plains, moderate to high mostly stony ridges, and some low stony basaltic hills. Near the Bowen River the landforms comprise gently undulating alluvial flood-plains, often with marked terraces, levees, and shallow drainage depressions which rise to the south to moderate to strongly undulating lands with an occasional low hill.

KP125-KP190 Leichhardt Range

The Leichhardt Range includes strongly undulating lands with some low cuesta-like hills that frequently have massive sandstone outcrops of the Suttor Formation. This can include low sandstone mesas and lateritic scarps. There can also be level plains, with broad low lake-like depressions. The undulating lands include shallow sands with some evidence of leaching and on the lower slopes, sandy or loamy duplex soils. In the level plains and broad depressions, loamy yellow and red earths are present, with areas of cracking clays with gilgai microrelief present. In some steeply sloping areas, stony soils occur, while mesas can have kaolinised sandstone derived soils.

KP190-KP468 Inland Plains

The landforms are dominated by undulating lands, level alluvial sandy plains and clay plains. Undulating lands consist of level to sloping plains interrupted by low mesas, lateritic scarps, gravelly ridges or their dissected remnants where sedimentary rocks outcrop. These units become more strongly dissected at their margins. The intrusive rocks generally develop small steeper sided hills.

The alluvial plains are level to very gently undulating and include sandy alluvium and alluvial plains associated with major streams. In some areas, clay soils dominate the alluvial plains and these areas can have moderate to strong gilgai microrelief.

Landscape units identified along the rail alignment are shown on Figure 13 to Figure 16. A detailed description of the landscape units is provided in Table 2.

Table 2. Landscape unit descriptions – rail alignment

LANDSCAPE UNITS	LANDFORM	SOILS	REMARKS
Va50	Undulating or gently undulating lands / small areas of granite outcrop	Dominant are sandy or loamy often gritty duplex soils	The unit have shallow coarse sands
Kf13	Level plains	Dominant soils are deep dark cracking clays with lesser grey clays	A slight gilgai microrelief is often present
Va86	Gently undulating outwash slopes and fans	Dominant are deep loamy duplex soils with closely associated deep bleached sands	The sands are confined to the relic stream channel infills and fans

LANDSCAPE UNITS	LANDFORM	SOILS	REMARKS
Sl16	Gently undulating plains	Dominant are deep loamy duplex soils. Included in the unit are areas of deep grey-brown and brown cracking clays	Data is limited
Qa14	Moderately or, less commonly, strongly undulating lands with occasional isolated hills surrounded by strongly dissected steep slopes; limited rock outcrop may occur throughout. Very occasional small areas of dark clays or red-brown clays may also be included in the unit	Dominated by loamy red duplex soils of shallow to moderate depth. In some areas, yellow loamy duplex soils are locally dominant. Often closely associated, particularly on lower slopes with mottled yellow duplex soils	The hilly areas have very shallow stony duplex soils
Qa11	Low hilly to hilly lands with some strongly undulating marginal slopes; hill crests are often rounded and slopes are moderate	Dominated by mostly shallow and often stony loamy red duplex soils. Occasional areas of red friable earths. On some lower slopes and valley floors, yellow or brown loamy duplex soils occur	Rocky outcrop is common throughout
Qa12	High hilly lands with some mountainous areas; nearly all hills have steep slopes but crests are often rounded	Dominant are shallow stony loamy red duplex soils. Small areas of red friable earths are associated in some areas. Higher hill crests and more stony sites have shallow stony loams	Marginal to the unit, topography may be strongly undulating; rock outcrop is common throughout
Sl17	Valley plains	Chief soils are probably hard alkaline yellow soils	Associated are crusty loamy soil and cracking clays
Vd5	Moderate to strongly undulating lands with occasional high strike ridges with sandstone outcrop	Dominated by loamy duplex soils with mottled yellow-brown subsoils. Associated small alluvial plains have grey loamy duplex	Occasional highly calcareous ridges have shallow loams. Where sandstone outcrop are prominent, shallow sand soil occurs
JJ13	Strongly undulating lands with some low cuesta-like hills that frequently have massive sandstone outcrops	Dominant soils are shallow sands, with some leached sands. On lower slopes, sandy or loamy duplex soils occur	In some areas, higher levels of quartz gravel may occur. Data is limited
Kb26	Undulating lands with gently sloping plains, moderate to high mostly stony ridges, and some low stony basaltic hills	Dominant soils are those of the plains and lower ridge slopes, these have dark clays of moderate depth	Often display linear gilgai. The higher ridges and low hills have rock outcrop and shallow stony soils
Qb27	Gently undulating alluvial flood-plains, often with marked terraces, levees, and shallow drainage depressions	The dominant soils are those of the older terraces and levees. They have deep sandy or sandy loam. A horizons (0.3 to 0.6 m) with a clear change to reddish brown clay or sandy clay	On the most recent terraces that may be subject to flooding

LANDSCAPE UNITS	LANDFORM	SOILS	REMARKS
Sl23	Moderate to strongly undulating lands with an occasional low hill	A complex array of loamy duplex soils is present, most are shallow	The area is usually strongly dissected by many small streams and nearly all soils have a gravel-strewn surface and are often eroded and outcrops are common
Ms5	Level plains with many broad very shallow lake-like depressions	Dominant soils are loamy yellow earths with some areas of loamy red earths. The shallow depressions have cracking clays	In many of the yellow earths nodular or massive nodular laterite occurs at relatively shallow depths with a slight sink-hole-type gilgai
Tb119	Undulating to strongly undulating lands with many low sandstone mesas, lateritic scarps, and their dissected remnants	The dominant soils are probably those on higher sloping sites where very pale grey loamy duplex soils. More extensive level plains or plateau surfaces have loamy yellow earths	On the low dissected kaolinised sandstone mesas and pallid-zone scarps shallow stony sands are common associated with very pale sandy or loamy duplex soils
Cd14	Low hilly to strongly undulating elevated lands with some steeper high hilly areas	Dominant soils are very shallow (0.15 to 0.45m) stony gritty leached sands or sandy loams. Less common are similar stony loams	Throughout this unit there may be small remnants of unit Tb119
Sl12	Level to very gently undulating alluvial plains	Dominant soils are moderately deep-surfaced loamy duplex soils. The chief associated soils in lower sites are massive mottled cracking clays	Numerous anastomosing old infilled channels
Mr1	Undulating lands consisting of some level or sloping plains interrupted by low mesas or their dissected remnants, marginally the unit may be more strongly dissected	Dominant soils of the plains and slopes are loamy yellow earth. Most soils contain much nodular ironstone at depth. Associated with areas of loamy red earths and grey earths. The low mesas consist of mottled or pallid rock or kaolinised sandstone	Included in the unit in the Mt. Coolon area are some small areas of units Cd14 and CC33
Sl12	Level to very gently undulating alluvial plains	Dominant soils are moderately deep-surfaced loamy duplex soils. The chief associated soils in lower sites are massive mottled cracking clays	Numerous anastomosing old infilled channels
Mz17	Undulating lands with occasional lateritic scarps and low mesas	Dominant soils are slightly acid loamy red earths which often contain many ironstone nodules at depth. Associated with neutral loamy red earths and lesser loamy yellow earths. The soils of the scarps and mesas are loamy red earths on the more extensive surfaces, elsewhere shallow stony loams	Has slight to moderate gilgai microrelief

LANDSCAPE UNITS	LANDFORM	SOILS	REMARKS
CC33	Level or very gently undulating clay plains	Dominant soils are deep grey clay but areas of deep brown clays are commonly associated In some areas brown clays occur on the gilgai banks and grey clays in the depressions. Closely associated throughout the unit are areas of loamy duplex soils	Slight to moderate gilgai microrelief, occasionally stronger. Where the unit is adjacent to major streams, many small braided channels occur
CC35	-	Dominant soils are deep grey clays. Some clay soils possess a slight to moderate gilgai microrelief. Associated are lesser areas of thin-surfaced loamy duplex soil	Numerous braided channels may occur and many areas are subject to irregular flooding
Sl19	Moderate or occasionally strongly undulating lands	Dominant soils are extremely gravelly (quartz) loamy duplex soil. On some higher ridges, shallow gravelly loams occur	There may be small areas of gravel-strewn moderately gilgaied grey clays in lower sites
My35	Undulating lands, often with high gravelly ridges	Dominant soils are loamy or sandy red earths that are often gravelly. Lesser areas of yellow earths occur on lower slope sites	The high gravelly ridges have either sandy red earth extremely gravelly sandy soils
CC29	Level plains with moderate to strong gilgai microrelief	Dominant soils are grey or light grey deep clays with loamy duplex soils closely associated in non-gilgaied sites	Small flood-plains occur adjacent to associated drainage lines
II4	Gently undulating plains	Dominant soils are very deep clays. Occasional areas of very deep brown clays may occur, and also shallow highly calcareous soils	Occasionally have linear gilgai on slopes
SI21	Gently undulating plains	Dominant are loamy duplex soils with a slightly gravel-strewn surface. Also occurring, are smaller areas of slightly gilgaied or non-gilgaied grey clay	In some localities there may be occasional high stony ridges with shallow stony soils
Vd2	Level or very gently undulating plains	Dominant soils have deep sandy A horizons. Smaller areas of loamy-surfaced soils are associated with some drainage lines. Occasionally swampy depressions with clay soils	Broad shallow valleys associated with drainage lines
My20	Level or very gently undulating plains	Dominant soils are loamy red earths with some loamy yellow earths and limited occurrences of gilgaied clays	Small flood-plains associated with drainage lines

LANDSCAPE UNITS	LANDFORM	SOILS	REMARKS
Ms2	Very gently undulating or level plains	Dominant soils are slightly acid sandy yellow earths. Small areas of loamy red and yellow earths also occur and broad shallow drainage depressions have sandy-surfaced duplex soils	Ironstone nodule layers often occur at moderate depths
Sl11	Small flood-plains	Chief soils are hard alkaline yellow and brown soils. Some areas may have a surface covering of stones	Largely derived from sandstones, quartzites, and limestones; occasional sandstone ridges
Ro5	Undulating lands	Dominant are brown loamy duplex soils, often with gravelly A horizons. Associated are red duplex soil and small areas of cracking clays	Other alkaline duplex soils with bleached A2 horizons also occur
My19	Level or very gently undulating plains	Dominant soils are sandy or loamy red earths with some yellow earth. In other depressed areas, shallow red earths are underlain by a clay D horizon. Small areas of clay soils may be included	Often in the form of low dunes
Qa15	Level or very gently undulating alluvial plains that are often dissected by older channels	A complex range of soils are present but mostly dominant by soft loamy red duplex soils with moderately deep A horizons. Closely associated with soft loamy or occasionally sandy red earths	Low sand dunes and slightly elevated sand-filled prior stream channels are a prominent feature of the unit
Ms1	Gently undulating or level plains	Dominant soils are sandy or, less commonly, loamy yellow earths. Throughout the unit are small areas of earthy sands	These soils are mostly underlain by nodular or concretionary laterite at shallow to moderate depths and occasionally outcropping
Fz7	Strongly undulating to low hilly lands	Dominant soils are shallow stony loams. Small areas of sandy red earths	-

Figure 13. Landscape Units – KP05 to KP85 (Map 1 of 4)

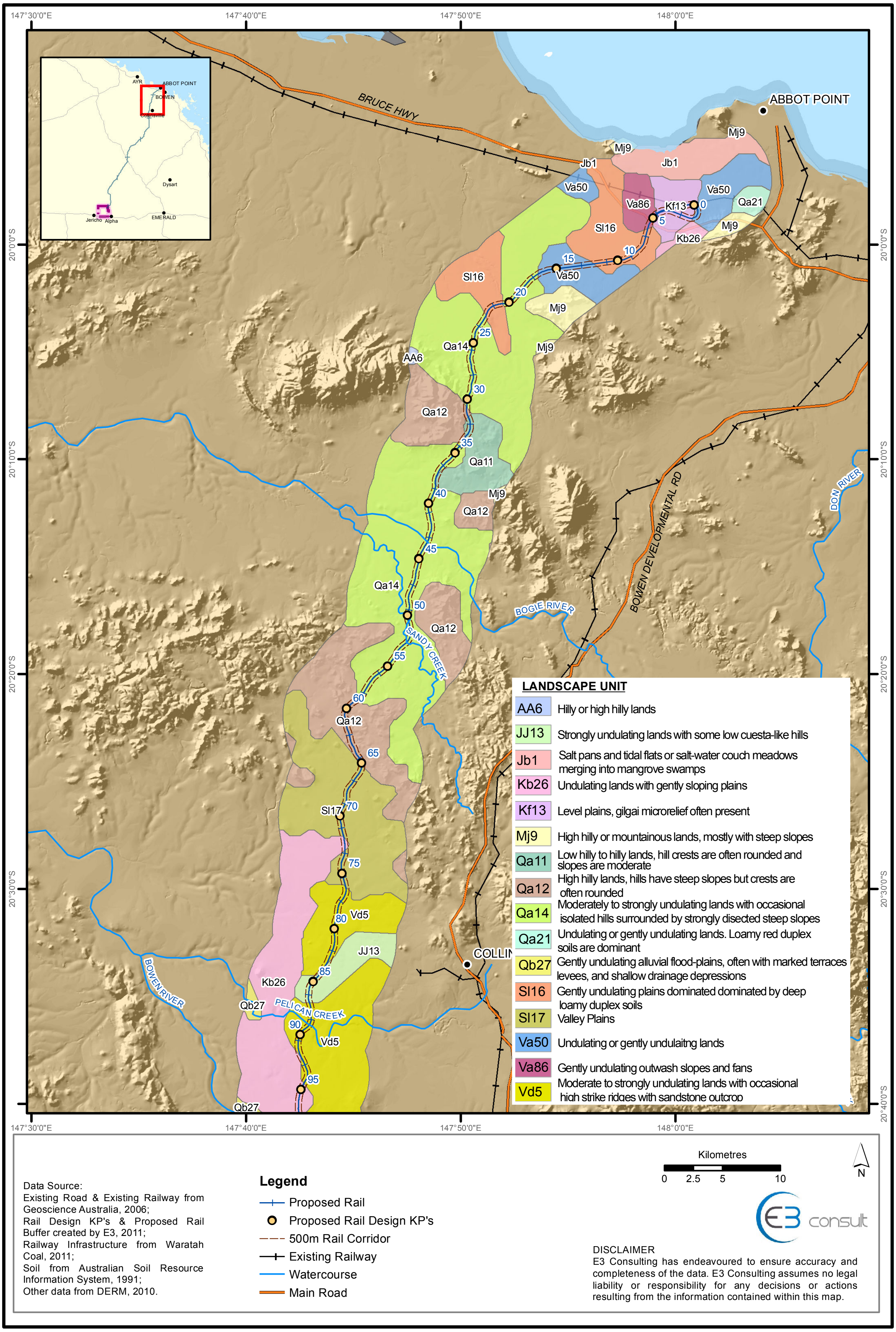


Figure 14. Landscape Units – KP85 to KP235 (Map 2 of 4)

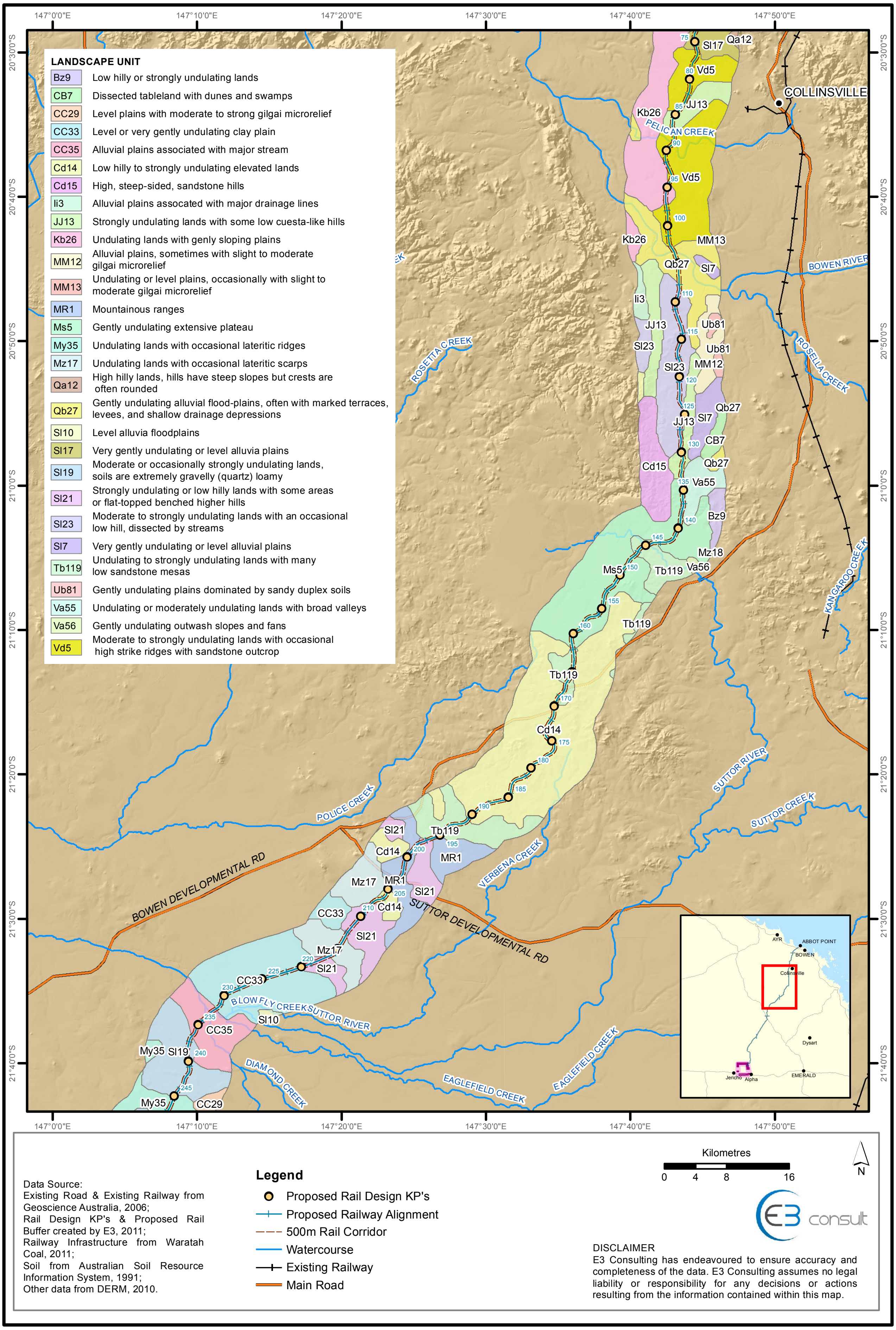


Figure 15. Landscape Units – KP235 to KP360 (Map 3 of 4)

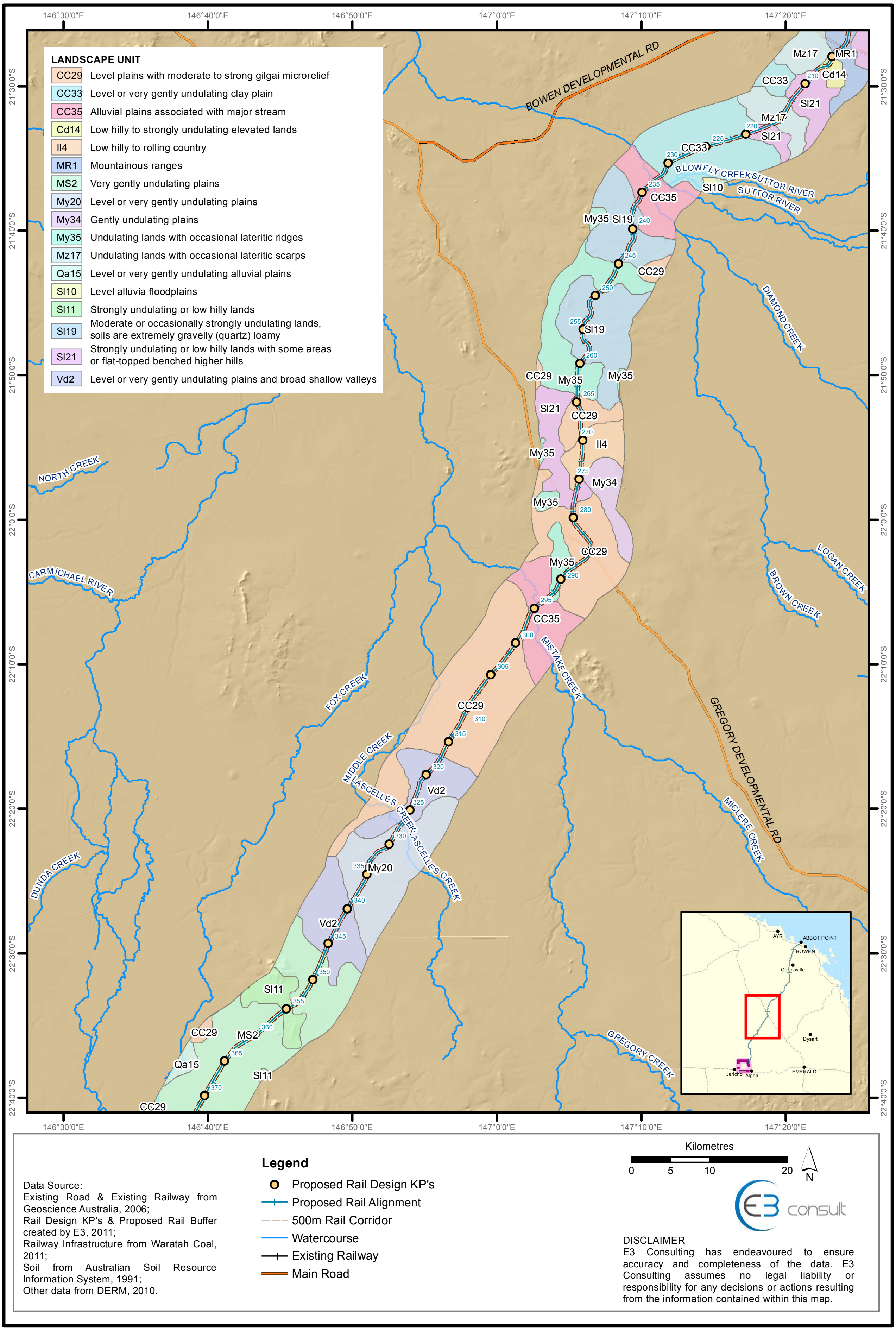
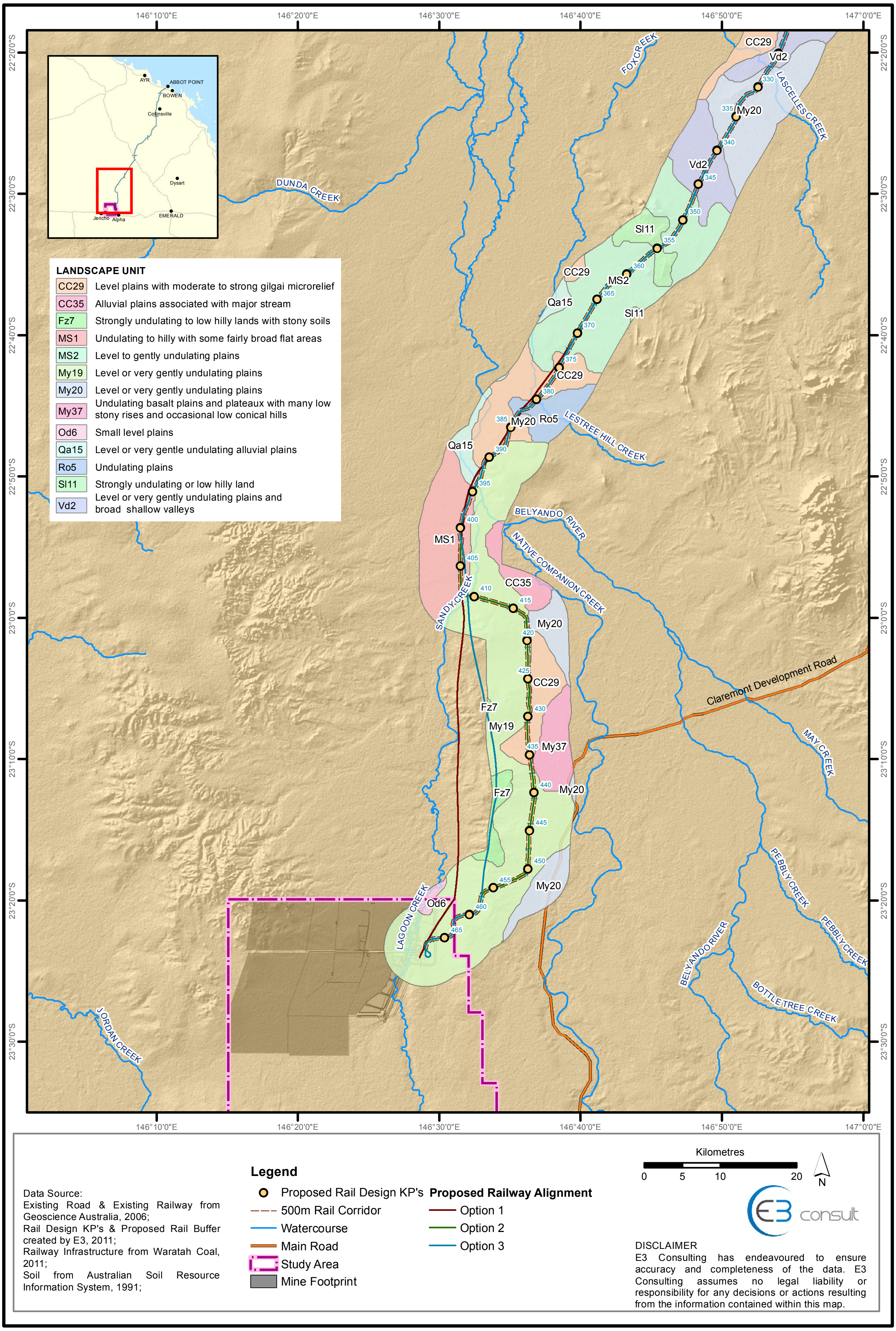


Figure 16. Landscape Units – KP360 to KP468 (Map 4 of 4)



3.4.5 GOOD QUALITY AGRICULTURAL LAND (GQAL)

The assessment of GQAL is based on the results of soil sampling, site observations and regional soil data. A summary table of GQAL assessment is provided in the Geology, Soils and Landforms Technical Report.

KP5-KP25 Coastal Plains

Class C GQAL (only suitable for grazing or native pastures) extends from KP5 to KP15 except where inundated saline areas indicate land is not suitable for agricultural production. Class A GQAL (land suitable for cropping with minimal limitations) occurs in small areas between approximately KP15 and KP25.

KP25-KP85 Clarke Ranges

This section of the rail alignment includes Class C GQAL from KP25 to KP60 and Class A GQAL from KP60 to KP85.

KP85-KP125 Bowen River Valley

GQAL in this area includes class D GQAL (land not suitable for agriculture) from KP110 to KP125 with Class C (KP85-KP105) and Class A (KP105-KP110) GQAL in discrete areas.

KP125-KP190 Leichhardt Range

This section of the rail alignment has limited areas of GQAL reflecting the low fertility of the soils. Class C GQAL extends from approximately KP125 to KP155, while Class D GQAL extends from KP155 to KP190.

KP190-KP468 Inland Plains

Discrete patches of GQAL occur over the extent of this section of the rail alignment. Class A GQAL occurs between KP320 to KP355 and KP385 to KP430. Class B GQAL (marginal for current or potential crops due to severe limitations) intersects the alignment between approximately KP190 to KP225, KP255 to KP290 and KP355 to KP385. Class C GQAL extends from KP225 to KP255 and KP290 to KP320.

GQAL along the rail alignment can be seen on Figure 17 to Figure 20.

Figure 17. GQAL – KP05 to KP85 (Map 1 of 4)

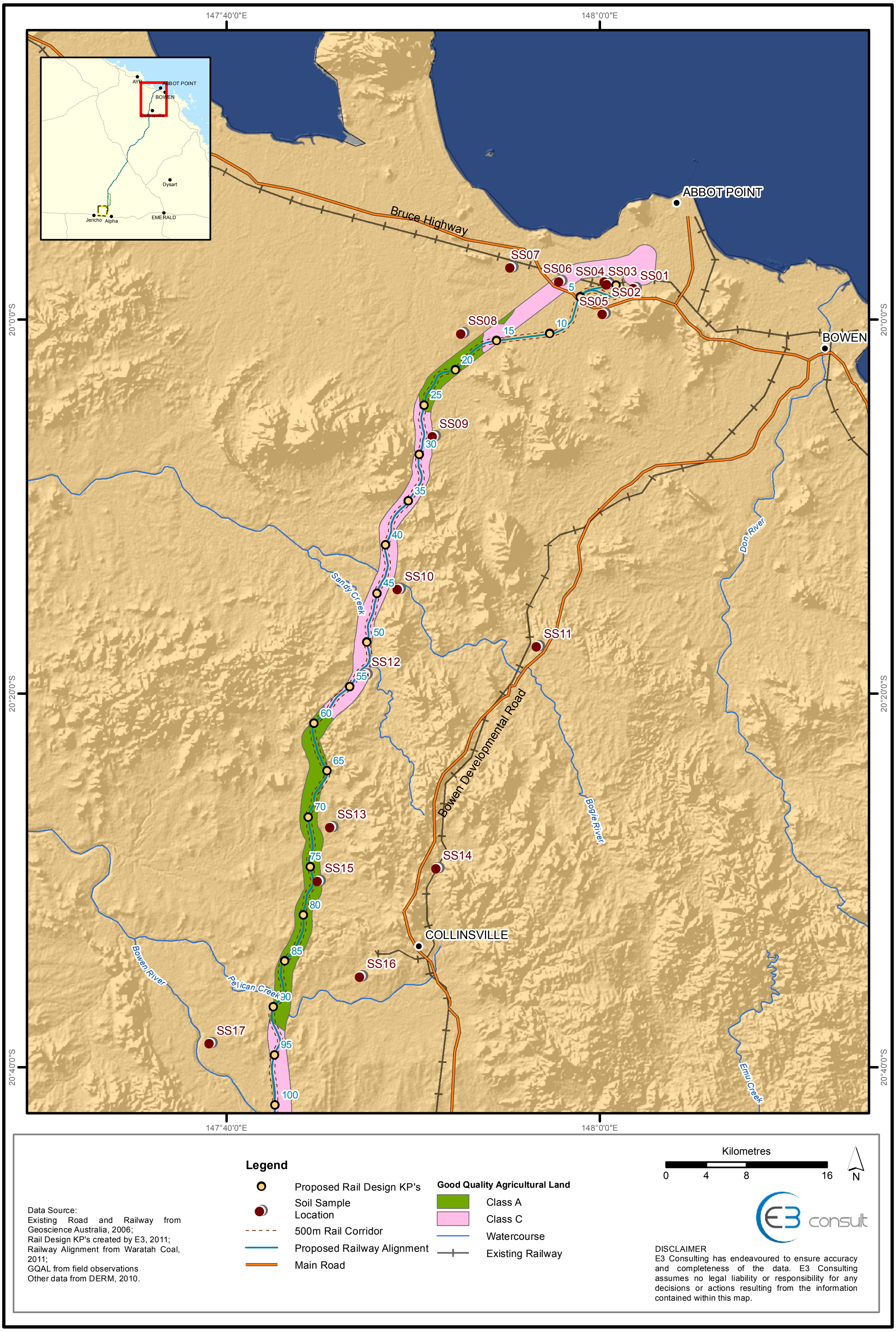


Figure 18. GQAL – KP85 to KP235 (Map 2 of 4)

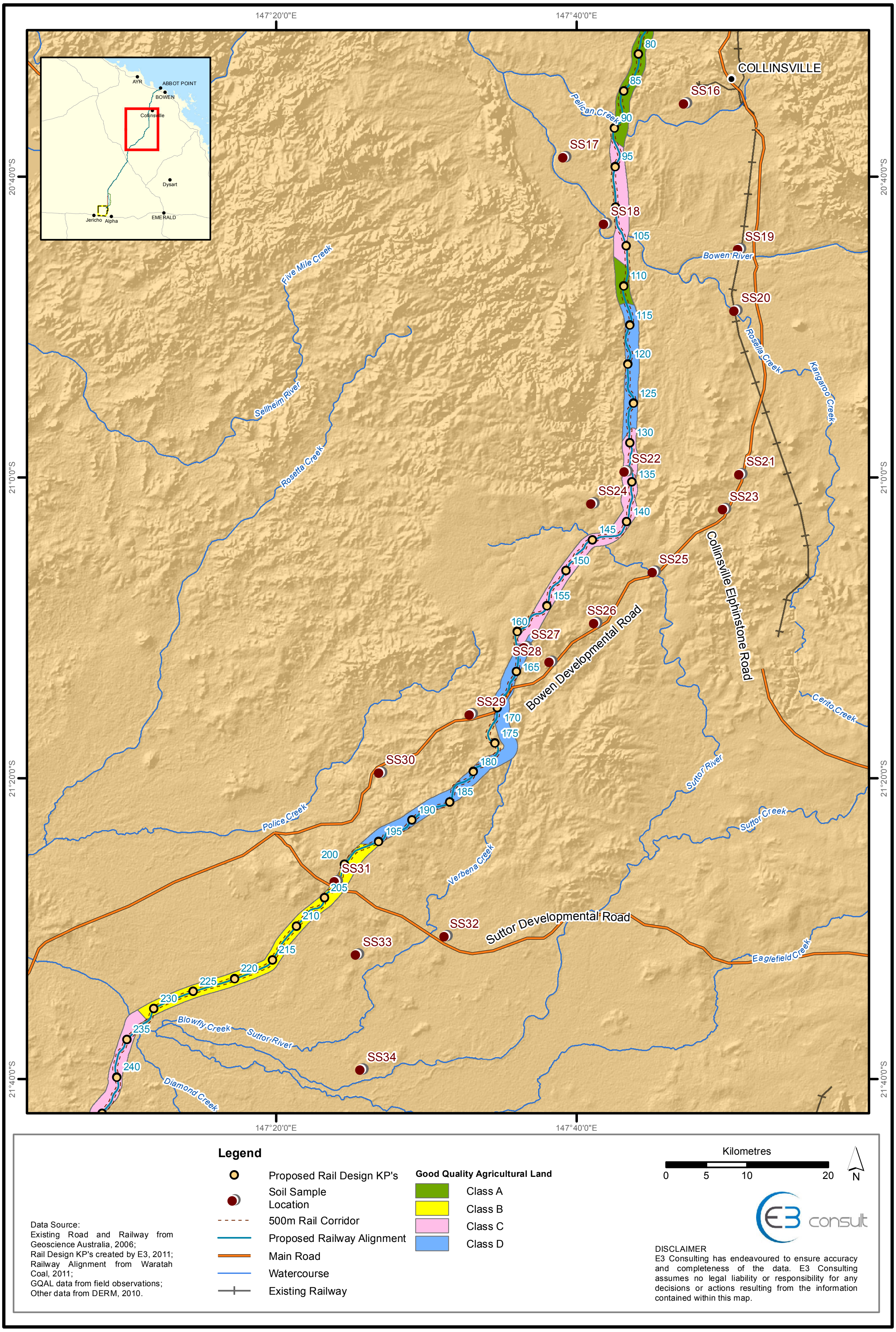


Figure 19. GQAL – KP235 to KP360 (Map 3 of 4)

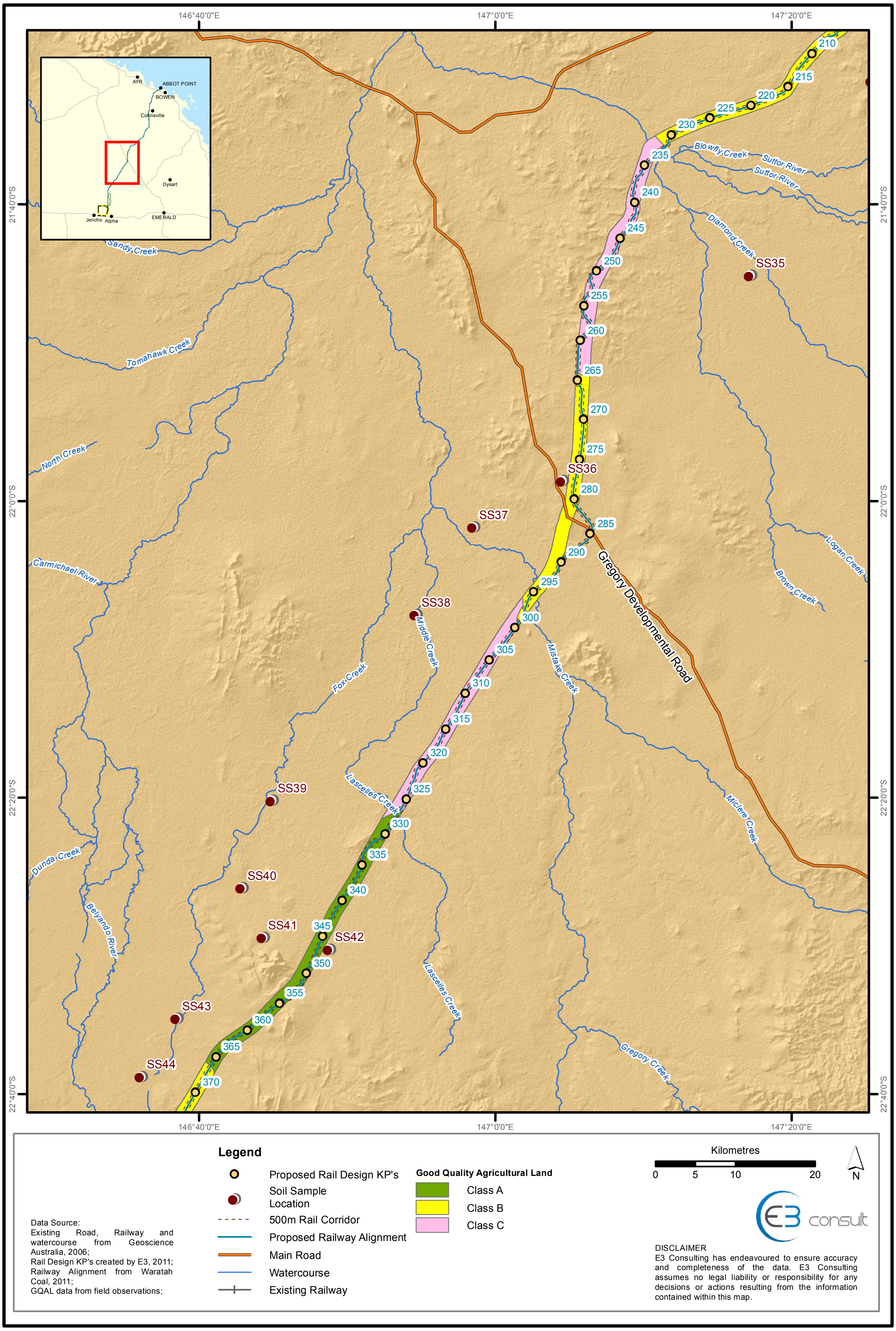
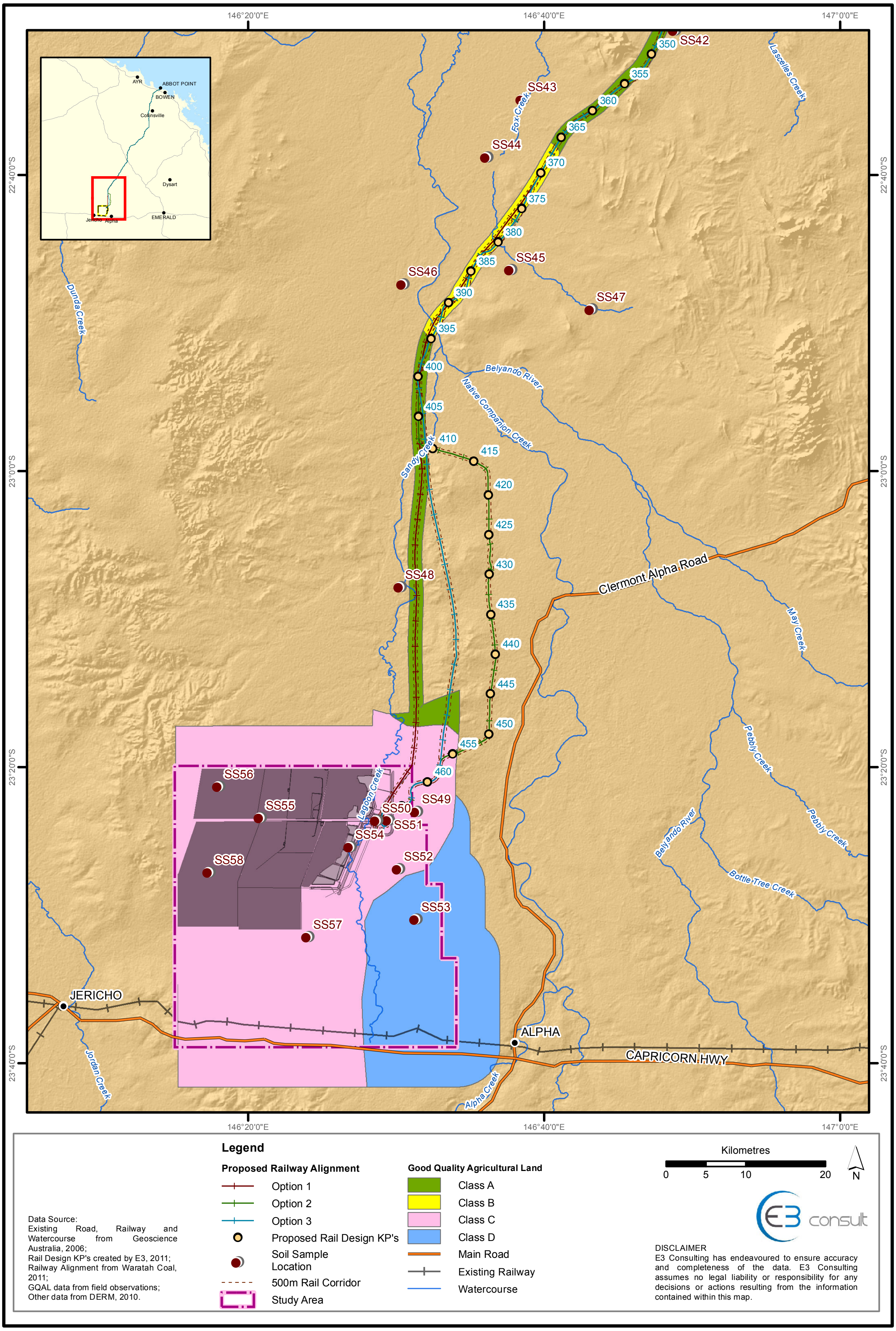


Figure 20. GQAL – KP360 to KP468 (Map 4 of 4)



3.4.6 CONTAMINATED LAND

Fifty seven lots intersected the rail alignment buffer area. Based on the tier risk assessment:

- four lots were identified as high risk with one lot listed on the EMR for a Hazardous Contaminant (Arsenic). The primary land use for the lots was listed as Transport Terminals and extractive uses; and
- fifty two lots were classed as rural land use and were ranked as medium risk. Searches of these lots on the EMR reported one as having the notifiable activities of a livestock dip or spray race and petroleum product or oil storage.

A PSI was undertaken for the lots listed on the EMR being, Lot 5 RU81 with the notifiable activities of cattle dip and petroleum storage and Lot 211 on SP122341 with the notifiable activity of a hazardous contaminant (arsenic).

During the site inspection of the rail alignment, additional cattle dips were observed. PSIs for these lots were undertaken to assess the risk posed to the rail alignment; however, no sampling was undertaken.

A number of lots were identified as being listed as extractive industry but were not included on the EMR, desktop PSIs were undertaken for these sites.

The locations of the lots identified above can be seen on Figure 21 and Figure 22.

3.4.6.1 EMR sites

A PSI was undertaken for the lots listed on the EMR being, Lot 5 RU81 with the notifiable activities of a cattle dip and petroleum storage and Lot 211 on SP122341 with the notifiable activity of a hazardous contaminant (arsenic).

The findings from the PSI for the two lots are summarised below.

Lot 211 SP122341

- the lot is an elongate north-west trending lot following the north coast rail line;
- Lot 122 is currently under land lease and is classified as a Transport Terminal for QR Northern Line's existing corridor;
- a current and ongoing activity for the rail corridor will include line maintenance and weed management;
- there is a low likelihood for shallow aquifers to occur on the site. There is however potential for fresh groundwater reservoirs associated with the dune ridges parallel to the eastern coastline;
- the Caley Valley Wetland is located 1 km east of the lot on a privately owned cattle grazing property;
- aerial imagery was available from DERM for 2001 until 1961. No information indicating site specific potential for contamination was evident;
- a current and historical title search was undertaken for Lot 211 on SP122341. The Lot is owned by the State of Queensland (DTMR) and prior to that, by QR as a rail corridor (1996);
- soil samples were collected immediately adjacent to Lot 211 on SP122341 in which the rail alignment traverses;
- the laboratory analytical results indicate that all soil samples collected and analysed reported organic concentrations below the laboratory detections limit and adopted Soil Assessment Criteria (SAC); and
- the laboratory analytical results from the site reported concentrations of chromium (total) above the adopted Environmental Investigation Limit (EIL) criterion of 50 mg/kg for CrVI.

Lot 5 RU81

- Lot 5 is a medium risk site. Desktop studies have been undertaken although no preliminary soil sampling has been conducted at the time of writing;
- Lot 5 RU81 is located about 55 km northwest of Clermont and intersects the rail alignment between KP265 to KP325;
- the site comprises open Brigalow and Gilgai country used for grazing. The cattle dip is located at approximately 22°16'10"S. 146°52'18"E and is about 1 km west of the rail alignment;
- Lot 5 is leased land with the primary land use activities including cattle grazing and breeding;
- based upon DERM records, the groundwater in the vicinity of Lot 5 RU81 is hosted in shales, sandstones and clays;
- surface water receptors include Fox and Middle Creeks in the north west of the lot and Miclere and Mistake Creeks in the east of the lot, all being ephemeral;

Figure 21. Contaminated Land – Rail Alignment Northern Section (Map 1 of 2)

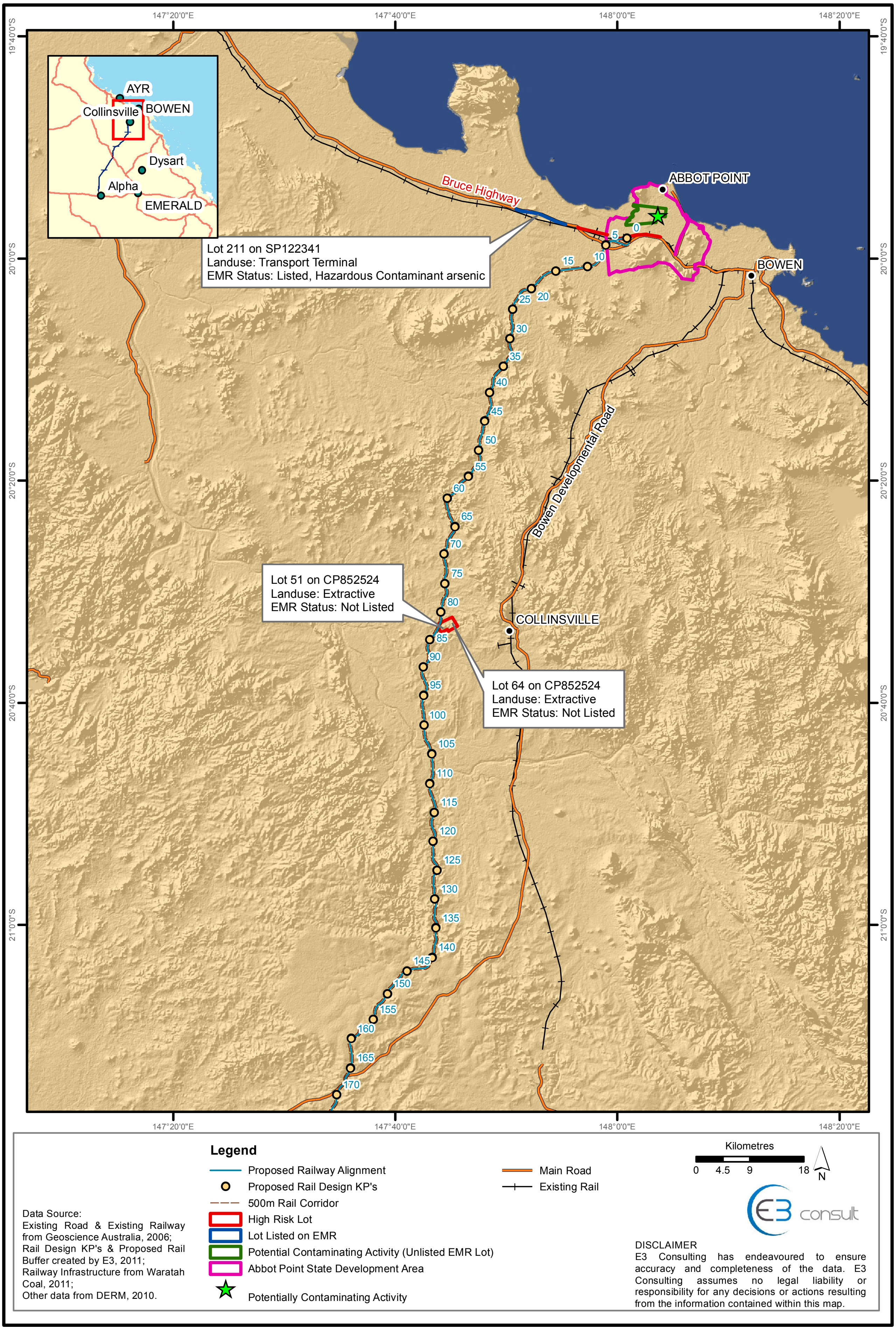
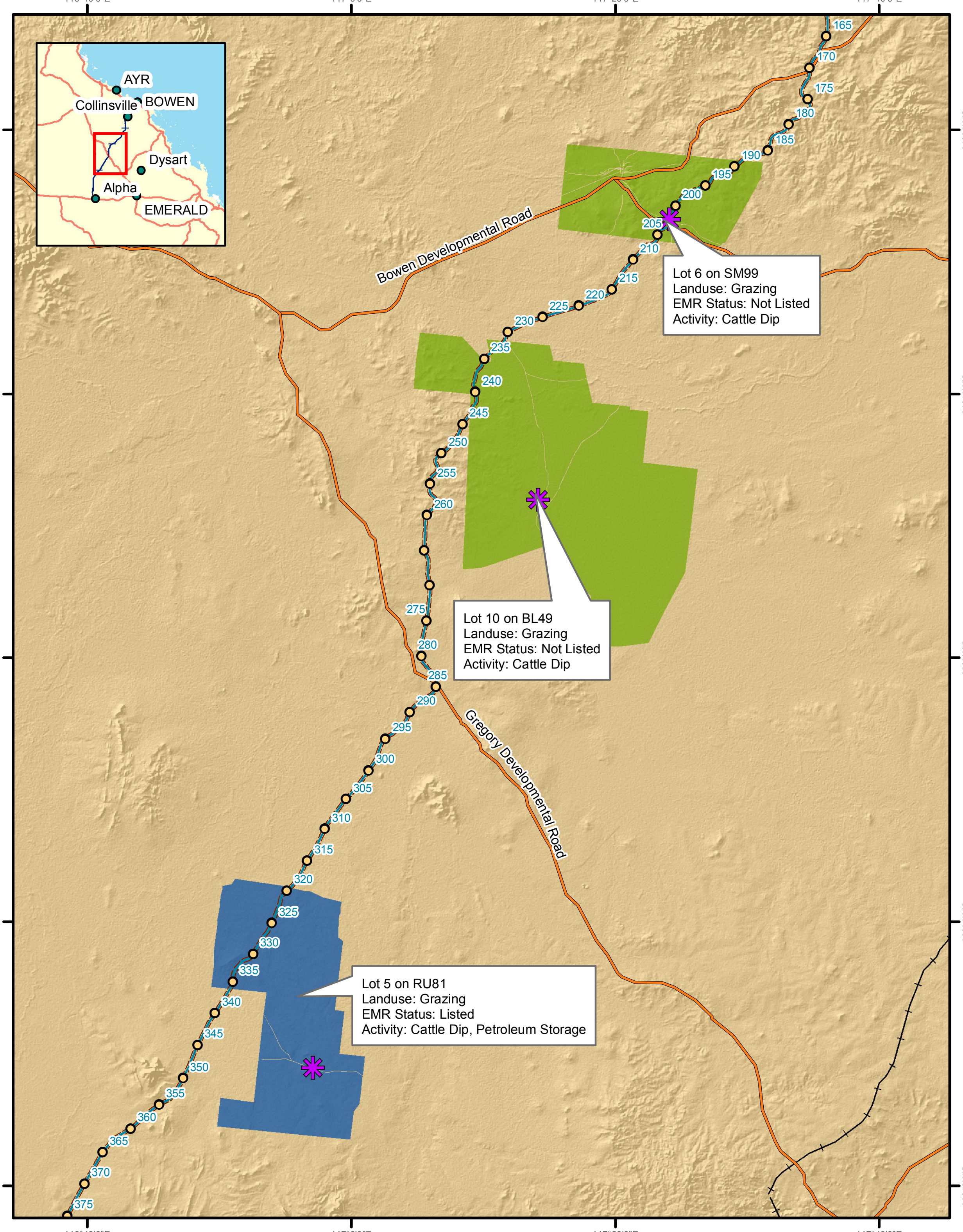


Figure 22. Contaminated Land – Rail Alignment Southern Section (Map 2 of 2)



Data Source:
Existing Road & Existing Railway from Geoscience Australia, 2006;
Rail Design KP's & Proposed Rail Buffer created by E3, 2011;
Railway Infrastructure from Waratah Coal, 2010;
Other data from DERM, 2010.

DISCLAIMER
E3 Consulting has endeavoured to ensure accuracy and completeness of the data. E3 Consulting assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

- the nearest sensitive human receptors are likely to include the landowner's residence. No major residential areas are present within a 10 km radius of the site; and
- historical aerial imagery for the area was available from 1998 to 1987. No significant changes in the lot with potential for site contamination were present.

3.4.6.2 Cattle Dips – Additional Observations

Due to the length of the rail alignment, a helicopter survey was undertaken to identify lots which may have the potential for contamination, particularly the operation of cattle dips which are common in agricultural areas and often have not been notified to DERM. The helicopter survey identified four cattle dips of which two (Lot 6 on SM99 and Lot 10 on BL49) intersected the buffer area of the rail alignment activities while two lots were outside the rail alignment buffer.

Lot 6 intersects the rail alignment between KP185 to KP200. The observed cattle dip is within the 500 m rail buffer boundary.

The north-west portion of Lot 10 is interested by the rail alignment between KP225 to KP235; however, the cattle dip is approximately 12 km south-east of the buffer area and will not be impacted by or impact the Project.

On-site observations identified these lots are primarily associated with cattle and had livestock dips or spray race and / or petroleum storage facilities.

3.4.6.3 Extractive Industries

One lot that intersects the rail alignment (Lot 64 on CP852524) contains an extractive industry on as its primary land use. As a result of the realignment of the rail line, these sites are now adjacent to the corridor have not been physically assessed. Adjacent lot 51 on CP852524 is listed as having a primary land use as cattle grazing and breeding; however, an investigation of current aerial imagery suggests that the whole lot is actually an extractive resource operation.

Lot 64 is operating under an existing mining lease and QVSS indicates the primary land use as extractive. The lot is intersected by the rail alignment within the mining lease area. The site is not listed on the EMR with respect to notifiable activities that may be being undertaken on the site.

3.4.6.4 Evaluation of Risk

Site specific assessments of soil and aquifer characteristics including leaching potential and hydraulic conductivity have not been undertaken and therefore the potential for the contaminants to leach to the groundwater, as well as the rate of migration of groundwater contamination is unknown. Where the subsurface profile is predominantly clay, groundwater contamination may be retarded due to the lower hydraulic conductivity. Therefore a detailed assessment of the risk cannot be completed due to the limited sampling undertaken in comparison to the scale and extent of the rail alignment. However, a qualitative assessment of risk indicates the following potential risks.

Several sites are at some distance from the rail alignment including:

- the cattle dip on Lot 6 SM99 is located within the rail corridor and east of the rail alignment;
- the cattle dip on Lot 10 BL49 is located approximately 12 km from the rail alignment; and
- the cattle dip on Lot 5 RU81 was not sighted during aerial flyover; however, aerial imagery indicates it may be close to the rail buffer.

Where there is no complete pathway between a potential contaminant source and a receptor (in this case the project), there is low potential for risk from that contaminant source to the project. Therefore, unless the rail line directly intersects the cattle dips and associated infrastructure such as drying yards there is a low potential for risk from these contaminant sources to the project.

The laboratory results from samples adjacent to the rail line reported arsenic concentrations less than the EIL. This suggests a low potential for widespread arsenic impacts around this part of the rail alignment. However, the association of arsenic contamination with rail activities indicates that the potential for arsenic along the extent of the rail alignment and this therefore cannot be discounted and an un-quantified risk remains.

The extractive industry land use has the greatest potential to pose risk to the project as soil / rock that has the potential to generate acidity or leach contaminants (i.e. heavy metals), is likely to be widespread and could be disturbed by construction activities.

3.5 POTENTIAL IMPACTS

3.5.1 TOPOGRAPHY

Through the Clarke and Leichhardt Ranges, the topographical features such as rocky outcrops and steeply sloping ground can present an increased potential for landslip. Further, major rivers and tributaries may affect the extent of clearing required during construction, the type of equipment required to undertake construction and the amount of time that disturbed construction areas are in use. In these areas, there is greater potential for landslips to occur in the areas of steeper topography between KP25-85 and KP125-190 if construction works are not managed properly.

3.5.2 GEOLOGY/SOILS

Fault and slips can result in greater landslip potential or require more shallow batter angles in cuttings. The rail alignment carries the greatest potential for impacts from geological structures where it intersects the Glenore Shear Zone around KP20, extensions of the Collinsville Fault system and associated dykes between KP25-KP85, and north-west trending fault systems between KP85-KP125. These can be avoided if detailed geological / geotechnical studies are undertaken and issues are highlighted for final design. Where encountered, lower slope angles or greater setbacks for construction may be required leading to potential for erosional impacts over larger areas.

Where the alignment crosses exposed bedrock, dykes (KP25-KP85) and acidic intrusive rocks, there is potential for drilling and blasting works to be required, leading to greater potential for erosion and generation of silicic dusts from acidic intrusive rock types.

Where the alignment crosses gilgai relief, cracking clays and soils with erosive or dispersive properties, there will be potential for impacts relating to erosion to occur. Cracking clays occur in discrete areas around creeks and low lying portions of the rail alignment mainly between KP5-KP25 and KP85-KP125. In addition, cracking clays with shrink / swell properties can result in damage to structures, foundations and buried services from differential ground movement. The degree of impact is dependent upon the soil profile thickness and the type of clay.

3.5.3 SOIL EROSION

Thin Tenosol soils with little structure are susceptible to erosion when disturbed and occur in portions of the alignment between KP5-KP25 and KP125-KP190.

Visual observations of waterways along the alignment identified that a number of them likely have moderate to high erosion potential. Potential impacts resulting from erosion include increased sediment loads in the waterways as well as impacts to infrastructure such us undercutting of bridge buttresses.

Erosion potential at waterway crossings needs to be further assessed during detailed geotechnical investigations. The placement of infrastructure will need to be carefully considered at sites identified as having high potential with structures designed and constructed to avoid creek banks.

3.5.4 FOSSILS

There is limited potential for fossilised material to be discovered during the rail alignment construction as the geology with potential for fossils is limited to the Back Creek and Blenheim group of the Collinsville coal measures and the Blackwater group. Further, rail construction is anticipated to include generally shallow earthworks with lower potential to intersect less weathered rocks with intact fossils. If significant fossil finds are encountered, all works would avoid the find and appropriate experts contacted.

3.5.5 TOPSOIL

Soil depth varies within dissected areas of the alignment from thin soils on slopes with Tenosols to deep soils in valleys below these areas. Areas of the rail alignment with thin topsoils include Tenosol areas with portions of the alignment around KP5-KP25, and KP125-KP190. Deeper clay soils are present in areas between KP25-KP85 and KP85-KP125. A balance of topsoil volumes can be undertaken as the final alignment of rail construction is achieved.

3.5.6 SOIL SALINITY

The most sodic soils were encountered around KP185, although inundated saline soils may also be encountered around creek crossings and low lying land between near KP5-KP10. Areas of saline soils in the alignment have the potential to result in increased erosion risk during construction and increased potential for corrosion of buried steel and / or concrete materials. These are generally in creek and river valleys and carry the greatest potential impact to disturbance by project construction from mobilisation of saline sediments and corrosion of infrastructure at creek crossings or where below grade cuttings are required.

3.5.7 ACID SULPHATE SOILS

Potential impacts associated with the rail corridor consist of the impacts associated with the excavation of ASS during construction works. There has been no ASS investigations available for review for the rail corridor and ASS mapping is limited to the broad scale (1:2,000,000) which show low probability of ASS in the areas where the rail corridor crosses. However, at this mapping scale, ASS risks associated with past and present stream channels are not addressed. There is therefore a risk that ASS may be encountered within the rail corridor alignment at or below 5 m AHD where the rail corridor crosses creeks and streams.

There is therefore a requirement for ASS investigations to be undertaken along the rail corridor at locations below 20 m AHD where the rail corridor crosses creeks and stream channels and where the alignment is identified as being in areas below 5 m AHD.

3.5.7.1 Mechanisms for Impact

The mechanisms for impact for ASS associated with the rail corridor consist of the excavation and removal of ASS oxidising Potential Acid Sulfate Soil (PASS) currently below the groundwater table and or the displacement of ASS such that it may leach acid and metals into receiving waters. These impacts would likely occur during construction works associated with bridges or culverts where the rail alignment crosses water ways. The potential impacts of excavating or removing ASS include:

- the oxidation of PASS producing sulfuric acid and leaching out of metals (principally iron and aluminium) from the soil matrix and the resulting surface water impacts of lowered pH, metals contamination, dissolved oxygen depletion, iron staining of water ways and effects on marine biota such as mass mortalities and chronic disease; and
- the shortening of the lifespan of built infrastructure due to corrosion of metal and calcium substitution in concrete.

3.5.7.2 Construction Impacts

The principal potential impacts are expected to consist of the excavation or removal of ASS involved with the construction of bridges and culverts for creek and stream crossings leading to the oxidation of ASS. These are principally environmental impacts associated with the release of acid and metals into receiving waters.

3.5.7.3 Operational Impacts

Operational impacts associated with the ASS within the rail corridor if not managed correctly, are the ongoing environmental impacts associated with the release of acid and metals into receiving waters and the impacts on the rail infrastructure such as the corrosion of concrete and steel on culverts and bridge footings requiring increased maintenance and repair costs to avoid the failure of the structures. If the results of ASS investigations indicate significant PASS on the approaches to creek and steam crossings then the potential impacts of filling on ASS will be an ongoing operational impact.

3.5.8 AGRICULTURAL LAND USE / GQAL

The rail alignment will sterilise GQAL within the footprint of the alignment and fragment land parcels potentially leading to loss of access to agricultural land. The most significant agricultural land is potential Class A land between KP25-85 and KP322-355.

As discussed in Section 3.5.5, during the construction phase of the Project topsoil will be stripped and stockpiled for later reuse during rehabilitation works. Quantities of topsoil stripped, stockpiles and used for rehabilitation will be documented. Excess topsoil will be used in project areas with topsoil deficits. If required, Waratah coal will source further top soil from local suppliers in the project area.

3.5.9 ACID SULFATE SOILS

The principal potential impacts are expected to consist of the excavation or removal of ASS involved with the construction of bridges and culverts for creek and stream crossings leading to the oxidation of ASS. These are principally environmental impacts associated with the release of acid and metals into receiving waters.

Operational impacts associated with the ASS within the rail corridor if not managed correctly, are the ongoing environmental impacts associated with the release of acid and metals into receiving waters and the impacts on the rail infrastructure such as the corrosion of concrete and steel on culverts and bridge footings requiring increased maintenance and repair costs to avoid the failure of the structures. If the results of ASS investigations indicate significant PASS on the approaches to creek and steam crossings then the potential impacts of filling on ASS will be an ongoing operational impact.

3.5.10 CONTAMINATED LAND

The potential for impacts from cattle dips or arsenic impacts from existing rail lines along the rail alignment is considered low; however, potential for impacts arises from:

- leaching of contaminants to groundwater or via overland flow to surface waters;
- where the project construction intersects the footprint of the contaminated areas of the cattle dips, drying yards and associated infrastructure there is potential mobilisation of contaminants if not appropriately managed;
- where the project construction intersects the existing rail lines, there is potential to encounter arsenic impacted soils. There is potential for mobilisation of this contaminant if not appropriately managed;
- where the project construction intersects areas of extractive resources, there is potential for mobilisation of contaminants from the elevated levels of minerals, elements or compounds in the resource material;
- demolition of buildings in the rail alignment has the potential to impact soils with hazardous materials if not appropriately assessed and managed; and
- spills and leaks from various contaminating sources such as, petrol and other chemicals stored on site during construction and operations should be managed properly. These sources may have the potential to leach and migrate into sensitive receptors such as waterways and permeate into the existing soil profile.

In managing existing land that can potentially be contaminated from rail activities such as construction, commissioning and operation, Waratah has committed to undertaking detailed investigations in accordance with *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland (EPA, 1998) and the National Environment Protection (Assessment of Site Contamination) Measure 1999* should contamination be identified or reasonably suspected. Furthermore, potentially polluting activities such as the storage and use of hydrocarbons and the management of waste will be managed in accordance with the EMP for the rail project

3.5.11 DECOMMISSIONING AND REHABILITATION PHASE

At this stage it is envisaged that the rail, once constructed, will not be decommissioned as it will remain a valuable transport corridor from the Galilee Basin to Abbott Point. At the end of Waratah's operational phase all temporary facilities will be decommissioned and sites rehabilitated to a suitable standard in accordance with legislative compliance, and where applicable, with landholder requirements. Further discussions with respect to decommissioning and rehabilitation works are outlined within Volume 2, Chapter 1.

3.6 MITIGATION AND MANAGEMENT

Management measures will be implemented along the rail alignment to include:

- in order to minimise erosion and slope failure, the final route for the rail line can follow ridges and spur lines or traverse the less steep mid to lower parts of hill slopes;
- where there is the potential for significant fossil finds to be uncovered during earthmoving activities, the significance of the fossils will be assessed through a contingency plan including the following measures:
  - works are to be ceases immediately;
  - consult with the Queensland Museum for identification of fossils;
  - if there are significant finds of small fossils, obtain representative samples of the media and both set aside for further analysis and contact the Queensland Museum; and
  - if significant finds of large fossils are observed, contact and seek an expert's advice as to the possible extent of the fossils and stop work immediately.
- topsoil should be stripped from all disturbed areas and retained for use in rehabilitation areas. Records should be maintained to ensure useable soils are retained

and logs of stockpiles kept to reconcile predicted and actual soil volumes;

- strongly sodic or dispersive materials will not be used for rehabilitation purposes, where construction exposes such soils they will be treated with gypsum / dolomite amendments to reduce sodicity / dispersion in the soils with topsoil to minimise the impact of these soils;
- site specific investigations for ASS should be carried out prior to construction in areas along the rail alignment considered to be high risk (i.e. < 5 m AHD). If ASS are identified an ASS Management Plan for specific construction works will be developed;
- an Erosion and Sediment Control Plan (ESCP) will be prepared to address the potential issues arising from the field investigations. Erosion in active construction or development areas cannot be eliminated, however, impacts can be controlled and minimised through the following management actions:
  - limiting the area of disturbance and progressively clearing areas immediately before construction;
  - strip and stockpile topsoil prior to construction;
  - divert surface water runoff around construction areas;
  - minimise the period that exposed soil is left open during construction;
  - place sediment traps and silt fences to minimise off-site impacts;
  - place organic mulch and / or plant exposed soils to reduce dust generation and wind erosion; and
  - maintain a site monitoring program recorded in an EMP to assess erosion control measures.
- areas of identified dispersive soils should be closely monitored to assess the efficacy of the erosion control measures;
- where land is disturbed progressive land rehabilitation will occur as use of those areas ceases;
- post disturbance regrading should be undertaken to produce slopes that are suitable for the proposed land use;
- a drainage design that addresses runoff volumes and erosion minimisation will be put in place;
- where possible use lighter vehicles and / or larger wheel / track size to reduce compaction; and
- should areas of saline soils be intersected these will be set aside for specific rehabilitation with salt tolerant plant species.

Measures employed to manage land contamination issues along the rail alignment will include (in order of preference):

- re-alignment of the rail alignment to avoid these areas;
- where re-alignment is not possible, undertake an assessment of the soils to be intersected by the rail alignment to assess the scale and extent of contamination in the soils and the potential for groundwater impacts in order to produce a DERM compliant Stage 1 and 2 Environmental Site Assessment (ESA) report for each affected lot;
- based on the results of Stage 1 and 2 ESAs, the lots that are subject to a hazardous contaminant will be notified to DERM to be recorded on the EMR / CLR;
- where the level of contamination exceeds the current land use a Site Management Plan (SMP) will be prepared to be attached to the EMR / CLR listing;
- where site contamination is present and remedial measures are required a SMP / Remedial Action Plan (RAP) will be prepared in line with possible construction techniques that will minimise excavations for site preparation;
- where site contamination must be excavated for the rail alignment, the work will be completed under a RAP and validated to assess the effectiveness of the remediation. A validation report will be prepared suitable for submission to DERM to assess the effectiveness of the remediation, the proposed management measures (if any) and allow a site suitability statement to be issued for the lot by DERM;
- no contaminated soils will be removed from a lot without a DERM disposal permit; and
- remedial measures will include (in order of preference) risk assessment, on-site containment, on-site treatment and / or off-site treatment or disposal.

3.7 CONCLUSION

The Project will occur over a large area of central and northern Queensland. As part of the EIS, an assessment of the terrain and a soil survey was undertaken for the rail alignment and to identify existing environmental values and potential engineering and / or environmental impacts.

A complex of soil units were identified across the project area, including areas of Tenosols, Chromosols, Kandosols, Vertosols and Sodosols and cracking clays. The soils present within the Project area are generally suitable for grazing. Some are prone to erosion and dispersion. The majority of the soils are also unsuitable as topsoils.

The rail alignment is currently used for low (Class C/D) intensity cattle grazing. As a result of this historical and current land use of low intensity cattle grazing, there has been extensive tree clearing throughout the area, which is consistent with that of the adjoining land.

The main potential impacts of the proposed rail alignment will include changes to agricultural land capability and increased risk of erosion in areas of construction and / or operation. In addition, some soils encountered will be sodic and / or dispersive and this may affect excavation conditions for portions of the rail alignment. Further, areas of geological shear zones, faulting and / or with dykes were identified that may impact upon rail construction.

Based on the tier risk assessment, four lots were identified as high risk of containing contaminated material with one lot listed on the EMR for a Hazardous Contaminant (Arsenic). The primary land use for the four lots was listed as Transport Terminals and extractive uses.

A total of 52 lots were classed as rural land use and were ranked as medium risk. Searches of these lots on the EMR reported one as having the notifiable activities of a livestock dip or spray race and petroleum product or oil storage.

During the site inspection of the rail alignment, additional cattle dips were observed. PSI data for these lots was undertaken to assess the risk posed to the rail alignment; however, no sampling was undertaken.

The contaminants of concern associated with the above activities include arsenic and OC and OP. Potential impacts from extractive industries include acidity and heavy metals associated with the particular deposit.

Where there is no complete pathway between a potential contaminant source and a receptor (in this case the project), there is low potential for risk from that contaminant source to the project. Therefore, unless the rail line directly intersects the cattle dips and associated infrastructure such as drying yards there is a low potential for risk from these contaminant sources to the project.

The laboratory results from samples adjacent to the rail line reported arsenic concentrations less than the EIL. This suggests a low potential for widespread arsenic impacts around this part of the rail alignment. However, the association of arsenic contamination with rail activities indicates that the potential for arsenic along the extent of the rail alignment and this therefore cannot be discounted and an unquantified risk remains.

The extractive industry land use has the greatest potential to pose risk to the project as soil / rock that has the potential to generate acidity or leach contaminants (i.e. heavy metals), is likely to be widespread and could be disturbed by construction activities.

3.8 COMMITMENTS

Waratah Coal commit to:

- identify specific access areas and determine goals for rehabilitation of disturbed land to minimise areas that will have lower land use quality post-mining;
- manage lay down areas in a manner that will not result in a reduction in land quality;
- prepare and implement erosion control measures and continue to monitor and maintain the measures implemented;
- ESCPs will be developed and put in place prior to the commencement of construction works for all areas of the rail that may cause erosion;
- topsoil management measures will be documented, monitored and maintained with a reconciliation of top soil excavation and rehabilitation maintained. Excess topsoil will be used in project areas with topsoil deficits. Waratah coal will source further top soil (if required) from local suppliers in the project area;
- prior to construction carry out soil sampling at waterways to better identify erosion risk and put in place appropriate management measures;
- prior to construction undertake soil resistivity surveys of high risk areas, record the current salinity status of these areas and implement measures to ensure no further significant salinisation occurs due to the project activities;

- where possible the project footprint will be re-aligned to avoid areas of potential or identified contamination;
- where contamination is present within the project footprint, Waratah Coal will enter into agreements with the owner of the contamination to assess and appropriately manage or remediate the contamination;
- any building / structures to be demolished will be assessed for hazardous material content with preparation of demolition management plans for the appropriate demolition and disposal of the hazardous materials;
- where the project footprint cannot be re-aligned, DERM compliant Stage 1 and 2 ESAs will be undertaken to assess the scale and extent of contaminant impacts;
- where contamination is identified it will be managed and / or remediation under the Environmental EP Act with DERM approved SMPs and / or RAPs in order to make the sites suitable for the proposed use;
- Waratah Coal will appoint a third party reviewer to assess all contaminated land assessment and remediation work; and
- any notifiable activities that are required for the project will be implemented and managed in accordance with relevant guidelines and legislation once construction commences and also during the operational phase. The notifiable activities may include:
  - storing hazardous contaminants;
  - petroleum product or oil storage; and
  - chemical storage.