TOPOGRAPHY AND SOILS 10

10.1 INTRODUCTION

The EIS Study Area has a topography of generally low relief. The area around Olympic Dam is dominated by a landform of low undulating dunes, swales and clay pans. To the north the land is generally flat to undulating and comprised mainly of gibber plains and rises, outwash plains and dunefields. To the south are various tablelands, dunefields and alluvial plains, occasionally separated by plateaus and steep escarpments. Surface materials range from stones through sands, silts and clays.

The soil types of the Olympic Dam area and the study corridor to Port Augusta were detailed in both the 1982 and 1997 Olympic Dam EIS (Kinhill-Stearns Roger 1982; Kinhill 1997). This chapter describes the topography and the physical and chemical properties of the soil types within the EIS Study Area. It also explains how soil disturbance during the construction and operation phases of the proposed expansion may affect the surrounding environment. Where necessary, management measures that would reduce potential impacts are identified.

The assessment also addresses the potential for soil contamination from accidental spills. Potential health and safety risks associated with soil contamination are discussed in Chapter 22, Health and Safety.

Descriptions of the geology and geochemical properties of sub-surface materials relevant to the study area of the proposed expansion are discussed in Chapter 12, Groundwater, because of their direct influence on groundwater quality.

10.2 ASSESSMENT METHODS

10.2.1 TOPOGRAPHY

Descriptions of topographical conditions across the project components are based on the data sources shown in Table 10.1 and presented in Figures 10.1 and 10.2.

An analysis of the terrain of the Olympic Dam Special Mining Lease (SML) was undertaken as part of the 1982 EIS at a 1:40,000 scale. The terrain pattern and terrain unit classification system was based on a combination of the underlying geology, landform type, physiographic description and soil type.

10.2.2 SOILS

Soil descriptions

Houghton Environmental Management Pty Ltd (gas pipeline corridor options) and URS Australia Pty Ltd (southern infrastructure corridor) (see Appendix I1 for details) conducted desktop and field survey investigations of soils within the EIS Study Area. These studies also referenced the soil surveys and descriptions undertaken as part of the two previous EIS documents for the existing Olympic Dam operation (Kinhill-Stearns Roger 1982; Kinhill 1997). The publications reviewed as part of the desktop investigation are cited, where relevant, within this chapter and listed in full in Appendix I1.

Field investigations were undertaken to confirm the soil types of the EIS Study Area and soil samples were collected to assess their physical and chemical properties in the laboratory. Samples were obtained for the gas pipeline corridor options from 22 test holes along the three alignment options (see Figure 10.3). Samples were obtained for the southern infrastructure corridor from 91 test pits, with at least three representative samples collected from each soil type (see Figure 10.4). The depth of the test pits varied from 1.5 to 3.5 m, consistent with likely depths of excavation works associated with proposed infrastructure.

Soil profiles were logged and described at each site in accordance with the *Australian Soil and Land Survey Field Handbook* (McDonald et al. 1990) and soil types were described according to the unified soil classification system (USCS).

Figure 10.1 Topography of the project area

Table 10.1 Topographic data sources

Location	Scale	Source	Date
South Australia	1:250,000 (50 m interval contours)	Geoscience Australia	2006
Water and power infrastructure corridors	North of 32° latitude: 1:250,000 (50 m interval contours)	Geoscience Australia	2006
	South of 32° latitude: 1:50,000 (10 m interval contours)	Department for Environment and Heritage	2005
Rail line corridor	1:250,000 (50 m interval contours)	Geoscience Australia	2006
Gas pipeline corridor options	1:250,000 (50 m interval contours)	Geoscience Australia	2006
SML and Roxby Downs	1:12,500 (2.5 m interval contours)	Fugro Spatial Solutions	2006
Roxby Downs	1:5,000 (1 m interval contours)	Fugro Spatial Solutions	2006
Port Augusta	1:25,000 (5 m interval contours) plus spot heights	Department for Environment and Heritage	2006
Point Lowly	1:10,000 (2 m interval contours) plus spot heights	Department for Environment and Heritage	2004
Port Adelaide	1:10,000 (5 m interval contours) plus spot heights	Department for Environment and Heritage	2006

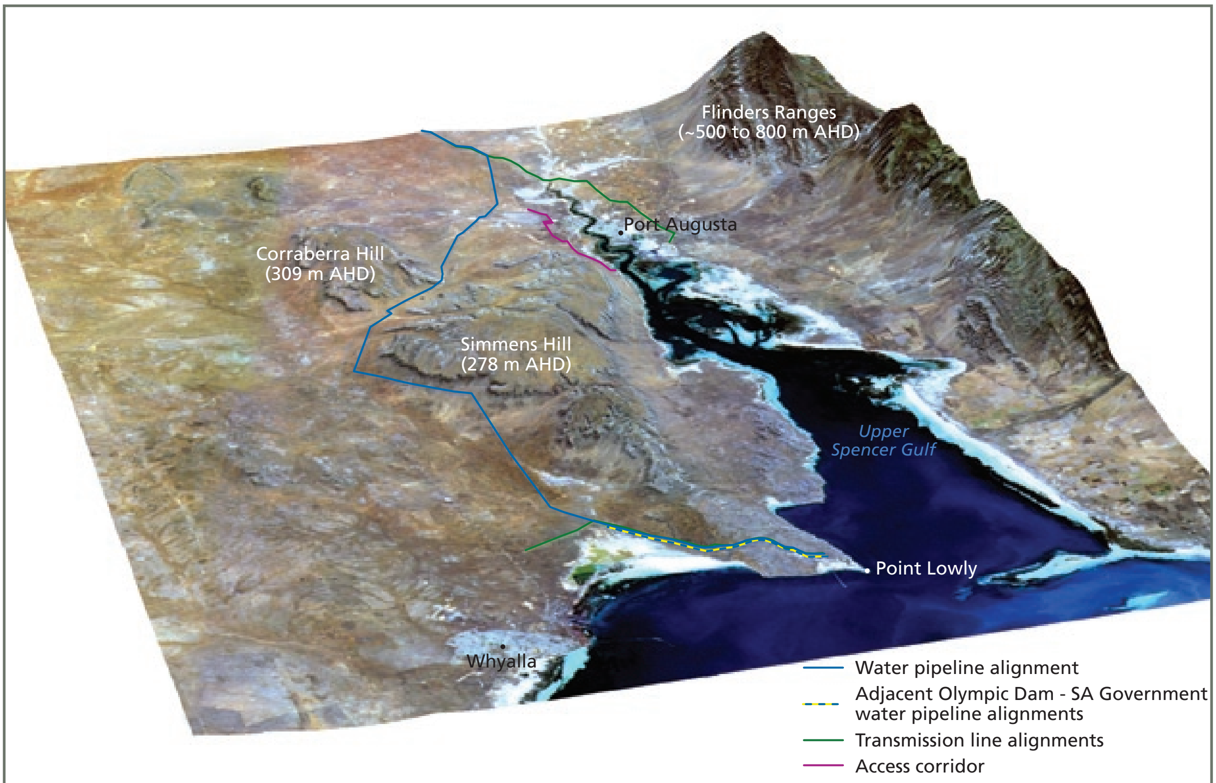

Figure 10.2 Topography from Point Lowly to Port Augusta

Laboratory testing of collected samples was undertaken at NATA accredited laboratories to quantify the physical and chemical properties of the material; these influence erosion potential and soil stability. Chemical analysis was also undertaken to establish baseline data for future comparison.

The parameters tested included field pH and electrical conductivity, and concentrations of arsenic, cadmium, chromium, copper, lead, nickel, zinc, mercury, uranium, ammonia, nitrogen, phosphorus and organic matter.

Figure 10.3 Land systems and soil sampling locations along the gas pipeline corridor options

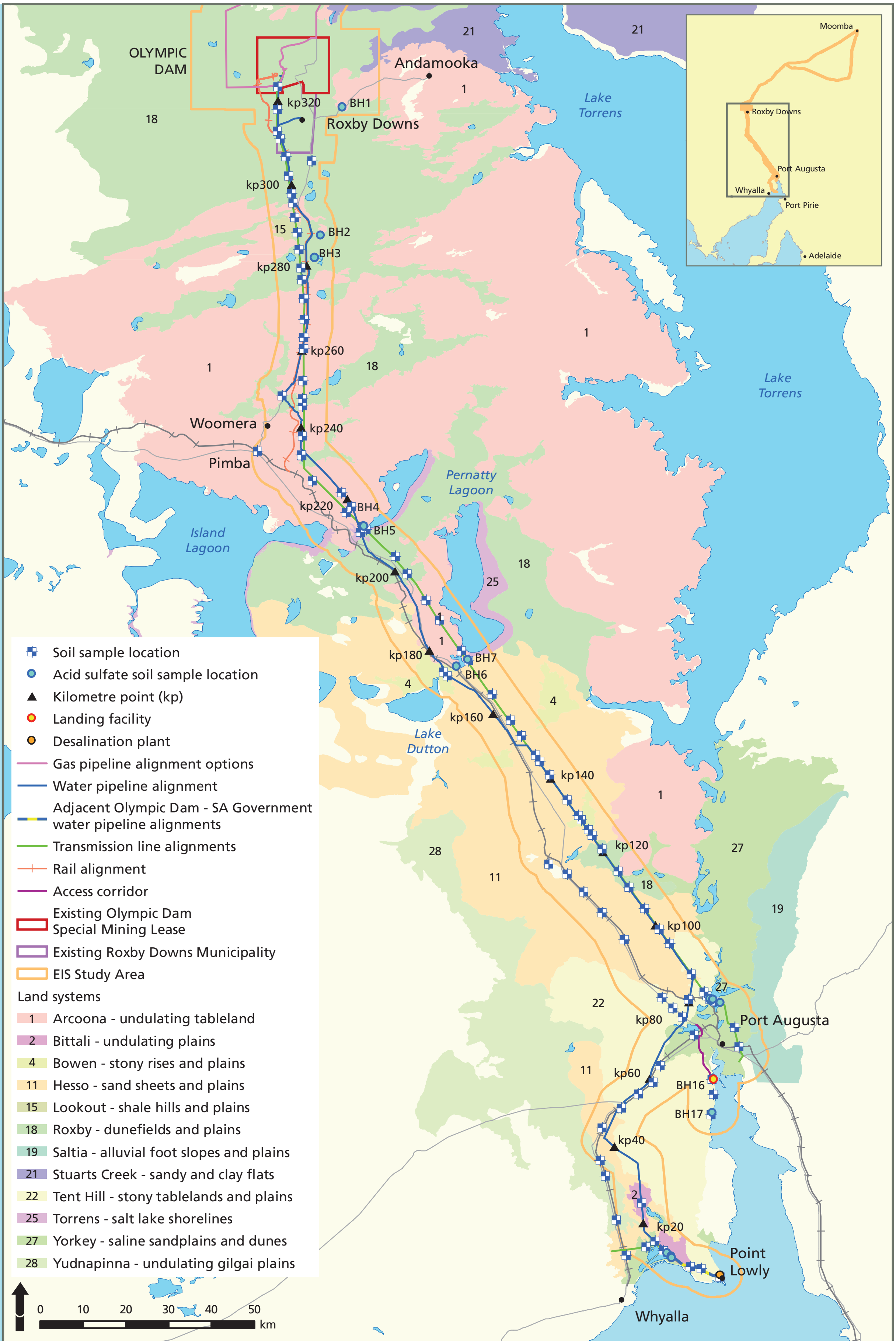

Figure 10.4 Land Systems and soil sampling locations along the southern infrastructure corridor

The concentrations of metals and nutrients were compared with the National Environment Protection (Assessment of Site Contamination) Measure (NEPM) health and ecological based investigation levels (NEPC 1999). The concentrations of uranium were compared to the United States Environmental Protection Agency health based investigation level (US EPA 2004), as no such level is published for South Australia or Australia.

Acid sulfate soils

ENSR Australia Pty Ltd (ENSR) undertook desktop and field investigations that assessed the potential for acid sulfate soils (ASS) within the EIS Study Area, and to investigate the potential effects of exposing such soils by excavation and trenching in these areas. A summary of the assessment is provided in this chapter, with supporting information provided in Appendix I2.

The term actual acid sulfate soils (AASS) is used when soils have already oxidised and developed elevated acidity. AASS typically have a field pH of less than 4 and mobile acidity in the form of ionic hydrogen, aluminium, iron or acid salts. The term potential acid sulfate soils (PASS) is used to describe soils that have significant potential to generate acid on oxidation, but which have not yet been oxidised.

South Australian ASS risk maps (Merry et al. 2003) and topographic data were reviewed to locate areas within the EIS Study Area with the potential to support the formation of ASS (typically coastal areas below 5 m AHD and inland salt lakes).

Samples were collected and handled according to the *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines* (Dear et al. 2002) and *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland 1998* (Ahern et al. 1998) because there were no detailed South Australian guidelines at the time of sampling. A guideline for acid sulfate soil materials was published in 2007 by the South Australian Environment Protection Authority (EPA 2007). It adopts the action criteria published by Ahern and others (1998) and used in this assessment.

An auger was used in the field investigations to dig 14 holes to a depth varying between 0.3 and 2.3 m in those areas identified through the desktop assessment as having the highest potential for ASS. The depth of some holes was limited because hard material was intercepted that could not be penetrated with the hand auger. Nine sites were located in low-lying coastal areas near Port Augusta and Point Lowly, and seven were located in inland salt lakes and playas (see Figure 10.4 for locations). Descriptions and samples of soils were collected from the test holes at intervals of 0.5 m (maximum) or at changes in stratigraphy.

During the field inspections, potential indicators of acid sulfate soils were recorded if present. These include the presence of acid tolerant plants, dieback and iron staining. Sediments within the auger samples were reviewed for the presence of jarosite, colour, texture, odour and neutralisation capacity (e.g. shell content).

Fifty-eight samples were collected and screened for AASS using the field pH in water (pH_f) test, and screened for PASS using the field peroxide pH test (pH_{fox}) (see Appendix I2 for details).

A range of factors influences the magnitude and duration of effects that may arise from the oxidation and leaching of PASS. When interpreting the results of soil analyses the most important of these are the permeability of the soil and the quantity of acid that would be produced on oxidation. The permeability of a soil is strongly influenced by its texture and clay content, while the potential to produce acid is best quantified by laboratory analysis to determine percentage of oxidisable sulphur. Based on the field observations and the field screening tests, 18 soil samples were selected for laboratory analysis for total actual acidity (TAA), chromium reducible sulphur and total sulphur (see Appendix I2 for details).

The combination of these factors defines the levels above which the acid generating potential of a soil is considered to be significant, and treatment is required if the soils are disturbed (adapted from Dear et al. 2002). The criteria are shown in Table 10.2.

Table 10.2 Criteria to determine significance of disturbance

Type of material		1–1,000 tonnes disturbed		>1,000 tonnes disturbed	
Texture range (McDonald et al. 1990)	Approximate clay content (%)	Oxidisable sulphur (%S)[1]	Total actual acidity (molH+/t)[1,2]	Oxidisable sulphur (%S)[1]	Total actual acidity (molH+/t)[1,2]
Coarse texture – sands to loamy sands	≤5	0.03	18	0.03	18
Medium texture – sandy loams to light clays	5–40	0.06	36	0.03	18
Fine texture – medium to heavy clays and silty clays	≥40	0.1	62	0.03	18

[1] Calculated on an oven dry basis.
[2] Moles of hydrogen ions per tonne of soil. A measure of soil acidity.

10.2.3 IMPACT AND RISK ASSESSMENT

The assessment of impacts and risks for the proposed expansion has been undertaken as two separate, but related, processes (see Section 1.6.2 of Chapter 1, Introduction, and Figure 1.11).

Impacts and benefits are the consequence of a known event. They are described in this chapter and categorised as high, moderate, low or negligible in accordance with the criteria presented in Table 1.3 (Chapter 1, Introduction). A risk assessment describes and categorises the likelihood and consequence of an unplanned event. These are presented in Chapter 26, Hazard and Risk.

10.3 EXISTING ENVIRONMENT

10.3.1 TOPOGRAPHY

Figure 10.1 shows topography and spot heights, illustrating the generally flat terrain of the EIS Study Area. Dunes trending east–west and up to around 8 m in height, swales and clay pans (see Plate 10.1) dominate the Olympic Dam landscape. The elevation is about 100 m AHD.

The gas pipeline corridor options between Moomba and Olympic Dam vary between extensive dunefields, parallel dunes with swales and clay pans, alluvial outwash plains and gibber plains and rises (see Plate 10.2). The EIS Study Area from Pimba to Port Augusta supports sand sheets and clay plains with low topographic relief (see Plate 10.3). Between Port Augusta and Point Lowly, the southern infrastructure corridor follows the alluvial flood plains that separate the plateaus and steep escarpments of the Tent Hill Formation (see Figures 10.2 and 10.4, and Plate 10.4). The highest point in the EIS Study Area, Corraberra Hill (309 m AHD), is located approximately 55 km north of Whyalla (see Figure 10.1).

The East Arm of the Port of Darwin lies within the Darwin Harbour catchment. The topography of the catchment ranges from flat intertidal and estuarine (marine) plains of negligible slope, through to undulating hills and plateaus. Elevations within the catchment range from sea level at the coastal margins to around 140 m AHD in the southern foothills (Haig and Townsend 2003). The proposed BHP Billiton facilities would be located on flat, reclaimed land.

10.3.2 LAND SYSTEMS

The Department of Primary Industries and Resources SA (PIRSA) has mapped South Australia's land systems. This method integrates several environmental features, so that each land system combines areas of similar climate, geology, landform, soil type and indigenous vegetation. The land systems within the EIS Study Area are summarised in Table 10.3 and illustrated in Figures 10.3 and 10.4.

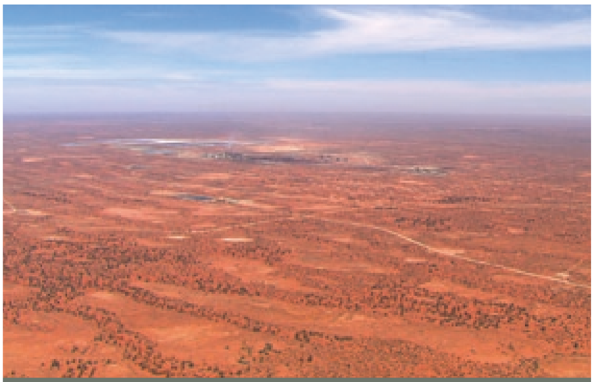

Plate 10.1 Olympic Dam landscape showing the east-west trending dunes, swales and clay pans

Plate 10.2 Landscape between Moomba and Olympic Dam showing parallel dunes and interdunal clay pans

Plate 10.3 Low topographic relief between Pimba and Port Augusta

Plate 10.4 Alluvial plains separating plateaus and steep escarpments

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Table 10.3 Land systems of the EIS Study Area

Land system	Location (kilometre point (kp))	Description	Approximate coverage (% of EIS Study Area)
Gas pipeline corridor options (see Figure 10.3)			
Arcoona	28–1 (28–1)[1]	Arcoona tablelands. Contains areas of undulating tablelands with bladder saltbush, neverfail, plover daisy and glasswort; escarpments of bladder saltbush, glasswort and woolly bluebush; swamps of blackbush, nitre goosefoot, cottonbush or canegrass and watercourses of dead finish	1.5 (1)[1]
Blanche	298–306	Salt lake country often with pale dunes on lake margins. Lake margins of bladder saltbush and samphire; Cobbler Desert with nitre bush, samphire, native myrtle and canegrass	2.5 (<1)
Collina	307–319 (400–482)	Highly eroded and saline dunefield of truncated parabolic dunes adjacent and north of the Lakes Callabonna/Blanche/Gregory complex; predominantly nitre bush dunes with broad saline flats and small plains and many small saline depressions	3 (15.5)
Cooper	420–448 (491–562)	Field of parallel dunes and extensive system of interconnected clay pans periodically flooded by Cooper Creek. Mixed cover of chenopod shrubland, tall shrubland with grass and forb understorey, hummock grassland, grassland and fringing woodland (Laut et al. 1977)	7 (11.5)
Cooryaninna	259–297 (262–275)	Channels, swamps and extensive crabhole floodplain of Cooryaninna Creek. Channels with coolibah, river cooba, Broughton willow and lignum; swamps with Queensland bluebush, canegrass and lignum; alluvial plains with Mitchell grass, common nardoo and annual grasses	8 (2.5)
Emu	30–35	Sandstone ridges of Billa Kalina. Ridges of mulga over emu bushes, cassias and grasses; slopes of bladder saltbush and grey glasswort with Mitchell grass and neverfail; shrubland plains of Oodnadatta saltbush with bladder saltbush, cottonbush and grasses	1 (0)
Flint	276–288 (292–300)	Steep rocky mesas of the Flint Hills, low hills and plains with dense silcrete gibber. Mesas with rock fuchsia bush, bladder saltbush and Mitchell grass; low hills and plains with bladder saltbush, cotton bush, tangled poverty bush, satiny bluebush and Mitchell grass	<1 (4)
Hope	320–419	Dunefield with north-south linear dunes between Cooper and Strzelecki creeks. Lacks any form of drainage systems but susceptible to flooding of eastern and western margins from high flows of the Cooper Creek	22.5 (<1)
Kalatinka	143–216 (143–216)	Clay and loam flats with Mitchell grass, neverfail, bladder saltbush and cottonbush and patches of prickly wattle and canegrass; low dunes with sandhill canegrass, nitre bush and sandhill wattle	13.5 (12.5)
Kopi	(244–256)	Relatively small areas of grey, gypsiferous crabhole flats and undulating plains with sparse cover of tangled poverty bush, flat topped saltbush and soft horns; shallow creeks with bushy groundsel, thorny saltbush and samphire	0 (1.5)
Mumpie	238–258 (227–244) (257–261) (289–291) (301–399)	Undulating gibber tableland country. Tableland with gilgais supporting barley and curly Mitchell grass, cottonbush, samphire, bladder saltbush, neverfail and bindyis; mesas with scattered mulga and low bluebush; larger creeks with river red gum, coolibah, Broughton willow and river cooba; minor creeks with dead finish and plumbush	7 (22.5)
Oodnadatta	93–142	Undulating gibber tableland with gilgai depressions, mesa and plateau country north and east of Marree. Gilgais with Oodnadatta saltbush, bladder saltbush and scattered samphire over native millet; barley, Mitchell grass, Flinders grass and annual herbs; low hills and mesas with low bluebush, bladder saltbush, harlequin emu bush and blackbush; creeks with mulga and coolibah	13.5 (10.5)
Roxby	0–27	Extensive dunefield over a calcareous plain. Dunes of native pine and mulga woodland over hopbush, woolly butt and kerosene grass; swales of mulga woodland over sandhill wattle, hopbush and grasses; myall woodland plains over pearl bluebush and limestone copper burr; flats of saltbush, star bush and sea-heath with swamps of tea-tree, canegrass or lignum	2.5 (2)
Strzelecki	217–237 (232–237)	Dunefields of Strzelecki Desert in the south-east of the district. Red dunes with whitewood, mulga, sandhill wattle, sandhill canegrass and lobed spinifex; sandy interdune flats with colony wattle, straggly corkbark over copper burrs and annual grasses; clay swales with Mitchell grass, neverfail and plate grass	4.5 (<1)

Table 10.3 Land systems of the EIS Study Area (cont'd)

Land system	Location (kilometre point (kp))	Description	Approximate coverage (% of EIS Study Area)
Gas pipeline corridor options (see Figure 10.3) (cont'd)			
Stuarts Creek	31–92	Sandy and clay flats with widely spaced sand dunes found in the south and west of the district. Sandy plains with low bluebush and bladder saltbush; clay flats with tea tree, starbush, lignum and swamp canegrass; dunes with sandhill wattle, mulga, hopbush and sandhill canegrass	13.5 (10.5)
Tingana	(483–490)	Linear dunefield east of Strzelecki Creek of mostly hummock grassland and tall shrubland dunes, lacking any definite drainage. Dunes have a SSW-NNE trend. Cottonbush is the main bluebush species	0 (3)
Tirari	North of pipeline alignment	Sandhills and flats of the Tirari Desert east of Lake Eyre, often known as Peachawarinna country. Includes channels and floodplains of the lower Cooper, Warburton and Kalakoopah creeks; dunes with sandhill canegrass, desert cynanchum and scattered sandhill wattle; variable flats with starbush, low bluebush and annual grasses; channels with coolibah and scattered nitre bush goosefoot swamps; salt lakes and clay pans with samphire	1 (<1)
Wirringina	North and south of pipeline alignment	Red sandplains, dunes and sand accumulations on stony country. Salt lakes including Lake Harry; sandplains and dunes with needlewood, sandhill wattle, sandhill canegrass and starbush; salt lakes with samphire, tangled poverty bush and water weed; kopi lunettes with blackbush, bladder saltbush and Tates bindyi; creeks with coolibah, river cooba and old man saltbush	0 (1.5)
Olympic Dam and southern infrastructure corridor (see Figure 10.4)			
Arcoona	175–195 215–230 235–245 250–275 290–295	Arcoona tablelands. Contains areas of undulating tablelands with bladder saltbush, neverfail, plover daisy and glasswort; escarpments of bladder saltbush, glasswort and woolly bluebush; swamps of blackbush, nitre goosefoot, cottonbush or canegrass and watercourses of dead finish	21
Bittali	5–10 20–30	Extensive undulating calcareous plains. Dominated by mallee woodland plains; myall, mallee and black oak woodland plains with cassia, wattles, sheepbush and daisy bush; and pediments of myall open woodland with mallee, pearl bluebush and spiny goosefoot	4.5
Bowen	125–130 170–175	Stony rises of bladder saltbush low shrubland with slender glasswort; plains and rises of pearl bluebush shrubland with brilliant hopbush, saltbush and spiny goosefoot; salt lakes fringed with samphire, bladder saltbush and star bush	3
Hesso	15–20 30 40–50 85–90 95–110 120–125 130–170	Extensive sand sheets with calcareous soils. Plains of myall, sugarwood woodland over pearl bluebush +/- bladder saltbush; and plains and rises of mulga and myall woodland with pin bush wattle, pearl bluebush and spiny fan flower	24
Lookout	West of water pipe alignment	Silicified shale hills of the Stuart Range. Plains with low shrubland of bluebushes, saltbush, silvertails and spiny goosefoot; and rises with low shrubland of bluebushes, saltbush, spiny goosefoot and silvertails	<1
Roxby	110–120 195–210 230–235 245–250 275–290 295–335	Extensive dunefield over a calcareous plain. Dunes of native pine and mulga woodland over hopbush, woolly butt and kerosene grass; swales of mulga woodland over sandhill wattle, hopbush and grasses; and myall woodland plains over pearl bluebush and limestone copperburr; flats of saltbush, star bush and sea-heath with swamps of tea-tree, canegrass or lignum	26
Saltia	South of Port Augusta	Alluvial foot slopes and plains of stony red soils with bladder saltbush, low bluebush and scattered groves of black oak and prickly wattle	<1
Stuarts Creek	Eastern boundary of SML	Sandy and clay flats with widely spaced sand dunes. Sandy plains with low bluebush and bladder saltbush; clay flats with tea tree, starbush, lignum and swamp canegrass; and dunes with sandhill wattle, mulga, hopbush and sandhill canegrass	<1
Tent Hill	0–5 30–40 50–70 75–85 90–95	Strongly dissected stony tablelands complex. Plains of bladder saltbush and glasswort shrubland with bluebush; footslopes and plains of low bluebush and bladder saltbush with some black oak; tablelands of bladder saltbush and slender glasswort; and watercourses of black oak and bladder saltbush	15

Table 10.3 Land systems of the EIS Study Area (cont'd)

Land system	Location (kilometre point (kp))	Description	Approximate coverage (% of EIS Study Area)
Olympic Dam and southern infrastructure corridor (see Figure 10.4) (cont'd)			
Torrens	210–215	Lake Torrens salina and shoreline. Salt crusted lake bed; flats and lake fringes of bladder saltbush, starbush or samphire; and lunettes of sandhill wattle and narrow-leaf hopbush over grasses	1.5
Yorkey	10–15 70–75	Saline sand plain. Dunes of mulga, myall or northern native pine over narrow-leaf hopbush and blackbush; swales of blackbush, slender glasswort and bladder saltbush; sandy flats of myall open woodland over blackbush, bladder and bitter saltbushes; and salt pans and fringing samphire flats	3
Yudnapinna	West of water pipe alignment	Dissected, undulating plains. Gilgai plain with low shrubland of bladder saltbush, slender glasswort, bluebush and bush minuria, or bladder saltbush, low bluebush and blackbush. Low lying areas with low shrubland of blackbush, low bluebush, bladder saltbush, bush minuria and cottonbush	<1

[1] Numbers in parentheses refer to the southern route of the gas pipeline corridor options, and numbers not in parentheses refer to the northern route of the gas pipeline corridor options and include the common section from Olympic Dam to near Lake Eyre.

10.3.3 SOILS

Soil descriptions

A description of soil units of the Olympic Dam region and the infrastructure corridors is provided in Table 10.4. This table also presents the corresponding land system, soil landscape and environmental associations as described in the *Atlas of Australian Soils* (CSIRO 1960 and 1968) and by Laut and others (1977).

The East Arm of the Port of Darwin is characterised by alluvial and estuarine plains with extensive intertidal flats of saline muds, clays and silts, foreshore areas of deposited sands and shells, and a hinterland of shallow gravelly, sandy soils (NRETA 2007; Haig and Townsend 2003). East Arm (where the proposed facilities would be located) was constructed through the process of land reclamation and was formed from fill from the surrounding area.

Table 10.4 Soil unit descriptions and corresponding soil landscapes and land systems

Soil unit	Plate	Coverage	General description	General soil characteristics	Soil landscape[1]		Land system[2]
					Description	Map unit	
Gas pipeline corridor options (see Figure 10.3)							
Parallel dunes with inter-connected interdunal clay pans (Cooper drainage system)	10.3	From the Moomba gas fields area for approximately 30 km to the south-east or approximately 54 km to the south; (northern route, kp 420–560; southern route, kp 480–560)	Whitish sand dunes with broad interdunal clayey soils. Dunes are generally devoid of significant vegetation while clay pans have grass cover with some eucalypt vegetation	Sands: highly permeable siliceous sands, neutral Clays of depressions: grey self-mulching cracking clays, alkaline	Uc1.21 (sands) Ug5.24 (clays)	B51	Cooper (Cooper Creek)
Sand dunes with interdunal clay pans	10.5	Located along northern route from approximately 30 to 150 km south-east of Moomba; (northern route, kp 320–420)	Red and yellow sand dunes with massive earths in the depressions. Generally low vegetative cover	Sands: red or yellow siliceous sands, neutral Clay pans: red massive earths, neutral	Uc1.23 (sands) Gn2.12 (earths)	B51	Hope (Strzelecki Desert)
Eroded dunefields with intermittent saline flats	10.6	To the north-east of Lake Gregory and east of Lake Blanche; (northern route, kp 307–320; southern route, kp 400–480)	Whitish sand dunes with saline clay pans. Sparse vegetative cover	Sands: yellow siliceous sands, neutral Clay pans: grey self-mulching cracking clay, alkaline	Uc1.23 (sands) Ug5.24 (clays)	B51	Collina (Strzelecki Desert)
Salt lakes, deposits and associated margins	–	Near Lake Gregory; (northern route, kp 295–305)	Salt crust overlying, clays, silts and quartz sands, or grey, plastic muds; some cracking clays. Generally devoid of vegetation	Calcareous, neutral to alkaline	Lakes and immediate environs	CC118	Blanche (Lake Frome)

Soil unit	Plate	Coverage	General description	General soil characteristics	Soil landscape[1]		Land system[2]
					Description	Map unit	
Gas pipeline corridor options (see Figure 10.3)(cont'd)							
Dunefields	10.7	Southern extremity of Tirari Desert; (northern route, kp 215–235; southern route, kp 220–225)	Red and yellow sand dunes. Sparse low vegetative cover	Red or yellow firm siliceous sands: neutral	Uc1.43, neutral	B43	Strzelecki (Kallakoopah)
Stony downs and gibber plains of the Blanchewater and Marree formations and associated outwash	10.8	Forms a large portion of the east-west arm of the southern route; (northern route, kp 200–260; southern route, kp 200–400; combined route, kp 90–200)	Undulating tablelands with extensive gibber surface rocks and little vegetation. Includes areas of clay and loam flats with increased vegetation	Crusty loamy soils with brown cracking clays Stone surface matrix with expansive, slightly acid to alkaline clays in subsoils	Gibber surface rocks with grey/red clayey subsoils (Dr1.33)	Nb35/ Nb36	Mumpie, Flint, Kalatinka, Oodnadatta
Alluvial outwash plains	10.9	Channels and floodplains associated with Cooryaninna Creek and various creek systems associated with southern route; (northern route, kp 260–300; southern route, kp 260–275)	Alluvium and associated valley plains. Saltbush and some eucalypt adjacent to channels	Brown self-mulching cracking soils, neutral to alkaline	Ug5.2 or Ug5.3	BG1	Cooryaninna

Plate 10.5 Sand dunes of the Hope land system

Plate 10.6 Eroded dunefields of the Collina land system

Plate 10.7 Sparse dunes of the Strzelecki land system

Plate 10.8 Stony downs and gibber plains of the Blanchewater and Marree formations

Plate 10.9 Alluvial outwash plains associated with Cooryaninna Creek

Table 10.4 Soil unit descriptions and corresponding soil landscapes and land systems (cont'd)

Soil unit	Plate	Coverage	General description	General soil characteristics	Soil landscape[1]		Land system[2]
					Description	Map unit	
Gas pipeline corridor options (see Figure 10.3) (cont'd)							
Shallow soils overlying Arcoona Quartzite and Bulldog Shale	–	To the north of the Olympic Dam SML; (combined route, kp 25–30)	Thin fine-grained topsoil (~100 mm) with gibber surface rocks over heavy clays. Sparse vegetative cover	Highly expansive clays, low permeability when wet, slightly alkaline. Shrink-swell movements of the clayey soils have formed distinct mounds and depressions called gilgai	Crusty loamy soils with red clayey subsoils (Dr1)	Nb41	Arcoona
Sand dunes with interdunal clay pans	10.10 and 10.11	From Olympic Dam to approximately 90 km: (combined route, kp 0–90)	Red to reddish brown sand dunes with interdunal clayey soils with gibber surface rock and little vegetation Clay pans generally have no surface rock and are devoid of vegetation	Sands: highly permeable, alkaline Clays: expansive and low permeability when wet, cracking under low moisture conditions, alkaline, forms a hard surface skin	Sands (Uc1.23) Brown calcareous earths (Gc)	DD1	Roxby and Stuarts Creek
Olympic Dam and southern infrastructure corridors (see Figure 10.4)							
Sand dunes with interdunal clay pans	10.10 and 10.11	From Olympic Dam to approximately 15 km south of Purple Downs pastoral station; (kp 275–335, kp195–210)	Red to reddish brown sand dunes Interdunal clayey soils with gibber surface rock and little vegetation Clay pans generally have no surface rock and are devoid of vegetation	Sands: highly permeable, alkaline Clays: expansive and low permeability when wet, cracking under low moisture conditions, alkaline, forms a hard surface skin	Brown calcareous earths (Gc)	DD1	Roxby

Plate 10.10 Sand ridge of the Roxby land system

Plate 10.12 Gibber plain of the Arcoona land system

Plate 10.11 Clay pan of the Roxby land system

Table 10.4 Soil unit descriptions and corresponding soil landscapes and land systems (cont'd)

Soil unit	Plate	Coverage	General description	General soil characteristics	Soil landscape[1]		Land system[2]
					Description	Map unit	
Olympic Dam and southern infrastructure corridors (see Figure 10.4) (cont'd)							
Shallow soils overlying Arcoona Quartzite and Bulldog Shale	10.12	South of Purple Downs to Lake Windabout; (kp 215–275)	Thin fine-grained topsoil (~100 mm) with gibber surface rocks over heavy clays	Highly expansive clays, low permeability when wet, slightly alkaline Shrink-swell movements of the clayey soils have formed distinct mounds and depressions called gilgai	Crusty loamy soils with red clayey subsoils (Dr1)	Nb41	Arcoona
Salt lakes and deposits	10.13	Found predominantly to the north of Port Augusta e.g. Lake Windabout, Ironstone Lagoon, Yorkey's Crossing; (kp 210–215)	Salt crust overlying, clays, silts and quartz sands, or grey, plastic muds	Calcareous, neutral to alkaline	Lakes	Lakes	Torrens (north of Port Augusta)
Quaternary sandplains and sand dunes	10.14	Between Lake Windabout and approximately 20 km north of Port Augusta. Also present to the east of Woomera; (kp 85–170)	Red sandy soils with little or no fines and little or no surface rock	High permeability, low fertility, alkaline	Brown calcareous earths (Gc)	DD1	Hesso
Shallow soils overlying Pernatty Grit	10.15	Generally found to the west of Pernatty Lagoon; (kp 180–195)	Red sandy topsoil up to 200 mm thick with gibber surface rock, over clay and clay loam	Highly permeable sands. Highly plastic and expansive clays, low permeability when wet, slightly acid to alkaline	Crusty loamy soils with red clayey subsoils (Dr1)	Nb42	Arcoona
Quaternary soils of alluvial plains	10.16	Found between Port Augusta and Whyalla; (kp 15–20, kp 40–50)	Alluvial sands with some clays and silts up to 500 mm thick, over clay	Slightly acidic to alkaline	Brown calcareous earths (Gc)	DD2	Hesso

Plate 10.13 Salt lake deposits

Plate 10.15 Gibber surface rocks overlying soils in the Arcoona land system

Plate 10.14 Red sandy soils typical of the Hesso land system

Plate 10.16 Alluvial sands of the Hesso land system

Table 10.4 Soil unit descriptions and corresponding soil landscapes and land systems (cont'd)

Soil unit	Plate	Coverage	General description	General soil characteristics	Soil landscape[1]		Land system[2]
					Description	Map unit	
Olympic Dam and southern infrastructure corridors (see Figure 10.4) (cont'd)							
Near coastal Quaternary soils	10.17	Located in the coastal plains of the Port Augusta area and in the vicinity of False Bay near Point Lowly; (kp 10–15, kp 70–75)	Sandplains, salt pans and sand dunes Interdunal swales with light clay loam soils	Generally saline, collapsing sands with low strength when wet, slightly alkaline	Sand soils of minimal development (Uc1) Amorphous loamy soils (Um5)	A2 BB2	Yorkey
Shallow soils overlying Tent Hill formation	10.18	Found west and south of Port Augusta and near Point Lowly; (kp 0–5, kp 50–70)	Thin loamy topsoils (up to 200 mm) overlying clay and shallow sandstone	Alkaline	Crusty loamy soils with red clayey subsoils (Dr1)	Na1	Tent Hill

[1] As described in the *Atlas of Australian Soils* (CSIRO 1960 and 1968).
[2] Corresponding environmental associations, as described by Laut and others (1977), are provided in parentheses.

Plate 10.17 Near coastal sand plains of the Yorkey land system

Plate 10.18 Shallow soils overlying the Tent Hill Formation

Erosion potential

Erosion potential is a measure of the degree to which soils are susceptible to erosion. Classifications of low, medium, high or very high are provided for each soil unit in the EIS Study Area (see Table 10.5 and Figures 10.5 and 10.6). These classifications have been based on laboratory tested Emerson Class, field tested electrical conductivity and field observations of soil properties, landform and erosion features (see Appendix I1 for details).

Table 10.5 Soil unit erosion potential

Soil unit (as per Table 10.4)	Erosion potential	Description
Sand dunes with interdunal clay pans	Low to high	Dunes highly susceptible to wind erosion. Bare clay pans subject to scalding from surface water
Dunefields	Moderate to very high	Dunefields inherently mobile and susceptible to wind erosion
Stony downs and gibber plains of the Blanchewater and Marree Formations and associated outwash	Low to high	Surface gravel offers high degree of natural protection, however, exposure of dispersive subsoil in undulating terrain may have the potential for significant erosion
Quaternary alluvial plains	Low (often high to very high at stream crossing)	Stream channels highly susceptible to stream bank erosion. Plains may be susceptible to sheet erosion
Shallow soils overlying Arcoona Quartzite and Bulldog Shale	Low	Removal of surface gravels may lead to some minor loss of surface soils
Salt lakes and deposits	High to very high	Susceptible to gullying and wind erosion when surface cover disturbed
Quaternary sandplains and sand dunes	Medium to high	Minor gullying associated with drainage features Highly susceptible to wind erosion where surface cover disturbed
Shallow soils overlying Pernatty Grit	Low	Removal of surface gravels may lead to some minor loss of surface soils
Near coastal Quaternary soils	Low to medium	Removal of surface vegetation may lead to some minor loss of surface soils
Shallow soils overlying Tent Hill formation	Low to medium	Removal of surface vegetation may lead to some minor loss of surface soils. Higher risk on the stony slopes, where large gullies can form in areas of surface disturbance

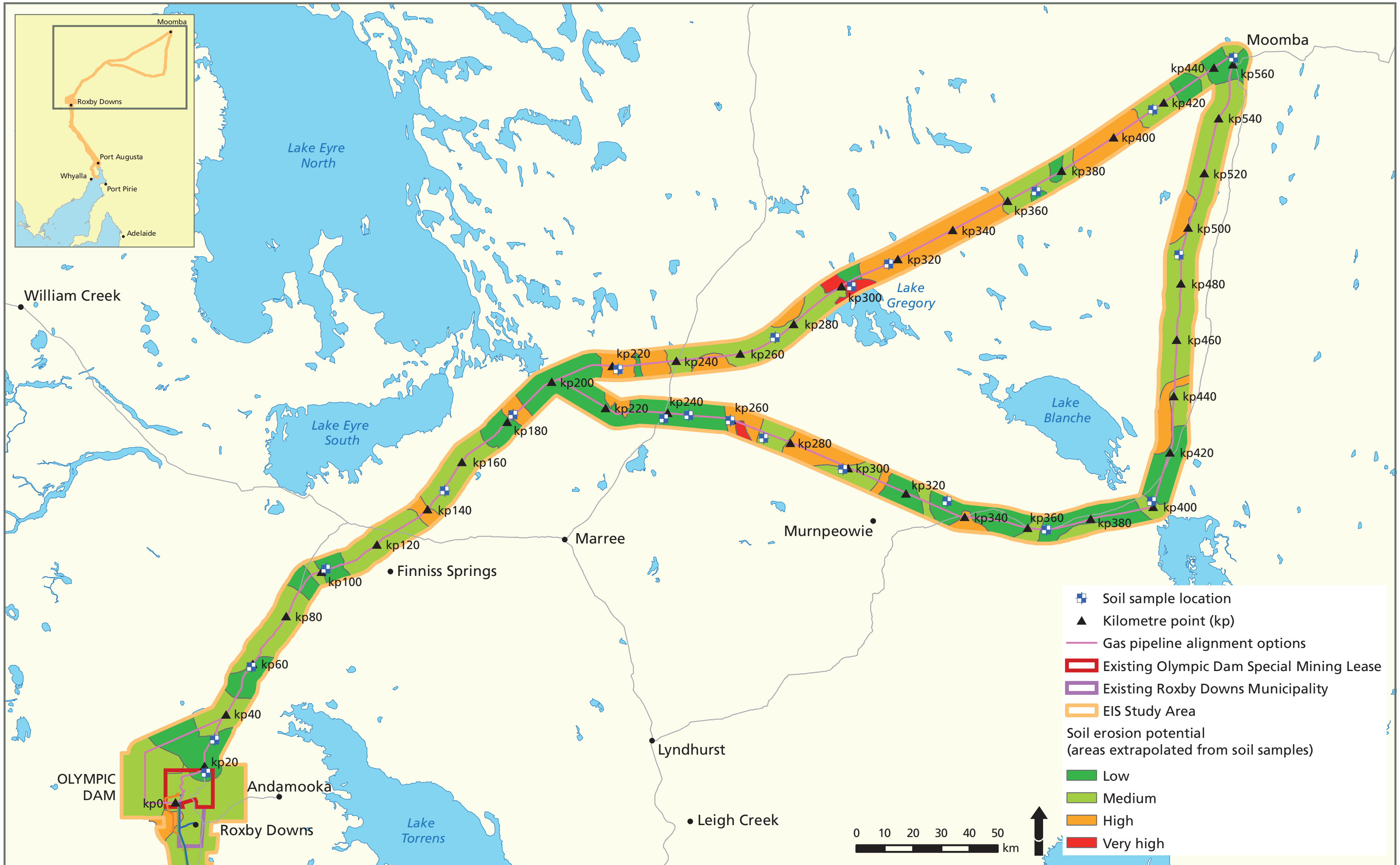

Figure 10.5 Soil erosion potential along the gas pipeline corridor options

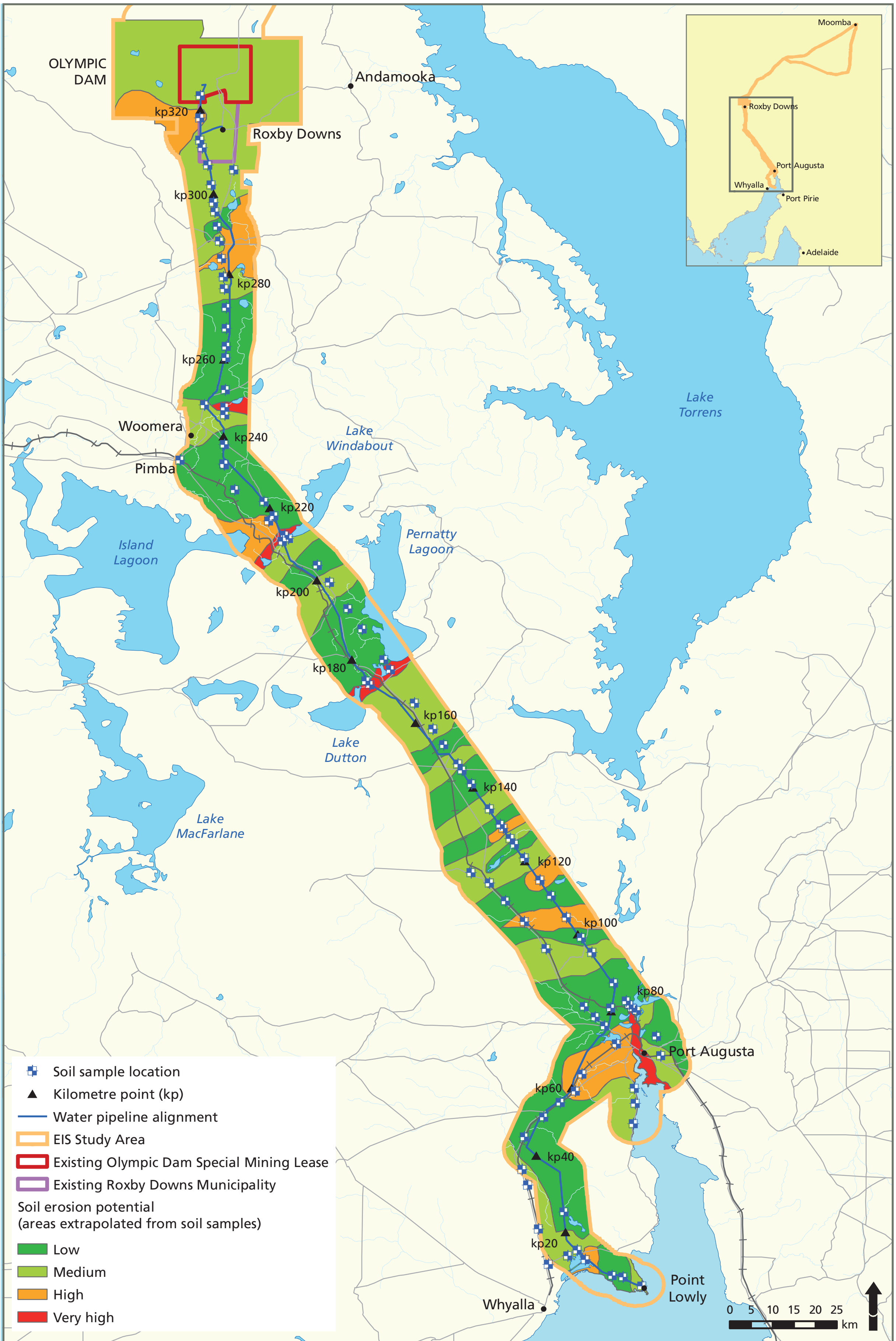

Figure 10.6 Soil erosion potential along the southern infrastructure corridor

Soil metals and nutrients

Soils sampled from the EIS Study Area reported concentrations of metals typical of background levels (as presented in Berkman 1995). No concentrations were above NEPM health or ecological-based guideline levels. Reported concentrations of uranium were below the US EPA health-based soil investigation level (see Appendix I1, Table I1.5 for full details).

Concentrations of soil nutrients and organic matter were also low to very low. This is typical of soils in arid and semi-arid environments that have a low natural fertility.

Acid sulfate soils

Two types of acid sulfate soils (ASS) were identified:

- Inland ASS – these ASS form in situations where there is a sulphate source, iron source and organic matter, all of which occur in inland salt lakes. They occur in the near-surface sediments (<10 mm) of salt lakes in the form of mono-sulphides or 'black ooze'. When disturbed, monosulphides can react rapidly to form acid (i.e. within minutes to hours).
- Coastal ASS – these ASS are generally associated with estuarine (marine) clays, but they also occur as sands and gravels, and most often in areas below 5 m AHD. Sulphide minerals are generally present in the form of iron sulphide (pyrite). When exposed to oxygen these soils and sediments become acid forming over longer periods (from days to years), depending on the grain size.

The ASS risk mapping (Merry et al. 2003) suggests that the coastal ASS may occur in some sections of the EIS Study Area (see Figure 10.7). Section 10.5.2 presents the findings of the field and laboratory investigation for inland and coastal ASS and the potential impacts associated with the proposed expansion.

10.3.4 FOSSILS

As fossils are either composed of stone or embedded in stone, and therefore fall within the definition of 'minerals', the Crown owns fossils in South Australia, including fossils found on pastoral or perpetual leasehold land and lands subject to native title by virtue of the *Mining Act 1971* (PIRSA 2004a).

Fossils of significance in South Australia are registered on the Australian Heritage Places Inventory, the Australian Heritage Database and the South Australian Heritage Register. The significance of fossil assemblages is generally defined by the abundance in which the fossil occurs. There are no areas of registered fossils of significance within the EIS Study Area. However, an official fossil reserve, Lake Callabonna, is located within 1 km of the gas pipeline corridor options (see Figure 10.8). The significance of the Lake Callabonna fossil assemblage is the presence of fossils as articulated specimens, including Australia's largest Pleistocene aged marsupial, the Diprotodon (Aussie Heritage 2008).

A second official fossil reserve, Lake Palankarinna, is located approximately 30 km north of the gas pipeline corridor options and is considered significant as it contains a diverse stratigraphic sequence of Tertiary aged vertebrates (N Pledge, SA Museum, pers. comm., 22 January 2008).

While not listed as being of significance, some fossils are known to exist in the following lithologies (see Figures 10.8 and 10.9):

- Cretaceous aged Bulldog Shale – grey, shaly mudstone known to contain fossil assemblages of macrofaunas dominated by molluscs (Drexel et al. 1993)
- Late Palaeocene aged Eyre Formation – silicified sandstone that may contain plant fossils or 'silcrete floras'. These fossils are particularly widespread south of Lake Eyre to Lake Pernatty (N Pledge, SA Museum, pers. comm., 22 January 2008).

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10.4 DESIGN MODIFICATIONS TO PROTECT ENVIRONMENTAL VALUES

10.4.1 ENVIRONMENTAL VALUES

Soils provide a natural foundation and supply of minerals and water to plants and provide habitat for many organisms. Disturbance to soils can affect structural integrity, change chemical properties and alter the potential for re-establishment of plants and animal habitat.

10.4.2 MAJOR ELEMENTS OF THE PROJECT DESIGN

The key components of the project design that influence the assessment of soils (see Chapter 5, Description of the Proposed Expansion, for the full description of the project components) are:

- the extent of the proposed expansion and the corresponding areas requiring ground disturbance
- the excavation of trenches to bury the gas supply pipeline, water supply pipeline and the intake and outfall pipes for the desalination plant
- the location of electricity transmission line towers (e.g. on topographically elevated sites)
- excavation and construction of embankments for the railway line and access corridor.

Planning provides the greatest opportunity to reduce the potential impacts on soils of the EIS Study Area. Where possible, project infrastructure would be located to:

- minimise disturbance to soils of high and very high erosion potential
- avoid areas of actual and potential acid sulfate soils.

Additional mitigation measures and standard controls to avoid or reduce impacts are presented in Section 10.5.

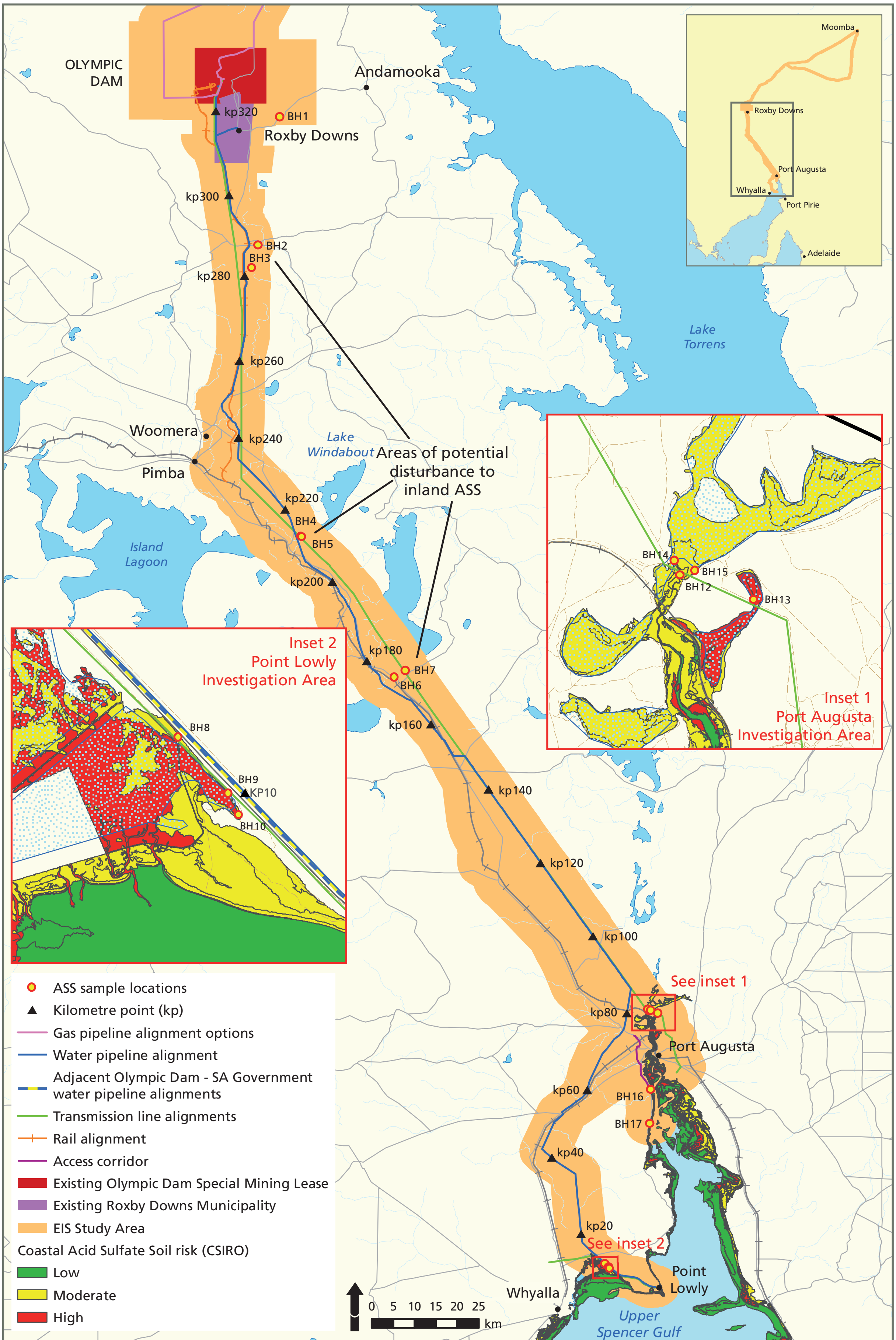

Figure 10.7 Coastal acid sulfate soils (ASS), risk mapping and areas of potential disturbance to inland ASS

Figure 10.8 Geological units known to contain fossils along the gas pipeline corridor options

10.5 IMPACT ASSESSMENT AND MANAGEMENT

10.5.1 SOIL EROSION

Soil erosion may occur during and after rainfall or high winds. The risk of erosion is increased if disturbance to the ground surface breaks the crust or removes surface gravels or vegetation. The degree of soil erosion depends on the susceptibility of the disturbed soil type to various wind velocities and rainfall volumes and intensities, as well as landscape features such as slope and vegetation coverage.

The susceptibility of the various soil types to erosion was described in Table 10.5 and illustrated in Figures 10.5 and 10.6. On a linear basis, around 126 km of the northern route for the gas pipeline corridor options has a high to very high erosion potential, 180 km has a medium potential and 137 km has a low potential. For the southern route option, around 47 km has a high to very high erosion potential, 161 km has a medium potential and 150 km has a low potential (see Figure 10.5). For the southern infrastructure corridor, around 5 km has a very high erosion potential, 49 km has a high potential, 170 km has a medium potential and 175 km has a low potential (see Figure 10.6).

Given the relatively flat terrain and the small, contained catchments for most of the EIS Study Area (see Chapter 11, Surface Water, for details), standard engineering practices would control erosion in those areas with low and moderate erosion potential. Such practices include minimising the area of disturbance and stockpiling topsoil and cleared vegetation for subsequent re-spreading over disturbed areas.

Additional erosion control measures would be implemented in those areas with soils of high and very high erosion potential, and at the site of the landing facility, desalination plant, Port of Darwin facilities and associated infrastructure (as sediment generated from these areas may enter ecologically sensitive marine waters). These additional control measures are:

- Erosion and sediment control plans (ESCP) that would:
  - be developed in consultation with a marine ecologist with knowledge of the relevant receiving environment (i.e. Upper Spencer Gulf, Darwin Harbour) so that potential impacts on ecologically sensitive places are avoided or minimised
  - include marked-up design drawings that show the location, extent and type of erosion control measures proposed (e.g. silt fencing for terrestrial areas, silt curtains for marine areas, catch banks or drains and rock armouring for areas of potentially concentrated stormwater flow).
- An ESCP for areas of high to very high erosion risk along the gas pipeline corridor options. The plan would specifically address:
  - dunefield areas, particularly those associated with the Strzelecki, Collina and Hope land systems (see Figure 10.3), as the susceptibility of these areas to erosion is increased by the prevailing direction of the longitudinal dunes (i.e. north-north-west to south-south-east) in relation to the direction of pipeline construction, which would necessitate traversing the dunes in an east to north-east direction
  - undulating downs and rolling hills within the Mumpie soil unit where removal of the protective gibber surface would increase susceptibility to water erosion due to the dispersive subsoils and steep terrain
  - the bed, banks and overflow channel areas of the main watercourses, where flood flows with a significant velocity may cause or increase stream bank and stream bed erosion. Many soils associated with the stream channels are dispersive cracking clay soils that are particularly susceptible to erosion and most channels currently exhibit significant erosion due to high cattle stocking pressures.
- Suitable erosion protection measures (e.g. silt fencing) would be installed on the downstream side of the disturbance areas for the transmission line towers where soils of high erosion risk have been identified (see Figure 10.6) and in areas within 50 m of a drainage channel or watercourse.
- Erosion protection measures would be implemented to limit the disturbance to protective gibber surfaces (such as those within the Arcoona land system between Woomera and Roxby Downs) and salt crusts (e.g. at Lake Windabout and Pernatty Lagoon). Where possible, ancillary infrastructure (such as borrow pits, access tracks and laydown yards) would be located outside these areas. Site clean-up in these areas would also avoid grading or shallow ripping of traffic compacted areas to retain the integrity of the compacted surface.

Monitoring programs would be developed to ensure erosion and sediment control measures were inspected, and maintained if required, following each potentially erosive rainfall event (this would be determined during the Environmental Management Program (EM Program) and ESCP preparation). The monitoring programs would be implemented during the construction phase and continue during post-construction until the disturbed areas were stabilised.

With the successful implementation of these control measures, the residual impact to the environment from erosion and the resulting sedimentation is considered to be low.

All excavation works for the existing operation are required to be undertaken under the existing internal permit system. While the excavation permit system includes inspection of sites for potential heritage and native vegetation clearances, it also outlines procedures required for reinstatement and rehabilitation of excavations to promote regeneration of native vegetation and to limit the potential for soil erosion. The existing excavation permit system is considered appropriate for the expanded operation.

As discussed above, additional control measures would be implemented in areas with soils of high and very high erosion potential and where construction occurs adjacent to marine environments. Monitoring programs would be developed to ensure erosion and sediment control measures were inspected and maintained following each potentially erosive rainfall event (this would be determined during the EM Program and ESCP preparation).

10.5.2 ACID SULFATE SOILS

The desktop and field investigations established that some soils within the EIS Study Area appeared to have the potential to generate acid if disturbed (i.e. exposed to oxygen). The comparison of laboratory results for these samples with the action level criteria for ASS (see Table 10.2) is shown in Table 10.6.

The data in Table 10.6 show that total actual acidity is well below action level criteria for all sample locations. It does, however, show that some locations have the potential to generate acid if disturbed (as shown by the oxidisable sulphur data), in which case soils in these areas would need to be treated. The areas of potential disturbance to ASS include the inlet to Lake Windabout (site BH05), Yorkey's Crossing near Port Augusta (site BH08), small areas adjacent to Port Bonython Road (sites BH12 and BH13) and the proposed landing facility sites (BH16: see Figure 10.7). Note that elevated levels were also identified at BH01 (near Andamooka Road), but the proposed expansion would not disturb this site.

Lake Windabout

This sample collected at Lake Windabout (BH05) contained monosulphides in near-surface sediments. While monosulphides are known to be highly reactive, they were only found in very thin surficial horizons (to a depth of 0.05 m) and so the quantity of acid produced on oxidation would be very small. Lakes such as Lake Windabout also form a sink for surface water and groundwater flows, so the potential for off-site impact is negligible. Furthermore, the proposed level of disturbance at Lake Windabout would be minimal: the transmission line towers would generally avoid these areas or require fill rather than excavation and the water supply pipeline would be elevated across the inlet to Lake Windabout instead of being buried in an excavated trench. Given these factors, the standard engineering practice of minimising disturbance and the effectiveness of soil handling and lime dosing, if required, management measures would ensure the residual impact of ASS in this area is negligible.

Yorkey's Crossing near Port Augusta

The proposed transmission line would traverse intertidal areas at Yorkey's Crossing. However, the transmission line towers are likely to be located on elevated terrain, which is outside of ASS prone areas. If towers were to be located below 5 m AHD in the area near BH08, further ASS investigations would be conducted and an ASS management plan would be prepared if the sample analysis was found to exceed the applicable criteria. The plan, if required, would include control measures for ASS, including appropriate soil handling methods and lime dosing rates. The residual impact for potential disturbance to ASS at Yorkey's Crossing is categorised as low.

Table 10.6 Comparison of soil samples with action criteria[1]

Sample reference number (see Figure 10.7)	Texture range (McDonald et al. 1990)	Total actual acidity (molH+/t)	Oxidisable sulphur (%S)	Criteria exceeded	
				<1,000 t disturbed	>1,000 t disturbed
BH01: 0–0.5	Coarse	<2	**0.1**	Yes (0.03)	Yes (0.03)
BH02: 0–0.3	Fine	<2	<0.02	No	No
BH05: 0–0.05	Fine	<2	**0.19**	Yes (0.1)	Yes (0.03)
BH05: 0.05–0.3	Fine	<2	<0.02	No	No
BH06: 0.8–1.0	Medium	<2	<0.02	No	No
BH08: 0.45–0.7	Coarse	<2	<0.02	No	No
BH08: 1.0–1.3	Fine	<2	**0.03**	No	Yes (0.03)
BH09: 1.1–1.35	Fine	<2	<0.02	No	No
BH12: 1.7–2.0	Fine	<2	**0.06**	No	Yes (0.03)
BH12: 2.0–2.3	Coarse	<2	**0.11**	Yes (0.03)	Yes (0.03)
BH13: 1.5–1.7	Coarse	<2	0.02	No	No
BH13: 1.7–2.0	Fine	<2	**0.03**	No	Yes (0.03)
BH14: 1.5–1.7	Coarse	<2	0.014	No	No
BH15: 0.7–0.9	Fine	<2	<0.02	No	No
BH15: 1.8–2.0	Coarse	<2	<0.02	No	No
BH16: 0.2–0.25	Medium	<2	<0.02	No	No
BH16: 0.35–0.4	Fine	<2	**0.19**	Yes (0.1)	Yes (0.03)
BH17: 0.2–0.25	Coarse	<2	<0.02	No	No

[1] Numbers in bold indicate concentrations above or equal to the action criteria.

Proposed landing facility

The areas located at and adjacent to the proposed landing facility are below 5 m AHD and would be disturbed during construction. Shallow subsurface soils (0.35–0.4 m) exceeded the applicable action level criteria but have a low acid producing potential. Nevertheless, more extensive ASS investigations would be undertaken at this site prior to construction activities. Should these further investigations detect oxidisable sulphur levels exceeding the applicable action criteria, a site specific ASS management plan would be prepared. The plan, if required, would include control measures for ASS, including appropriate soil handling methods and lime dosing rates. As management of ASS, once detected, is easily achieved, the residual impact for disturbance is categorised as low.

Small areas adjacent to Port Bonython Road

The area adjacent to Port Bonython Road that may be disturbed during pipeline construction has no, or very low, pyrite content and has a low acid producing potential. As the action level criteria were exceeded, and given the sensitivity of the receiving environment, further ASS investigations would occur once the final pipeline alignment had been determined and an ASS management plan would be prepared before excavation works commenced in this area. Given the practical ease and effectiveness of ASS control measures, the residual impact for potential disturbance to ASS near Point Lowly is categorised as low.

Port of Darwin

The construction of facilities at the Port of Darwin would generally be on reclaimed land and therefore would not disturb acid sulfate soils. However, trenching below 5 m AHD may be required to install service infrastructure. Prior to such ground disturbance in these areas, testing would be undertaken for potential and actual ASS. An ASS management plan would be implemented for areas that exceeded action criteria as listed in Table 10.2 or other relevant Northern Territory guidelines. Given the minimal trenching required, the planned ASS testing in risk areas and the implementation of an ASS management plan where required, the residual impact for potential disturbance to ASS at the Port of Darwin is categorised as low.

10.5.3 COLLAPSING AND SWELLING SOILS

Collapsing soils are present in some areas of the EIS Study Area, particularly the sand dunes near Port Augusta (kp 75; see Figure 10.4). The trench proposed to be excavated through these soils for the water supply pipeline has the potential to become unstable and collapse. This may impact construction personnel should they enter the trench in these locations. Standard engineering practices such as shoring or similar measures that retain the trench's structural stability would be used in these areas.

Expansive, cracking clays occur in several sections of the EIS Study Area (see Table 10.4 and Figure 10.4). Significant shrink-swell movements could damage the water supply pipe. Appropriate bedding and backfilling of the pipe is standard engineering practice in such soil types and would be used to avoid potential impacts associated with the expanding and swelling of cracking clays.

The rail line would cross the undulating sand dunes, swales and clay pans of the Roxby land system and the highly expansive clays of the Arcoona land system (see Figure 10.4). Pooling of surface water following prolonged or major rainfall events, though uncommon, could potentially cause slumping in parts of the rail line as these clays softened. The problem is easily managed by using culverts or other drainage features at topographic low points. This has been considered during the concept design phase (as is evidenced through the inclusion of up to 140 culvert structures for the rail line), and would continue to be investigated during the detailed design phase.

The residual impact associated with swelling and collapsing soils is negligible.

10.5.4 SOIL CONTAMINATION

Mine area

Elevated concentrations of metals and other potential contaminants (including radionuclides) present in stormwater run-off from on-site facilities such as the metallurgical plant, hardstand areas and the RSF may lead to localised soil contamination. Haul roads and bunds would be used to intercept and convey stormwater run-off from these facilities to naturally low lying areas within the landscape. Stormwater run-off would be contained within the SML, and run-off potentially containing radionuclides would be contained within a defined area (see Chapter 11, Surface Water, for further detail). Post closure, potentially contaminated soils would be assessed and remediated as required (see Chapter 23, Rehabilitation and Closure, for further detail).

As potential contaminants present in stormwater run-off would be controlled and not go off-site, and identified contaminated soils would be remediated post closure, the residual impact is categorised as low.

Port of Darwin

The concentrate storage and loading facilities at the Port of Darwin would be managed in a closed system including negative pressure and automatic doors for the storage shed and dedicated enclosed conveyors. Rail wagons would be sealed with suitable covers to ensure containment of the load during transport. Uranium oxide would be transported in sealed drums within sealed shipping containers. Therefore, the likelihood of contamination leading to environmental harm is low and the residual impact of soil contamination from the storage and transport of uranium oxide and concentrate is categorised as negligible.

Existing contaminated soils

No register is present in South Australia to identify areas of known contaminated soils. However, contaminated soils may be associated with industrial areas such as around Port Augusta and Point Lowly. Strategies to identify and manage existing contaminated soils prior to construction of off-site facilities would be included in the EM Programs.

The Darwin Port Corporation consider the material used at the East Arm for land reclamation to be 'clean fill' (GHD 2006). Therefore, it is unlikely that contaminated soils would be encountered during construction of the facilities.

Chemical storage and accidental spills

Details of chemical storage and use are presented in Chapter 5, Description of the Proposed Expansion. As some of the Olympic Dam material is radioactive, spillages of all process materials and products are treated seriously by BHP Billiton and systems and procedures are in place to ensure that spills are identified, reported, cleaned up and investigated to prevent recurrence.

Operational procedures at Olympic Dam require all spills (or loss of containment spills) to be reported internally as environmental incidents. At Olympic Dam the frequency, duration and severity of all spillages are currently monitored including information on the quantity of material and type of material.

A process to notify external agencies if the spill triggers the external reporting level is also in place. Reporting criteria are based on volume of spillage and whether the spill has occurred inside or outside a bund which has been designed for the purpose of containing a spill.

As part of contingency management, all parts of the existing plant have undergone hazard and operability (HAZOP) reviews to identify the potential for spills and the likelihood of spillages. These reviews would occur for new plant or facilities, including facilities at the Port of Darwin, installed as part of the expansion project. Controls include bunding requirements and access and egress for cleanup. Those areas which require specific legislative requirements for spillage prevention, control and management would also be addressed further in the detailed design stage.

In the event of a spillage, there are a number of controls available for operational personnel to contain spills including temporary bunds and spill kits for spillage response and operational and emergency response personnel are trained in their use.

Fuel storages and other hazardous materials would be appropriately bunded as required by South Australian, Northern Territory and Australian statutes. The residual impact of soil contamination associated with storage of fuels and other chemicals is categorised as low. Risks as a result of accidental spills and other unplanned events are addressed in Chapter 26, Hazard and Risk.

10.5.5 FOSSILS

There are no areas containing registered fossils of significance within the EIS Study Area, although an official fossil reserve is located close to the gas pipeline corridor options (see Figure 10.8). The geological units within the EIS Study Area that potentially support fossils (Bulldog Shale and Eyre Formation) are generally found at greater depths than would be exposed by excavation during construction, which limits the chance of disturbance. However, these geological units do occur within the surface geology in some parts of the EIS Study Area (see Figures 10.8 and 10.9), such as:

- Bulldog Shale – occurs in surface geology within and around the SML, along the southern portion of the gas pipeline corridor options, approximately 10 km south of Roxby Downs township and the local Woomera area.
- Eyre Formation – occurs within the surface geology of the gas pipeline corridor options and approximately 30 km south of the Roxby Downs township.

As leaf fossils within the Bulldog Shale and plant fossils within the Eyre Formation are relatively common and are not considered to be significant by the South Australian Government, no action would be taken should such fossils be discovered.

Fossil bones within the Bulldog Shale are considered to be noteworthy. A procedure for identifying and treating such fossils, should they be found during ground disturbance works, would be included in the EM Program for the project components requiring excavation in the Bulldog Shale areas as shown in Figure 10.9 (see Chapter 24, Environment Management Framework, for details of management plans). The procedure may, for example, require the fossils to be photographed and an appropriate person contacted at the South Australian Museum to determine their significance and any further mitigation measures that may be required. Given the low likelihood of encountering significant fossils and the measures that would be adopted in the event of a discovery, the residual impact on fossils is categorised as negligible.

10.6 FINDINGS AND CONCLUSIONS

Soil erosion

Soils within those areas proposed to be disturbed for the expansion project have a susceptibility to erosion, once disturbed, which varies from low to very high. However, the degree of disturbance, the generally flat terrain and the small catchment areas suggest that erosion categorised as low or moderate can be readily managed. Additional erosion control measures have been identified for those areas where the soil erosion potential has been categorised as high and very high. Implementation of management controls results in the residual impact to the environment caused by erosion and subsequent sediment deposition to be categorised as low.

Figure 10.9 Geological units known to contain fossils along the southern infrastructure corridor

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Acid sulfate soils

Areas of potential disturbance to acid sulfate soils (ASS) include several salt lakes, Yorkey's Crossing near Port Augusta, and small areas of coastal ASS adjacent to the proposed landing facility and Port Bonython Road. The residual impact of potential acid generation is low as areas that support potential ASS are generally avoided or have low potential to generate acid if disturbed. Where this is not the case (e.g. at the inlet to Lake Windabout and the proposed landing facility), additional ASS assessments would be undertaken and an ASS Management Plan detailing required soil handling methods and lime dosing rates would be developed prior to disturbance. As management of ASS can be readily achieved, the residual impact of disturbance in these area is also categorised as negligible to low.

Collapsing and swelling soils

Some areas supporting collapsing and swelling soils were identified and mapped within the EIS Study Area. As standard engineering practices can be readily implemented to ensure protection of personnel and infrastructure assets, the residual impact is negligible.

Soil contamination

Transport, handling and storage of fuel and other hazardous materials within the SML, and at construction sites for the associated infrastructure, will be in accordance with the relevant State and Australian statutory requirements.
The objectives are to prevent spills from occurring and, if they do, to contain the spillage to the immediate vicinity. Current spill management and reporting procedures would continue for the expanded operation. The potential for accidental spills resulting in significant soil contamination is low.

Fossils

As the likelihood of encountering significant fossils within the EIS Study Area is low, and contingency measures have been identified in the event of a discovery, the residual impact is categorised as negligible.